

**Bit Bang 8:**

# **Digitalization**

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*Yrjö Neuvo, Erkki Ormala & Meri Kuikka (eds.)*







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Aalto University's Multidisciplinary Institute of Digitalisation and Energy (MIDE)

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## Foreword

This book is the 8<sup>th</sup> in the Bit Bang series of books produced as multidisciplinary teamwork exercises by doctoral students participating in the course Bit Bang 8: Digitalization at Aalto University. The course was facilitated by Professor, Research Director and former Nokia Chief Technology Officer Yrjö Neuvo; and Professor Erkki Ormala, former Vice President of Nokia. 21 students took part in the course during the academic year 2016-2017. The students were selected from diverse academic and cultural backgrounds: 12 nationalities were represented by students from all six Aalto Schools, leading to spirited in-class discussions and multidisciplinary teamwork.

The learning objectives of the course centered on teamwork, multidisciplinary collaboration, and gaining global perspectives and foresight on the future of digitalization. These were achieved through weekly lectures from visiting industry leaders, writing the chapters of this book, and other teamwork assignments. As textbook material and to support class discussions and teamwork the students used *The Second Machine Age* by Erik Brynjolfsson, as well as selected chapters from previous Bit Bang publications.

Working in teams, the students set out to answer questions related to digitalization. Technological progress brings new solutions at an increasing speed. Digital convergence, next generation Internet, cloud computing, ubiquitous computing, mobile sensing, self-driving cars, and the smart grid are all examples of the new developments taking place today. Digitalization has also brought great opportunities for economic growth, productivity gain and job creation in our societies, and will change the way industry will operate in the future. Bit Bang 8 addressed the topic of digitalization from the perspective of its economic, environmental and social sustainability. The course elaborated on the interconnectedness of these phenomena, and linked them to possible future scenarios, global megatrends and ethical considerations. How will digitalization shape our future? How can we prepare can prepare our societies to respond to these changes?

By the end of the autumn term, four teams had produced four points of view on the effects of digitalization published in this book: *Is Digitization Making Work Precarious? Implications of the Global e-Lancer Economy; Messianic Visions or Path to Technocorruption: Are Cryptocurrencies a Root of All Evil or Future*



*Wealth of Nations?; Subjective Context Awareness: Machines That Understand Personal Accounts, Feelings, and Emotions; and University Education in 2035: Paving the Way for a Digital Future.*

At the start of the spring term, the groups were reshuffled and set to tackle new topics: *The Digital Health Society: Perspectives on Real, Predictive, and Preventive Care; Digitalization reshaping conflicts – the ordinary citizen as the new peacekeeper; Disrupting the water industry* and *Digitalization: unlocking the potential of Sharing.*

During the spring term, the course also visited Seoul for a week-long study tour. The tour program and short reports on the company and institution visits are available in the appendices of this book.

The Bit Bang series of courses is funded by the Multidisciplinary Institute of Digitalisation and Energy (MIDE). The unique nature of the course has generated lots of positive feedback from the academic community, and produced an extensive network of alumni connecting doctoral student and graduated doctors. We are very proud of the community we have been able to gather around this unique and thought-provoking course.

We wish to give our special thanks to this year's tutors and Bit Bang alumni Synes Elischka, Jussi Hakala, Vincent Kuo and Noora Pinjamaa for their tireless work with their teams and valuable advice given whenever needed. We also wish to thank our esteemed guest lecturers representing government, industry and academia. Their presentations and discussions gave valuable insight into the issues studied, and their role was essential for the success of the course.

We wish you captivating moments with the book!

***Yrjö Neuvo, Erkki Ormala and Meri Kuikka***





**Digitalization**



# *Is Digitization Making Work Precarious? Implications of the Global e-Lancer Economy*

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**ABSTRACT:** *This article explores the phenomenon of e-lancing and its effects on labor relations, migration of work, and the resulting global redistribution of wealth. A comparison of three e-lancing platforms paints a more accurate picture of what e-lancing actually means in terms of work content, organization, and potential challenges. On a national level, e-lancing sparks a discussion about social rights, the mechanisms that drive long-term sustainability of social security contribution and coverage schemes. On a global level, the question of fair wages and quality-of-living standards is taken up anew. Taking the Northern European perspective, we present policy recommendations on how to foster the positive effects of e-lancing, while trying to minimize detrimental effects.*

**KEYWORDS:** *e-lancing, labor relations, social security, taxation, global fair wage*

# 1 Introduction

Freelancing has long been a common term and mode of work organization [1]. The Oxford open web dictionary defines freelancing as being “self-employed and hired to work for different companies on particular assignments” [2]. A term less commonly accepted and less generally known, e-lancing leans on this definition and places it into the virtual; Wikipedia defines e-lancing as “the recent trend of commending and taking free-lancing work through so-called e-lancing websites. E-lancing websites are hubs where employers place tasks, which freelancers from around the world bid for” [3]. Thus, e-lancing is freelancing that occurs online and that is mediated via Internet platform providers. In consequence, there is no longer a direct, nonmediated relationship between the e-lancer and the employer. This appearance of an intermediary may have implications for e-lancers’ employment and broader social rights.

E-lancing is a trend strongly driven by digitalization. The increasing connectivity enables more and more people to participate in this global market. At first sight, this creates a lot of opportunities and positive effects for e-lancers and organizations; employees in remote locations now receive ever easier access to the global market via the Internet, increasing the pool of talent for potential employers. E-lancing enables people to work more flexibly from home, or any other place they may choose—no more set hours and no more time lost in commuting to work. Further, there is the opportunity for specialization; with the market being global, it might be profitable for e-lancers to specialize. Overall, the quality level of the skills available in this global market might be much higher than in national markets. For client companies, this is also great; qualified e-lancers don’t need to apply for working visas, or move, but can work from where they are located. Having e-lancers all over the globe also means having 24/7 access to the labor force, and jobs can get done quicker. Moreover, global competition drives down prices for jobs offered, and employing e-lancers as contractors rather than employees drives down the cost of labor for companies.

However, although e-lancing provides many positive effects to e-lancers, platform providers, and client companies, there are also negative sides that shouldn’t be ignored in our analysis of this brave new world. Where does this trend leave the individual e-lancer? And do e-lancers globally benefit from e-lancing in similar ways? This article aims to provide an informed view of the more problematic issues at hand. Because traditional power relations between employees and employers are changing as a result of this influx of new labor, this ought to affect labor relations more broadly. In the following discussion, we take a closer look at what e-lancing really is today and how the work organization is structured.

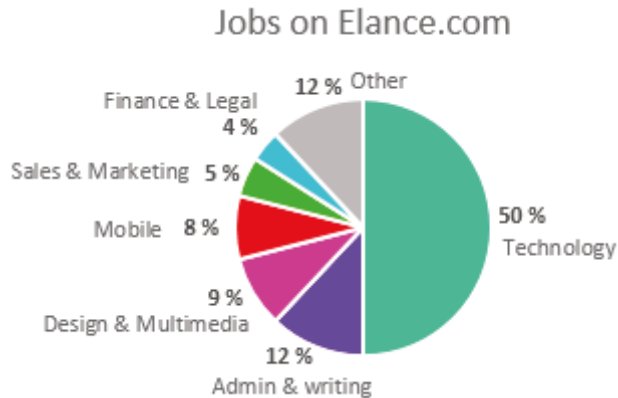
Moving on to an enquiry into how e-lancing affects the national level, we examine the complex relationships between employees, employers, and governments. Considering these national dynamics, we extrapolate how e-lancing is driving globalization of the labor market and what implications this has for equality and fairness in the global labor market. In concluding this article, we present recommendations for promoting the positive effects of e-lancing and keeping negative effects at bay; we show how e-lancing can be a liberating mechanism for global equality rather than one of exploitation.

## **2 E-lancing in Practice—What Happens on Platforms?**

In this section we examine three of the most prominent e-lancing platforms. We selected them to include a wide range of examples; specialized professional work (Upwork/Elance), creative design work (99designs), and menial unskilled tasks (Mechanical Turk). In addition, we describe the on-demand taxi platform with reference to its champion service provider, Uber. Each platform has a very different operational model, described here from the employer, client, and e-lancer users' perspectives.

### **2.1 Platform 1: Elance/Upwork ([www.eLance.com](http://www.eLance.com))**

Upwork, the self-proclaimed “premier platform for top companies to hire and work,” is the result of a 2014 merger of competitors Elance and oDesk. In 2014, Elance reported combined corporate earnings of 941 million USD, with 2.8 million job postings and 4,700 talents. Upwork has 9.7 million e-lancers, with a category breakdown shown in Figure 1 and 3.8 million companies registered [4]. The top hiring countries are the United States, the United Kingdom, France, and Germany, with the top work providers being the United States, the Philippines, and Russia. Upwork provides a detailed user agreement that defines the terms of the three-way relationship between employer, e-lancer, and platform. Different work models are laid out, including hourly contracts, fixed-price mobile contracts, and fixed-price contracts. The platform takes a 10 percent service fee from the payment from the employer to the e-lancer in all cases.



*Fig. 1. Breakdown of the job categories of e-Lancers on the Elance-o-desk platform, reproduced from data in [4]*

E-lancers create profiles with details of education, skills, and experience and can increase status by completing Upwork skills tests. Employers post detailed work descriptions, including the skills and experience level sought and the range of payment rates. E-lancers can then apply, indicating their expected compensation along with justification of their suitability, often including samples of previous work. After the work is carried out, the employers have the option to give a 1- to 5-star rating of the work, and this is the key metric of e-lancer performance; the e-lancer also has the opportunity to rate the client [5].

## **2.2 Platform 2: 99designs (www.99designs.com)**

The 99designs platform claims to be the world’s largest online graphic design marketplace; it connects almost 1.2 million e-lancer designer members from 196 countries with approximately 250,000 employer clients [6]. The company has experienced remarkable growth over the last few years, with over 100,000 completed design projects and a total payout of over 114 million USD to its e-lancers to date. The company started with a focus in logo and branding design but has since expanded to include web design, advertising, merchandising, art and illustration, packaging and labeling, and book designs.

The client company advertises a design brief and selects compensation in terms of bronze, silver, gold, and platinum packages, which range from \$300 to \$1,200. The platform takes a flat fee of \$39 (for a seven-day turnaround, increasing for shorter time frames) plus 10 percent of the payout [7]. In the opening stage, any designer can submit draft designs, and the client has the opportunity to give feedback



and guide the design process. The client then selects up to six finalists who refine their designs and compete for the client's patronage. Only one design is selected as the winner, and copyright is then transferred to the client when payment is made. Feedback ranking is applied to designers' profiles to highlight top designers.

### **2.3 Platform 3: Amazon Mechanical Turk ([www.mturk.com](http://www.mturk.com))**

The mechanical Turk (MTURK) is not technically an e-lancing platform, but rather a crowdsourcing platform in which small tasks that are inherently difficult or impossible for computers to do, called human intelligence tasks (HITs) are assigned by clients (requesters) to users (Turkers) for completion [8]. Examples include identification of articles in photos, correction of grammar in translated text, and quality control for images and audio or video media. At any time, there may be 150,000 to 250,000 available HITs, with rewards of up to \$25, but predominately in the range 1 to 5 cents. At present, the requesters are restricted to U.S. Internet protocol (IP) addresses. Turkers, of which there are more than 500,000, are predominately found in the United States (48.6 percent) and India (30 percent). Although Amazon does not provide any financial reports on MTURK, estimates of yearly HIT revenue are from \$10 to \$150 million, with Amazon collecting a fee of 10 to 20 percent.

Turkers register on MTURK and can immediately begin carrying out HITs, but their level of activity is restricted and closely monitored in the beginning. Requesters accept or reject completed HITs, which affects the Turkers' rating, a crucial performance metric. In order to be eligible for high-value hits (around 10 cents and above), the Turkers must have qualifications that are based on tests or number of approved hits for each rejection (often in the thousands).

### **2.4 On-Demand Economy (Uber, Airbnb, etc.)**

The "on-demand" economy lies at the edge of our definition of e-lancing. However, the scale of labor market disruption caused by on-demand applications such as Uber cannot be ignored in this article. In the summer of 2015, Uber was available in 300 cities in 58 countries, and the company has been valued at around \$50 billion. The privately held company does not directly report on financials or volumes, but a Bloomberg report on leaked Uber financial documents estimates revenues of \$415 million, with even greater (operational) losses and a year-on-year growth of 300 percent [9]. *Forbes* reports a total of 1 million rides per day and 140 million rides in 2014, with 50,000 new drivers joining the platform every month [10]. Many other platforms, Airbnb, for example, apply a similar model to

connect providers of services to customers. Such is the success of the business model that a wide range of industries are now looking toward it, and the term *uberification* has been coined.

With Uber, customers and drivers register, and the traditional taxi hailing is carried out via the app. The price is fixed by Uber, and payment is made automatically through the app, making the transaction cashless and convenient. Both the driver and passenger can give a rating of the experience, contributing to profile reputation. Uber has traditionally taken 20 percent commission on transactions, although it has experimented with levels from 5 percent to 30 percent. Uber carries out a background check on its drivers, but circumvents the licensing and insurance obstacles of the traditional taxi industry.

## **2.5 Similarities and Differences**

The selected platforms are vastly different in terms of their value proposition to the client, employers, and e-lancers. Whereas Upwork appears to provide real value for highly skilled professionals to connect with employers, the latter two platforms come under strong criticism from a majority of their e-lancer users. Considering the competition-based 99designs, it turns out that a huge amount of effort from e-lancers is ultimately carried out in vain. This is certainly an economic injustice and can result in a strong e-lancer demotivation and disenfranchisement from their work. Uber does provide value to drivers by channeling the market toward them, thus optimizing collection routes and reducing idle time.

Upwork and 99designs have a policy in place to protect e-lancers from non-payment and provide procedures to settle client–e-lancer grievances. Upwork provides the best protection for its e-lancers by applying a number of payment-protection mechanisms. Escrow, for example, obtains payment from the client and secures its delivery to the e-lancer once milestones and deliverables are met. Argument over deliverables requires detailed justified reasons, and the platform provides e-lancers with ample opportunity to improve or defend their work using the platform’s “Dispute Assistance” feature. In a similar fashion to Upwork’s Escrow, 99designs collects the payment at the opening of the design competition and ensures the designer gets paid once the copyright of the design is transferred. In cases of payment dispute, the platform’s customer service personnel step in to review the delivery in the context of the specifications and will enforce a judgment on the grievance. MTURK, however, gives ultimate power of acceptance or rejection of HITs to the requesters, and there is no recourse for aggrieved Turkers. The low value of the work simply does not justify any level of intervention from the platform operator. Uber takes payment for the passenger before taking

the ride and provides it to the driver. If passengers are not satisfied with the service provided, their only recourse is through the feedback mechanism, which may damage the drivers' reputations.

Job security and social insurance are topics on which the platform providers remain quiet. Again, the more professional-oriented platforms fare somewhat better. Upwork provides a lot of functionality that enables e-lancers with desired skills to be visible and recognized for their work, and it is effective in keeping its qualified e-lancers in work. Whereas 99designs was initially only competition oriented, it is evolving because of the recognition that this format is not desirable to the majority of designers. The platform encourages the building of relationships between clients and winning designers and has developed a one-to-one task service to enable this. Uber is careful to define its relationship with drivers as contractors and not employees, therefore removing any responsibility in terms of employment conditions or social rights.

In terms of tax, it appears that the platform, employer, and e-lancer at present remain three mutually exclusive entities. The platform collects its slice of revenue and pays corporate taxes in the country where it operates. The employer should pay value-added tax (VAT) in the country where the service is provided, and at least Upwork provides a service to bill this as an additional charge to the employer, whereas the other platforms claim to include VAT and local taxes in their prices. Across the board, e-lancers should declare their income in their country of residence and pay appropriate income taxes, including social security charges, as a traditional self-employed freelancer.

Social security is an issue that these platforms consider to be outside their scope. The contractor relationship between platform and e-lancer relieves any obligation on the platform to assure the social security of its e-lancers. Therefore, under the current e-lancing paradigm, it appears that the responsibility of social security lies solely on the shoulders of the e-lancers themselves. If operating within the formal economy with no other formal working contract, the cutthroat competition for work might make it difficult or impossible for e-lancers to charge high enough rates to be able to cover their personal social security overhead. This is particularly true for e-lancers located in countries, such as the Nordics, with an excellent social welfare system and therefore large overhead costs. The problem is further accentuated for the lower-end workers, for example, on MTURK and Uber.

As we demonstrated from this comparative view, there are few key issues and concerns on both the national and the global level of analysis. On the national level, there is a question about employment rights (i.e., security and benefits when working) and social security (i.e., the benefits available when not working). This may challenge the status quo of current society—especially the Nordic wel-

fare model, in which employment rights and social security are held dearly—and at great cost. Where should the responsibility for these expensive provisions lie, and how should they be administered—by the state, by the platform, by employers, or by individual e-lancers? This also leads to the question of how taxes can be collected in a fair and transparent way—where should they be collected, and what are the implications for the traditionally affluent countries?

On the global scale, there is the concern about the impact this globalization of labor markets has on the traditionally dominant Western countries and developing countries. One may argue that e-lancing creates a platform for exploitation of the vulnerable, or conversely that it is a platform for liberation of third-world talents from their current limitations. With the exception of geographically locked Uber, a pattern that emerges from the three platforms is that there is a strong skew in origin of clients toward affluent nations with an advanced level of digitization, such as the United States, which leads in all three platforms. The e-lancers are quite often found in developing countries, with a large proportion also found in the United States. The topic of fairness and equality applied on a global scale also raises questions relating to justified compensation and benefits.

### **3 National Social Rights and the Redistribution of Social Responsibility**

As touched upon, one of the pressing issues to be considered in the move toward a global e-lance economy is social rights and benefits at the national level, as well as the role of national governments in providing these. Current societal structures of social security are based on the presumption that the vast majority of the workforce is in a steady employment relationship with a firm. In this section we map the distribution of social responsibility on a worldwide scale, focusing on national differences. We then discuss the mechanisms that drive the development of social coverage of e-lancers in a world where social security is continuously evolving toward improved coverage and more comprehensive schemes. These mechanisms help explain the tensions between a global labor market and nationally defined social rights.

#### **3.1 Definition of Social Rights**

Although there are arguably national differences in how social rights are defined, we can seek a more universal definition within the Universal Declaration of Human Rights [11] and the International Covenant on Economic, Social and Cul-

tural Rights [12]. Considering the social rights and benefits discussed in relation to e-lancing [13], the Universal Declaration of Human Rights sets the baseline for social rights by stating the following [11]:

*“Everyone has the right to rest and leisure, including reasonable limitation of working hours and periodic holidays with pay.*

*Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control.*

*Motherhood and childhood are entitled to special care and assistance. All children, whether born in or out of wedlock, shall enjoy the same social protection.”*

### 3.2 A Global Perspective on Social Rights and Responsibilities

Globalization has created headlines about employees in developing countries being exploited in the name of pressing down production costs. Although this has undoubtedly created an image of the lack of social responsibility and consequent weak social rights in developing countries, this image is slowly becoming outdated, as the growing economies in Asia and South America, and at a slower rate Africa, are building their social security coverage [14]. As a result, social programs related to old age, disability, survivors, and employment-related injury could be said to exist almost globally (see Figure 2). And although there are national differences in how these and similar types of programs manifest themselves (and consequently how comprehensive they are), there is a clear trend that social security is improving on a global scale.

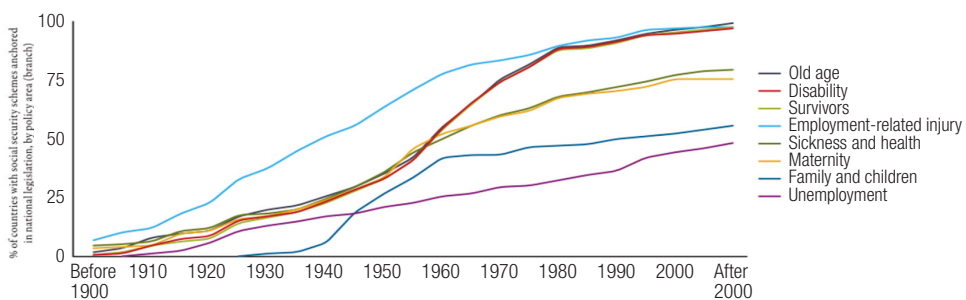
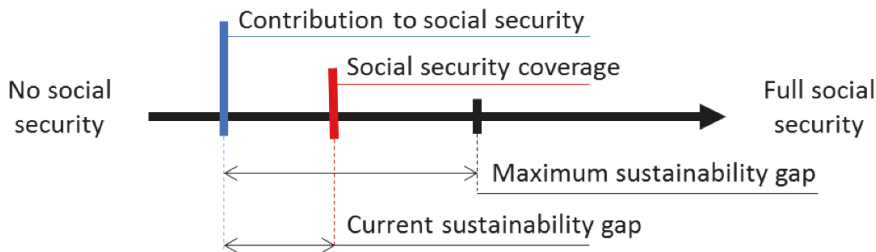


Fig. 2. Development of social protection programs anchored in national legislation by area (branch), pre-1900 to post-2005 (percentage of countries) (from the International Labour Organization, [15], p. 4).

Despite the positive trends in social security, a recent report from the International Labour Organization notes that only 27 percent of the global population enjoys access to comprehensive social security systems [15, p. xxi]. A persistent problem is that of including the self-employed, from both the formal and informal economies [16]. This is especially challenging in parts of the world where the informal economy counts for a large share of economic activity; for example, in Africa it is estimated that the informal economy accounts for 61 percent of economic activity [17]. Considering e-lancing as a manifestation of self-employment, we show the most important mechanisms for the evolution of the individual e-lancer’s social security.

### 3.3 The Evolution of the E-lancer’s Social Security

The problem of the self-employed is twofold. On the one hand, it is about reaching and providing social security to the most vulnerable group in society; on the other hand, it is about securing their contribution to the upkeep of the social security system [16]. In developing countries, with substantial rural populations, the former problem is typically prevalent. In developed countries the latter is the issue, and especially relevant considering this study because e-lancing and equivalent activities could (at this point) be argued to be part of the informal economy. Further, the extent of coverage of a certain group (be it the e-lancers of Finland or the farmers of India) has to be somehow relative to the contribution of this group. If this isn’t the case, a sustainability gap appears and generates an economic deficit, which needs to be covered by the contribution of some other group. This creates a feeling of injustice in society and is problematic in modern democracies.



*Fig. 3. Conceptualization of the evolution of social security through contribution and coverage.*

In considering this conceptualization (Figure 3), we discuss the mechanisms (Table 1) that steer the evolution of the social security coverage of e-lancers within the societies they physically live in.

Table 1. The effect of the identified mechanisms on contribution and coverage

	Contribution to social security	Social security coverage	Maximum sustainability gap
<b>1. Universality of coverage</b>	No direct effect	Increases	No effect
<b>2. Formality of e-lancing</b>	Increases	Conditional increase	No effect
<b>3. Amount of e-lancers</b>	No direct effect	No direct effect	Decreases
<b>4. Complementarity of e-lancing</b>	No effect	Conditional, limited decrease	No effect
<b>5. Labor organizations of e-lancing</b>	Conditional decrease/substitution	Conditional increase/substitution	Conditional increase

*Mechanism 1: Universality of coverage*—Universal social security coverage is by its nature provided by governments for their citizens, and raising the level of universal social security coverage will consequently raise the level of social security also for e-lancers. This requires no additional contribution (taxing benefits is here not considered as a contribution). Considering the spectrum of social security, there are naturally differences in the costs of making social benefits universally available. In the case of some benefits, these costs are controlled through offering means-tested benefits; however, these benefits typically increase administrative costs. The restricting factor of universal coverage is the sustainability gap between universal social security coverage and aggregate contribution.

*Mechanism 2: Formality of e-lancing*—This mechanism relates to the extent to which e-lancing is a part of the formal economy, that is, declared and taxable. Formalization of e-lancing would lead to taxation similar to that of the employer–employee relationship, likely leading to an improved level of social security coverage. However, there may be a problem with the structure of contribution because this would only lead to higher “employee” contributions and no increases on the side of employers. Further, formalization adds an administrative load both for e-lancers and governments.

*Mechanism 3: The amount of e-lancers*—A growing number of e-lancers would result in growing pressure to include e-lancers in the formal economy. As more e-lancers are included in the formal economy, this would boost contribution and increase the maximum sustainable gap. Further, a growing group of e-lancers would enjoy greater influence in society—on one hand driving up the social security coverage, and on the other hand (at least theoretically) enabling a larger sustainability gap.

*Mechanism 4:* The complementarity of e-lancing—If a large portion of e-lancing is complementing labor (e-lancers have some sort of an employment relationship, which is highly likely, especially if e-lancing takes place in the informal economy), “full-time” e-lancers without complementary steady employment may find themselves in an especially precarious position. In this situation, the “part-time” e-lancers would enjoy social security coverage through their employment relationships and would thus be against actions that would increase social security coverage in e-lancing.

*Mechanism 5:* Labor organizations of e-lancers—Through labor organizations, e-lancers could affect their social security in two ways. Such a labor organization could (and arguably would) engage in political lobbying for increased social security coverage and a greater negative sustainability gap (paying for less than you get). This e-lancer labor organization could also offer its members some form of social security services; however, these would naturally count as a private (nongovernmental) increase in social security coverage with a respective private increase in contribution. This development is manifested in the Association of Independent Professionals and the Self-Employed (IPSE) in the United Kingdom [18]. If taken a step further, assuming that e-lancers would evolve into a highly organized and unified group (perhaps unified by a common skill, or service-specific platform), they would have further possibilities to improve their positions. This was envisaged by Laubacher and Malone (2000) as the “rise of the guilds” [19], in which they oriented themselves by following the example of the emergence of the Screen Actors Guild (SAG) in the California film industry in the mid-20th century. In this example, social coverage was offered to members of the SAG and funded by a 30 percent premium in negotiated compensations for acting work. In effect, the SAG became so powerful (due to its coverage of acting professionals) that it was able to affect the wages paid. The question is, however, whether a skill-based group of e-lancers, say, graphic designers, could reach the same level of organization in a global labor market.

### **3.4 Will E-lancing drive Jobs to Cheaper Countries?**

Given that social security is still very much of a national issue, we could hypothesize that the future of e-lancing in a global labor market would drive work to where the costs are the lowest, in other words, to where social security is weakest (or cheapest). However, with an increasing global minimum level of social security coverage, this differentiator is bound to reduce in the long run. This reasoning applies even in the case of e-lancers operating in the formal economy, as the average national cost of living could be expected to serve as a better indicator of





employer propensity to outsource work to global labor markets, due to higher employment related costs in the home market. The position on the y-axis indicates the general cost of living [25], which serves as an indicator for the national cost of (e-lancing) labor. The tendency here would be for work to move down to cheaper countries, but keep in mind that task-specific cultural barriers may hinder or reduce the movement of work. However, the effect of culture (indicated by the colors in Figure 4) needs to be evaluated on a task-by-task basis. Furthermore, it should be noted that the cost of living may vary significantly within countries, leading to outsourcing work within national borders instead of going global.

## 4 Internationalization of Labor Markets in the E-lancing Age

This comparison of local costs of living relative to employer contribution to social security schemes brings us to the other important aspect of e-lancing: the globalization of labor markets and the impact this has on the determination of a global fair wage. How much is an identical task of work worth in two different settings? Is it fair to pay less for the same job in another location? What are the implications if wage levels for e-lancing in the Western world are driven down by competition from Asia and Africa? Further, what does this mean for individual e-lancers' lives?

### 4.1 Fair Wage and Equal Pay

E-lancing platforms have various operational models and wage-determination policies, some of which we discussed earlier. The fairness of wages and the operational models can be debated, but it is good to note that fairness itself is recognized as a somewhat vague term. There is no uniform way to measure fairness, and therefore an accurate definition is hard to find. It has even been argued that the principle of universal fairness may not exist due to its subjective nature [26] [27].

Suranovic [26] defines seven principles of fairness, one of them being positive reciprocity fairness, which can be simplified as “do unto others as they do unto you,” in a positive sense. When applied to fair wages, the principle says that “the employee generates benefits to the employer in the form of output, and [...] deserves to be compensated with wages and fringe benefits that are approximately equal in value to one’s contribution”. Another principle, distributional fairness, states that if there is a presumption of all humans being equal, then the benefits—in this case the compensation of the work—should be distributed in such

a way that everybody has the same level of well-being, wealth, and so on. Both principles give way to questions about measurement. How should the value of an employee's contribution be measured, and is the value the same throughout the world? How should the benefits, those in addition to a salary, be measured so that the requirements of distributional fairness are met despite the varying living costs and cultural differences?

It can be argued that there should be the same global wage for the same job. This is already the case in many e-lancer jobs, for example, in MTURK, where submitting an accepted task results in a fixed payment for any worker. It has been proposed [28] that the payment for the tasks in MTURK should be decided based only on the expected time used in completing the task. However, there are also studies [29] [30] saying that the task completion time should not be the only metric, because the expected time has to be determined by piloting the task, and time variations between testers are usually significant. The median time may possibly give a sufficiently accurate result, but the value of the average time used is in most cases misleading. It seems fair that the worker's time is worth the same throughout the world—especially if thinking that all humans are equal. However, an e-lancer is able to work anywhere in the world, so the job can be done in India or Finland as well as in the United States or Egypt. The living costs vary between the countries, and the same wage as monetary units has a different value depending on the place the worker is living, so what is pocket change to one can be equal to a month's normal income for another one. In this sense, would a global wage be fair, after all?

One possibility to make the wage somewhat fair for everybody would take into account the living costs of the area the worker is living in when deciding about the wage and adjust the wage so that its local value would be approximately the same all around the world. There are regular surveys made on the costs of living, for example, the Worldwide Cost of Living Report [31], which could be used for making the wage decision. The Internet also offers online tools for wage decisions, one of them being Numbeo, which is a database of living costs and conditions in over 5,000 cities around the world [25]. The downside of living-cost-based decision making is that if the employers decide to determine the wage for a job according to the worker's location, the temptation is to use as much low-paid labor as possible. This has been realized in the traditional manufacturing industries for decades, as the factories have increasingly been moved from Europe and the United States to the Asian countries. In the e-lancer world, if the wage is decided by the employer based on the worker's location, a job seeker may not get a job just because the worker happens to live in the wrong place.

When discussing fair wage and equal pay, there is actually nothing radically new. The same kind of debate has been going on for decades, with the “poor peo-

ple” being women, workers of color, or third-world inhabitants, and now e-lancers in cheap-labor countries. In the 1980s, when companies started moving factories from the first-world countries to the third-world countries in order to cut labor costs, Lehman (1985) published an article in which he took part in an ongoing discussion about the third-world workers’ right to equal pay for equal work [32]. Lehman states that although it might feel wrong to pay less for the third-world workers than for the first-world workers, it must be noted that it is much more beneficial for the third-world nation when its citizens get lower-paid jobs than not getting jobs and money at all. This may sound hypocritical, but as Lehman puts it, a high salary does not help to raise the standard of living if there are no goods and services to buy. Instead, the companies should be obligated to improve local water supply, sewage, healthcare services, and so on, and help to enhance the quality of life that way. According to Lehman, it is not the sum of money paid to a worker but the total utility that counts, and therefore lower wages for the third-world workers can be justified.

In addition to equal pay, there is another ongoing debate: minimum wage. All countries have their own way to deal with the issue; many have set minimum wage laws, some rely on trade unions and collective wage bargaining, and, of course, there are also nations that have no legislation. However, e-lancing puts this question into a new context. Employers and employees are dispersed around the world. The minimum wage cannot be decided based on the location of the factory or office because there is no such central place. Further, the influence of national governments is limited. Because there is no global standard of living, but the costs of living and conditions vary from nation to nation, a common minimum wage for e-lancing jobs is a hopeless effort. Therefore, it seems that the question about the legal minimum wage easily comes back to the issue of wage fairness. Of course, the employee wants to get paid at least reasonably well, but, naturally, the employer wants to keep the labor costs as low as possible. In this situation the employer may be tempted to set the salary so low that it annoys the employees, who either do not take the job at all or make sure that they will not work for the same employer twice. Whatever is the employer’s wage policy, it should be noted that paying reasonable salaries gives the employer a good reputation in the e-lancer communities and most probably provides the employer with good employees and high-quality work in the future.

## **4.2 Implications of E-lancing on Families**

The number of young single-person families has been constantly growing in the Western countries since the late 20th century [33]. Taking a look at many professions today, well-paid e-labor being one of them, and the reasons why they are

living alone, the answer seems simple: because they can. Klinenberg (2012) finds several reasons for why people choose to live alone [34]:

- *Independence*: nowadays, marriage is not financially necessary, even for women.
- *Communications revolution*: everything is reachable via Internet or other communication channels.
- *Urbanization*: in the cities, living alone does not mean being alone; it is easy to be with others.

All Klinenberg's findings are apparent in the Northern European society. The independence, and a certain type of selfishness, of the young people has already been rising for some time now, and living alone by choice is only one manifestation of this trend. Working as an e-lancer can be seen as a natural development of a working life, but it also offers the freedom of work that many young people desire. Working is not tied to a place or time or even to a certain employer.

This vision of e-lancing as liberation turns sour when considering low paid e-labor and cases without additional sources of income. Then, the reasons for living alone are totally different; insecure income expectations may cause people to shy away from making a commitment to raise a family. Full-time e-lancing might further accentuate these fears. In societies where a husband is presumed to feed the family and a wife stays at home with children, living alone may be the only option. Even in the societies where both spouses are able to work, the financial insecurity caused by e-lancing can lead to a condition where commitment raises fearful feelings. The consequences can be far-reaching if people do not find the security in their lives early enough to start a family and have children.

However, from an economic perspective, family can also be seen as a hedge against insecurity and as an opportunity to share the costs of living. Generally, living alone is more expensive than living together, and having two workers in a family makes life more secure and wealthy. In some countries extensive welfare benefits bring further safety to living by providing regular basic income, but that is not case everywhere. Insufficient wages are not the problem of e-lancing alone, but they continue the tradition of underpaying poor people. Even more so, the group of disadvantaged employees seems to be broadened by e-lancing. It is not the task of the companies hiring e-lancers to solve the poverty of the world, but as numbers of more and less qualified e-lancers are increasing, companies are in a position where they could offer disadvantaged e-lancers better conditions and an opportunity to support their families better, ultimately helping them to achieve a better quality of life. A reasonable, fair salary would make a difference.

### 4.3 E-lancing on a Global Scale: Liberation or Exploitation?

The social impact of an e-lancing economy will be both positive and negative. To illustrate both, let's consider two individual scenarios. If we consider a recent graduate who has a lust for travel, possesses recent and relevant skills, and is highly adaptable to changing work requirements, the e-lancing economy will provide an excellent standard of life. As can be seen from the example of Blake Moore, an English e-lance writer living in Asia, it can be a dream to carry out short, intense bursts of work while globetrotting from one paradise to another. In Blake's words:

*To say my time as an e-lancer has been interesting so far would be an understatement. As my career as a content writer and editor is still in its infancy, it has been a huge learning curve.*

*In terms of the e-lancer lifestyle as a whole, it definitely has its pros and cons. It's pretty tough working whilst people around you are on vacation. I've found it's taking some serious self-discipline but I'm getting much better as time goes on. Also the world's most beautiful beaches are not always the most practical places to work due to sand, bugs and poor WIFI. When I find a great co-working space with good AC and endless coffee I really do feel like I've hit the jackpot.*

*Despite the negatives, I think there is so much to gain from my new lifestyle. Firstly, I have the flexibility to work in some of the world's most exotic locations. In six weeks I've already visited the pristine waters of Thailand, the cultural melting pot of Kuala Lumpur and the endless hospitality of Vietnam. Also due to comparably low living costs in South East Asia I have infinitely more time to build my skill set and experiment with new career paths, something I was craving when I was working in London. I'm curious to see where remote working takes me and I'm excited about the possibilities.*

*So far the only two e-lance platforms I've used are Upwork and PeoplePerHour. Upwork has been my least favourite of the two. The site is largely focused on the US and although there are considerably more jobs on there than PeoplePerHour, competition is fierce and I've found people are working at crazily low rates. PeoplePerHour is my favourite thus far. The UX and UI just seem better to me, but that may be a personal preference. Although there are not quite as many opportunities on PeoplePerHour as Upwork, I have found people are willing to spend a little more for quality work. The biggest reason why I like using both platforms is the opportu-*

*nity to build up my personal brand and connect with people from so many different countries. The world has definitely become a smaller place.”*

*– Blake Moore, English e-lance writer traveling in South East Asia*

E-lancing can thus be a liberation; it provides freedom and flexibility—but the low wage levels that might be a nuisance to some people can represent a serious problem for others. The main mediator here is, as indicated earlier, the local costs of living in relation to the wages that can be earned as an e-lancer in the global e-lance market. This thus highlights the problem of the global wage levels. Taking a look at the account of Mariia, a freelancer from Helsinki in Finland, this problem becomes apparent:

*As a freelance writer I decided to try Upwork because I thought it would be a great platform to get new clients and more jobs. There are a variety of jobs offered on the website and it is easy to browse them. Also, the website offers freelancers different tests to take, for instance English ability test, to prove that they can perform at a high standard. When the job is done, the client evaluates the result and can ask for edits before paying, which ensures the quality of the project. The website is easy to use and customer service answers quickly offering helpful solutions.*

*The only downside is that clients are not willing to pay enough that the freelancers, at least here in Finland, can make ends meet depending only on work coming through Upwork. It is common to earn approximately \$0.02 a word in translation and content writing. Upwork takes 10 percent of the payment, which the freelancer has to pay. Depending on the country, using Finland as an example, a self-employed person may only get to keep around half of the earnings. The law here obligates a self-employed to pay a high percentage in social security contributions, pension and tax.*

*Upwork is a good platform to build a portfolio and make contacts with clients. However, the payment is not high enough for a freelancer who works in Europe. I think that freelance jobs will increase in the coming years and Upwork could benefit in the progress. My only concern is that all the freelance jobs are going to Asia, when the clients want to save in payments. If Upwork wants to keep freelancers who live in Europe, they have to update the payment scheme.*

*– Mariia, a Finnish freelancing writer living in Helsinki*

So what does this mean for e-lancing jobs that are located in the Western world? It appears as though Northern European e-lancers will be priced out of the market and an increasing amount of work will be conducted in lower-cost countries. But ought this to be a universally problematic issue? We think e-lancing will pose short- to medium-term problems for Western societies as an increasing amount of jobs will be relocated to Asia or Africa. However, this is good for those countries, which experience the influx of jobs. Indeed, this is a mechanism of global equality. Thus, the challenge for Western countries is how to adjust their social systems in order to react to this development in the long term.

## **5 E-lancing as Global Equality Mechanism and Policy Recommendations for Northern European Governments**

The benefits of e-lancing for business are immense, including hiring to meet demand, eliminating overheads such as social security and medical coverage, training and development, human resources and well-being departments, and office accommodations. We project a stark increase of e-lancing by 2040, both for primary occupation and for moonlighting. In all areas where work is done digitally, the share of e-lancing will grow, with highly independent project-based work leading the way. Also, areas of digital work where a higher level of interaction coordination is required will have a growing share of e-lancers, along with the emergence of “system integrator” roles, which are facilitated by the e-lance platforms. Nevertheless, jobs that are culturally bound to a specific setting will resist this trend. Competition-based platforms such as 99designs are expected to be short-lived, unless they evolve their model of operation, as the e-lancer numbers grow and the volume of “work in vain” increases. More professionally oriented platforms with good e-lancer relationships are expected to enjoy the lion’s share of the growth in the projected future. An even higher level of growth will be seen in service-specific platforms (such as Uber and Airbnb), where the scope of such platforms will grow (including, e.g., food and healthcare) and existing platforms will gain further traction. Some platforms will be victims of the very digitalization that they drive; for example, most of the simple and menial tasks done within Mechanical Turk will be performed by artificial intelligence (AI) within the coming 10 years, and self-driving cars will make a service such as Uber obsolete within a couple of decades.

So, although e-lancing is a great way forward for companies, we need to take a closer look at e-lancers. This trend toward more flexible labor relations has different effects in different parts of the world. Considering first those e-lancers













































in places with lower wage levels and less developed social security schemes, platform-facilitated global labor markets will arguably channel work (and thereby wealth) to nations with lower costs of living, in effect promoting global equality. This is especially the case for merit-based platforms, where global variance in wages is less than global variance in living costs. These platforms will arguably also create opportunities for exploitation, in the form of traditional sweatshops, where the most vulnerable individuals of society may find themselves performing menial work in what could be described as “Turkshops.” However, although the work could be considered menial, it typically requires some liberating skills (such as reading, information technology literacy, and in most cases an adequate comprehension of English) and assets (such as a computer connected to the Internet). Further, the work would no longer be “buried” under complex supply chains, making the concealment of the social circumstances of production harder. These viewpoints lead us to believe that although activity of this nature will probably emerge, it will be relatively short-lived because it contains the ingredients of its own destruction.

As discussed earlier, measuring the fairness of wage more broadly is complicated because there are so many assumptions, considerations, and local conditions that need to be evaluated. Therefore, the fixing of one global wage can be argued to be unfair. However, is it exploitation to pay an e-lancer from a country of lower costs of living less money for the same job? Agreeing with Lehman [32], we argue that no, it isn’t, because it is not the sum of money paid to a worker but the total utility that counts. Yet, because e-lancing is a global market, this reduction in average wages for a given job might be unfair or at the very least problematic for those e-lancers who are physically located in higher-cost-of-living countries. To illustrate, let’s consider the local purchasing power an e-lancer earns per hour of work done on Elancer.com. Figure 5 demonstrates the hourly wage paid to an e-lancer through Elancer.com relative to the cost of living in the respective country when compared to Finland; that is, the hourly wages shown are not actual wages paid in Euros, but the average cost of living in Euros adjusted by cost of living.

$$\begin{aligned}
 & \text{Average wage in euros adjusted by cost of living, where Finland is 1,0 (country)} \\
 & = \text{Average wage in euros (country)} * \frac{\text{Consumer price index (Finland)}}{\text{Consumer price index (Country)}}
 \end{aligned}$$

In euros (exchange rate usd = eur 0.944380699)

This clearly shows that there are winners as well as losers in e-lancing.

	South Africa	48,41 €		Sweden	33,43 €		France	27,76 €
	Mexico	45,78 €		Netherlands	33,17 €		Finland	27,39 €
	Nigeria	43,16 €		Russia	32,80 €		Kazakhstan	26,43 €
	Colombia	43,05 €		Indonesia	32,38 €		Portugal	25,86 €
	India	40,91 €		Thailand	32,27 €		Switzerland	25,66 €
	Czech Republic	40,82 €		Saudi Arabia	31,64 €		Argentina	25,56 €
	Algeria	40,69 €		Pakistan	31,38 €		Norway	25,25 €
	Poland	40,32 €		Denmark	31,25 €		Qatar	24,33 €
	Brazil	38,86 €		Egypt	30,84 €		Japan	23,46 €
	Turkey	37,51 €		Israel	29,96 €		Greece	23,42 €
	Germany	37,43 €		United States	29,69 €		Ireland	22,77 €
	Austria	37,30 €		Canada	29,63 €		United Kingdom	22,62 €
	Chile	36,89 €		Malaysia	29,59 €		South Korea	22,40 €
	Belgium	35,02 €		Spain	29,53 €		Italy	22,07 €
	Peru	34,68 €		Australia	28,40 €		Philippines	18,13 €
	China	34,11 €		United Arab Emirates	27,98 €		Venezuela	14,03 €

*Fig. 5. E-lancer average income (based on Elance.com statistics) adjusted for cost of living (Finland = 1,0).*

Taking now the Northern European perspective, e-lancers are suffering from a change in their local conditions to less regular income and an increased uncertainty of future income. For individuals with part-time employment, this is less severe because they are usually covered by their working contract and benefit from making additional income. Most platforms work on the principle that work done over them is complementary to a regular “day job,” But for the limited group of individuals consisting of full-time e-lancers on a typically complementing work platform operating within the informal economy (an illustrative example would be a full-time Uber driver), this is more difficult. Especially when operating in the informal economy, they might be paid just enough, but they are not covered by unemployment or other social security schemes. It is mostly for this group of e-lancers that work becomes precarious.

Therefore, we need policies that cope with the development of e-lancing in Northern European economies and that assure that the issues laid out in this article are tackled in the long term. The underlying major cultural shift, in which society is slowly moving from the industrial conception of work as a nine-to-five activity with long-term employment relationships to an entrepreneurial conception, with more flexible definitions of work and more dynamic relationships, needs to be mirrored in national governments’ policy and structural decisions. Thus, it is clear that nations that fall behind will be at a disadvantage in the global marketplace. Currently, developing nations are building their administrative

structures, while developed nations desperately seek to increase efficiency in their administrative structures. Keep in mind, however, that in the long run, success is increasingly dependent on flexibility, so efficiency cannot be sought at the expense of it. We hope that as the balance of employment tips toward e-lancing, governments and international regulatory bodies will intervene to curb the erosion of employee rights such as social and employment security. In the end, it will always be the government that is responsible for the individual's social security. In order to be able to cope with these changes, we propose three policies, presented next.

### **I. Differentiating between e-lancing as complementary or full-time source of income**

The absence of a steady employment relationship causes an increased variation in the individual level of income, leading to higher personal risk through poorer income dependability, a challenge that is further amplified by other societal phenomena, such as the growing amount of single households where a spouse or family has traditionally served as a risk-reduction mechanism. The severity of this effect is influenced by the status of the e-lancing activity—is it complementary or full time? The original, binary view on work needs to be refined, and more precise categories need to be established. In the short term, governments need to create new categories for the different statuses in their social security systems: full-time employment in a traditional sense, part-time employment in a traditional sense, part-time employment complemented by e-lancing, and full-time e-lancing. Only if individual e-lancers' particular income situations are known and accounted for can an effective social security treatment be established. However, the creation of these additional categories will lead to large additional administrative costs and therefore is not sustainable in the long term—a more flexible and more accurate solution is needed.

### **II. Formalizing digital work via flexible, digitized social security systems**

In order to promote digitalized work in the long term, the government needs to adopt more flexible administrative processes. This would mean abolishing the categorization of working-relations status altogether and taxing work “on the go,” as it is done. In practice this might mean taxing each individual by the hour. In this case, it would no longer be tied to any given job contract, but to any work time paid, whether that be by an employer in the traditional sense, through an e-lancing agreement, or through other forms of traditional freelancing. This implies a reconsideration of what it means to work, and the traditional division into employee and freelancer/e-lancer would be history. Having these more flex-

ible administrative structures in this sense would serve as a national competitive advantage. This also entails making digitalized work, and e-lancing in particular, formal—dragging the work out of the currently informal economy. If and when the digitalized economy is formalized, the added administrative load needs to be digitalized, and hence the implementation via a government-administered platform. Further, the interface to commercial platforms is also naturally digitalized.

This needs to be defined through politics, but implemented through digitalized platforms. The reasons for this are twofold. First, it is simply not possible to follow the actual work accomplished by an individual through nondigital means. For example, all work accomplished would be automatically tied to the individual's tax number and then taxed cumulatively, regardless of the source of the wages. Moreover, the integration with social security services would be much easier this way. Second, even if it were possible to follow through work nondigital means, the administrative cost would be too large. By automating this process with the Internet, much of the workload for the tax and social security authorities can be reduced. To further aid this endeavor, the government could offer an accounting platform and other useful tools to limit the barriers for e-lancers to turn their informal work legit. A critical point here would be the potential resistance of administrative personnel in the government who might be afraid that their jobs may largely disappear.

### **III. Implementing a new taxation scheme for e-lancing**

In Northern Europe (i.e., nations with a higher cost of living), e-lancers working in the informal economy will see a personal benefit in keeping it there. However, as e-lancing gains in economic volume, it will provide more attractive prospects for taxation, leading to the inevitable formalization of e-lancing. Organizing this taxation in a manner resulting in the lowest possible added transaction costs for the individual will provide an opportunity for building a national competitive advantage in these international labor markets. This calls for digitalization and automation of taxation and social security beyond the web-interface—a more comprehensive platform with various features (as described in policy recommendation, point II) that could be described as a “citizen platform.” Here we note that developing nations may have a slight advantage because there are fewer existing structures causing rigidity. Questions that should be tackled are both substantial (whether a certain amount of complementary e-lancing, or more broadly “digital work,” should be tax-free) and technical (how to automatically integrate the government taxation system and existing e-lance platforms to make it as convenient as possible). Last but not least, these changes have to be started soon, but the formalization process itself should follow the idea of “start slow and let it grow—keep it light.”

These three policies build on one another and need to be approached simultaneously in order to get fully understand the situation and make sure that all the benefits of e-lancing can be realized without inviting too many of the negative effects e-lancing brings.

## 6 Concluding Discussion

We are of course aware that our recommendations come with major challenges. But before considering what these challenges are and how to tackle them, let's imagine what life would look like if they were to be implemented as suggested. Basing both social security coverage and tax contribution schemes on actual work accomplished (i.e., wages earned, regardless of working time or contract status) would enable individualized social security, where the benefits would be matched flexibly to the individuals' needs. This would not only reduce administrative hassle and uncertainty about social security statuses, but also provide a better overall coverage of each citizen's needs. Reflected against the reality today, this would remove lengthy considerations of whether one should officially switch one's status; individuals could work when there is demand and be sure to be provided for when jobs are scarcer. This would also enable citizens to have a lucrative source of additional income in addition to a "day job" or to work as full-time e-lancer, without risking discrimination of either one. By doing all of this digitally, over a government platform, administrative hassle would be minimized—implying savings in government spending—and less of citizens' time wasted through filling out forms and filing applications. Taxing would be so easy for employers and e-lancers as transaction costs for occasional "gigs," virtual work more broadly, and even non-platform-based short-term employment would decrease, ultimately encouraging growth in the formal economy. On a societal level, this means that the contribution-to-coverage relation for every individual would be fairer, making the system sustainable, even in the long run.

When considering the implementation of our suggestions, we see various problems that can be divided into political, societal, technological, economic, and legal. On a political level, agreement needs to be reached, within society and the parliament, upon which should be the new regulations that govern a category-free social security and taxing system. If employment contracts are no longer the base for establishing categories, what should be the new base? Will society be able to agree on a new base, such as, for example, the monthly absolute income? These decisions will be based on value-laden assumptions of politicians and voters, and the decision-making process will be cumbersome. We expect to see resistance also

from labor unions, making a lively discussion in society a necessary precondition for success. Further, once decisions are made, a structural reform of administrative regulations is needed. On a societal level, citizens need to overcome their rooted conceptions of how work should be categorized. This requires novel ways of thinking, and acceptance, reshaping the very identity of members of society. Further, it will take some time for people to accept being a work provider as a new part of their identity, regardless of their contractual relation to potential employers. Technological issues are deemed as comparably smaller; there is the issue of cybersecurity and platform infrastructure, but at least on a technical level such issues should be rather easily solvable in the future. However, the integration of different platforms creates critical economic issues; national platforms such as the one we want the government to provide need to be provided by someone. This platform will become the standard; it will set the standard other platforms have to comply with (i.e., be compatible with). Yet, most of the platforms organizing e-lancing and other work are global. Will they agree to this automatic integration and data transfer of their users' activities to the government's taxation and social security platform? There are legal issues of data privacy to be considered, possibly causing resistance also by users of these platforms. Moreover, competitive considerations play a role; first, platforms consider their user data an important asset and are not likely to share this data lightly. Second, the platforms' corporate taxation differs among countries—are platforms willing to be so transparent about their operations? Last but not least, there are likely also other, broader competitive considerations. Therefore, we expect to see great opposition from these platforms, and it will require substantial negotiations and political mobilizations to make this integration happen.

In conclusion, a full-scale implementation of our suggestions poses challenges. Nevertheless, no nation has governmental structures that are compatible with the future global digitalized labor market, and considering the magnitude of changes required, these challenges need to be addressed, beginning today. Further, much of what needs to be changed is deeply rooted in society, which means that not only e-lancers, but all citizens, need to embrace this change, as the future of the welfare state depends on it.

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# *Messianic Visions or Path to Technocorruption: Are Cryptocurrencies a Root of All Evil or Future Wealth of Nations?*

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**ABSTRACT:** *Monetary systems have underpinned our societies throughout the ages, by both enabling individuals to carry out their daily activities and fulfilling a range of other needs and functions. The emergence of digital currencies, in the context of digitalization, has given rise to a host of questions about the future of our monetary systems. Drawing perspectives from various disciplines of literature and expert opinions, this article examines how digitalization has and will continue to shape the future of our monetary and economic systems and societies, from online banking systems to cashless societies and distributed alternative currency systems such as Bitcoin.*

**KEYWORDS:** *bitcoin, blockchain, cryptocurrency, digitalization, digital money, future, money, virtual money*

# 1 Introduction

“Money, Money, Money...it’s a rich man’s world,” as so ardently uttered in 1976 by the Swedish super-group ABBA, in a song of the same name, underlies the deep and complex relationship humanity has with money. So vigorously numerical, yet tenderly sentimental at the same time, money has undoubtedly been intertwined with everything in which humanity has sought an identity. The notion of “value” is as old as time and understandably associated with the notion of “purpose,” which is an elusive concept that has been battled with throughout the ages. Money or currency, as an artifact—a physical manifestation—of value, thus shares a profound bond with all that one may deem purposeful or meaningful. Despite this terribly abstract perception of money, therein also lies a dimension of arithmetic pragma, which seems to be all that the modern age is about. After all, so goes the social anecdote that one cannot manage what one cannot measure. Constantly adjusting our perceptions through the ever-growing diversity of measurable entities is a fundamental human endeavor that has changed little since the dawn of history.

In our human quest to quantify and objectify all things, the abstraction of money has thus changed and today has adopted strong analytical dimensions leading to the emergence of such modern concepts as the financial, economic, and monetary systems, which are ubiquitously acknowledged as the strongest drivers of the development of the civilized world, beside the forces of (almost ironically) military competition. This began discreetly with the simple discarding of bartering practices and the adoption of a medium of exchange and progressed all the way through to the development of money as we know it today. This development has ultimately detached money from a straightforward convertibility to anything valuable, and now we bestow value just in the concept and manifestation of money itself. Furthermore, currently the overall control over the value in various currencies rests in the ivory towers of central banks and their policies regarding inflation.

Ultimately, the expressions of value have certainly morphed from one guise to another over time. Yet now, interestingly, we seem to have gone full circle, envisioning the possibility of a cashless society—a society without a physical manifestation of money. New perspectives of money are emerging rapidly, and indeed expectedly so, in the wake of the mass digitalization. The notion of cashless societies is not at all farfetched from the perspective of developed Western world; the inclination away from physical money can already be easily observed. This almost seems inevitable because, for many, money has already become strings of ones and zeros within plastic cards, computers, and smartphones. That said, perhaps it is good to stop and ponder whether we express value in a dif-

ferent way when using “electrons” instead of printed paper. However, given the dramatic force fields of digitalization, it is also good to remember that technology is not inherently benign or neutral even though we often seem to intrinsically assume so [1] [2]. Consequently, digitalization as a whole will have unforeseen side effects on society along with digitalization of money, which may result in numerous unwanted symptoms with possibly catastrophic irreversible consequences, despite the promising prospects it holds in the global scale. For example, what happens to personal privacy when all the monetary transactions are traceable?

A new solution to the problems associated with national currencies, inflation, and digitalization of money has emerged in the form of cryptocurrencies. This pseudo-expression of money has added an additional dimension to discussions of monetary value, trust, inflation, privacy, lack of transparency, and centralized control—both for better and for worse. Originating from the almost messianic visions of a mysterious person or entity with the pseudonym Satoshi Nakamoto, cryptocurrencies promise to solve issues with monetary privacy, inflation tied to centralized control, and imperative of placing trust in third-party operators in monetary transactions. The vision paints a picture of future with “digital cash” in which monetary transactions would be both private yet still transparent and where control over currency would be distributed equally among the participants. The new technology associated with the mythic Nakamoto and cryptocurrencies also offers applicability beyond just the financial context because the technology can be adapted to solve various issues in the digitalizing world of tomorrow. Despite the idealistic visions, especially considering Heidegger’s axiom [1], promises of cryptocurrencies’ capabilities still may not be the utopia we will or want to attain. Therefore, it remains to be seen whether cryptocurrencies will truly challenge established structures built around national currencies, coexist with them, or wither down in the pages of future history as another example of unfulfilled vision of technological and societal revolution.

Needless to say, it is of cardinal significance that the interventions regarding the development of digitalized money along with evolution of cryptocurrencies will be handled with care and profound contemplation. In an attempt to project and predict the future trajectory of the monetary system along with the potential technological disruptions molding them further, it is necessary to understand the development of money as a humanistic as well as a numerical construct. It remains to be seen whether digitalization of money infused with cryptocurrency disruption will devolve to epitomize the old biblical phrase that money is the root of all evil, or whether it will evolve, in Adam Smith’s terms, into the future wealth of nations.

To explore answers to these questions we structure this article in the following manner: After the (1) introduction, we take the reader on (2) a journey through the

emergence of value and money and how technology has enabled numerous expressions thereof in modern times. We then continue by explaining the most recent technological challenge to the modern monetary systems by explaining (3) what cryptocurrencies really are through their most prominent case, Bitcoin, and going through the ideological underpinnings of the cryptocurrency infrastructure—how it works and what it really promises. We then continue with an evaluation of (4) what the current state of the cryptocurrency systems is, who really uses them, and how these people use them. To properly comprehend the flexible capabilities of the new technological innovations packed into cryptocurrency systems, we also further elaborate (5) what kind of applications can be drawn from the technology beyond just the currencies, payments, and the whole financial sector. Next, to provide comprehensive perspectives on future developments of digitalization of money, cryptocurrencies, and the possible impacts of the technology behind cryptocurrencies, we (6) report results from a round of expert interviews that we conducted to bolster our findings. We interviewed six parties that represent a diverse knowledge base relating to cryptocurrencies and their various aspects. In this qualitative work, we ask questions on four topics: How will the digitalization of money pan out generally in the future? What will be the impact of cryptocurrencies on this development? How will the challenge of unregulated cryptocurrencies affect the heavily regulated monetary environment of national currencies and commercial banking? What will be the general impacts of the cryptocurrency technology beyond just the financial sector? Ultimately, (7) we will draw summative conclusions of our findings in the anterior literature and expert interviews.

## **2 Background on Money—and a Bit on Banking and Society**

### **2.1 What Is Money?**

*What is money?* is a question that one does not often ask oneself in developed countries because the conception is so heavily hardwired in our consciousness and society that the answer seems too obvious. In fact, money has multitude of functions that one would not regularly consider. Historically, money can be defined as basically whatever can function as a medium for payments as well as a balance for credit and debt [3]. However, the concept of money also possesses dynamicity—depending on the time and place, the term *money* may have different meanings and functions [3] [4].

Davies [3] described how the general functions of money can be viewed through

abstract macroeconomic functions, such as money acting as a liquid asset that is easily convertible to something else, such as tradeable for goods or services; a framework for setting prices in an economy; a driver setting the economy in motion; and a controlling element in the economy. Nonetheless, money also has plenty of important specific microeconomic functions in abstract terms, such as acting as a unit of account, a measure for value, or a standard for deferred payments. Furthermore, there are also significant practical specific functions, such as a medium of exchange, means of payment, and storage for value.

Money can also take a variety shapes and forms compared to the traditional conception of money. As opposed to common currencies such as the euro or the dollar, in different cultures across the world, a variety of artifacts are used to store value and buy things in a particular context, such as relating to specific food items or for usage only in certain locations. Such money is referred to as “special-purpose money.” Special-purpose money is only applicable in a specific context, be it dependent on a remote location or the exchanged goods and services [5]. Examples of special-purpose money include the company scrips common in remote 19th-century mining and logging camps. Company scrips were company-issued money for employees that were usable only in the company-owned stores. Although company scrips may seem archaic nowadays, these tenders are not completely detached from current times, considering that less than 10 years ago a court order was required to cease such employee payment practices at a Mexican branch of a large American retailer [6].

## **2.2 History of Money: Evolution of Currencies, Societies, and Banking**

As can be seen following Davies’s [3] definition, money has taken many shapes throughout history and emerged independently in various parts of the world for various purposes. Starting from barter, dealing of early societies’ money for transactions has involved precious minerals, metallic products, farm products, furs, yarn, and other goods. However, barter—exchange of goods and services—was not always the primary reason for the invention of money in a society. For example, many societies needed an objective measure for paying compensation regarding legal disputes. The ubiquitous need for inventing money for various purposes has been so encompassing that throughout history virtually every society has adopted a form of money, apart from the Incas [3].

The way money is best understood in Western societies nowadays is through forms of cash: coins and banknotes. Even though cash money and banking are often viewed to have developed hand in hand, banking in fact predates even coins; in ancient Mesopotamia—now a part of modern-day Iraq—temples began

storing grain and other commodities for safekeeping and issuing receipts for depositors around 2000 BCE. Later, around 640 BCE, minting of coins began in Lydia, a region in western Turkey, from which it spread quickly to neighboring regions. Even though various metallic proto-coins had been in use in different regions around the world, the Lydian coinage was the first to use standards for round shape, weight, and metallic purity accompanied with a proper metallurgic seal for proof. All these measures were put in place to fight against counterfeiting, which was plaguing other proto-coins [3]. Therefore, even in the earliest societies, easy money has always enticed people.

With the early coins, the value of the metal in the coin also represented the base value of the coin. Therefore, each coin could be repurposed by melting it, but this process would not really change the value inherent in the coin. Furthermore, the use of money became more convenient because the trust in official standards enabled users to discard the requirement for weighing each coin to ensure its value. The issuers of the standard for coins minting were normally part of the ruling class or monarchs themselves. They were also in charge of the minting process. Because the ruling class controlled the supply of money through issuing the standards, they could also profit from it. Thus, by the Middle Ages, control over money had become a convenient source of income for European monarchs [3].

However, the stability of value in coins was still dependent on the supply of raw materials for minting the coins. Disruptions in the supply of coin raw materials, such as silver, naturally led to disruptions in the supply of money, thus creating the first concrete experiences of inflation, such as that which took place in ancient Greece. To counter this disruption of supply, some Greek city-states started to issue coins that contained only a thin coating of silver and other metal underneath. This development marked the first account of standard coins detached from their base value, and it naturally led to different valuations for these coins among the people. The difference in valuation gave a boost for bank establishments because a new banking practice—in addition to deposits and money lending for business investments—had to be created: money exchange. As city-states began to end up with multiple different coins with different valuations, it was natural for places such as banks, in which money had the tendency to gather, to start to profit from exchanging money for the various needs of the people [3].

The disruptions in raw material supply led to innovations for new forms of cash, such as paper money—the first form of fiat money. Fiat money is money that does not have any intrinsic value, or value in and of itself, but it is treated as if it has that value because of a proclamation by an authority [7] [8]. Paper money was invented in China and became commonplace after approximately 940 CE. The invention was the result of disruption in the supply of copper, which was a com-

mon raw material for local coinage [3]. Subsequently, the idea of paper money spread to Europe during the 13th century through explorers [9]. Paper money was appealing for its convenience; it was easier to produce and not as dependent on volatile raw materials compared with coins. Furthermore, for users, paper money proved to be more convenient to handle in large quantities, although it lacked the durability of coins. However, the introduction of paper money further detached money from its base value because the inherent value was even less present in the physical artifact compared with coins. Consequently, trust in paper money's value was fostered by backing it with some physical commodity, such as precious metals stored in a central bank [3].

Traditionally, the value of paper money—or banknotes, as money is commonly referred to nowadays—had been backed with silver deposits up until the early 19th century. However, that century saw a further transition from silver to the gold standard for all money [3]. These standards were intended to ensure the value of paper money, but they proved to be too rigid for the evermore rapidly developing societies and markets. The two world wars and the Great Depression in between made it impossible for many countries to maintain sufficient reserves of gold to back the money circulating in the economy, causing them to switch in and out of following the gold standard at their own convenience [10].

The needs for money in the new market economy ultimately caused money to be detached permanently from its base value in precious metals. After the Second World War, many countries tied their currencies to the fixed gold exchange rate of the American dollar [10] in what is known as the Bretton Woods agreement. The purpose of the Bretton Woods agreement was to help postwar reconstruction and economic and monetary stability by means of open markets—removing barriers to trade and the movement of capital. The system laid down the global monetary system, which then further assisted the quick global spread of new monetary developments to national monetary systems. Once again it was war—the Vietnam War in this case—that crumbled down the gold standard system, this time for good. In the 1970s the United States cancelled the convertibility of the dollar to gold and thus effectively ended the Bretton Woods system and created a new global standard for money: the modern form of fiat money. This monetary form has been also labeled as “savage money” because of its detachment from labor and goods [4] [11].

### **2.3 The Modern Days: from Fractional Reserve Banking to Technology Shaping Transactions**

The end of Bretton Woods brought about an era of flexible deregulation in banking and finance, which then gave rise to a flurry of new financial products and relation-

ships and a new culture of risk in financial markets [4]. It also enabled fractional reserve banking, the current system of banking in which banks hold only a small part of their deposits as a reserve and lend and invest the rest [12]. Naturally, having only fractional reserve of the deposit creates a risk for the sustainability of banks in an event in which all of the customers would like to cash in their deposits simultaneously. However, this risk is soothed by heavy governmental regulation and central banks. Whereas regulation attempts to keep commercial banks from taking too-high risks, the central banks help by providing insurance for deposits and supplying new money in form of loans in case of demand increasing over fractional reserve thresholds [12]. This aforementioned flexibility of fiat money has offered a great environment for the large average economic growth experienced globally since the 1970s because central banks can supply new money based on demand rather than being limited by rigid reserves of precious metal resources. Simultaneously, this system has granted a heightened status for central banks in their money-creation role. However, fiat money and the system around it have been also accused of contributing to economic shocks [13] [14].

Technology has also shaped our conception of money from 19th century all the way to the 21st century. The financial sector has always been among the first to make use of new technologies—whether they be electricity, the telegraph, the telephone, mainframe computers, or satellite links—culminating in the “Big Bang,” the digitalization of the London Stock Exchange. From a consumer perspective, the development of manufacturing processes in the 19th century saw the rise of the mass-produced metal plates used in stores to record customer details and charge customer accounts. Not dissimilar in looks to a modern credit card, customer details would be embossed upon the plates and read using a paper transfer to reduce errors. With developments in plastics, the modern, and much lighter, credit card made of plastic was introduced in 1951, reducing the need for cash.

The end of the Bretton Woods agreement, banking deregulation, and the growth of computing facilitated the development of new financial instruments as money came to consist more of bits and bytes than paper money. Cash has started to disappear from daily consumer use in many modern Western societies. It is not just that our physical cash is transforming into plastic cards in our wallets, but also much of the monetary transactions are conducted in a fully digital environment through online banking services. Shifting to intangible, digital money also influences consumers, and this tendency may have further societal implications. Personal detachment from physical money—cash—has been shown influence consumer habits: consumers tend to spend more money on same products when using digital money through debit and credit cards rather than using cash [15].

At an institutional level, the marriages between banks, credit card companies,



and national currencies have become a maxim for transactions in modern societies over the decades. This maxim has also endured the ongoing transition of digitalization of money—that is, money becoming less and less of a physical artifact. However, technology has also shaped these institutional structures as new players have been able to enter the market through technological innovations. With the developing information technology infrastructure and the invention of the web browser, the World Wide Web became accessible to all. As a result, PayPal, an online money transaction provider, was one of the first to break into the credit card company stronghold of online transactions. Thereafter, other technology giants—such as Google with Google Wallet and Apple with Apple Pay—have followed suit by targeting monetary transactions, especially through smartphones. However, a striking aspect of these new monetary transaction services is that they only attempt to disrupt the position of credit card companies—and to some extent commercial banks—regarding online transactions. However, these technology companies providing transaction services do not really challenge the position of central banks or national currencies because those very same national currencies are the foundation for all their transactions services.

Technology has also had an impact on money in other ways. Despite the prevalence of national currencies, there are also alternative special-purpose money systems existing in offline environments. These local exchange and trading systems often operate on more of a social basis and within smaller communities [4]. Yet still, online environments have some of their own “local” currencies. Many online games have well-developed trading systems that run purely on communal, virtual currency, such as gold in World of Warcraft, Linden dollars in Second Life, and Interstellar Credits in EVE Online. These currencies are in fact fully virtual—non-physical, mediated only in and by computers—because they exist and operate only in a virtual environment and have no basis in physical commodities or value derived from the physical world. These communal currencies are virtual to such an extent that usually they are not straightforwardly convertible to national currencies, such as the U.S. dollar. Therefore, as such, these communal currencies will not challenge the current monetary system based on national currencies. However, there are also other alternative currency systems that have emerged through the development of computing technology and with an ideological foundation that runs counter to the current institutional maxim of the global banking and monetary system. Recently, cryptocurrencies have emerged to truly challenge this system from its foundations. The most prominent cryptocurrencies, such as Bitcoin, are operating in both online and offline environments with a convertible exchange rate to national currencies, and yet these currencies are operating beyond the control of central banks, national governments, and global banking regulation.

## 3 What Are Cryptocurrencies?

### 3.1 Introduction to Cryptocurrencies and the Blockchain

Cryptocurrency is a specialized form of digital currency. Cryptocurrency can be defined generally as referring to digital currencies that utilize cryptography to ensure security and enforce anti-counterfeiting measures [16] and operate beyond the control of central banking systems [17]. The term *cryptocurrency* usually refers to a distributed form of digital currencies that uses cryptography to provide security. The narrower conception of the term is to be attributed to the example set by the currently most established cryptocurrency: Bitcoin. It was the first cryptocurrency to break into the discussions of the mainstream media. However, not all cryptocurrencies are distributed or decentralized, as many of the early cryptocurrency propositions have not adopted the current ideological background.

The current form of cryptocurrencies stems ideologically from the works of Dai Wei [18] and Timothy C. May [19]. These works contain a solid antithesis toward centralized control, which is often analogous to central government control, or central bank control in this particular context. Thus, these ideological underpinnings advocate a shared, distributed foundation for currently trending cryptocurrencies. Because the current forms of distributed cryptocurrencies—mainly derived from Bitcoin—have gained some mainstream attention as opposed to other forms of cryptocurrencies, this article will mainly describe and discuss cryptocurrencies according to the distributed technology structure, especially through its most championed specimen, Bitcoin.

Although Bitcoin's success has led to a search for the origins of cryptocurrencies—often attributed to Satoshi Nakamoto's white paper [20], which described the first proposal for initiating the Bitcoin cryptocurrency system—the concept of cryptocurrencies has a long history. As early as the 1980s, David Chaum had described a similar type of transaction system using cryptography to secure the privacy of the parties involved [21]. However, Chaum's endeavors in the 1990s with centralized cryptocurrency concepts were ultimately unsuccessful because, at the time, they were no match for the competition set by credit card companies [22]. However, the misfortune of Chaum was not the end of centralized cryptocurrencies; as new alternatives are still being proposed by describing the new systems in white papers [23].

MaidSafeCoin, the first decentralized cryptocurrency, was launched in 2006. However, it was not able to attract a large-scale following. This has been partly attributed to the lack of openness regarding how the system actually worked [24]. The new era for cryptocurrencies did not dawn until 2009, after the description

for Bitcoin was released under the pseudonym of Satoshi Nakamoto [25]. From the beginning, Nakamoto has been an elusive and mythical character, or perhaps group, that has been guiding the emerging Bitcoin community forward in an almost messianic fashion. Adding further to this aura of mysticism was the disappearance of Nakamoto from the Bitcoin community; as of late 2010, he or they had ceased any involvement with Bitcoin. Perhaps this mysticism surrounding Bitcoin was originally part of its appeal, but nonetheless what has made Bitcoin remarkable compared to any earlier attempts with decentralized or distributed cryptocurrencies is the innovation called blockchain.

Blockchain is effectively a public ledger, an open public record of all transactions made within the Bitcoin system since its inception. Therefore, it is an integral part of the Bitcoin system. It was designed as a distributed solution to tackle a pervasive problem of digital currencies: double-spending. In digital environments, it is problematic to verify that a payment has been withdrawn from an account and deposited into another simultaneously as a sign of the payment unless there is an independent third party acting as an intermediary to broker trust between the transaction participants. Despite the fact that blockchain can be described as merely a distributed public ledger, its potential actually exceeds that of the whole Bitcoin system around it, and therefore it must be discussed separately from the Bitcoin system and its potential as well. The Bitcoin system is heavily tied to the financial sector because it is effectively a monetary transaction system with its own currency and incentives to participate. Bitcoin as a whole offers an interesting ideological challenge regarding how we should view and possibly also reorganize the systemic structures of our economic and financial sectors by using the help of latest information technology. However, considering solely Bitcoin limits the discussion to these sectors and their structures.

Blockchain, on the other hand, is a system with a vast application potential far beyond the economic and financial sectors (Goldman Sachs Global Investment Research, as cited in [26]). Furthermore, Bitcoin's run-ins with various scandals—these are discussed further in Section 4—have resulted in companies previously associated with applying the Bitcoin technology actually distancing themselves from Bitcoin and concentrating on using the more neutral blockchain as a platform for innovation [26]. A further elaboration of the applicability of blockchain to various context is provided in Section 5.

### **3.2 Ideological Underpinnings of Bitcoin**

In the current system of monetary transactions, there is an inherent necessity to use trusted intermediaries, such as banks or credit card companies, to facilitate

these transactions. This underlying structural assumption also underpins the whole ideological basis of the Bitcoin system because it is this enforced trust mediation that the whole system aims to challenge ideologically.

The story begins after the fallout of the financial crisis in 2008. Disillusioned with the undertakings of banking authorities and taking inspiration from Wei Dai's cryptoanarchy manifesto [19], Satoshi Nakamoto proposed the Bitcoin system, which would eradicate the need for intermediaries controlling the monetary transactions [27]. Ideologically, Nakamoto saw this breakaway from the control of centralized intermediaries as an execution of individual freedom—or an act of libertarianism, if you will. Moreover, there was also practical value for this type of proposal because distributed structures were more difficult for governments and regulators to shut down [20].

The current system for monetary transactions requires users of the system to place trust in intermediaries—namely, banks. However, in the fallout of the financial crisis of 2008, we can take a retrospective view on developments in the financial industry: commercial banks have taken a powerful position in society by influencing regulators and politicians to attune policies with their self-interests. Ultimately, if the risks of their endeavors have materialized, it is usually the taxpayers who are left to pick up the bill [14]. This leaves us to ponder Nakamoto's implicit question of whether we can or should place trust in these financial intermediaries even in the case of simple monetary transactions if we cannot always be certain that the interests between transaction parties and consumers aligned. Furthermore, this institutionalized necessity to place trust in a third party for bilateral transactions also grants that third party an option to seek compensation for mediating the trust, which ultimately can lead to increased transaction costs [20]. Hence, these third-party intermediaries can profit simply by providing a platform for transactions. For these reason, Nakamoto's vision was to create a platform that did not require a trust intermediary; rather, the issues of trust would be circumvented by using cryptographic proof for transactions, which are explicit and inherent within the system's algorithmic functions.

It is also noteworthy that Bitcoin, and the technology behind it, was developed independently without any apparent influence from lawyers or regulators. As a result, the current Bitcoin system is not controlled by any single individual entity. Rather, all the relevant information regarding the transactions is stored on a distributed network of participants in which anybody can participate. Bitcoin accounts are free and accessible for anyone, anywhere, regardless of the individual's personal history or current financial situation. Additionally, participants do not even need to reveal their real identity when making transactions. Thus, the Bitcoin system is considered to provide a more private, less regulatory-dependent scheme

for payments than the current nationally led system [28]. Furthermore, the technical solution behind Bitcoin evokes trust by enabling trustworthy money creation and transaction tracking, which in turn are placed on the system to prevent counterfeiting and double-spending [29] [30]. Therefore, Bitcoin does have the potential to offer an “open, decentralized, trustless and secure infrastructure,” which could reduce transaction costs and increase transactional efficiency in a dramatic manner [29]. To further understand how the Bitcoin system actually works, we need to take a look “under the hood” to see the bits and bytes behind the ideological layer.

### **3.3 The Bits and Bytes of Bitcoin Technology**

Distinctively, Bitcoin-like cryptocurrencies have the following characteristics: money supply is managed algorithmically by computer software instead of institutionally by central bankers, supervision of transactions is distributed and non-hierarchical—network nodes do the verification—and online wallets of bitcoins cannot be straightforwardly connected to offline entities, ensuring anonymity. Regarding the supply of money, Bitcoins are created in a process called mining. The term stems from a gold-mining analogy because Bitcoins are supposed to mimic gold and its supply in the global economic system; there is a steady output of Bitcoins to the market, just as there is a steady output of gold extracted from the ground by miners [20].

In practice, Bitcoin mining means solving hash functions [31] as a proof of work for transaction verification. Basically, a hash function translates a piece of varying-length text or numbers into a defined-length number code. These hash functions are the basis for the cryptographic foundation of the whole system. Whichever network node is able to solve the hash function the quickest, that is, translate the hash function correctly, is rewarded with a specific amount of new Bitcoins. The creation of new Bitcoins is governed by a protocol that adjusts the difficulty level of hash functions to accommodate an increasing supply of computing power so that the network can verify new transactions by creating a new block to the public ledger, blockchain, every 10 minutes. The blockchain operates as a public verification of all the transactions made with Bitcoins. After a new block is created, it is added to the blockchain and linked to the anterior blocks. Each block represents both all the encrypted Bitcoin transactions over a 10-minute period and a proof of added Bitcoins to the circulation. Therefore, blockchain can be utilized to trace how much each account should contain in Bitcoins and to aggregate how many total Bitcoins there are in circulation. Furthermore, the linking of blocks together is important because it prevents falsification of transactions, which could lead to double-spending (i.e., spending Bitcoins that one does not own). Because of the

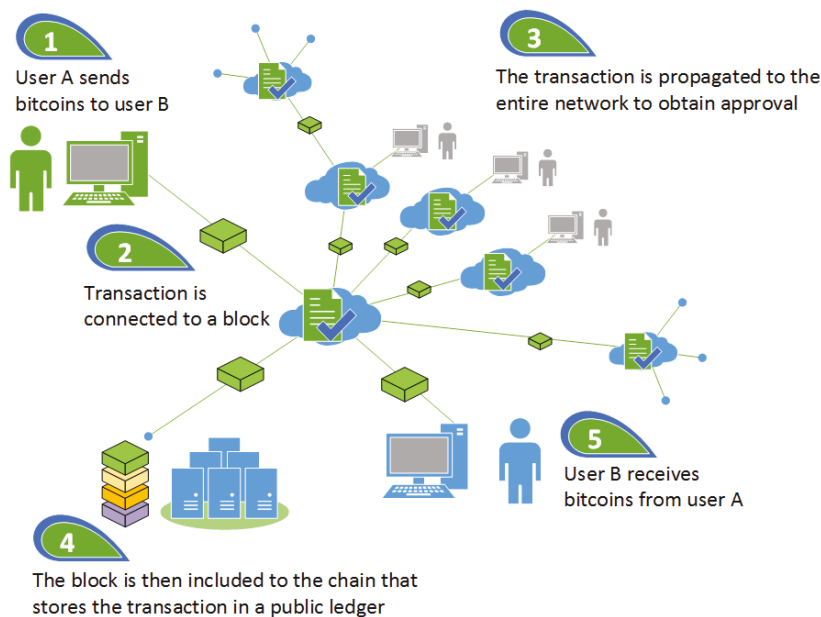
linked blocks, in practice, one would have to falsify all the blocks in the blockchain in order get away with the falsified transactions. This in turn would require an immense amount of computing power, effectively at least approximately 51% of the processing capability of the whole Bitcoin network [20] [32].

There is also a limit in the creation of Bitcoins. The maximum amount of Bitcoins in circulation is defined as approximately 21 million Bitcoins [29] [33]. After this amount has been reached, there will be no new Bitcoins to be mined and thus the original incentive to participate will cease to exist. Once the limit has been reached, the incentive to participate and lend computing power is expected to be realized through transaction costs. However, due to the Bitcoin protocol dictating the adjustment of difficulty in solving the hash functions, the upper limit of Bitcoins is not expected to be reached until approximately 2140 [33].

Regarding the supervision of transactions, the Bitcoin system essentially is a network of nodes operating together to verify the validity of transactions between different nodes. Practically, payments between participants occur in a credit–debit process in which the sender’s account is debited by the agreed amount of Bitcoins, and the receiver is credited the respective amount. These payment exchanges operate through asymmetrically encrypted messages. Each participant has two unique encryption keys, one of which is a public key and the other a private key. As the names imply, the public key is publicly available for other participants to view, whereas the private key is only known by its owner. As an example, a receiver’s public key can be used by a sender to send an encrypted message or payment to the receiver. Only the receiver can open this message by decrypting it using his or her private key. Thus, the messages are asymmetrically secured so that no one else except the receiver can open the messages encrypted by his or her public key. Basically, in the Bitcoin transaction context, the encrypted messages contain account addresses to other users so that an agreed payment can be conducted [32].

For users, Bitcoin operates through wallets. A wallet is basically a software file that constitutes an account for a user and stores whatever amount of Bitcoins the user owns. They are normally stored in users’ personal computers. In these wallets the Bitcoin assets are usually divided into multiple Bitcoin addresses, and the creation of new addresses is encouraged to increase privacy. Even though Bitcoin addresses as such can be seen as analogous to various bank accounts, the operating logic is a bit different because these addresses are used also for transaction purposes. If a user would like to transfer a Bitcoin payment to another user, the user that will receive a payment would create a new Bitcoin address to which the sender can transfer the agreed Bitcoins using encrypted addresses as described previously. A summative illustration on how the Bitcoin system works from a user perspective is provided in Figure 1. Technically, the encryption leaves each transaction and its

participants anonymous. However, the privacy necessitates that no Bitcoin address can be traced to a certain person in order to assure anonymity [34].



*Fig. 1. Bitcoin transaction operations from the user perspective (adapted from Goldman Sachs Global Investment Research [26]).*

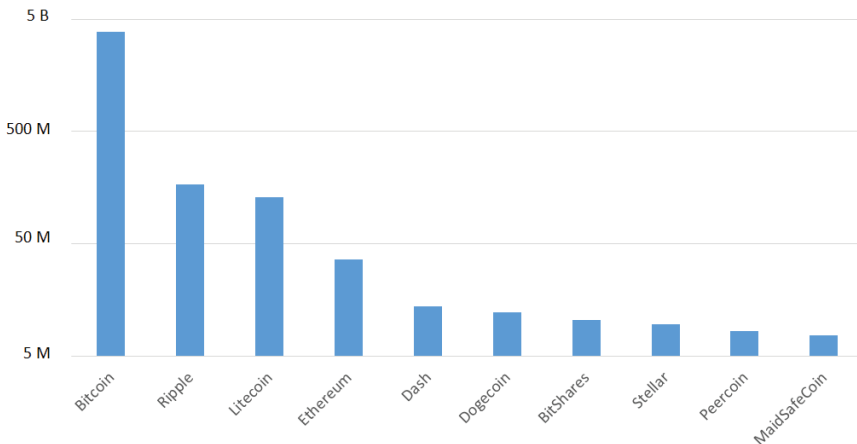
### 3.4 Overview of the Cryptocurrency Market

A deeper understanding of the impacts of cryptocurrencies entails going beyond just a view of the origins of the market leader and a description of the technology. A broader understanding requires also looking into the recent historical developments of cryptocurrencies as well as examining how the cryptocurrency market connects to the surrounding global financial market. Cryptocurrencies and Bitcoin particularly have been in the outskirts of the global financial market, partly because they are still emergent and unknown currencies for the majority of the population and partly because they are formed beyond the structures of the global financial market. Furthermore, cryptocurrencies are virtual currencies that require access through computer technology, a technology that is widely available only in the most developed nations of the world. Yet still, almost throughout the existence of Bitcoin, cryptocurrencies have been marred with controversies and scandals because they have been associated with unlawful behavior tied to the trade of illegal goods, money laundering, and terrorism.

In spite of this scandal-ridden history, cryptocurrency usage in terms of volume has been experiencing continuous growth. The creation of new Bitcoins has fol-

lowed a nearly linear growth pattern since the inception of the cryptocurrency, and the current amount of Bitcoins in circulation is closing in on 15 million units. Furthermore, both average transactions per day as well as amount of unique Bitcoin addresses in use have both shown a steady growth. The daily transactions have grown from less than 10,000 transactions in the start of the Bitcoin boom in mid-2012 to current nearly 150,000 transactions, whereas the number of unique Bitcoin addresses has grown in the same time period from around 10,000 addresses to nearly 290,000 addresses [35].

Bitcoin is currently the dominant cryptocurrency, with a market capitalization fluctuating around 4 to 5 billion U.S. dollars (henceforth abbreviated as USD) [36]. This means that the worth of all Bitcoins available for use is approximately 4 billion USD. Compared to the other over 650 different cryptocurrencies listed at coinmarketcap.com, Bitcoin has wildly more valuable market capitalization, as shown in Figure 2. The figure is illustrated in a base-10 logarithmic scale because the real differences in magnitude are so enormous between different cryptocurrencies. Whereas the market capitalization for Bitcoin is approximately 20 to 30 times larger compared to the two biggest rivals, Ripple and Litecoin, the magnitude of differences in market capitalization compared to other cryptocurrencies is already several hundred times larger. Even though Bitcoin appears as a giant against other cryptocurrencies, it is still merely a tiny dwarf compared to the leading currencies of the world, such as the euro or USD. To put the magnitude differences in perspective, there are estimated to be more than 10 trillion euros—equivalent to approximately 10 trillion USD—measured with the M2 monetary aggregate containing currency in circulation, overnight deposits, deposits with a maturity up to two years, and deposits redeemable with up to three months’ notice [37]. To put this magnitude difference in perspective, the euro is more than 2,000 times larger than Bitcoin.



*Fig. 2. Comparison of the top 10 cryptocurrency market capitalizations measured in USD on a base-10 logarithmic scale captured on October 20, 2015 [36].*



Cryptocurrencies can be described as extremely volatile currencies [38] because they have seen rapid value displacements compared with formal national currencies. For example, Bitcoin averaged around 100 USD during most of 2013, yet surged to over 986 USD in November and dwindled back to average around 250 USD in 2015, resulting in nearly 75% of its value lost [29] [36]. In addition, since its inception, historically, price volatility— variation of price over time— has been over 130% in the case of Bitcoin. This volatility exhibits price risk 7 times greater than gold, 8 times greater than the S&P 500 indicator, and 18 times greater than the USD [39]. Other cryptocurrencies also have experienced rapid booms and general price volatility, but to a lesser extent compared with Bitcoin, presumably because of their smaller size [36].

Despite fluctuations, Bitcoin and many other cryptocurrencies keep growing with generally rather steady and sustained development in the supply of new coins as well as the amount of transactions if measured in a term of multiple years [35]. Currently, it seems that in spite of heavy price fluctuations in the past and the scandals associated with it, Bitcoin is here to stay. Although its impact on the global monetary market is miniscule in terms of size, the demand for and utilization of Bitcoins are likely to continue in the foreseeable future. Therefore, it is important to ask: Who is really using Bitcoins or other cryptocurrencies? Furthermore, it is equally important to understand how and why these users choose to use them.

## **4 Popularity of Bitcoins—Users, Investors, Opportunities, and Risks**

### **4.1 Explanations for Bitcoin’s Appeal**

There are number of explanations for why Bitcoins—or cryptocurrencies in general, for that matter—have become popular. According to Böhme et al. [28], the popularity of Bitcoins is likely to be related to the early market launch compared to other distributed cryptocurrencies. The early release caused excitement and interest among early adopters as well as favorable press coverage. Additionally, privacy and independence from national regulation are things that Bitcoin supporters seem to value highly. More specifically, the popularity is partly attributed to the whole system’s inherent freedom from organizational and governmental power as well as controlled monetary policies [30]. From a more practical perspective, people using Bitcoins for transactions often value the possibility of a certain level of anonymity—or better, pseudonymity, in which a real identity

is hidden behind a pseudonym (i.e., a made-up user name). The possibilities of anonymity can also lower transaction costs due to the lack need for financial intermediaries [40].

The enthusiasm toward Bitcoin and other cryptocurrencies has been curtailed by the unpredictable changes in the value of these currencies. However, Bitcoin advocates state that the volatility of Bitcoins is irrelevant, and that the focus should rather be shifted to the revolutionary technology it is built on, the blockchain, which could be the basis of an entire new-era payment system. The Internet's effect on money still has not been seen, because—until now, at least—it has been unable to remove the middlemen and bottlenecks that are present in our current monetary systems [29]. Nonetheless, Bitcoin is not only about money and payments. It is argued to also have an effect on how assets, such as bonds, securities, and real estate, are owned, tracked, and traded. Bitcoin's technology can and is likely to decrease frictions currently related to international remittance and payment services, and in a short amount of time. This could make a vast difference in how we experience the global business environment and operate in it. Also, the technology should have a large impact on micropayments channeled through social media as well as on the ability of subscription-based publishers to monetize their content. Bitcoin's platform provides a stimulus for financial innovations that is a fundamental aspect of attracting investors, as they state that the "bitcoin protocol contains the digital blueprints for a number of useful financial and legal services that programmers can easily develop" [40, pp. 15–16]. In addition, because alternate add-on services can be built on top of the Bitcoin protocol, it leaves a window for further innovation and development as well.

There may be also some vanity and appeal of novelty involved in the popularity of cryptocurrencies. For example, investing in cryptocurrencies can also provide real pleasure to some of the owners because cryptocurrencies represent the leading edge of technical innovation incorporated with an idea of appealing ideology and ingenuity [41].

## **4.2 Cryptocurrencies as Investment Assets**

Beyond just novelty, anonymity, ideology, and possibility lowered transaction costs, cryptocurrencies can also offer real practical value if they are viewed as risky investment assets. Given that the usability of Bitcoins is still fairly limited, demand is partly driven by speculators who expect its value to increase in the future. Counting on this trend, speculation encourages people to invest in Bitcoins, in other words, to invest in speculative assets [29]. However, accusations also have been hurled toward Bitcoin from financial sector while simultaneously

Bitcoin is considered as a potential investment instrument. Accusations claim that Bitcoin is just an elaborate investment fraud, a Ponzi scheme [42]. Even though Bitcoin's possible status as simply an investment fraud is questionable and even controversial, the European Central Bank has found some similarities between the use of Bitcoins and the traditional characteristics of a Ponzi scheme. However, Bitcoin does not completely fulfill the definition of a Ponzi scheme, making these accusations somewhat questionable [43].

In the end, if the Ponzi scheme accusations are set aside, the more people believe in the increase of Bitcoins' usability and thus consider them to be currently undervalued, the more market participants will bid up their price until it reaches the equilibrium price. However, this speculation could also lead to a bubble if prices divert from the fundamental value [41]. Yet, in the case of Bitcoins, the fundamental value is extremely difficult to assess. A good example of this fact is the sharp rise of Bitcoin value in 2013, when Bitcoin value measured in USD rose almost a tenfold within a single month, followed by a subsequent heavy value loss of almost 75 percent during 2014 [36]. Subsequently, treating Bitcoins as an instrument of investment has been accused of hurting the future success of Bitcoin and making it problematic for all cryptocurrencies to establish themselves as a real, widely accepted medium of exchange equivalent to national currencies. However, the crash in Bitcoin value can be seen as a possible way to lower expectations of future prices, which in turn could speed up and facilitate the adoption of Bitcoins as an alternative to money in everyday use [29].

Viewing this from another perspective, if the price volatility is disregarded, one of Bitcoin's advantages lies in its relation to inflation—that is, an increase in the prices of goods and services in relation to the value of a currency. Bitcoin's inflation can be estimated at a fairly predictable rate because the total supply of new Bitcoins is predetermined and limited [29]. This is very different from fiat currencies, for which the supply is regulated by central banks, whose money-printing capabilities are in theory unlimited and dictated by nothing else than economic policies. Because creating more supply causes inflation, by extension, currencies' relation to inflation is also dictated by economic policies. With a sustainable and predetermined supply of money, Bitcoin and other cryptocurrencies would be free of influences of inflation—at least in theory.

Currencies' value is in their liquidity and usability, both for fiat money and cryptocurrencies. Yet, if cash is needed to be kept at hand, of course it would be desirable from the consumer's perspective that it would also have good value-preservation characteristics. Thus, Bitcoins could be used as financial instruments against fiat currency inflation. Still, the current concerns about the price volatility of Bitcoins are making it rather difficult to view Bitcoins as a credible

instrument against fiat currency inflation. However, if and when Bitcoin or some other cryptocurrencies become more widely accepted and mature, they are more likely to maintain their value.

In addition to investing in Bitcoins directly, many people are also investing in businesses that operate around Bitcoins. The new way of conceptualizing money of course provides many business opportunities, and it has accelerated the rise of new companies, from new-age brokerages to cryptocurrency storage sites [29]. Thus, it is an interesting concept for people willing to take risks based purely on the new, fascinating business opportunities that the hype and potential future success support. As a result of the hype and enthusiasm, Silicon Valley venture capitalists and Wall Street investors have been pouring money into the currency during the last few years. The future is yet to be determined, but this new form of digital currency has been said to have the potential to disrupt the existing highly regulated payment systems that were developed long ago and have been in use for centuries [29].

#### **4.3 Emerging Opportunities in the Developing World**

Bitcoin may offer an opportunity and power to change the lives of people living in the developing countries, where the access to basic financial services is a rarity. In 2014, nearly 40 percent of adults, that is, over 2 billion people, around the world remained unbanked [44]. More than half these unbanked people live in developing countries in South or East Asia or the Pacific. The most common reason identified for this by the people themselves is the lack of sufficient money that keeping an account would be advisable or necessary. Other reasons are as follows: no need for an account, a family member has an account, accounts are too expensive, and financial institutions are too far away.

Due to the most common reason identified—the lack of flowing money—it is too expensive for financial institutions to establish large, efficient banking networks in these kinds of environments. Consequently, alternative currencies such as Bitcoin and other cryptocurrencies can provide opportunities, and the adaptation is also likely to occur in a simpler manner than in the West [29]. The risky scenarios linked to Bitcoin that threaten the existing monetary systems and well-developed infrastructure and thus lead to adaptation problems are a far larger problem in the developed world than in the developing countries.

For the people themselves, Bitcoins would be, due to their open-system nature, able to provide inexpensive access to financial services worldwide, despite the location and crossing of borders [40]. Another reason for people to use Bitcoins in the developing countries is to oppose capital controls and central bank mismanage-

ment. Furthermore, being a fully virtual currency, Bitcoin is also programmable, and traceable if necessary, so that any allocated funds could be programmed to be used only for a certain kind of use in order to avoid funneling them to any form of corruption. After all, developing countries are generally among the most corrupted countries in the world [45]. Bitcoin's mining and transaction processes are strictly controlled through a distributed system as opposed to the centralized control of national currencies, and thus the amount of the currencies available cannot be capped or manipulated by a single central authority, and there is also no authority that would be able to revoke or restrict transactions and exchange [40].

However, despite the possible opportunities cryptocurrencies could offer, these currencies are inherently virtual, and they come with a requirement for stable infrastructure. Bitcoin relies on the same architecture as the Internet itself. Therefore, the Internet infrastructure must be in place to support the creation and use of Bitcoins. This is the very issue that may collapse application of cryptocurrencies in the developing countries. The communications infrastructure—involving, for example, computing power to generate and administer coins, high-speed fiber links, and satellite links—is simply not yet there in the developing countries. The production and management of digital currencies requires huge amounts of computing power and infrastructure, not just to mine new Bitcoins, but also to manage the system of trust, the blockchain. Implementing such an infrastructure requires energy to run it and very specialized manpower. Many developing countries face major issues with power networks, power availability, and power reliability, and they struggle to train basic healthcare, staff let alone highly skilled cryptographers.

The second doubt is that creating such an infrastructure not only requires a culture that accepts that new system of transactions and the infrastructure associated with it, but may also change the economies and societies in subtle ways that may not be reversible. For instance, we may have to invest increasing amounts of resources in the computing power required without necessarily seeing a corresponding gain [2]. However, we should not underestimate the adaptability and inventiveness of people living in societies where resources are scarce. In some countries ingenious people have adapted solutions with digital currencies and mobile banking in environments where the current infrastructure does not support such systems that we would not consider proper, reliable, or even functioning in the developed countries. A prime example is the mobile payment system M-Pesa originating in Kenya and spreading from there to other developing countries [46] [47]. In M-Pesa, people use the phone as a store of value and a means to send payments to one another through PIN-code-secured text messages. However, the M-Pesa technology has not been unscathed either; the

system has been accused of being technologically limited and causing problems such as lost payments, barriers to access, and high costs [48].

#### **4.4 The Dark Side of Cryptocurrencies: Relationship to Crime and Terrorism and Other Risks**

Even though cryptocurrency enthusiasts have made promises regarding how this new era of digital currency will pave the way for a better tomorrow without corrupted centralized control and more transparent accountability regarding monetary transactions, cryptocurrencies such as Bitcoin are close to controversy themselves because there are many ties to various illicit practices. As an example, European banking authorities have focused on examining the “evil” in the phenomena, and the work has paid off, as they have identified over 70 risks associated with virtual currencies [49].

Virtual currencies do not face the risks of bank robberies in the traditional sense, but rather virtual robberies via hacking. Approximately 900,000 Bitcoins with current worth of nearly 300 million USD were stolen between 2011 and 2015 [29]. Moreover, Bitcoins have been used to enable black-market transactions, which has brought a shadowy reputation of a crime-enabler to the whole currency and its associates. Cash is still the primary medium for criminal transactions, but real cases show how criminal organizations are taking the next step and moving part of their operations to make use of Internet and digital currencies to legitimize “dirty” money by means of cyberlaundering—money laundering in cyberspace [50]. Consequently, the multiple questionable and controversial ties of Bitcoin include serving as primary funding currency for individual hacking groups [51], terrorist organizations [52], and black-market transactions through the now-defunct portal Silk Road [28]. In breeding further distrust from nonparticipants, it also does not help that Bitcoin is nationless, meaning that it is not regulated, and no single entity has control, responsibility, or ultimately accountability regarding it [29].

Trading in illegal goods such as drugs can be done using the same Internet protocols that make Bitcoin anonymous. The anonymity of the currency also makes it well suited to money laundering. However, the virtual anonymity is not completely detached from a real, physical world. For example, in drug deals, which are agreed upon in an anonymous online network through anonymous cryptographic payment systems such as Bitcoin, the delivery of these illegal goods is still done via postal service. The postal service is only anonymous to the extent to which the service itself is oblivious of the contents of the delivery. Therefore, trading illegal goods with the aid of cryptocurrency is not really anonymous, showing that

a totally anonymous economy is not really possible—at least not yet. Although the use of Bitcoin for money laundering is a bigger problem because it is more difficult to trace, it is still not completely impossible to track; monitoring points of exchange can still lead officials on the trail of illicit behavior. Therefore, the anonymity of Bitcoin is not absolute: someone with the skills can trace transactions and break the anonymity [53].

Bitcoin is also vulnerable to other forms technological attacks and hacking. Even though the Bitcoin system is considered secure and stable on the surface level [54], there are a lot of techniques through which malicious parties can harm individual participants or the system as a whole. For example, temporal suppressing of the blockchain formation can affect the fairness and ultimately the trust among the participants of the Bitcoin system [55] [56]. Furthermore, so-called double-spending attacks are possible through hoarding of computing power and taking advantage of the nature and structure of the network [57]. So called botnets—distributed networks of malware-infected and subsequently virtually hijacked computers—have been found dedicated to operations regarding Bitcoin mining and influencing the whole system [58]. Additionally, the incentive structure built into the whole Bitcoin system has been criticized [59]. In fact, it has been shown that the some of the participants are actually motivated to commence attacks against other participants [60] [61].

An added layer to these technology-based attacks is the considerations of how to form secure enough novel digital financial systems. The security threat from exploitation of these novel systems will certainly grow in the coming years. Prevention of and protection against these attacks is, however, an ever-elusive objective. Given the rapid rate of change in the digital world, system security solutions based on only a single snapshot in time will quickly become obsolete as new waves of hackers will constantly try to find ways to circumvent and bypass them in order to exploit them [62].

In order to mitigate all these controversial developments, a nonprofit organization, Bitcoin Foundation, was founded in 2012 for the standardization, protection, and promotion of Bitcoin as a currency [63]. However, despite the Bitcoin Foundation's efforts, Bitcoin has not been free of reputational difficulties. Prominent exchange portals—including the largest Bitcoin exchange, Mt. Gox—have suspended trading and ultimately collapsed after losing the funds of their customers. Furthermore, a Bitcoin Foundation board member was forced to resign after news surfaced about his ties to the black-market portal Silk Road [64]. However, currently the Bitcoin Foundation maintains that it has a dependable and strong board following mutually agreed-upon guidelines in order to steer Bitcoin toward a more prominent position in global monetary markets.

Ultimately, the concerns regarding Bitcoin also tie in with the underlying ideology. The aim of Bitcoin is to have a currency that is free of political manipulation. However, despite this noble ideology, its absolute independence may yet be arguable. Bitcoin, being a virtual, computer-generated entity, still relies on the politics governing the computing infrastructure, including access to energy, broadband, hardware, and computing skills [65]. Furthermore, these political entities can also “pull the plug” on the whole system infrastructure if they deem it too troublesome or disruptive. The digital infrastructure is also the weak point considering that the digital world always relies upon the physical world. Going fully digital with currencies such as cryptocurrencies would make societies more vulnerable to partial or full collapse of the hardware infrastructure that is supporting the whole system because there is no way of redeeming fully digital money without the sufficient hardware in which this money actually exists.

#### **4.5 Who Are “Bitcoiners” Really, and How Do They Use Bitcoins?**

Now that we have discussed what makes cryptocurrencies appealing and repelling from various perspectives, a question remains: Who is using cryptocurrencies such as Bitcoins currently? The question is not easy to answer; users are hard to observe because they are masked by the shadow of anonymity. However, Yelowitz and Wilson [66] managed to answer this question by using Google search data. Their study resulted in a description of four generic user profiles for the Bitcoin user base: (1) computer programming enthusiasts, (2) speculative investors, (3) libertarians, and (4) criminals.

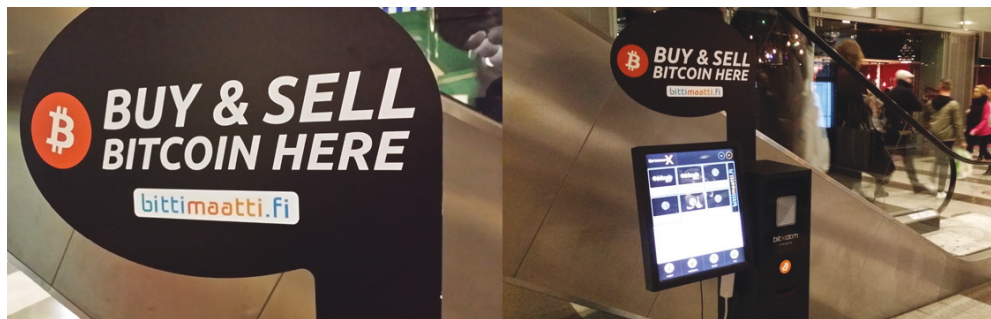
The computer programming enthusiasts are described as being attracted to the opportunity create money from “nothing.” By lending their computing power to the network, they can earn new Bitcoins and spend them for whatever purpose they want. The incentive of speculative investors has been discussed already in an earlier subsection. The currently high volatility of Bitcoin prices is a tempting opportunity for many to try to make quick earnings in the rapidly changing price listings in various currently operating Bitcoin exchange portals. Due to high price volatility, the risks for these speculators are high; high earnings can be as instantaneous as heavy losses. For the libertarians, the appeal of Bitcoins lies in the ideological foundations. Libertarians do not believe in or accept the control of central banks and governments over monetary policies regarding national currencies, and Bitcoin offers them a way out of this prison of control. For libertarians, the current fiat money system involving heavy regulated control of central banks represents an inflation-ridden economy that serves only the interests of very few individuals and institutions. The last profile group, the criminals,



are naturally attracted to the anonymity and privacy related to the transactions. Therefore, the various Bitcoin exchanges incorporated with deep-web black-market portals have proved to be a good place for arranging deals regarding trafficking of illegal goods, conducting money laundering activities, and allocating funds for terrorism and other illicit practices [66].

Besides just the generic user profiles, it would be interesting to know how the whole Bitcoin user base is composed of these different generic profiles; which of them is the most dominant one? Unfortunately, Yelowitz and Wilson [66] did not provide an answer for that question. Furthermore, we have to note that these generic profiles are not mutually exclusive either; people with libertarian motivations can also have a desire to conduct some speculative investing, whereas a computer programming enthusiast may aim to maximize his or her participation by conducting speculative investing and trade of illegal goods. Interestingly, though, it has been suggested that uninformed users, with a limited knowledge of the whole Bitcoin system and its operating principles, are more enticed to view Bitcoin as an asset type of an investment instrument rather than a system for transactions [67]. This could suggest that most of the participants in the Bitcoin system are at least partially motivated by the speculative investor motivations.

For investors who wish to trade Bitcoins, there are a wealth of different online exchange portals in which one can buy and sell Bitcoins against different national currencies. Nowadays these portals are not just restricted to personal computer access; rather, the trade can be accessed through various mobile apps as well as through Bitcoin “ATMs,” as illustrated in Figure 3. There are also multiple store locations that accept Bitcoins as a means of payment. Often these shops illustrate this by putting an official sticker on the window with a text inscription: “Bitcoin accepted here.” Currently, the development is still in its early phases because companies have been a bit sluggish to accept Bitcoins as a means of payment. Therefore, Bitcoin still remains on the margins compared with national currencies.



*Fig. 3. A Bitcoin ATM in the Kamppi shopping center and metro station, central Helsinki (photos: Iñigo Flores Ituarte).*

Figure 4 illustrates current estimations of the physical locations that accept Bitcoins as a means of payment. The concentration of these locations is heavily in the Western developed world. Yet still, the diffusion of locations accepting Bitcoin is far from prevalent in heavy-concentration regions; the world has around 6,700 locations, whereas Europe alone has around 2,700. This figure is very low compared with the total amount of companies in the world or in Europe. For example, the United Kingdom, the single main business hub of Europe, has almost 2,200 publicly listed companies [68]. But this figure includes only the publicly listed companies, which are the largest corporations in the country, and therefore only accounts for a small fraction of the total companies in the United Kingdom. Furthermore, all of these figures only include the companies, but not their branch offices, stores, and shop locations, which could be measured in hundreds or thousands in the case of the largest corporations. Therefore, we can conclude that potential locations for accepting Bitcoins are actually manifold compared to locations that already accept Bitcoins, even in the most concentrated Bitcoin areas.

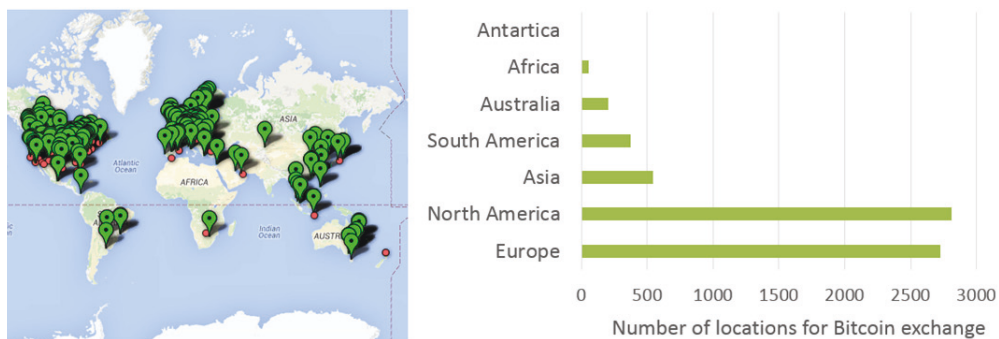


Fig. 4. Locations for Bitcoin use in November 2015 (adapted from Bittiraha.fi [69]).

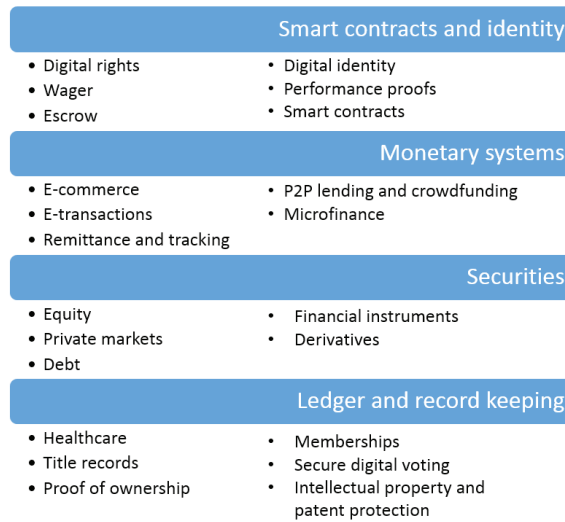
## 5 Possible Applications for Blockchain Technology

### 5.1 From Financial Applications to Nonfinancial Applications

The impact of cryptocurrencies and the technology behind them is not just limited to the widely encompassing economic sector. The technological innovation behind cryptocurrency has its roots in information technology, embodying mathematics and cryptography. On this level, it is clear how cryptocurrency technology can be adapted for a variety of other application uses beyond the financial field. The blockchain technology, originating from Bitcoins and currently used in

other cryptocurrencies too, is underpinned by a distributed database that maintains a continuously growing list of data records that are designed to be hardened against tampering and revision, even by operators of the data. This record is enforced cryptographically and hosted on machines working as the data store's nodes. Essentially, the blockchain method allows for records to be stored in many places, yet enables redundant, repeated, or conflicting instances of record nodes to be identified and avoided. In other words, blockchain technology can be used to solve any problem involving the need for distributed, decentralized computing events and the robust ability to verify and authenticate a new event to ensure its uniqueness. Herein also lies the core advantage of the financial application: numerous transactions can be managed online from undetermined location points, while maintaining the ability to authenticate these transactions before they become confirmed.

Cases of blockchain application have been increasing by the day. One can easily see how the technology could be used in an application where assets are linked to a blockchain and then traded digitally, with improved security compared with traditional methods—even commodities such as physical bars of gold, silver, and diamonds are being tested for authentication by blockchain. Blockchain could be applied to all cases where the sale and purchase of digital assets are involved and anti-counterfeit measures need to be improved—for instance, digital security trading, document and information exchange, and delivery over multiple computers. Likewise, any operation that requires authentication of personal identity and proof of ownership in a distributed context could be greatly improved. This can even include, for example, patient record verification, employee peer-review authentication, smart contracts, real estate ownership, birth certificate management, and voting management [70]. All in all, because the range of the aforementioned applications is very wide, it is helpful to divide it into smaller domains. Figure 5 presents and further elaborates on the four main application domains for blockchain technology: smart contracts and identity, monetary systems, securities, and ledger and record keeping [71].



*Fig. 5. Prime application areas of blockchain technology (adapted from [71]).*

## 5.2 Is Blockchain Paving the Way for a Digital Product Lifecycle Management Revolution?

It is evident that blockchain technology presents not only a computational innovation, in the form of a new database schema, but also a direct cause of subsequent economic innovations in implementation. In a way, the real significance of blockchain’s cryptographic innovation is in its influence on the traditional economic models. Blockchain enables trust to be maintained between large-scale peer-to-peer activities, and thus it can be seen as the driver of the essential ingredients of an open “shared economy.” Due to trust issues and the susceptibility of any system to be misused, great efforts have been invested in protecting and policing operations. Just imagine how much waste and inefficiency could be saved given the existence of a fair and open operational context in which suspicions of counterfeits or even unintentional duplicate events are void.

This ideology is of course evident in many problem domains where cloud or distributed computing is employed to facilitate operations, and where duplicates of operational events or entities pose a challenge. Numerous examples can also be inferred from the product lifecycle management context. The term product in this case would include any artifact that is engaged in a design-production-operation cycle, such as vehicles, buildings, machinery, tools, clothing, and mechanical components or assemblies. Product lifecycle management is ubiquitously digitalized in the modern era and thus heavily reliant on data and information exchange about a product’s components, elements, and associated attributes.

Consider the design management of a cruise ship or passenger plane, for

instance. Design data are generated by large design teams spread over many disciplines and even geographical areas. There are also often dozens of subcontractors working on the design under possibly numerous main contractors. From the beginning, this makes the coordination efforts of the design quite complex and inherently fraught with errors that cause rework in the interfaces, which are exacerbated by the human-regulated communication streams. Moreover, often the production or construction of the product may begin even before all the detailed designs have been finalized. These design-management and change-management challenges are ubiquitous within all complex engineering designs, including those for buildings, industrial plants, and other infrastructures. Design data management over the product lifecycle can be quite controversial, as there are usually sensitivities regarding the ownership of the data and whether certain data need to be kept confidential for certain groups of designers. Therefore, despite the noble vision of open communication during design, not all project participants may have authorization to view or modify the data, which is a big challenge, especially because designs are typically done digitally and, more often than not, in the cloud in shared models.

Blockchain technology, and its cryptographic basis, can well address these challenges of design operations. Blockchain technology can be used to ensure the provenance of data (who accountable for which part of the design data, and how dependable the data are), the identity of users in an open cloud environment, and the validity of access rights to different parts of the data. Overall, it is ideal for engineering designers to publish all design data openly online, not only for the purposes of design and production teams, but also to allow users of the product to provide input when appropriate. Feedback from users would allow designers to improve their understanding of the implications of their designs throughout the many phases of the lifecycle. However, these ideologies of product lifecycle management that still haven't been fully achieved.

If the management of data access could be totally autonomous (similar to how blockchain technology has paved the way for the regulation of secure financial transactions), all project participants over the lifecycle of the product would be more likely to share their information with less concern. Designers, contractors, and operations would be able to garner much higher levels of trust amid the complex product design/production/operation processes, without the impedance of defensive provisions to ensure data security and user authentication. Blockchain is potentially a mechanism that could bring these kinds of functionalities into distributed computing settings in the cloud—that is, semi-open information sharing without any centralized servers—while maintaining the reliability of all data transactions and the authenticity of the people making

those transactions in real-time settings. The value of blockchain technology in engineering design management, and its comparison to financial transaction management, is clear.

Cryptography, a fundamental branch of mathematics, is not just limited to specific application fields. Blockchain technology is merely a name bestowed upon one rather successful use case, that of Bitcoin transaction management; however, it does not need to be confined to the financial context. Indeed, blockchain technology, used in tandem with Bitcoins, lends itself to helping people better understand the underlying mechanisms and logic behind its value. Nevertheless, from the mathematical perspective, the use of blockchain can be broadened to almost any context concerning shared data, and with the current mass digitalization trends in almost all fields, shared data is becoming a default condition.

## **6 Future Popularity and Use: Empirical Work and Experts' Opinions**

In order to go beyond the historical views and thoughts presented in the literature described in the prior sections, we decided to gather and study external opinions on the topic. Using the results of empirical methods based on qualitative data gathering, in this section we present the perceptions of individuals with diverse educational backgrounds as well as expertise on the topic and then compare these with our own views. The purpose of including these views is to enrich the perspective on the topic. In summary, the following discussion provides a predictive view of the impact of cryptocurrencies and blockchain technology on society as well as of the future development of monetary systems, regulatory systems, and alternative applications, where trust will not be exclusively owned by third parties.

The experts were interviewed via e-mail and in face-to-face meetings. The interviews focused on examining four main concepts: digitalization of monetary transactions, the rise and popularity of cryptocurrencies, the future of blockchain technology, and views on regulations and the evolution of legal frameworks. Views on these aspects were investigated by posing a few questions related to each topic. The answers were gathered and condensed, and they are presented here in the form of tables to help the reader compare the perspectives. Table 1 gives a brief summary of the contributors' academic and professional backgrounds.

*Table 1. Profile description of the contributors.*

Contributor	Profile
<b>1. Giorgio Scarabattoli</b>	Recent graduate with a master's degree in intellectual property law with a specialization in new technologies and legal challenges.
<b>2. Henry Tirri</b>	PhD in computer science and a C-level executive with broad academic experience, technology background, and business experience on a global scale
<b>3. Elizabeth Ploshay McCauley</b>	Member of the board of the Bitcoin Foundation and the board of Code to Inspire and Global Business Development Head at Coinsecure; she previously handled nonprofit and political outreach at BitPay and also served as Director of Operations and Outreach at Bitcoin Magazine
<b>4. Frans Valli</b>	Student at the University of Applied Sciences in Jyväskylä and an active member of the Bitcoin community in Finland; interested in topics such as trading, mining, Bitcoin startups, Bitcoin-related technology, programming, and how to utilize Bitcoin for businesses
<b>5. Jonas Hedman</b>	Associate professor in the Department of IT Management, Copenhagen Business School, Denmark; involved in projects researching the cashless society and future payments, firms' greening processes, and business models
<b>6. Bank of Finland representatives: Päivi Heikkinen, Heli Snellman, and Kari Kempainen</b>	Päivi Heikkinen is the head of the Cash Department and a member of the ESCB Banknote Committee; Heli Snellman is the head of the Division of Oversight of Market Infrastructure and a member of the Payment and Settlement Systems Committee; Kari Kempainen is an advisor in the Financial Stability and Statistics Department. Please note that these experts express their personal opinions, which may not be in line with the official stance of the Bank of Finland.

Table 2 provides the contributors' views on digitalization as method to shape economic and monetary systems on multiple levels, especially regarding the digitalization of payments. The following question was posed the contributors: Digitalization is shaping the economic and monetary systems on multiple levels and especially concerning digitalization of payments. How do you see the future of digital money span out in the future?

*Table 2. Views on the digitalization of monetary transactions.*

How do you see the future of digital money span out in the future?	
1.	I envision the end of physical currency and the creation of big regional marketplaces (i.e., European, American, Asian, etc.) in which the monetary value in different countries is updated online in real time and transactions are made by just pressing a button or reading a code.
2.	The current disruption is related to “money” adapting to the decentralized nature of computing. In a programmable world there is a need for “programmable money” in order to utilize the rich connected infrastructure and decentralized computing of the Net.
3.	Digital money is the way of the future. Bitcoin is one of the most secure and efficient ways of payment and completely global. Never before have we seen a currency that is borderless, without barriers to entry, and enables individuals to have global, secure transactions.
4.	As people begin to understand this system they will vote with their feet and switch to cryptocurrencies. People who stick within the traditional system will see their savings diminish in value, and thus they will become less relevant in the economy.
5.	Digitalization of money will kill cash. This will have an impact on society, organizations, and the individual level, touching multiple dimensions. It will change everything, and people will lose control of their economy.
6.	Digitalization of payments and money beyond the current electronic payment instruments is both promising and inevitable. From central bank perspective, the role of money is relevant.

The emergence of cryptocurrencies such as Bitcoin has introduced an alternative view on how to perceive currencies in the digital environment. Table 3 provides views related to the following questions: Emergence of cryptocurrencies such as Bitcoin has introduced an alternative view on how to perceive currency in a digital environment. How do you view the future of cryptocurrencies? Are cryptocurrencies going to survive as a marginal phenomenon, or are they going to challenge the traditional economic system?

*Table 3. Views on the rise and popularity of cryptocurrencies.*

	How do you view the future of cryptocurrencies?	Are cryptocurrencies going to survive as a marginal phenomenon, or are they going to challenge the traditional economic system?
1.	The main driver for future adoption will be demand. If there is a large demand for the technology, in the future governments and regulatory bodies will need to adapt.	If the user base is large enough and the technology is mainly used for the right purposes, the regulatory bodies will be forced to deal with the new scenario, rather than fight it.
2.	Cryptocurrencies are here to stay. The disruptive element is that cryptocurrencies allow the elimination of trusted intermediaries.	If globally adopted, this technology will shake all the players that have business models relying on the need of such trusted parties.



3.	Traditional financial institutions and payment processors are not only establishing streamlined digital payment mechanisms, but looking at and embracing Bitcoin.	I see Bitcoin as the strongest and most mainstream digital currency. It stands out, as there is only a fixed number of Bitcoins that will ever enter the ecosystem, leading to an inflation-free currency, which is of great value to international economies.
4.	Cryptocurrencies are the most interesting development in the monetary system, as they will completely rewrite some of the fundamentals of our economy.	The payment system is still quite undeveloped, and a limited number of web stores and people accept Bitcoins. Also, Bitcoin hobbyists are now more excited about the future potential of Bitcoins and use the system as a means of investment. All in all, people should be now educated on what Bitcoin is, why should they care, and how to use it.
5.	Hopefully national banks will enter the market to create something that is equivalent and allows us to have digital cash. Otherwise, there is a risk that more and more transactions will flow outside the financial system, which will create equity problems for the banks.	I think they will be marginally used, but they are in fact an evolution as well as innovation of the traditional banking system.
6.	Current cryptocurrencies fulfill the requirements for money rather poorly. The Leading Adviser at Bank of Finland (BOF), Kari Takala writes in his blog post <i>Missä määrin bitcoinit ovat rahaa?</i> (Euro ja Talous) that money's main purposes are to maintain purchasing power, serve as a means of exchange, and allow price comparisons. But we are only in the beginning of a potential disruption.	According to Takala, many of the existing Bitcoins are currently not in short-term circulation, which indicates that possibilities for Bitcoin use are too limited, ownerships are small, use is too troublesome, or the primary motive for obtaining Bitcoins is not the intention to use them for payments. Digital currencies' future as means of payment is dependent on the availability, acceptability, and transfer costs, as well as other aspects such as anonymity and real-time possibilities.

The introduction of Bitcoin's blockchain technology has been touted as one of the most important innovations of the 21st century because it has given an alternative for how to disseminate trust among participants in anonymous transaction situations. Table 4 presents the views of the contributors on possible applications of blockchain technology. The participants answered the following questions: The introduction of Bitcoin's blockchain technology has been touted as one of the most important innovations of the 21st century because it has given an alternative for how to disseminate trust among participants in anonymous transaction situations. How do you see the future of blockchain technology? Are there any other avenues in which this technology could be applied besides monetary transactions?

Table 4. Views on the future of blockchain technology.

How do you see the future of blockchain technology?	Are there any other avenues in which this technology could be applied besides monetary transactions?
1. Blocks that form the chain of a Bitcoin create trust in the currency and decrease the possibility of the currency being counterfeited.	An interesting application would be validating and verifying authenticity of digital identities and even votes during elections.
2. Blockchain is a transactional mechanism for “shared economy,” as it solves trusted recording of large-scale peer-to-peer activities. The importance of such a transactional mechanism increases with the emerging programmable world.	Financial instruments such as payments, trading records, and smart contracts can be built on blockchain technology, which then prevents double-spending, forgeries, or false disputes.
3. Currently, it is used as a payment gateway and a place to store information. Blockchain technology extends far beyond a currency.	Organizations are looking into options of storing records on the blockchain and even voting on it. Thus, the options are truly endless with blockchain.
4. The best application areas are in e-commerce and peer-to-peer transactions.	
5. The main idea of a blockchain technology is that the system is a public ledger or public bookkeeping system. It takes a strong role in trust.	The blockchain can be applied to whatever digital information or value that one wants to keep track of, from security content of a document to personal ID and information in general. For businesses, imagine a firm with an open ledger, so that you see all the incomes and costs in real time.
6. <i>The Economist</i> recently wrote about it as “a machine of trust.”	Blockchain is indeed an intriguing technology with huge potential for various transactions needing verification, irrevocability, and trust.

Regulatory bodies and the current legal framework have a reserved attitude toward distributed cryptocurrencies. Table 5 provides the contributor’s views on the legal overview of cryptocurrencies. The experts answered the following questions: What is the impact of cryptocurrencies on the current global regulated environment? Are cryptocurrencies forced to adapt to the legal standards, or does the current legal system need to adapt to the challenge created by cryptocurrencies? How do you predict the legal framework will evolve to deal with cryptocurrencies?

Table 5. Views on regulations and the evolution of legal frameworks.

<p><b>What is the impact of cryptocurrencies on the current global regulated environment?</b></p>	<p><b>Are cryptocurrencies forced to adapt to the legal standards, or does the current legal system need to adapt to the challenge created by cryptocurrencies?</b></p>	<p><b>How do you predict the legal framework will evolve to deal with cryptocurrencies?</b></p>
<p>1. It is hard to involve payment intermediaries over the Internet (e.g., for taxing cryptocurrency transactions or fighting against law violations in the cyberspace), but with regulatory and technological measures, we can map the various actors operating online.</p>	<p>If cryptocurrencies will be widely adopted in the future, law would not be able to stop it; it is likely to make the transition between the "old" and the "new" world smoother.</p>	<p>Law adapts to the reality rather than shaping it.</p>
<p>4. I think one big reason behind our heavy financial regulations is to create trust into our monetary system. In cryptocurrencies trust is built into the design, so they do not need to be regulated the same way. This will give more room for innovation and allow us to build better financial services.</p>	<p>One of the most important aspects of cryptocurrencies will be to give regular citizens tools to fight back against unjust regulations and limitations imposed by the state.</p>	<p>Ultimately cryptocurrencies will transfer power from big regulators to small citizens and empower people to have more control over their own finances and lives. This will eventually make the whole question of regulation a little less relevant than it is today.</p>
<p>5. I think that cryptocurrencies will change the current legal framework.</p>	<p>Cryptocurrencies need to be traceable. Otherwise the system won't comply with the current financial and legal regulatory systems.</p>	<p>They need to adapt somehow. I believe that cryptocurrencies will push legal frameworks toward the change, but predicting how is very difficult.</p>
<p>6. Cryptocurrencies without explicit issuer or home country are difficult from a legal point of view. However, exchanges and other actors have already been put under regulation. Consumers should also keep in mind that holding virtual currencies may have tax implications, and the tax liabilities are country-specific.</p>	<p>According to the European Banking Authority (EBA), consumers hold currently the responsibility themselves. Thus, they need to be aware of the risks associated with virtual currencies and understand that virtual currency exchange platforms tend to be unregulated and that the EU has not established any regulations that would protect consumers from financial losses (e.g., if an exchange platform fails or goes out of business).</p>	<p>Transactions in virtual currencies allow a high degree of anonymity; they may be used for criminal activities, including money laundering. This can then again lead to law enforcement agencies closing exchange platforms and preventing consumers from accessing or retrieving any of their funds that the platforms hold.</p>

## 7 Conclusions and Summary of Recommendations

In this research we were eager to study one interesting side of digitalization: the digitalization of money. Martin Heidegger [1], and many others, have concluded that technology is not inherently benign or neutral, and because we are chained to it and unable to control it, digitalization will have unpredictable side effects on our society. Thus, we wanted to examine the good and the evil that the phenomenon of digital money presents to us and the possible consequences. Let us now take a look back on what our research journey has covered.

In the introduction, we first presented the topic and the objectives of the research. We elaborated on the aim of this article, which is to provide the reader with information from different sources and diverse backgrounds that would assist in comprehending the important phenomenon of digitalization of money and, moreover, the impact of cryptocurrencies on that phenomenon. We also explained that the aim was to take a glance into the future and try to examine how our society and the surrounding regulations can and will be affected by this new era of digital money.

After the introduction, we started by examining the meaning of money for society and the historical evolution of currencies. We examined the societal impact of currencies and presented reflections on modern digitalized banking systems. The second section also presented how the concept of value has been transferred into money and currencies that function as means of exchange and also how the modern digitalized monetary systems have been formed based on trust.

The third section introduced cryptocurrencies as a specialized form of digital currency with a distributed nature. It also explained the underlying technology of Bitcoin, blockchain technology. Additionally, the relevance of Bitcoin as the most notable operating cryptocurrency was presented. Then, to further enhance understanding of the cryptocurrency scene, the fourth chapter described the nature of current cryptocurrency users, the so-called “bitcoiners,” and also presented reasons for cryptocurrencies’ appeal. The popularity of the currency has been related to factors such as the privacy, anonymity, and independence of the users, as well as its potential to function as a sort of investment asset. In addition, an overview of risk and cryptocurrencies’ relationship to crime and terrorism was provided.

The fifth section explored the possibilities of expanding blockchain technology to other applications. It was noted that the underlying technology could potentially have a massive impact on the financial as well as industrial sectors on a global scale, because these sectors are built on ledgers for record keeping, and trust is needed to be able to manage the systems. Next, the sixth section pro-

vided our empirical contribution, a study presenting expert views on the impact of cryptocurrencies and blockchain technology on our society. This section also presented contributors' views on the future development of our monetary systems as well as on policies and regulatory systems.

After this journey, our aim was to answer the provocative question on everyone's mind: Are Bitcoins the root of all evil or the future wealth of nations? Well, because we live in a constantly changing and digitalizing world, we still do not have a ready answer. Yet, to conclude this work we present a summary of our "11 lessons to learn" that we have gathered along the way. We hope that by studying these key points, the reader is able to understand and keep in mind our key findings from studying the digitalization of our economy while describing the messianic visions—and travel with these to the future, to the unknown.

(1) We believe that digitalization has had and will continue to have a strong impact on how value is shared in society. Therefore, digitalization will continue to affect our economic and monetary systems on multiple levels. As an example, the idea of decentralized cryptocurrencies is disrupting and challenging the way we perceive digital payments, monetary transactions, and money in general. In addition, we believe that the structure of monetary transactions is moving toward a digital cashless society; eventually, the digitalization of payments will kill the cash-centered society as we today know it.

(2) The digitalization of money is promising, inevitable, and even essential. Regardless of the dark side and setbacks related to Bitcoin scandals, we believe that cryptocurrencies are here to stay. Even though the current Bitcoin system is marginally used in comparison to the traditional banking system, it indeed represents evolution of the monetary system. However, it remains to be seen if cryptocurrencies can truly challenge national currencies, especially in regions where monetary instability is common, or if they will solely coexist with national currencies as an alternative phenomenon or as a virtual special-purpose money.

(3) We think that consumers' perceived purpose of use for cryptocurrencies will determine their ability to reach a status of "real money" on a global scale. As long as cryptocurrencies are used as an investment instrument, which seems to be the current use in most cases, it is unlikely that they will obtain a real status of being equal to national currencies, because the purpose of money and currencies is to serve as means of exchange. (4) Moreover, the future use of cryptocurrencies will be dependent on the amount of users, availability, and acceptance as a means of payment. In this regard, the use of unregulated cryptocurrencies is likely to be marginal if they are not approved, mediated, and/or regulated by third parties such as commercial banks as well as national and extra-national regulatory bodies.

(5) However, the introduction of Bitcoin's blockchain technology as a means

to disseminate trust among participants is here to stay, and it is likely to be adopted as a transactional mechanism for the “shared economy.” The technology can be applied to monitor all digital peer-to-peer transactions needing verification, irrevocability, and trust. (6) Future systems built on blockchain technology can solve the problem of trusted recording of large-scale peer-to-peer activities, as well as taxation issues, in the digital economy. The idea behind blockchain technology is that the system works as a publicly accessible and traceable ledger or bookkeeping system. Trust is embedded into the software due to the programmed validation chains having a transparent as well as objectively measurable flow of information in every peer-to-peer transaction. (7) Systems built on blockchain technology have the potential to be secure, fully traceable, and unbiased from third-party lobbying interest, avoiding unnecessary corrupted third-party intervention to provide validity. These descriptions regarding blockchain’s applicability set the foundation for what will be needed in digital environments in the future. This is also the reason why there is so much enthusiasm surrounding blockchain within the entire Bitcoin system.

In any case, given the current track record, some aspects of blockchain technology need to be improved in order to achieve the ideological benefits of digital money and to avoid the risks associated with it. (8) We feel that the transition toward blockchain-based monetary systems and cryptocurrencies will not be successful in the near future if they are not mediated and regulated, as there needs to be increased traceability and decreased anonymity of transactions. Otherwise, peer-to-peer cryptocurrency systems will not be compatible with the current financial and legal regulatory systems that are deeply rooted in our society and form the basis of welfare societies. To cultivate these systems, for instance, the possibility to tax cryptocurrency transactions in peer-to-peer activities needs to be embedded into the system. (9) Blockchain can replace the need for centralized structures based on trust and provide an automated mechanism to track online peer-to-peer activities on a wide scale, and it also provides a mechanism to feed the welfare state straight from the digital economy.

(10) All in all, we believe that blockchain is able to provide a solution to ongoing problematic societal issues, such as the difficulty of involving payment intermediaries over the Internet on a global scale and regulating Internet platforms, such as Airbnb, Uber, or e-lancing activities, with the aim to spread the wealth and avoid societal models based on the “winner-takes-all” principle. (11) In this regard, the applications of blockchain can go far beyond monetary transactions. As an example, blockchain can provide the possibility to digitalize any security content and to build a database to store the digital identities of individuals or any type of recordable and traceable sensitive information. Blockchain has also

the potential to impact the global financial as well as industrial sectors that are built upon record keeping and trust. Future innovations related to blockchain structures open up a new playfield for inventive and forward-looking business endeavors—as well as further research.

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# *Subjective Context Awareness: Machines That Understand Personal Accounts, Feelings, and Emotions*

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**ABSTRACT:** *In this work, we argue that context awareness can and should move toward more subjective and personal accounts of entities. We thus define subjective context to augment the objective context, currently in the focus of context-awareness researchers. We then engage the technologies required and the business challenges and opportunities related to subjective context awareness. We argue that the current developments in machine learning and data collection can help us to achieve subjective context awareness. We also suggest that, business-wise, the added value to consumers can become a significant competitive benefit. We end by discussing the social implications of subjective context awareness, such as the implications it has for self-understanding and concepts such as truth.*

**KEYWORDS:** *subjective context awareness, context awareness, objective context awareness*

# 1 Introduction

Computers' capability to adapt to situations has been in the interest of academia for over 20 years [1]. This context awareness has been discussed in academia (e.g., [2], [3], [4]). Most recently, services such as Google Now and Amazon Echo have brought up these ideas as part of everyday life. These tools help us to automate parts of our everyday lives by sensing and learning about our surroundings. We envision a future where these systems will *acknowledge our values and accommodate our needs and desires better than our friends and even ourselves*. For these purposes, however, we need to extend the concept of context to take into account subjective matters. Imagine that in 2050, everyday life would be similar to following story:

*I've just arrived home from busy day at the office. I have a tough week coming up, and there's a premade cooking instruction present for simple dinners. The ingredients have been ordered from Amazon's home delivery service, so all I need to do is some cooking, which also relaxes me a bit. It's always good to know that the products sent are locally and organically produced. However, it seems we haven't bought the same brand of cookies as last time—good, because the other brand has too much trans-fat. Indeed, my daughter would rather have the previous brand, even though she likes chocolate chip cookies in general.*

*I'm able to enjoy a relaxing time every evening with a special mix of tea; the children are taken care of during that time. I have a major deadline coming in two weeks, and I really need the time to relax. Because I try to get some work done before going to sleep, I always have a perfect working environment ready. The lights are correctly dimmed and the air is refreshingly cool—just the way I like it.*

*Before I go to sleep, I go through my day and reflect on what I've been doing and how it made me feel and think, in the form of digital diary. I also explore my fears and dreams too, both to reflect and to get them off my mind.*

In this story, a *context-aware system* was able to perceive the user's needs and act on them. The interaction was so fluent in this case that the system became invisible and ubiquitous, trusted by the user to make the correct actions and to always be there to react to the user's input. Examining the short motivational story in detail, however, the user's needs were subtle and sensitive, even based on aspects only known by the user—such as feelings of stress and fear or the values user has. We refer to this knowledge as *subjective context*, an extension of the traditional context awareness.

Additionally, we address trust issues relevant to subjective context awareness in this text as an example of how subjective context can contribute to the building or destruction of it. On one hand, we deal with trust as something we place on a particular source and the information provided by that source. On the other hand, we place trust in a system with detailed personal information so it will infer our needs and act accordingly.

In the first case, selecting trustworthy information from reliable sources is a considerable challenge for those living in this era of information overflow. The second case, where sensitive information may be provided to a system for subjective context understanding, has other consequences further discussed in later sections as a relevant topic for automation and user habits. However, in the face of waves of information made available to us by the minute, we envision the use of subjective context as a more effective tool to empower users by enabling them to corroborate the reliability of information sources, for example. The following story illustrates the meaning of trust and how subjective context may contribute to its construction:

*Since the refugee crisis, there have been waves of information about the immigrant population entering Finland. A considerable amount of it is misleading and overall untrue. This has contributed to social turmoil in some sectors of Finnish population. A regular Finnish middle-aged male may feel overwhelmed by the flow of information and a bit unsure about the political and social situation developing around him. Stressful times coming, he might think. However, the advancement of subjective awareness devices such as Google Truth or Truth systems (our suggested names) help him make sense of the situation. Through keyword recognition, a Truth system may track the original source of an online shared link instantly. It can also verify that the source is reliable according to public rating and a value scale that accounts for honesty, truthfulness, and other related factors. It also adds personal comments and voice recordings in which the system captures voice register—not only words—and hand or head movements to account for body language to add sentiment to the discourse. As parts of the discourse are unveiled through the social media spectrum, comments and sentiments are taken into account.*

This story depicts our vision of how subjective context may be added to promote a value such as truth. It correlates comments and sentiments to the stream of information about a topic, generating a deeper understanding and contributing to the overall feel of the users. For example, when cuts on social welfare are announced by politicians who speak political jargon with a straight face, people

might not quite understand the meaning of the figures and data that are being thrown at them. Because it's difficult to verify if what the politician says is accurate, true, or only partially true, a *Truth system* could run an immediate search for the original data and sources for comparison. The value added to the experience is real trustworthiness through real-time verification.

We refer to perspectives (values, philosophies, and beliefs) as part of the subjective context, which we will elaborate in the next section. After this, we explore how current technologies can sense, collect, and interpret this contextual information and discuss how business value may emerge in these cases. We conclude the work by discussing societal and philosophical implications and the future outlook of the subjective context.

## 2 Two Types of Context

As noted, context-aware computing aims to simplify and enhance life experience through systems that take over simplified tasks for humans. The formal definition for context-aware systems is rather broad; the term refers to any system that uses a relevant context to adapt to users' needs [1]. Thus, to understand context awareness, we must first understand what context is and how different fields, especially computer science, has approached it.

As a research field, context-aware computing has existed since the early 1990s, to extend ubiquitous computing. However, even computer science has several definitions for context (see Perera, Zaslavsky, Christen, and Georgakopoulos, 2014, for a list of definitions [5]), which are then used to describe context-aware services. In this work, we are motivated by Abowd et al.'s (1999) proposed definition, which is widely accepted in the literature [1]:

*Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves. (emphasis ours)*

The definition is indeed broad; one might argue that this is a nondefinition, in a way. It states that context is any (relevant) information that characterizes the situation. This highlights the scale and variety of different applications already envisioned in 1999. However, many context-aware services focus on specific context information only, such as location (criticism of this, see Schmidt, Beigl, and Gellersen, 1999 [6]). In this article, we see a continuum between the objec-

tive and the subjective context. Subjective context extends current attempts to explore context awareness as social constructions. Naturally, authors such as Dourish (2004) [7] pose context as an interactional problem in which the main focus is to explore how and why people reach mutual understandings.

In our view, the subjective context is a product of interaction too; however, it also takes into consideration overarching concepts, philosophies, and values that make people reach certain understandings—or not—and the way they do so (e.g., values such as honesty, nature, health, or respect). The former implies that something that can be detected from sensors directly is considered objective context, whereas subjective context links to a person's values, perceptions of the situation, and understanding of relationships. In the following sections, we further elaborate the notion of context in detail, exploring first the history of (objective) context in computer science and then discussing its criticisms, in the form of the new notion of (subjective) context.

## 2.1 Objective Context

In the early 1990s, the idea of context-aware computing was first introduced by Schilit et al. (1994) as an extended form of mobile computing [3]. The basic idea was that because computations can span over several locations and situations (e.g., office, home, etc.), there is a need for new types of services that are aware of these contexts. Although the idea of using contextual information in applications was quite fascinating, the instances of using this idea in practice did not exceed the lab experiments based on location context. It was not until late 1990s that new trends in hardware manufacturing started to prepare a good environment for context-aware applications. At that time, smartphones started to become cheaper and more powerful, and sensors started to become more a common addition [2].

Nowadays, context-aware computing has proven to be successful in understanding sensor data. Context-aware applications have been successfully used in navigation, advertisement, recommender systems [8], [9], monitoring of patients, and other situations. At the same time, the number of sensors around the world is rapidly growing, and the Internet of Things (IoT) has provided the necessary infrastructure for connecting these billions of sensors through the Internet [5]. However, the remaining question is: Are these massive amounts of measurable contexts enough to understand and accommodate human inner needs? Our argument in this work is that context-aware computing cannot accommodate human needs based solely on directly measurable contexts (i.e., objective context). Machines will only be able to fully complement human lifestyles when they are able to comprehend the subjective contexts.

## 2.2 Subjective Context

As mentioned in the previous section, sensing mechanisms used to infer location and other objective data are common nowadays. Because these sensors can encompass so many locations, the collection of contextual data is possible given a stable environment where context is independent of our actions and interactions. However, to become truly responsive and integrated—that is, for computational systems to be fully integrated and invisible to human interactions, to understand our intentions and the reasons for our behavior—they must address how our values and perspectives influence our actions and thoughts and how we interpret our shared experiences and reach common understandings.

In other words, how do people agree on what is relevant while interacting, and how does this contribute to the flow and construction of a conversation? For example, in an interaction, meanings are constructed by utterances and ideas that precede one another.

In this work, we introduce the term *subjective context* as the context generated through our experiences and interactions with one another or an object. The objective context has been criticized by Dourish (2004), who stated that context is also “a relational property that holds between objects or activities” [7]. Our approach to the subjective is closer to the human values; in other words, it is of a more intimate nature and closely related to what we judge important in life and influences how we relate to others. We therefore define subjective context as *any information that can be used to characterize the user’s personal accounts, feelings, and emotions about an entity*.

Disciplines such as phenomenology and ethnomethodology—which draw from social sciences fields—study the settings in which actions unfold, offering insights into how context can be studied through interactions and concentrate on understanding how people use practical reasoning instead of formal logics to *account* for their experience of the world [10], [11], [12]. This is how they come to understand their world.

The aforementioned terms are relevant to understanding the subjective context because numerous interpretations and reinterpretations may occur during an interaction or phenomena—such as a conversation between two people, which requires a system to process the utterances made by the individuals involved (natural language processing), but also to understand references to the physical world and social conventions under which these conversations take place. *Subjective context* also accounts for the inner thoughts and feelings that a situation or interaction may provoke and thus presents difficulties for data collection. It may seem that for a computational system to recognize the data encrypted in



subjective context, it would require cognitive processes in which systems can infer different courses of action.

Figure 1 is an attempt to illustrate a new suggested typology for subjective context in which there is a direct correlation between the objective and what we consider to be the first- (values) and second-order of subjective context. The new typology arranges data through values, intentions, and feelings. The typology is produced by extending the original dimensions of objective data into broader levels of understanding and deeper levels of intimacy. In other words, the typology reflects the type of data that would be understood through a phenomenological point of view, the phenomena accounting for my values, my intentions, and the meaning of my actions (e.g., the use of a space by someone carries with it certain types of associated meanings and feelings; a conversation that takes place between my employer and myself in which we reached a certain understanding).

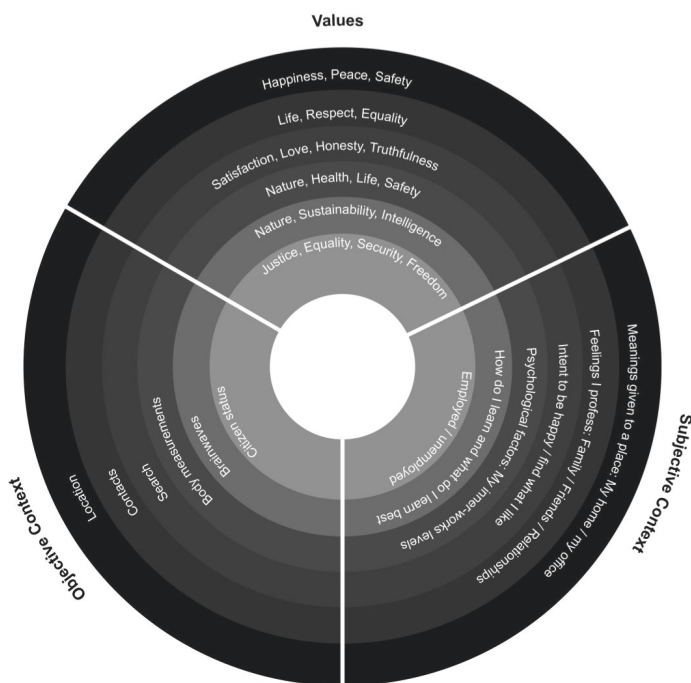


Fig. 1. Typology of subjective and objective context awareness.

However, after introducing the notion of subjective context, we must address how to computationally detect it. One implication of subjective context is that for each participant, the subjective context is variable even if the objective context is constant. Is it possible to get more from the objective—and easy-to-detect—context than from the subjective and individual subjective context? What types of techniques are required to collect and analyze the data to be able to work with the

information? The following section presents an overview on how new types of technologies approach data and provide insights of people's state of mind that go beyond the objective. It also discusses the probable lines of service for the future and their respective technical challenges.

### 3 How Do Machines Learn Context?

Before engaging the details of technology, we must understand that in the world of ever-increasing digitization, networked computing devices have been infiltrating our everyday lives. Every new day we find ourselves interacting with more and more digital entities. This progression indicates that computing will most likely move forward toward gathering subjective context in addition to the objective context. For example, your smartphone is following everything you do, everywhere you go, every piece of information you run through it. Although it has potential to know more about you than your closest friend, it is not yet a sentient being. Making sense of this sort of a soup of bytes is not something a smartphone can do. For your mobile device to make sense of all that information and comprehend you as much as your closest friend, your phone needs to have access to and ways to decode your subjective context.

In principle, context awareness requires the machine to be perceptive of its environment and elements that interact with it. Because any perception must be preceded by a sensory stage, machine sensing has to take place before we can talk about its perceptivity. In that regard, we can safely claim that the context-awareness capabilities of the machine are initially shaped and bounded by its sensing capacity and variety. Considering the machine as a black box that maps an input to an output; it does not differentiate between the nature of the data it crunches to be objective or subjective on any level. The differentiation of objectivity and subjectivity realizes itself as a practical problem in the real world (i.e., deciding on how to computably represent it).

In this section, we provide an overview of a wide spectrum of research to get a feeling of the state-of-the-art machine sensing and learning capabilities that will potentially lay the foundation of future context-aware services. In our typological terms, we first go through sensing of objective contextual elements, and later we explore the relatively new direction of machine learning on subjectivity. Before engaging this, we start by describing how machines are able to infer from the data in general, followed by more detailed analysis on specific applications. The following sections attempt to go deeper into machine learning techniques to illustrate their particularities to help the reader to understand the challenges of sensing and inferring context.

### 3.1 Learning by Example

The idea of learning by example, or *supervised learning* [13], is not new, and the theoretical algorithms for the basic methods have been available for several decades. However, there have been two main bottlenecks in its applicability, namely, computational power and availability of labeled data samples. In supervised learning the machine learns a pattern for identifying a phenomenon or an object, based on observing several instances of that phenomenon. For example, the machine can learn to discriminate between cats and dogs just by observing several hundred labeled pictures of those animals (see Figure 2). Nevertheless, this learning can go vastly beyond this simple application. In theory, machines can learn to classify, for example, human emotions based on gestures and facial expression and other sensory input; they can also learn to detect suspicious behavior in airports, or any other type of activity detection.

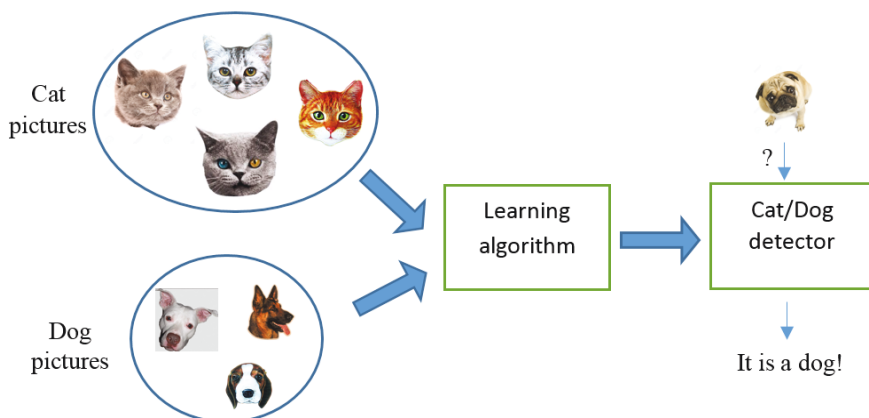


Fig. 2. Supervised cat/dog classification

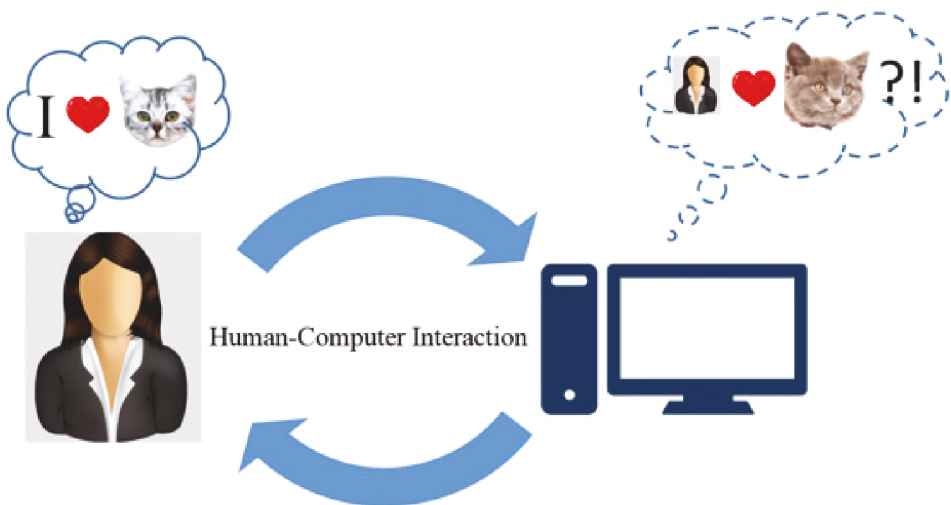
However, we ask, why don't we have all these possible applications in everyday life? The answer is that the learning and classification depend on the amount and quality of training data that the machine receives. If we were able to feed a million instances of each emotional state (subjective context) along with their (objective) contextual readings (appearance, health conditions, temperature, locations, etc.), then we could have the best possible emotion detectors.

One interesting development in this domain is what is known as “deep learning.” The access to well-labeled training data has allowed researchers to mimic what little is known of biological brain, where learning happens by adjustments in a network of neurons. This basic idea enables machines to learn complex functions that map inputs to outputs. Deep learning has been used, for example, for

image recognition, in which a digital image made of pixels is mapped to a set of labels. Along with the increase in availability of necessary computational resources, what makes this approach possible is actually the ever increasing amount of labeled data, such as text, audio, image, user activity, knowledge graphs, and so forth. Given enough variety of training data, neural networks can perform quite well in a lot of different applications. Thus, machines are getting better and better at tasks such as understanding speech and reasoning [14].

### 3.2 Learning by Reward

The second family of learning approaches that can be utilized in context sensing is learning by reward, or reinforcement learning. In this approach there is no need for labeled samples. These methods involve learning from the interactions with the environment and the “reward” signals received from it. Reinforcement learning is inspired from behavioral psychology and how humans, especially children, learn new skills based on their interaction with the environment [15]. Reinforcement learning is especially useful in learning the user’s intent, where the machine is the learner and humans are assumed as the learning environment. In intent learning, the system tries to learn the hidden state of the user based on the feedback that the user provides.



*Fig. 3. Reinforced learning preference classification. A system can learn the hidden intent of the user based on the history of user interactions with the system.*

Based on this new type of human–computer interaction, the system incrementally learns the hidden intent and employs it to predict the user behavior and to improve the personalized services. Nowadays, the idea of intent learning has

been implemented in applications such as personalized search systems [16]. The main bottleneck in these systems is that most of the users are not interested in actively engaging with the system. For example, users usually find it inconvenient to explicitly (e.g., by mouse clicks) state that they like or dislike an item (see Figure 3). This makes intent learning very inefficient in practice. Currently, there have been new studies to solve this problem by changing the type of feedback that the system can receive, for example, by monitoring implicit signals, such as brain signals or physiological signals [17] [18]. Thus far, the previous sections have explained how machine learning takes place. The following section provides an overview of the state-of-the-art technology in contextual sensing and data gathering.

### **3.3 Smart Devices as a Hub of Context Sensing**

At the state of the art in fields related to machine learning, sensing and perception such as computer vision, speech processing, and natural language processing, we see a trend that digital systems are becoming more capable of mimicking human senses and perception, with increasing success rates and performance. Because human interactions are mainly sensorial experiences, such systems ideally would involve the use and convergence of different senses to follow a conversation, for example. The sensing capacities of a system are key to the advancement of machines learning in a humanly fashion (Figure 4).

Yet the actual crucial change that made context sensing possible was the boom of devices with sensing capabilities, such as smartphones and other smart devices. The capabilities of these devices led Pejovic and Musolesi (2015) to depict a concept called anticipatory mobile computing, in which smartphones, with their many skills, will be the center of the operation and context sensing [19] (Figure 5). They acknowledge that context inference is a complex process that lies at the heart of anticipatory mobile computing, but the anticipation is said to differentiate from context awareness by taking action. Anticipatory mobile computing is envisioned as our mobile devices taking action by predicting the context. So in that sense, the system has to be both context aware and able to predict the immediate future context.

The latest commercial interest in smart devices centers on wearables, which offer interesting applications. We are already familiar with many wearables capable of measuring bodily functions. Bandodkar and Wang (2014) state that more advanced noninvasive electrochemical sensors are on their way [20]. These electrochemical sensors will be capable of monitoring metabolites and electrolytes in sweat, tears, or saliva as indicators of the wearer's health status. Chemical im-

balances are usually associated with certain inner states (e.g., cortisol levels and physical stress). As a result, the additional information can be utilized in more advanced context sensing.

Smartwatches, a member of the wearables category, offer a new way of interacting with mobile devices. As a new form factor, they have the potential to avail new sensing modalities and related applications. One recent and excellent example is EM-sense. Laput, Yang, Ziao, Sample, and Harrison(2015) investigate a novel sensing approach for object detection, triggered only when objects physically touch [21]. The approach exploits the electromagnetic noise emitted by many electrical and electromechanical objects, such as kitchen appliances, computing devices, power tools, and automobiles. These noise signals are highly characteristic and varying in a way that enables identification of the gadget. When a user touches these gadgets, the characteristic noise signal propagates through the user’s body because it is conductive. For example, touching the doorknob at the office in the evening might trigger a voice reminder to buy milk on the way home.

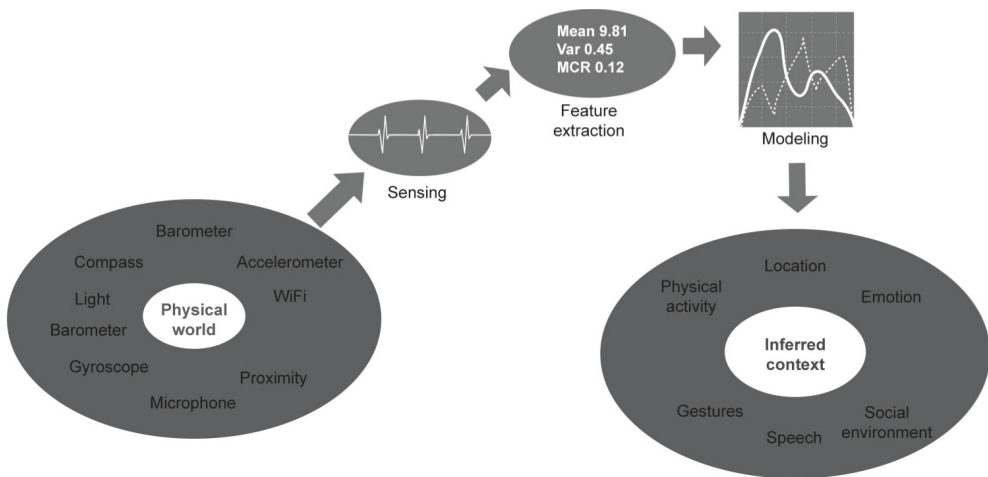


Fig. 4. Mobile sensing—from real-world signals to high-level concepts (adapted from Pejovic and Musolesi, 2015 [19]).

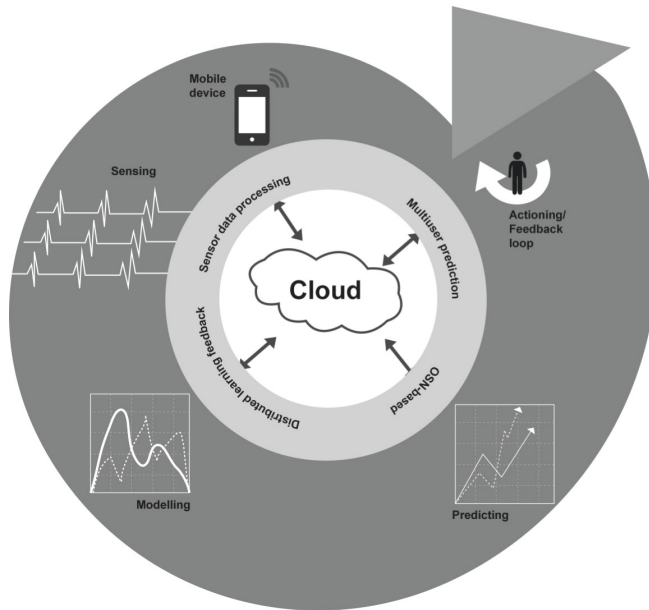
Finally, one of the pillars of science fiction, smart eyewear, is actually in the making today. Google has been working on Google Glass for a while now. As with any other novel form factors, face-based wearables also have the potential for new horizons. Ha, Chen, Hu, Richter, Pillai, and Satyanarayanan (2014) explore the potential of Google Glass as a means of cognitive assistance for elderly people in cognitive decline [22]. The prototype they implemented is capable of providing contextual information, such as face recognition, object detection, optical-

character recognition, activity detection, and augmented reality, to potentially support various aspects of the user's daily life. Ha et al. indicate that real-time scene analysis was first suggested nearly a decade ago, although the goal has remained unattainable until now for three reasons. First, the state of the art in technologies such as computer vision, sensor-based activity inference, speech recognition, and language translation was not up to the desired speed and accuracy. Second, the computing infrastructure to provide necessary computation was not there until mobile and cloud computing emerged. Third, suitable unobtrusive wearable hardware was not available [22].

### **3.4 Sensors Everywhere and Internet of Things**

As opposed to mobile computing, there is a new paradigm called the Internet of Things (IoT), which captures the fully connected nature of smart devices. In essence, the IoT embraces any connected device with sensing and/or acting capabilities, be it a Wi-Fi-connected coffee machine or an automatic door lock. The true potential of the IoT is expected to come from context-aware capabilities of the IoT environments. Kang (2014) explores the idea of mobile object recognition for context inference for the purpose of interaction with IoT devices [23]. Irrespective of the form factor of the client device, Kang describes a system based on image recognition of physical objects. In such an environment, recognition of objects within the user's proximity or the user's immediate interest can be used to identify relevant context. Ultimately this event can be used as a trigger for an associated IoT service to expose its interface for an automatic interaction to provide a seamless computing experience.

In a relaxed digital sensory setting, we potentially can design our environment to enable more advanced applications (e.g., smart rooms and homes). So even with less accurate sensory organs, we can devise solutions to achieve similar performance by making use of redundant information. Ijsselmuiden and Stiefelhagen (2010) created an experimental room to study high-level human activity recognition [24]. The room features multiple cameras mounted on the appropriate points in the room to track positions, postures, and eye-gazes of people in the room. They propose a framework based on the temporal logic to detect the working context in the room. For example, a group meeting or two people working together at a display can be detected. This information can be used to adapt user interfaces accordingly.



*Fig. 5. Anticipatory mobile computing architecture. The mobile device senses, models, and predicts the context, and through interaction with the user, it ensures that anticipatory decisions are implemented. At each step, the computation can be distributed between the mobile device and the cloud (adapted from [19]).*

Furthermore, we can make use of more apt sensors for the job (e.g., a utility usage sensor in a smart-home environment that detects if a utility is used or not, for example, a light switch, coffee machine, TV, or bathroom faucet). Choi, Kim, and Oh explore the potential of the deep-learning approach in human behavior prediction in a home environment [25]. They carried out a study based on the MIT home dataset, which only includes data of the utility usage sensors' on/off states over time. The study showed that it is possible to predict which utilities will be used at what time with considerably good accuracy. In return, this predictive knowledge can provide pre-emptive actions that can facilitate our lives at home.

### 3.5 Emotionally Intelligent Machines

So far we have explored the more tangible and objective contextual information that machines can sense. From a computational standpoint, the main challenge in sensing subjective context in practice is that it usually cannot be fully captured based on low dimensional sensory input. In other words, there is not a known magical mathematical model to put into the machine's mind as a program to figure out subjectivity in context. Even for humans, inferring



subjectivity (e.g., empathy) is a challenging task in itself. For example, an emotional state such as hidden sadness cannot easily be understood from singular observations such as appearance. One needs to focus on a friend's out-of-the-ordinary behaviors, such as how much she speaks or if she smiles as usual to jokes made, in order to suspect if she might be sad. In the computational realm, to make a robust prediction about the human state, the system needs to utilize any relevant information, such as history, experiences, health condition, location, time, and so forth. However, even after having all this information, making an inference about emotional state can be different from one person to another and might need to be learned and personalized for each individual. Nevertheless, it has to start somewhere.

In that regard, affective computing is the field of computational science that devotedly studies human subjectivity and its computability. Drawing from the previous suggested typology, it can be said that the affective computing field directly operates in the heart of subjective context. In domain terminology, *affect* is used as an umbrella term that covers broad range of feelings that people experience, whereas *emotions* are deemed to be intense feelings directed toward something or someone. Additionally, *moods* refer to feelings less intense than emotions. Mood and emotion differentiation is important because experts believe that emotions are more volatile and transient than mood, but moods can affect the characteristics of emotions. For example, during a bad mood, anger might not go away easily.

Zhang and Hui (2014) indicate that powerful sensors along with long-term usage of smart devices can enable unobtrusive collection of affective data, which in return is expected to improve traditional affective computing research [26]. As a result, researchers are seeking to explore new methodologies to infer affective states using the newly available data (e.g., touch behaviors, usage events, etc.). We choose to demonstrate the advantages in computational detection of emotions by demonstrating examples of the academic research.

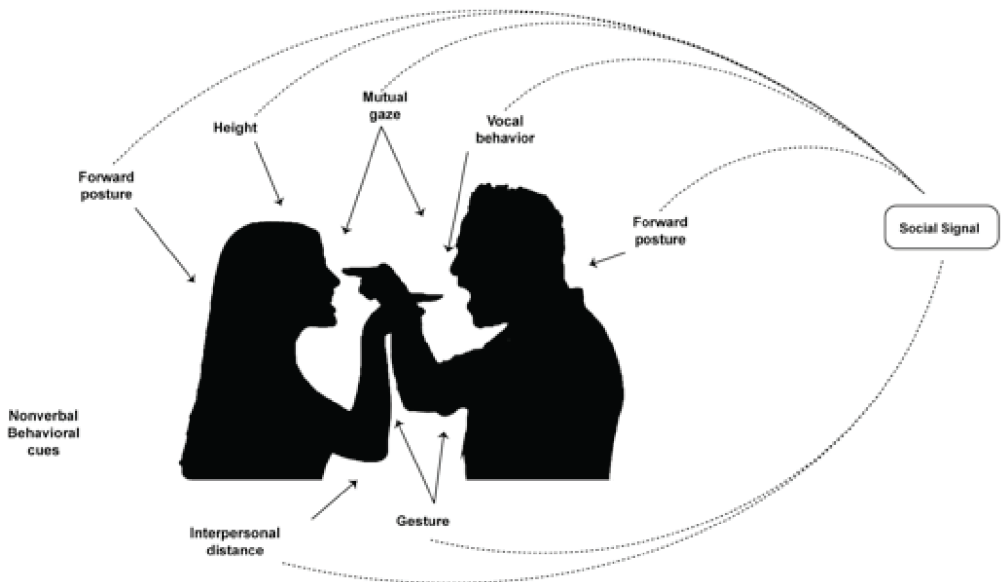
One of the most recent efforts in the area investigates the possibility of recognizing emotions by making use of low-level acoustic features of speech. Han, You, and Tashev (2014) explored the potential of the deep-learning approach to investigate utterance-level emotion detection [27]. As opposed to the feature-modeling approach, use of low-level acoustic features makes the methodology potentially applicable in cross-language and cross-cultural settings.

Apart from emotion recognition, in recent years there has been a surge of interest in computational methods for opinion mining and subjectivity and sentiment detection. Balahur et al. (2014) indicate that these methods typically focus on the identification of private states, such as opinions, emotions, sentiments,

evaluations, beliefs, and speculation, in natural language [28]. Subjectivity is usually classified as subjective or objective, whereas sentiment classification tries to add depth to analyses by classifying the text as either positive, negative, or neutral. Yet another important aspect in this body of research is the type of text, such as short messages, preferences, events, comments, and opinions in social media sites (e.g., Facebook, Twitter). Tailored automated analysis of these sources could be of great use to obtain the real-time unbiased opinions and emotions of the masses.

Personality is also an equally important aspect for human affect research. Chittaranjan, Blom, and Gatica-Perez (2011) studied the relationship between behavioral characteristics derived from rich smartphone data and self-reported personality traits [29]. The analysis showed that aggregated features from the obtained data can be indicators of Big Five personality traits, a concept well known in psychology research. These traits are claimed to capture most of the individual differences among people, and hence are fit to be used as a personality measure.

In conjunction with Chittaranjan et al.'s (2011) study [29], Staiano, Lepri, Ahorony, Pienesi, Sebe, and Pentland (2012) bring another angle to the same picture [30].



*Fig. 6. Nonverbal behavioral cues and social signals. With no more than these two silhouettes, it is not difficult for most people to guess that the picture portrays a couple involved in a fight. Nonverbal behavioral cues allow one to understand that the social signals being exchanged are disagreement, hostility, aggressiveness, and so forth, and that the two persons have a tight relationship (adapted from Vinciarelli et al., 2012 [31]).*

They refer to usage-based analysis as an “actor-based” feature, whereas they propose a “network-based” feature study. They claim that network parameters such as number of calls made or received, their average duration, the total duration of calls, the number of missed calls, and Internet usage can be predictive of personality traits. In this regard they define two different networks that can be constructed from the data collected from an individual smartphone. The first is based on distant communication, such as calls. The second is based on proximity to others utilizing the Bluetooth (BT) discovery mechanism, wherein the number of unique BT IDs discovered determines the size of the network. Consequently, they analyze the structural differences of call and BT networks to show that their relation is a predictor of Big Five personality traits.

Finally, a relatively new domain in human affect research is social signal processing (SSP). The aim of SSP is to bridge the social intelligence gap between humans and machines. Vinciarelli, Pantic, Heylen, Palacheud, Poggi, D’Errico & Schröder (2012) define *social signal* as communicative or informative signal that, either directly or indirectly, provides information about social facts, namely, social interactions, social emotions, social attitudes, or relations [31] (Figure 6). The state of the art in this area deals with problems such as social emotion recognition, role recognition (e.g., dominant), analysis of (dis-)agreement, group dynamics, and negotiation outcome.

## 4 Services and Value of Subjective Context

So far, we have argued that there is a new type of subjective context and suggested that technically it is possible to produce such systems, primarily thanks to increased access to data, via smart devices and digitalized environments and services. These services fuel applications of machine learning, which, as we saw in Section 3.5, allows development of analysis of emotions, indicating a step toward understanding personal accounts. This corresponds to the technical component related to the business model, but we have yet to discuss the value-added services that are used, or the funding models and actors in the value chain, which are also critical in context-aware business models [32]. Furthermore, adapting from De Reuver and Haaker (2009), each of these domains can be extended to subthemes [32], as elaborated in Table 1.

Domain	Objective context service	Subjective context service
Added-value? <ul style="list-style-type: none"> <li>• Targeting</li> <li>• Value-creating elements</li> <li>• Branding</li> <li>• Customer retention</li> </ul>	Targeting and value-creation are based on simplifying everyday life through automation.  Customer retention is based on providing services which provide the value-add.	Targeting and value creation are based on simplifying everyday life by understanding users' psychological and emotional needs.  Customer retention is based on the extensive relationship with subjective-context-aware services, including teaching them to further improve the predictability.
Funding model <ul style="list-style-type: none"> <li>• Pricing</li> <li>• Division of investments, costs and revenues</li> <li>• Valuing contributions and benefits</li> </ul>	The service is monetized by using the data to further, for example, advertising or partnership.  Potentially also subscription-based business models can also emerge, if the value added to end users is high enough.	The service is monetized by using the data to further, for example, advertising or partnership.  Potentially subscription-based business models can also emerge, if the value added to end users is high enough.
Value chains <ul style="list-style-type: none"> <li>• Partner selection</li> <li>• Network openness</li> <li>• Governance</li> </ul>	There will be data-collection hubs (e.g., Google, Amazon) that own customer data and control the building of these services.	There will be data-collection hubs (e.g., Google, Amazon) that own customer data and control the building of these services.

*Table 1. Business potential of context awareness according to De Reuver and Haaker [32], and exploration of what subjective context awareness can add to these opportunities.*

We compare our case between the objective and subjective contexts, and observe that their main differentiation emerges on the value-added component. In detail, we observe that in terms of value creation, added value emerges from catering to extended subjective needs in the context awareness, as seen in the case description. Furthermore, the customer retention dynamic is different because users are involved in providing data—both consciously and unconsciously—for the reinforcement learning algorithms. This will create more personal ties with the system and also a vendor-locking on data collection. Compared to objective context services, the subjective context services cannot be changed simply by replacing hardware, but require subjectification of the data. Regarding other domains of the business model, namely, funding models and value chains, we do not predict significant differentiation between objective and subjective services. Naturally, the fact that the value-added prospects—potentials for targeting, value creation, and customer retention—are different may have implications on the details, such as revenue sharing between operators or the emerging partner network.

However, we acknowledge that the business development process is more difficult. To illustrate this, we reference Kaasinen (2005), who explored adaptation of location-based services before they became mainstream [33]. She discusses factors such as critical mass, user control, and challenges in the patterns use of service adaptation.

The critical mass refers to the number of users as well as the variety of services offered by the system. Critical mass increases social acceptability in single-user services and social effects in collaborative services. Our examples thus far have reflected single-use situations (i.e., information is not shared between users); thus, the empirical observation of critical mass relates to social accessibility. We also highlight that several other human factors, such as user experience [34], are socially constructed. A recent example of critical mass and social acceptance failure is the introduction of Google Glass, which became a joke piece of technology and was thus discarded. Finally, Kaasinen (2005) observed that mobile use patterns are sporadic, and the technologies need to take this into account [33].

However, the emergence of business models is not only based on the users' needs and the social context. Rather, the existing value chains and business models limit the opportunities for new models [35]. Such mechanisms include access to data, existing business dynamics, and access to technologies, in the form of research and development (R&D) efforts and, for example, patents. Thus, to understand the emergence of subjective context awareness, we must engage these topics.

#### **4.1 Context as Data-Heavy Business**

In earlier sections, we discussed several approaches to how machines can understand context. Because many of the techniques depend on the access to data, this will limit the opportunities for emerging businesses. This is already visible in academia; if research depends on "big data," then it blocks new researchers entering the domain, as has already been observed [36]. Furthermore, access to data, even while technically possible, may not be sustainable business-wise. For example, Facebook, which once promoted an open application programming interface (API) to allow interoperability [37], recently closed access to some of its resources, most likely reflecting the dominance Facebook has achieved in the social area. We see similar opportunities thinking emerging in the industry, where the newest development is to provide machine learning systems as services.

Project Oxford (2015) by Microsoft provides image-based emotion detection as a service [38]. It provides an API for developers that can perform an emotion analysis on an image submitted to the API. The service essentially detects

individual faces in an image and returns a vector of emotions: anger, contempt, disgust, fear, happiness, neutral, sadness, surprise.

IBM Watson (2015) takes it up a notch and offers a wide spectrum of “cognitive” services that can give insights on contents such as image, speech, and text [39]. One of the rather interesting services is called Personality Insights. The Personality Insights API takes a text of 3,500+ words written by a single person to generate a personality inventory based on Big Five traits. Similarly, the Tone Analyzer service classifies a text as positive, negative, or neutral. It is naturally expected that more of these types of services will come as this ecosystem starts to generate value and trigger more research to take a solution-oriented approach.

## 4.2 Previous R&D Efforts Related to Context

Patents are an important aspect of business dynamics because they enable blocking of business for other organizations. The actual benefit of this, however, is limited, as seen during the smartphone patent war in early 2010s, where the courts were hesitant to limit the access to markets [40]. Thus, patents were not able to protect the vendors’ positions. Keeping this in mind, we explore the total number of patents to indicate the business position in the era of context awareness, as well as R&D output in the area.

As of November 2015, a Google Patents search found 15,000 patents using the terms context aware or context awareness (Figure 7). Major assignees of these patents were Microsoft and Nokia. Microsoft’s position is so strong that the other technology companies just barely sum up to the impressive count of 639 patents regarding context awareness. Naturally, we have not explored in detail what is patented. But we can presume that many of these patents relate to objective-context-awareness emerging services and technologies. Of these, the service patents are still relevant in the subjective context era because they define how context-aware data are used in business applications.

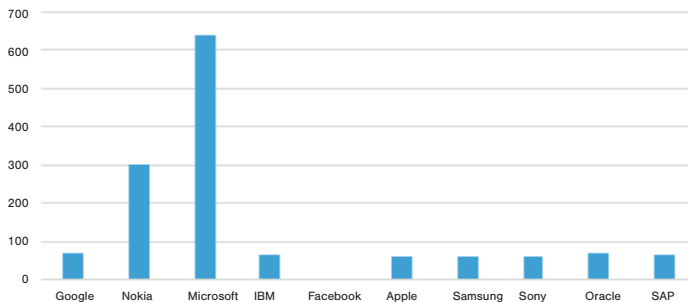


Fig. 7. Patents granted to different companies for context-aware products and services.

### **4.3 Example: Sensitive Cooking Advisor**

In our first story, we mentioned how a system was able to order food ingredients using various parameters. These parameters would include availability for cooking activities and preferred brands based on previous purchases and other behavioral data, but should also extend to deeper values, for example, in relation to the environment and choices made there, or reflecting preferences on cooking methods, or adapting to the overall household situation. This requires access to previous eating behaviors and understanding of the constraints for cooking. The end-user value emerges from the possibility to automate everyday activities, such as shopping, and trust that the automation will not screw up.

In this case, the business value naturally emerges from the shopping system; by deploying this type of system, the customer is also integrated with a specific vendor. This customer loyalty, we believe, will justify the initial investments in data collection and service development. In practice, this could emerge by some of the existing companies moving in this direction (e.g., Amazon or Walmart) or by a new platform operator developing the necessary infrastructure and operating as a broker between the customer and retail industries. This would naturally affect the value chain; in specific companies the risk is that the value chain would become retail-centric (i.e., each operator develops his or her own cooking advisor and they cannot share the data), whereas platformization risks change the revenue sharing throughout the retail ecosystem (e.g., make current vendors obsolete).

### **4.4 Example: Sensitive Smart-Home Automation**

Earlier, we discussed the case of a system that automatically adapts the home lighting, temperature, and other related aspects based on the intentions and preferences of the user. This would include previous user habits, but also personal preferences and interactions with other participants. Again, as is common in context-aware applications, the end-user value emerges from automation. Also, the business is networked; it needs to connect the context operators to the smart-home automation. However, we assume that the emergence of the business network here would be simpler because home automation vendors have the implicit interest to ensure that automation systems can integrate with other operators—as indicated not only by technology companies' interest to platformize this area, but also by emerging interest in the open-source community to create platform hubs that become technology agnostic. Thus, compared to the sensitive cooking advisor discussed earlier, we propose that this application would require less effort.

## 4.5 Example: Truth Machines

The second story exemplifying the automation of truth systems, in which users can verify information and rate the sources as reliable or not, is also based on the networked business model—however, not in the same sense as in the previous examples. These services will aggregate the personal input (comments and sentiments) of each user about pieces of information, which in turn will corroborate or contradict its truthfulness. We envision future business models of a sensitive nature; these could be potentially empowering if handled independently or profoundly misleading in powerful mischievous hands.

# 5 Implications of the Subjective Context

We have discussed what subjective context is and explored how it is achieved by sensing the surroundings and conducting different types of machine learning on the collected data. We also explored subjective context from business aspects, outlining the added value and added difficulty of developing such services. We have not, however, asked the question of how subjective context awareness might change human habits or surrounding society and how it may change our everyday chores (e.g., grocery shopping) or our interpretation of events (e.g., tracing information to its original source to have a better overview of history). Based on wide existing literature (most notably, e.g., Winner, 1980; also Gillespie, 2012), we know that technologies are socially shaped to fit to the environment [41], [42]. However, technologies also change social practices and thus the environment where they exist. Therefore, we ask the longer-term implications from subjective context awareness will be. How will our lives and our social, work, and business relationships be two decades from now? We first explore this topic at the personal level, then the interpersonal level, and finally at the society level.

## 5.1 The Self and the System

The Johari window [43] was developed in the 1950s to model how one perceives oneself and how others perceive us. It uses a two-by-two approach based on whether the information is known to oneself and whether the information is known to others. We use the same approach, but in terms of what is known to the user and what is known to the machine. We thus can outline four different types of subjective contextual information: mutual understanding, technology



and human misinterpretation, and unknown contextual cues unfamiliar to both the users and the system (see Table 2).

In our earlier examples, we explored the ideal situation in which there is a mutual understanding of context. In these cases, the system is able to correctly understand the context and adapt to those needs. Thus, this type of situation allows the user to trust the system. However, there are two other interesting cases in which there is knowledge imbalance. The first is technology misinterpretation, which occurs when the technology does not understand the context. The second is dehumanization, which occurs when the user does not understand the context.

		The system understands context	
		No	Yes
The user understands context	Yes	mutual understanding	technology misinterpretation
	No	dehumanization	unknown

Table 2. The Johari window for technology.

Technology misinterpretation leads to situations where the human cannot trust the context awareness and automation. Existing literature has also shown that in social services naïve automation (anticipatory computing) leads to challenges because it conflicts with the expected social rules in that situation [44], [45]. People engage in what is known as profile work, in which they go to great extent to carefully craft an image of themselves to their followers. However, social media automation does not respect such detail work, and therefore the users must circumvent the automation techniques to maintain a profile through manual labor, ensuring that the system represents them “correctly.” On the other hand, an additional attractiveness of future subjective context applications may rely on the fact that there is a potential for individual empowerment, as discussed in previous sections. Their appeal to a higher layer of understanding and not only to what users portray on their profiles—which may be more revealing of true feelings and states of mind, going beyond words and emoticon displays—is an added value.

As highlighted, this question is related to overall trust. As Fusco, Michael, and Michael (2010) discuss, trust both in the technical as well as the socio-technical system has a significant role in the uptake of these systems [46]. These researchers tackle problems relevant to technical trust and user privacy, or how a user trusts a system not to share sensitive data with other users. In addition, Cheverst, Davies, Mitchell, Friday, and Efstratiou (2000) [and Antifakos, Kern, Schiele,

and Schawaninger (2005) discuss how systems build reliability for the user to trust the information provided and actions proposed by the system [47], [48]. As we have observed, the question of trust becomes critical when automating tasks; users must trust that the automation works correctly and does not bring on negative consequences. The fear of feeding a system with sensitive data will never be an outdated discussion. However, the possibility for a system to understand human experience enough to account for its values and sentiments unavoidably involves data automation and invaluable value.

We find the most interesting cases to be those where the system is able to analyze—and thus adapt—the context correctly, whereas the human cannot do the same analysis. We refer to this as dehumanization; the human is no longer needed to adapt such context situations. Even though this sounds extreme, we have seen the emergence of such a level of understanding in more trivial tasks. For example, self-driving cars have been known to avoid animals unseen by the human eye.

In context awareness, we argue that such development is based on the habit-building capabilities of the technologies. It is well known that technologies change and build habits [49]. Through these changes, people will adopt technologies as part of their everyday lives. Furthermore, previously owned skills become obsolete and thus are forgotten or unused. A trivial example of such progress is the mobile phonebook application, which has reduced the need to remember phone numbers.

Thus, to understand habits, we must explore practice and reconfiguration of them. As Shove, Pantzar, and Watson (2012) argue, a (simplified) model of practices is the links between the competences, materials, and meanings [50]. In this terminology, the mobile phonebook application became an unused practice as material aspects, such as the possibility to directly call via the mobile phone, and the convenience of this technology reduced the need and the competences to maintain phone numbers.

Applying the notions of both habit and practice, we ask how subjective context awareness might reconfigure daily life. In the previous case descriptions, we observed that, similar to the phonebook application, previously commonly shared skills such as planning daily life or exploring information were automated. In general, we have argued that subjective context awareness will understand emotions and values as well as humans and then automate processes based on those understandings. Thus, this automation will replace many competences humans currently have and break the competence-material-meaning nature related to practices. This will disrupt the practices relating to self-regulation as well the management of interpersonal relations; however, we do not foresee that the

meaning of those activities would change, indicating that being a human remains a rather similar activity, albeit augmented by technology.

We find the conditions where the information is not mutually shared between the technology and the user most interesting. In a given case that there is a “technology misinterpretation,” then we can say that our previous discussion on technology has failed to achieve subjective contextual information. In these cases, the context-aware services will have failed to provide added value, and instead, automation will lead to negative experiences, as noted earlier.

Similarly, the condition in which technology could surpass humans in recognizing and adapting to the context is interesting, implying that humans cannot comprehend all relevant factors. We suggest that these services will create habits, and that this is a likely outcome for many cases where humans can currently determine the context. Said differently, we argue that as people build trust in these technologies, they will also consider more automation possibilities; and as humans automate tasks, inversely, their skills to carry on similar tasks will decrease. Our argument about subjective context awareness notes that some of the trivial subjective computational tasks will become automated as machines develop learning. We wonder if this contradictory process will make us less human in the end.

## **5.2 The Self and the Others**

Previously, we discussed how subjective context awareness will change the relationship between the self and the system. Next we engage with the topic of the relationship between the self and others. Based on the earlier discussion, we assume that the system augments or validates many of the contextual situations; it is successful in providing trustworthy automation services. As this automation happens, we argue that users’ skills and knowledge in the automated areas will decrease, as noted earlier.

Automation and awareness become relevant when users socialize. As defined, the awareness of the subjective context emerges through the interpretation of the relationships between users (and objects), and by the automation of these interactions. Thus, the interpersonal dyadic interaction is augmented by one or two systems that aim to be automated. In our case, the system reacted to stress and time-management challenges by adapting to the environment. Transforming the situation into social means that there are two or more users in this situation.

First, the stressed person’s subjective context awareness must react to this question: Is the environment acceptable to express stress (i.e., start adapting), or would that be considered socially unacceptable (i.e., extreme annoyance)? As Snyder, Matthew, Chien, Chang, Sun, Abdullah, and Gay (2015) demonstrate, the

experience of adaptation in social situations can indeed be cumbersome and thus socially unwanted [51]. However, this situation involves more than one user, and both user systems are exploring the social context to also adapt. These systems can detect the level of stress—or any other emotion—in the user, either directly, shared between context-aware systems, or indirectly, based on the social cues in the environment. Thus, the systems—both users expressing emotions as well as other surroundings—aim to adapt the environment based on this analysis.

We do not assume that it may work to the detriment of the users; however, it adjusts the relationship between the self and others by introducing adaptive systems into those relationships. Furthermore, these systems will automate some of the reactions people have in social relationships and thus take part in maintaining them.

### **5.3 What Is Truth?**

Foucault (1978) explained truth as being composed by a group of reliable and unquestionable discourses, the product of an interplay between power institutions; it is perceived by all and interpreted individually [52]. The idea of truth being a socially constructed product of interactions and self-awareness makes the concept in itself problematic, but how does truth relate to contextual information?

Subjective-context-aware systems pose the question of what “truth” is in many cases—for example, “Is this interpretation correct?” or “Is this action correct.?” Thus, finding truth is automatized by a system that follows presets. It is a system that essentially follows a thread of information—maybe even decontextualized—until it finds the original source and evaluates it against public rating. If there was a way to prove that public rating is a product of subjective context awareness automation, then we could rely on its veracity. However, is truth everything that we—in smaller and bigger groups—agree upon, or are we set to believe what a system points out to be true, believing that it is a reflection of a group’s consent, if we consider the possibility of a system to point to reliable sources without bias? On one hand, the solution might pose more questions on how we construct truth and how it is manipulated to benefit the few. On the other, it could be a revolutionary way to achieve justice, equality, happiness, security, and reliability—the true empowerment of the individual.

## **6 Discussion**

We have suggested in this work a new typology for subjective context that arranges data through values, intentions, and feelings. The typology is produced

by extending the original dimensions of objective data into broader levels of understanding and deeper levels of intimacy. With this typology we suggest new ways of understanding context in which automated systems—already versed in objective context—can process the subjective data and in turn enhance the building of human values and personality. We believe that this future symbiotic experience between users and subjective-context-aware systems may empower users to find more significant and intimate interactions with automated systems (e.g., the search for truth; Google Truth). In other words, as subjective context information is automated, the system will gather insights on human behavior and experiences; learn about the type of lives we aspire to live; determine how to provide company, care, and trust; and anticipate actions to fulfill our desires.

In the future, contextual information harvesting will most likely be taken for granted because sensors will be present everywhere, unless we choose otherwise. The already automated use of contextual information—location, contacts, searches, and consumer habits—and substitution of certain human habits (e.g., memorizing phone numbers, keeping appointments on paper calendars) indicate our reliance on machines accessing and using our contextual information to provide more personalized services. The effectiveness of machines to use and connect data has created different habits that in turn have given way to new services and business models.

In our discussion about subjective context and the possible services, we have discussed the inevitable change in habits, closeness, and understanding of truth. Because we present automated systems that will ideally know us better than any other human being, the questions about machines being capable of becoming our best friends, companions, or friends still stands. The question is, however, what does it mean to be a human? If a system is capable of augmenting our expressions and reactions to values and personality, does this change how we define humanity? We don't envision the substitution of human relations or changes in the core meanings of what it means to be human. However, we do envision the emergence of new types of relationships between humans and machines, extending further into the symbiotic paradigm in which humans and computers become codependent and work seamlessly together [53].

As we observed in the exploration of the business models, this type of seamless interaction adds consumer value. Thus is worth of pursuing in the era of experience economics, where services offering superior experiences are able to attract users from other vendors. Furthermore, technologies for both sensing and interpreting beyond the objective context exist, thus ensuring that this can be achieved. Finally, as we have highlighted, context sensing is data-intensive work. This implies that there is a good opportunity that platform economy rules

will apply; that is, dominant operators will emerge, become superstars, and take majority of the profit in this area.

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# *University Education in 2035: Paving the Way for a Digital Future*

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**ABSTRACT:** *The public discourse concerning education has identified how the educational system is too slow to react to changes in the external world, which inevitably translates to growing unemployment. The ability to generate growth and improve employment is largely dependent on the quality and adaptiveness of available education, as education is considered the key in innovation ability. In our quest for knowledge and better understanding, we contacted leading experts in academia to discuss how they as the frontrunners of this change perceived the future of education. In this highly conceptual and inspirational paper, we seek to illuminate some of the problems of current higher education and rethink the age-old paradigm of universities.*

**KEYWORDS:** *education, digitalization, e-learning, digitization, university*

# 1 Introduction

*University* is defined by Encyclopedia Britannica (1911) as “an institution of higher (or tertiary) education and research which grants academic degrees in various subjects and typically provides undergraduate education and postgraduate education” [1]. The origins of the word are in the Latin *universitas magistrorum et scholarium*, which can be translated to mean a “community of teachers and scholars.”

Commonly, the mission statements published by universities assert excellence in everything the university does. Webster (2010) argues that this merely underscores the universities’ lack of definition, and describes the pursuit for excellence as the “zombification” of universities because there are no core values in today’s concept of university [2]. Quoting Webster (2010):

*I have no doubt that universities will continue to survive, but maybe they will go on, at least in part, as zombie institutions (the living dead) since it is quite unclear what their distinguishing features will be. There is no special knowledge that defines a university, no clear hierarchy of academic disciplines, no core values to be upheld. In the postmodern university, pretty much anything is admitted, so long as it be presented as “useful.” [2]*

Is it possible that the university will experience the same fate as gin tonic in Douglas Adams’s novel *The Restaurant at the End of the Universe*? The book describes how

*85% of all known worlds in the Galaxy, be they primitive or highly advanced, have invented a drink called jynnan tonnyx, or gee-N’N-T’N-ix, or jinond-o-nicks, or any one of a thousand or more variations on the same phonetic theme. The drinks themselves are not the same, and vary between the Sivolvian “chinanto/mnigs” which is ordinary water served at slightly above room temperature, and the Gagrakackan “tzjin-anthony-ks” which kills cows at a hundred paces; and in fact the one common factor between all of them, beyond the fact that the names sound the same, is that they were all invented and named before the worlds concerned made contact with any other worlds. [3]*

In this highly conceptual and inspirational paper, we seek to illuminate some of the problems of current higher education and rethink the age-old

paradigm of universities. This, we argue, could enable us to pave the way for a digital future where education is free from its conventional boundaries. We discussed these revolutionary ideas with some of the leading experts in academia, and here we present a synthesized view on where our educational system is headed.

## 2 Are We Satisfied with the Status Quo?

In this section, we provide an overview as to why rethinking our current educational system is necessary. We begin by first discussing the deficiencies of contemporary education, followed by presenting a novel service-oriented frame of thought for thinking about universities. Much of the progress to be seen in the future will rely on current technologies and their advanced versions in the upcoming years. Therefore, we conclude this section with an overview of how e-learning technologies are currently employed.

### 2.1 Issues of Contemporary Education

It has now been eight years since the perhaps greatest economic crisis of our lifetime began and shook the world. In most countries, the effects of this crisis are still evident in daily lives, as the economies are still combating slow growth, high unemployment, and gloomy views of the future. The ability to generate growth and improve employment is largely dependent on the quality and adaptiveness of available education, as education is considered the key in innovation ability.

Justin Cook, the project manager for the Education for a Changing World research project at Sitra, raises the question of whether our school systems have the capability to renew themselves in order to adapt to the rising complexity in society [4]. Similarly, Angel Gurría, the Secretary-General of the Organization for Economic Cooperation and Development (OECD), voiced his concerns at the public governance ministerial meeting in Helsinki on how current graduates might not meet the needs of the labor market, and how nobody really knows what kind of education and skills the labor market is going to need in the future [5]. Essentially, the problem is that the educational system is too slow to react to changes in the external world, which inevitably translates to growing unemployment. This may be seen when looking at employment statistics (Figure 1) of recent graduates by education. Figure 1 shows that in Finland, higher education does not ensure employment after graduation and that, in recent years, the chances of finding employment has improved for those with a matriculation examination, whereas for others the situation has worsened.

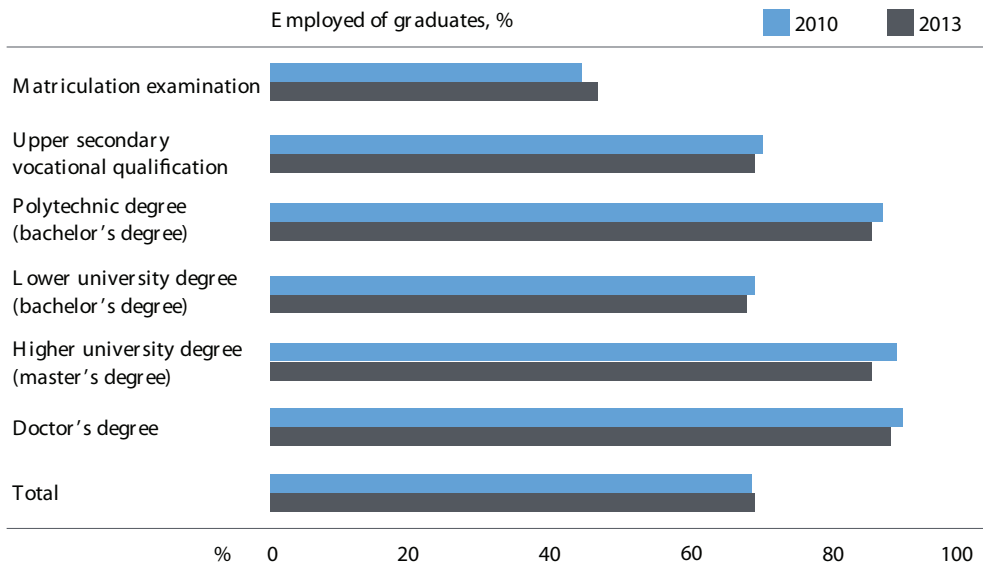


Fig. 1. Employment rate by education after one year from graduation [6].

Aleksi Kalenius, a specialist of Finland’s OECD mission, argues that unless Finland is able to carry out considerable changes, it is unlikely that Finland is going to remain a country with exemplary education [6]. “Education systems are likely to be significantly altered by megatrends like improving technology and the need for sustainability,” argues Justin Cook at Sitra [4]. To improve our innovation ability, we need to look at emerging trends in order to leverage them for learning and sustained well-being. This, we argue, could require a dramatic paradigm shift in higher education.

## 2.2 Toward a Paradigm Shift in Learning

Traditionally, universities have been seen as institutions that offer a specific kind of service—education—to their students. In addition to this core service, they offer degree certificates, which are a traditional proof of one’s knowledge and skill. The third big task for universities is to conduct research, of which both the public and private sectors can benefit from. Essentially, universities are providers of services that are meant to benefit our societies.

The IHIP definition of services [7] establishes that services are intangible, heterogeneous, inseparable, and perishable. Services are intangible; that is, they cannot be physically interacted with. They are heterogeneous because they are comprised of complex and packaged activities. Services can only exist in the moment they are produced and consumed; they cannot be owned. For this reason,

services are considered to be inseparable. Finally, even though services can be objects of capacity management and demand management, they cannot be stored. In other words, they are perishable.

Traditional education services have been widely studied, and they are generally compliant with the IHIP definition of services. Maringe and Gibbs (2009) define education as “the service by which past and current wisdom is passed to future generations through instruction designed by teachers. Generally the teachers prepare the students with all possible knowledge for the life after school” [8]. The education services often combine tangible elements, such as material or space, and intangible elements, such as experiences or processes [9]. Nevertheless, education itself is a pure intangible service [10]. At the same time, the combination of experiences and material bundled into a process make education heterogeneous. Conventional education is an inseparable service because it can only happen within a space where students meet to be instructed by teachers, and for this reason, it cannot be stored in order to be used on demand; it is perishable. In essence, these factors form the boundaries for education services.

One of the main functions of universities is to provide knowledge and abilities that allow students to be ready for work life. Upon closer analysis, we can identify that university-level education is essentially a unidirectional service (Figure 2), in which higher education institutions provide education services to their students. The nature of this interaction can be characterized as unidirectional because universities rarely attain substantial benefits from the work of students. Instances of value co-creation may be perceived only when students get involved in research activities. However, the impact of the jointly produced result is typically low for both parties, at least at the bachelor’s and master’s degree levels.

The unidirectionality of higher education services can be explained as the result of the current horizontal integration structure. In this model of organizing, there is a lack of intercommunication between the actors involved in higher education. Essentially, universities and their students comprise one side of this linear structure. In this side, universities provide a service to the society by giving education to the students. Interaction between students and industry first takes place after the students graduate and start their working lives. There is little interaction between the two far end sides—that is, no interaction between the university, which prepares students for their working lives, and the industry, which in turn hires such students. As a result, the service provider has a very limited awareness of the needs of the demand side. This notion is illustrated in Figure 2.



*Fig. 2. The traditional unidirectional model of how universities have operated.*

For the past 15 years, digitalization has been reshaping the structure of modern services, and education is not an exception. Higher education has experienced a dramatic change enabled by its integration with information and communication technologies. Since the world economic crisis in 2008, our system of higher education has experienced a lot of stress due to constant budget cuts. As a consequence, universities have been constantly reducing the size of their research and teaching staff. Universities have started using digital education material in order to maintain the quality of education services while saving costs. Digitalization allows universities not only to reduce teaching-related costs, but also to increase the reachability and customization of education.

Reducing the cost of education services is very important for universities. In the United States alone, student loan debts surpass \$1.2 trillion and have become the second largest form of consumer debt [11], dragging down economic development and even forcing many students to drop their higher education studies. Furthermore, by increasing the reachability of education through easily distributable digital material, education can be delivered faster to a greater number of people. Digital learning material is not constrained by physical spaces. Finally, customization of education means that everyone can build his or her own educational package according to his or her interest.

Productization is the process that aims at concretizing service offerings and professional expertise using more systematic processes and methods so that services are more product-like and are easier to buy and sell [12]. Productization is the key for a successful market entry [13]. The main output of productization is bundling offerings and deliveries together in well-defined packages so that the expectations of customers are better fulfilled [14].

The impact of productization of higher education services was studied by Aapoja et al. (2012) [14]. In this work, the authors argue: “The strength of universities lies in the wide variety of services they can offer and productize; different kinds of business-to-business (B2B) services e.g. consultations, research

projects and public services like education. University-industry cooperation can be enhanced through productization” [14].

The productization of education services that universities provide bring a big opportunity to increase and improve cooperation between higher education institutions and the industry. This enhanced cooperation translates into benefits for universities, students, and industry. For universities, having closer cooperation with industries will mean the possibility to know them better and understand their current problems. This could reflect on better and more concrete curriculums that address the needs of firms. This also benefits the students because they are exposed to real-life cases that help them acquire skills that are up-to-date and actually required by their future employers. For the industry, the benefits are even more obvious; having a better labor force can potentiate their growth and development—a firm is only as good as its employees.

Closer university–industry cooperation enhances other key aspects as well: research support, knowledge transfer, technology transfer, and collaborative research [15]. Tightening the cooperation in these aspects can have a huge positive impact on the quality of educational services that universities provide.

In essence, the university–society–industry entity is a symbiotic platform that brings mutualism to everyone within the system and benefits all parties. However, there are certain caveats that must be acknowledged. Even if a tighter university–industry cooperation can improve the quality of university curriculums, theses must not respond to the interests of the industry alone. Universities with better education services could be training better professionals, but they also have the duty of shaping the society by educating the future citizens. Therefore, independent research will be needed in the future as well.

### **2.3 Technological Development in University Education**

The development of information technology is shaping the way the future of university-level education is orchestrated. Some key technological developments of this rapid transformation include massive open online courses (MOOCs), collaboration material in the cloud, learning in virtual reality, and learning with social media. In addition, gamification may be employed to engage stakeholders in a way that traditional or regular interaction would not allow for.

**MOOCs.** Massive open online courses (MOOCs) started with a number of U.S. universities filming their lectures online and making them freely accessible to anyone. Soon thereafter, materials began to emerge also for other educational levels; for instance, Khan Academy provides various online lectures on a number of topics, mostly from the primary school level to the high school level. Interest-

ingly, however, MOOCs have not completely disrupted education. The typical MOOC student is still today an educated U.S. or EU male (Figure 3); that is, people who did not previously access higher education are still not accessing it to a large extent, even when content is available.

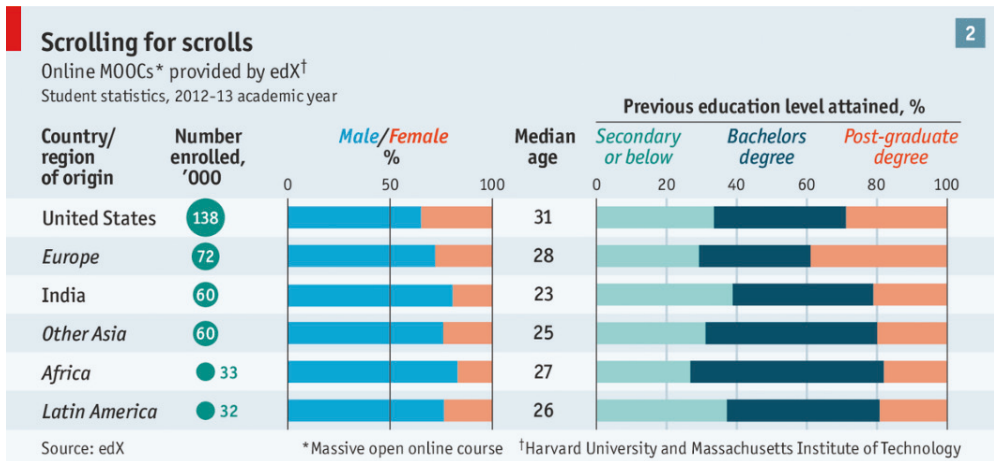


Fig. 3. The typical MOOC student is still today an educated U.S. or EU male [16].

**THE CLOUD.** With digital emergence, materials have started moving to the cloud. The old model in which knowledge was printed in the form of textbooks has started to shift to a model in which textbooks and other materials can be downloaded or accessed directly online. This way, knowledge can be constantly updated. Depending on the setup, collaborative creation of study materials can also be possible, for example, together with the industry.

**VIRTUAL REALITY.** Enabled by new display tech, faster graphics processors, and higher bandwidths, virtual reality (VR) headsets started to find their way to shop shelves in 2015. Their popularity is still an open question, but the ambitions are high. However, if a VR platform becomes widely successful, it seems likely that it will also play a role in the classroom. Teaching in VR could be comparable, for instance, to visiting a science exhibition, just without the need for any actual physical traveling. Explaining certain complex concepts, especially physical processes in, for example, a manufacturing plant, could be much easier, as students could play and explore with the concepts in a 3D world, instead of needing to imagine them. Potentially, this could provide the means for highly interactive learning through industry–student–university cooperation.

**SOCIAL MEDIA.** Using social media, it is possible to build learning communities, where, for example, students, researchers, and industry professionals can introduce themselves, converse with one another, ask questions, debate, reflect



on the materials and their learning, brainstorm together for answers, and take polls on learning progress. In addition, wikis could be used to build learning materials in collaboration with all other stakeholders.

**GAMIFICATION.** Many people love to engage with a game: an addictive game can guide a user to certain behavior by giving a reward for it. This kind of instant feedback has been often lacking in traditional education, where students may get feedback in the worst case only as a grade for the exam log after actual studying. Educational games have the potential to change this, providing feedback and increasing student engagement and motivation. The challenge lies in creating gamified approaches that engage all stakeholders.

### 3 Methodology

As part of the research for this paper, we contacted a number of leading experts (Table 1) in academia to discuss how they, as the frontrunners of this change, perceived the future of education. In our quest for knowledge and better understanding, we employed in-depth semistructured interviews with a predefined outline for the discussion. The interview structure was not followed rigorously, but it was used to provide a good framework for guided discussions that allowed the researchers to better come into contact with naturally occurring data [17]. Due to the exploratory nature of this topic, special concern was given to the interviewer's language to allow more room for sensitivity for the ideas and meanings of the interviewees [18]. This was particularly important because the researcher who defines the concepts is rarely able to control the meanings particularly well.

The interviews were recorded, and the researchers jotted down notes during the interviews. The interviews lasted from 40 to 60 minutes, which allowed for in-depth discussion of the topic. Some interviewees had requested the outline to be sent beforehand, which we complied with. The general structure of the interviews was as follows:

- Which technologies do you see as playing a major role in how university education develops?
- In the future, technology will enable making large parts or even all university degree studies online. What, in your opinion, would be the main benefits and drawbacks of that?
- How do you think online education would affect the quality of education?
- What are the main prerequisites for a person to be able to study for a university degree? (e.g., MIT courses are available online for free, but they do not reach people living in poor countries.)

- What is the main purpose of university studies now and in the future?
- What would an ideal university be like? Which purposes would it serve? Who would study there? How would it function in terms of teaching?

*Table 1. List of interviewees and their academic associations.*

Name	Title/Organization	Affiliations
<b>Tuija Pulkkinen</b>	Vice President (Research and Innovation) at Aalto University	Present duties as vice president include responsibility for the Aalto University research and innovation activities and related services
<b>Hannu Simola</b>	Professor of Sociology of Education at the University of Helsinki	Member of the board of the Doctoral Programme of Comparative Research on Educational Policy, Economy and Assessment (CREPEA) Member of the board of the Finnish Graduate School in Education and Learning (FIGSEL-KASVA) Head of the Research Group focusing on New Policy, Politics and Governance of Education (KUPOLI)
<b>Martti Mäntylä</b>	Professor of Information Technology at Aalto University	Focus area in applying ICT in industrial production, often termed the Industrial Internet
<b>Ahti Salo</b>	Professor of System Analysis at Aalto University	Member of the Strategic Foresight for R&I Policy in Horizon 2020 working group
<b>Markku Saarelainen</b>	University Lecturer at the University of Eastern Finland	

## 4 Findings and Discussion

Change in our society and our lives is happening at an ever faster rate, driven in large part by technological development that both enhances but also limits our traditional ways. Based on our interviews with leading experts and study of existing research, we provide a synthesis of the main trends that are predicted to ensue.

### 4.1 Purpose of University Studies in the Future

The dire economic situation, massive unemployment, and expiration of knowledge are some of the challenges our societies need to combat. In Section 2, we discussed how the rapid proliferation of MOOCs has basically made education accessible to everyone, regardless of the fact that predominantly they are still enjoyed by already-educated people from the United States and the European

Union. We see that these will have direct implications on the future of universities. In the case that massive unemployment cannot be avoided, it is possible that university studies will lose some of the attraction they have had in the past because, after all, most university students aim at a career in their field of study. On the other hand, in the case of an uncertain working life, a low-cost, informal alternative such as online university may well attract students. This may hold especially true if the cooperation between industries, students, and the universities can be enhanced to better build the skills required by the employers.

Because people are expected to live longer today than ever before in the past, universities are likely to have more elderly students, especially if future universities provide education for human refinement rather than preparing for working life. In fact, the expert views voiced in our interviews highlighted that unemployment, for example, might not reach such volumes as has sometimes been suggested in public discourse. For example, professions such as engineers will still be highly relevant, even though the nature of their work will change. Constant learning will be one of the key elements in avoiding massive unemployment in the future. Essentially, the role of human beings in our future societies will be the decisive element also when considering the development of future university education. Our university systems should be capable of adapting to the rising complexity of our society and the rise of new technologies. The aim of future university studies should be to enable graduates to meet the needs of the future society and the future labor market.

In essence, digitalization will affect universities both directly, through changes in technologies, as well as indirectly, through changes that take place in society due to digitalization. The essential notion behind this transformation can be reduced to the following argument: *Everything that can be automated, will be automated.* In the context of higher education, this will mean various changes with respect to technologies used for teaching and communication as well as how the teaching paradigm will evolve due to the increased variety of methods for teaching, in addition to the improved interaction with society outside of academia.

## **4.2 Democratization of Education**

On a societal level, one of the key changes caused by digitalization will be improved accessibility of university education. The concept of accessibility in the context of university studies already exists, but it traditionally refers to issues related to the physical environment, such as entering the university building with a wheelchair. However, in this study, we use the term *accessibility* to refer to all the physical and societal factors that specify which individuals have the chance to study at the uni-

versity level. This bears much similarity to *bioaccessibility*, a term meaning “the potential for a substance to interact with and be absorbed by an organism” [19]. In other words, not only the physical presence of a substance (be it a nutrient or a harmful substance) is needed in order for the plant to absorb it; other factors are also needed, such as the presence of water, for example. Although some may question this comparison, we feel the underlying notion is highly applicable.

Because information and university-level teaching and material will be available for a wider public than ever before, universities will no longer be the only places providing a high level of expertise. Online material will cause what can be seen as democratization of education. University knowledge will no longer be reachable for a very limited number of people, as it is today. As Bokor (2012) puts it: “Traditionally, universities held the key to knowledge, in both a physical and philosophical sense” [20]. As the number of sources for information and knowhow will increase, the role of university degrees can be expected to diminish. In some fields, such as medicine, universities will be protected by the need for certification for professional work. In many other fields, such as programming, the certificate will not be asked for by employers; having the skills and knowhow will suffice.

From the perspective of democratization of education, our list of accessibility factors shows how, in spite of improved access to teaching material, there will still be serious limitations for many people to enter higher education and to get a degree. Some level of prior education is always needed in order to be able to absorb university-level teaching. Additionally, university studies typically take several years, which is an investment in itself, even if no financial investments are required. The time required for studying is not equally available for everyone.

Need for university education or a degree is an important factor. The MIT OpenCourseWare project started in 2002, and today a lot of MIT course material is available online. However, this kind of material may not be what people in, say, third-world countries really have interest in, or need for, even though they can access it through the web. Most likely, the material is found useful by those already studying or having studied at another university and wanting to find complementary material, as already discussed in the previous section.

### **4.3 How Should Teaching Be Provided?**

Many see digitalization as a blessing for universities—this way the amount of routine work can be minimized and efforts can be saved for tasks that are more important. Such routine work includes traditional lecturing and, at least to some degree, revising assignments and exams. Many of our interviewees saw that digitalization holds great potential for improving teaching and learning results.

The Internet was seen as the key provider of a new kind of freedom to studies. Because lecture material can be provided online, students can choose the time and place for learning. At the same time, lecturers are freed from giving lectures with similar content, and it may be enough to update the material from the previous year. Similarly, there is a lot of potential for weeding out redundant and overlapping content—after all, many of the courses provided by one single university are provided by other universities as well.

Universities and societies that take advantage of the possibilities offered by digitalization will have a chance to thrive, but it will also be compelling to make changes, because even in this field, competition may become fierce. In order to endure, universities should become a platform for providing knowledge and skills. Learning is a natural process in humans; it occurs everywhere where humans are present. Despite being very natural, the process of learning is not fully understood. What we do know is that students bring with them all aspects of their lives—all of the joys and worries—and those all affect their learning.

Research by Paavola and Hakkarainen (2005) examines the relations between three metaphors of learning: monological, dialogical, and triological learning [21]. In essence, monological learning is a process in which the focus is on knowledge acquisition by individual learners, whereas dialogical learning focuses on participation through social interaction. Especially related to the notion of universities becoming a platform for knowledge is the third proposed metaphor of learning, the triological approach, which is a process of knowledge creation in which the focus is on “mediated processes where common objects of activity are developed collaboratively” [21]. It is characteristic for this triological approach that learning is examined in terms of creating social structures and collaborative processes that support knowledge advancement and innovation. The current way of learning in universities is mostly monological and dialogical, but the focus should move toward triological learning if we aim to tackle the challenges proposed by Sitra and the OECD, as discussed in Section 2 of this paper. Essentially, in triological learning, students do not merely acquire knowledge or create it in dialogue, but co-create triological objects with companies and public organizations.

Changes in technology will have an instrumental meaning for such learning. The Internet has already affected the settings of learning by enabling freedom in time and place of study. Its importance will only grow as technology becomes more prominent and methods of communication progress and enable, for example, efficient group work without group members being physically in the same location. Actual lecturing can be minimized, and contact teaching can be used to two-way communication, where specific questions by the students can be addressed. This could even be carried out in settings simulated by the industry.

Experience at the University of Eastern Finland shows that new technologies, together with a new way of thinking about teaching, can greatly improve the learning results of students. The teaching of electromagnetism has been renewed in a way that traditional lecturing is no longer provided. Students study the lecture materials online. Face-to-face meetings with the teacher are organized to help with specific problems and questions students might have. Also, group work is used. As a result, more time can be spent on coaching instead of lecturing. Because the university consists of three campuses far apart from one another, advanced distance communication technologies also are in active use, not only limiting the need for traveling, but also the need for overlapping courses being taught on different campuses.

#### **4.4 Personalized Learning and Automatic Teaching Assistants**

The traditional “same way of learning for everyone” appears to be something that technology could change relatively easily. Our social media feed is already customized, and e-commerce sites send us personalized offers. Why not also education?

Personalized learning appears especially necessary when online teaching is used. Whereas in class we get personalized tutoring at least to some extent, typical MOOC materials of today are the same for everyone. If a student “gets stuck,” online forums appear to be the best bet today, especially for massive courses in which instructors cannot help thousands of students with their individual needs. In the future, personalized help could come programmatically (e.g., editing of a study module/exercise), or through online mentors and/or other students.

In addition to personalizing study materials, personalization could be done on the study curriculum. Students could be able to construct freely a “learning map” containing what they want to learn, without fixed restrictions of a degree structure.

Personalized learning can offer significant advantages for teachers as well. A teacher can get feedback on what students are interested in and how effective their teaching materials are perceived to be. It appears likely that we will see better tools for teachers and study coordinators that will help them design future teaching in the best way possible.

One further possibility for supporting individuals could be in the form of an automatic teaching agent. Already today, it would technologically be possible to develop a system that would remind students to stick to a study schedule, ask students about what they have learned, and so on. In the longer term, such teaching assistants could learn further skills, for instance, asking about specific topics in the studied materials, or even teaching some parts of the material for individual students.

## 4.5 Remote and Automatic Assessment

In addition to teaching, universities have also adopted the role of assessing students. The question with digitization becomes whether we can make assessment better. For instance, in most current models, students need to walk to a physical classroom to take a paper-and-pencil exam that will be corrected by a teacher or a teaching assistant.

The first question that naturally rises is whether it would be possible to assess someone remotely. Some online platforms still hold in-person exams, but it appears to be a lucrative idea to see if a student could be assessed remotely. The issue of cheating is naturally a significant concern: how can we be sure that the person answering is the person taking the course, and also that nobody is helping the student? For instance, Coursera offers paid-for identity-verification services, which involve recording students' unique typing patterns.

The second interesting question is whether we could assess exams automatically. Multiple-choice questions can naturally be assessed automatically already, but also the assessment of more complex formats such as essays appears to be progressing; for instance, results in a machine learning competition<sup>1</sup> by Kaggle hint at the possibility that we could see automatic essay grading in the future, possibly starting with areas where a lot of data exists, for instance, with standardized tests.

It appears likely that we will see in the future more innovations for assessing students remotely and automatically.

## 4.6 What Should Be Taught at Future Universities?

Students who study at universities today will still be working 40 to 50 years from now. As it can be seen that the world around them will inevitably change a lot in those decades, it is essential to ask what kind of skills university teaching should be offering them. Which skills can they benefit from even in the remote, unknown future?

The very core of university teaching will not change radically. However, “knowledge” as a static set of things one remembers and masters will most likely not remain the same throughout a lifetime career. Therefore, it is even more vital than ever before to offer basic skills of thinking. Universities should teach the ability to think analytically, to look for information, and to solve problems. Developing these skills requires active rehearsing, and in this sense, universities

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<sup>1</sup> <https://www.kaggle.com/c/asap-aes>

do have a competitive advantage compared to providers of informal education or purely independent study. Being analytical, crafting sound arguments, solving problems, and so forth are all skills that need to be practiced; no one can learn them just by watching online material.

The importance of lifelong learning was recognized a long time ago, but its significance will only increase in the future, where rapid technological development will constantly require new learning. In fact, one of the goals of future university teaching can be seen as enabling students to develop a positive attitude toward continuous learning and constant change. Students should have the ability and the interest to keep on learning and to pick up new skills and competences a long time after they graduate and enter the working life.

The future work of, say, an engineer, will be very different from what it is today. To what extent such professionals will be needed compared to the current situation is debatable. Many of the tasks currently carried out by engineers will be automated. On the other hand, the work of an engineer has always changed over time; engineers no longer spend hours drawing on boards, but they are still busy with something else. Future engineers will have new kinds of interesting problems to tackle, and a similar development can be seen in many other fields as well.

#### **4.7 Drawbacks Caused by Digital Learning Technologies**

E-learning experiences will become commonplace due to the vast improvement of digital technology. However, surveys based on empirical data show the shortcomings of e-learning in cases where e-learning replaces conventional learning systems. There is no doubt that e-learning will cause an evolutionary change in learning systems. It provides accessible ways to deliver learning materials in organizations conducting education. However, the potential drawbacks, such as lack of peer-to-peer interactions and the need to invest on change management, are the challenges that an organization needs to carefully consider [22].

In the next paragraphs, we aim to summarize the negative perspectives and challenges of the technical implementations of e-learning systems.

##### **Drawback One: Significant Effects on Planning and Management.**

As suggested by research on the implementation of an e-learning system, the scheme requires an accurate design, monitoring, and control [23]. The educational materials archived in the digital system have to be transformed from traditional formats into digital file types according to the design and the construction of the system. The management of the materials, such as continuous updates and correction of errors, should be taken into account in the planning stage of



the system. The neglect of sustainable design for maintaining the ecosystem of e-learning will cause inevitable difficulties in the application phase.

Although many universities may hold their own individual implementations, the most beneficial way of working would be to have a system to exchange experiences in designing e-learning systems. The same approach may be applied in many similar circumstances. A sustainable approach to e-learning or a sustainable e-learning system has been widely discussed because researchers have noticed that there is an immediate need to create a culture or an environment that provides reusable models for other organizations interested in developing an e-learning system [24].

If we look at the short history of various e-learning systems developed in past 10 years, community-driven e-learning platforms such as Moodle are actively publishing new versions. However, the dotLRN platform, which is granted the highest mark in the usability research [25], released its newest version in 2010 seems to have stopped updating.

It is sure that the postponed development has resulted from various reasons, but we could see the significant effects on planning and managing e-learning platforms. Research suggests that universities are aware of the importance of providing e-learning systems and digital teaching material, but that universities are not paying enough attention to how ICT solutions should be implemented [26].

The lack of care during the development of an e-learning system may lead to negative effects. For example, learning management systems (LMSs) are widely used in universities to provide supplements to traditional education. Most universities follow the new trend, but they neglect the attitudes of teachers and students toward its usefulness [27].

The complexity of designing and planning an e-learning system to fulfill users' needs is the major issue that universities have to deal with. There are several possible approaches, such as studying the factors that influence adoption of e-learning through interviews and questionnaires. Existing studies suggest that it is important to (1) provide enough technical support and reliable infrastructure, (2) encourage teachers to try e-learning by having positive first-hand experience, and (3) let students develop and set clear expectations (see [27], [28]).

Nevertheless, many universities still struggle with the very early planning stages and with finding resources for managing the e-learning system. A drawback of e-learning implementation is that there are no simple rules for designing an effective e-learning system.

The effort required in planning and managing the system is one of the drawbacks of e-learning when it's implemented with limited resources and relatively weak ecology. It is an issue that universities need to actively solve or students and

teachers need to passively adapt to. On the other hand, if we compare e-learning with traditional education practices, the pedagogic considerations should be taken into account.

**Drawback Two: The Frustration Due to the Lack of Interaction.** E-learning models are basically a replication of traditional learning models but with the integration of digital technologies. Whereas the first e-learning models emphasized the role of technology in providing content delivery and electronic services, more recent models focus on pedagogical issues such as online instructional design and the creation of online learning communities.

A number of studies show that technology may be confusing or frustrating to students even if they have prior experience with using digital technologies. This is due to lack of informal social interactions [22], [23]. The educational interaction—or, at its heart, the communication between teachers and learners—has not been influenced by the advance in technologies in the same way as other social interactions in our society [29].

Many believe that education is not about giving access to more information, but giving students the abilities to construct knowledge from data. Researchers prompting e-learning believe that technology could provide the capacity to facilitate communication and result in qualitative enhanced outcomes beyond the access to information. The technological support of the development of knowledge structures is the positive impact that e-learning may generate [29].

However, according to existing research results, potential users of e-learning systems (i.e., the teachers and the learners) do not all have high expectations and are not all enthusiastic regarding e-learning. Researchers believe that e-learning could improve the quality of communication, but students see e-learning even as a distraction [28]. Teachers also do not see communication in the e-learning system, such as online discussion and online collaboration, as the most value-added aspect (see [27]).

**Drawback Three: Online Education as a Fraud.** It seems there is no way to directly link the growth of online education to an increase in online cheating. But more online classes will mean more online students, which will mean more potential customers for cheating providers. According to the 2014 Online Learning Survey, roughly a third of all higher education enrollments in the United States are now online, with almost 7 million students taking at least one online class. Online education is already poised to be a \$100 billion global industry. It seems that the entrepreneurs and freelancers openly advertise services designed to help students cheat in their online education studies. Those digital cheaters being hired will even assume a student's identity and take a whole entire class online.

Because the market is huge, there are also institutions taking advantage of it.

For instance, Knightsbridge University, founded in Denmark in 1991, is one of the institutions sometimes connected with unclear degrees. The university provides distance learning to some private customers globally, but is not officially recognized as an educational institution in Denmark since 1991. Numerous cases have been reported that involve the use of Knightsbridge University degrees [30]. In fact, it has been registered as a limited company since 2003 and has been accused of being a “diploma mill,” an organization offering illegitimate academic degrees for a fee.

## 5 Conclusions

In this highly conceptual and inspirational paper, we have sought to illuminate some of the problems of current higher education and rethink the age-old paradigm of universities. The motivation for this research has been in the publicly noted crisis concerning education in its current state and its inability to meet the demands of the labor market. In this paper, we have argued for the necessity of a paradigm shift in learning, that is, a change in the way university education and learning are perceived and carried out. One of the foundational premises of our paper concerns the creation of learning ecosystems by reorganizing universities, students, and industry. In doing so, the current unidirectional flow of information and knowledge could be developed toward an educational ecosystem where multiple parties collaborate on real issues in real or simulated contexts. Such an approach, however, relies heavily on advanced digital technologies. These unconventional ideas were discussed with some of the leading experts in academia and refined into conceptual propositions. Although the approach suggested in this paper has its benefits, it also carries with it some challenges that need to be considered, such as ensuring informal social interaction.

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# *The Digital Health Society: Perspectives on Real, Predictive, and Preventive Care*

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**ABSTRACT:** *In the near future, we will rely more on computers than humans to provide health diagnoses. Computers will help us improve our health and find cures for disease we are suffering. We foresee a future in which the ubiquity of sensors and data related to your health as well as life habits will be stored, centralized, and compared, enabling the accurate prediction of the evolution of your health. To analyze this future, we look at the challenges and enablers in the digitalization of health-care delivery. Traditional health-care delivery is based on regular health-care checks and corrective actions based on physician opinion. This paradigm is changing; patients are proactive users of their health-related information. We envision how and why machines will take control over medical decisions. Health-care delivery will become largely predictive and preventive, transforming societal institutions toward the digital health society.*

**KEYWORDS:** *Digitalization, health care, Big Data analytics, smart technologies, predictive and preventive healthcare*

# 1 Introduction

In the era of digital transformation, the health-care sector as a fundamental part of the society still remains largely unaffected by this change. Essentially, this sector has seen comparatively little change despite the proliferation of connected devices, availability of data, online platforms, and digital businesses. In addition, the low productivity and space for improvement of health-care services has received great attention in the literature [1]. Therefore, there is great potential for digital technologies to play a significant role in enhancing the efficiency of these essential services of a welfare state.

On the one hand, due to the profound changes in the population structure, most countries will need to execute changes in their health-care systems in the coming decades. Current prediction models estimate that population growth is coming to a saturation point; currently the world's population is estimated to be 7.5 billion, and in 20 years this number will reach 9 billion. If global trends in population growth are stable, the world's population may exceed 10 billion people before 2100 [2]. Meanwhile, the survival rates of heart disease, stroke, and cancer are all increasing, having an immediate impact on the increase in life expectancy [3], and decreasing mortality at more advanced ages has also become an important driver of population aging. As a consequence, it is predicted that health-care expenses will increase in order to be able to maintain the current standards of living [4].

On the other hand, smartphones, smart wearables, and smart homes are some of the main precursors of digital health-care services that will have a positive impact on the quality of health care and its economic sustainability [5]. Considering the growing number of start-ups in the health-care sector and the large investments in research and development, health-delivery processes will be drastically altered in the near future. The always-on activity tracking and the analysis of sleep, nutrition, exercise, and mental health provide ample opportunities for new value creation and the reduction of health-care costs [6]. Potentially, this new wave of digital medical solutions could predict diseases before symptoms develop by mining the historical health data and tracing patterns. Despite the growing amount of literature on digital health, public organizations and companies are struggling to understand how this new wave of technologies benefits health-care users as well as providers. As Andrew Cope, the head of Korea at Nokia Networks, commented to the Bit Bang class in regard to digital health: "What can we do that is real, predictive, and preventive care?"

Furthermore, a critical question still remains unanswered, who will be the party conducting the predictive assessment? In this regard, much of the current literature seems to adopt an institutional view where the "health-care system" as such stores and owns the data, rendering information easily accessible for

anyone requiring it, whereas privately owned platforms have access to the data and are challenging the established rules on the game.

Nevertheless, all experts argue that preventive and predictive care are welcomed because they can potentially provide more accurate health solutions but also potentially incur less costs over the long term, thus rendering it less expensive in comparison. Of considerable interest is, however, the societal impact of such a change toward preventive and predictive care. This would essentially influence the power relations between individuals and institutions. If preventive and predictive care become the norm, could we run the risk of individuals losing control over their own health because it would be managed by, for example, the national health-care institution? What would the implications be? A key element of this new trend is that patients are claiming ownership over their own health. Whereas traditional health-care delivery is based on physician-controlled tests and treatments, an increasing number of health-care users want to make decisions on how health care is provided to them. This has created a growing business opportunity for private companies offering various kinds of medical services as well as related devices.

Highlighting the fundamental role of the data collection in offering various health services, smart devices capture incredibly sensitive human data that can be used in the design of health-care delivery for the future. As presented in Chan et al. (2012), “Everything we say, do, or even feel, could be digitized, stored, and retrieved anytime later. Smart devices have the alleged ability to create a Big Brother society in which every individual activity is memorized and smart devices attempt to anticipate human thought” [5].

Having discussed the dimensions through which we look at digital health, we investigate the implications of digitalization on *real*, *predictive*, and *preventive health care*. We discuss the role of digitalization of health care and modernization of health-care systems, and we present the challenges and enablers in digitalization. The research questions that we address in this research can be summarized as follows:

**Q1:** How will the distribution of health-care services shift from highly relying on real care toward predictive and preventive care?

**Q2:** What are the main challenges and enablers for the shift toward health-care digitalization?

We begin by investigating the impact of technology in health-care systems during the past 100 years. Then we generalize the trend to the near future and create our main argument. In Section 2, we define the terms real, preventive, and predictive health care. In Section 3, we discuss the main enablers and challenge of health-care digitalization. In Section 4, we continue by presenting scenarios of how digitalization could potentially change the fundamental delivery of health care, based on expert opinion and our vision. Finally, Section 5 concludes.

## 1.1 The Impact of Technology in Health-Care Systems

To highlight the critical role of technology in the development and improvement of health-care treatments, Figure 1 depicts some of the important breakthroughs in this arena. For example, the discovery of vaccination in 1769 for smallpox can be considered as one of the prominent treatments in improving human health. About a century later in 1859, we can see the emergence of medical imaging with the introduction of the X-ray.

Passing through time, as shown in Figure 1, there is evidence of technology empowering the health-care services. By the late 20th century and the beginning of the 21st century, significant progress had been made. The accumulation of these developments in recent decades illustrates the role of digitalization in introducing new trends in health care. For example, consider initial movements in three-dimensional (3D) bioprinting in 2006 or the IBM Watson machine in 2015; both of these technologies would affect the health-care sector dramatically. As a result, there is a need to understand the various perceptions of digitalization that will enhance health-care services for better human welfare and how digitalization will continue to push the frontiers of the current health industry.

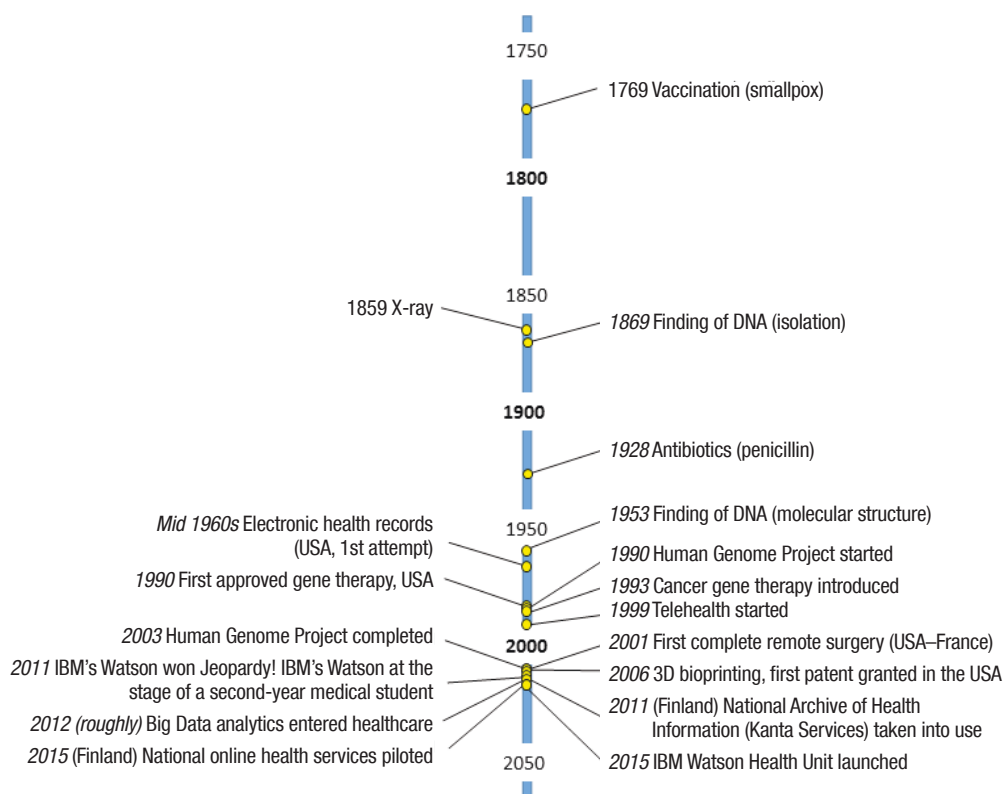


Fig. 1. Timeline for some of the major developments in health care.






Having showed the timeline of development in health care, the next subsection elaborates on the changes in health treatment in different periods of time.

## 1.2 The Past, Present, and Future of Health Care

Physicians have traditionally enjoyed an authoritarian status in matters concerning health, whereas patients act merely as objects of study. The provided care has largely been reactive in nature, aiming only to cure the patient. In many respects, the health-care model has seen comparatively little change despite the proliferation of connected devices, online platforms, and digital businesses. However, the modern approach differs from the past in regard to the patient’s role. Unlike in the past, modern patients seek information by themselves and may even be regarded as knowledgeable sources by physicians. Moreover, many patients adopt a more active role in measuring and tracking their health with various wearables in order to predict future scenarios. Despite this, however, few health-care providers are willing or equipped to take advantage of these data. The prediction is that in the future, patients are seen as co-creators of their well-being with the help of ubiquitous sensory data from wearables. Provided care is geared toward preventive and predictive care, relying heavily on patient data-sharing among multiple stakeholders. Table 1 summarizes the distinct characteristics of the past, present, and future of health care.

*Table 1. Distinct characteristics of the past, present, and of future health care*

 <p>Created by Orank Pal Gaudin from Noun Project</p> <p><b>Past</b></p>	<ul style="list-style-type: none"> <li>• Patient is seen as an object of study.</li> <li>• Physician is the authority who knows how to measure, analyze, and diagnose.</li> <li>• Provided care is real.</li> </ul>
 <p>Created by Thomas Helbig from Noun Project</p> <p><b>Present</b></p>	<ul style="list-style-type: none"> <li>• Patients are seen as knowledgeable sources who seek information on their own.</li> <li>• Smart technologies exist and produce data, but the data remain in isolation.</li> <li>• Provided care is mostly real and preventive.</li> </ul>
 <p>Created by Creative Real from Noun Project</p> <p><b>Future</b></p>	<ul style="list-style-type: none"> <li>• Patients are seen as co-creators of their well-being.</li> <li>• Ubiquitous sensory data acquisition from smart technologies.</li> <li>• Data are shared by multiple stakeholders and acted upon.</li> <li>• Provided care is real, preventive, and predictive</li> </ul>

This ability to render individual activity accessible through digitization also translates into improved contextual understanding that can be used for advancing our well-being in an unobtrusive and sensitive manner. In fact, research has acknowledged the importance of individual customer insights in creating value in the form of services [7] [8]. Such high-context sensitivity emphasizes the need for gaining deep, personal, and even highly tacit insights about the interactions in order for value creation to ensue [9]. If the future health-care system is considered a system providing real, predictive, and preventive care, high contextual understanding of the users is a necessity. Research has further identified that a platform approach enabling social connectivity may be used to promote the context sensitivity required in digital health applications [6].

Smedlund (2016) studied digital health platforms, and his research introduces key empirical findings regarding motives for participation in such a health platform [10]. According to the study, companies were motivated by pools of health and fitness data to improve their products, the simplified user experience of platforms, and the reduced development costs. Platforms were considered lucrative because they enable various parties to easily share and act upon the data. In some cases, companies sought partnership benefits, such as marketing value or in-depth relationships with global platform owners. A global platform was considered interesting due to the potentially large international user base. Interestingly, companies agreed on the importance of predictive health care and the value that a platform approach could provide but were hesitant to move toward that goal “because of the difficulties in connecting with the highly regulated industry that is not open to innovation” [10].

Following this discussion on the trends of health-care treatment throughout time, the next section briefly explains the concepts of real, preventive, and predictive health care.

## **2 Definitions of Real, Preventive, and Predictive Health Care**

*Real-time health care* can be defined as consisting of various health-care services offered by both public and private health-care sectors that advance a person’s well-being in his or her everyday life. The services cover all health-care professionals, from physicians and nurses to physiotherapists and dieticians. By definition, real-time health care is used by persons who have already fallen ill and need the help of a health-care professional.

It is evident that real-time health care is the most expensive form of health-

care services. In Nordic welfare states, the costs of the public health-care services are mainly covered by tax revenues, and in practice the services are open to everybody. In parallel to the state-financed system, there is also an extensive network of private clinics that offer some of the same services.

According to the Oxford online dictionary, *preventive health care* is “A medicine or other treatment designed to prevent disease or ill health.” Although there is a growing body of literature that recognizes the importance of preventive health care from various standpoints, understanding the traditional preventive health care can be valuable for enriching this concept for future growth and development. Over the past years, preventive health care mostly has focused on developing protocols and defining the periodicity of health checks for different segments of the population (i.e., gender differences from childhood to elderly people). This method allows for the storage of historical data on: (1) immunizations, physical exams, lab tests, and prescriptions; (2) measurements, growth (e.g., length, weight, and height), and sensory screening (e.g., vision, hearing); (3) developmental and behavioral assessment; (4) physical examinations; and (5) nutritional behaviors.

Yet, recognizing the logic underlying preventive health care is the key to the development of immune and new health-care systems for the future. This can benefit individuals through the provision of more efficient and accurate treatments while simultaneously helping to reduce the high operating and service costs of this sector for the government. The problem with the current way of visiting physicians and hospitals is that people are mostly aware of their medical problems when they clearly feel pain, see injured parts, or have some type of physical issue. Furthermore, it is an inescapable fact that in some cases, physicians may not be able to recognize the problem at an early stage, and therefore misdiagnosis may occur, leading to irreversible harm to patients.

Predictive analytics is the use of current and historical data in statistical methods, such as machine learning and data mining, in order to make predictions about future or unknown events [11]. Considering the health-care scenario, *predictive health care* refers to the prediction of individual health status based on health data, mostly recorded from the preventive health care of the individual and all other people [12].

To give an example of the predictive analytics in health care, we can think of a regression problem. In this case, given the health history and profile of several patients and their responses to a certain drug, the goal is to predict the drug response of a new patient (Figure 2).

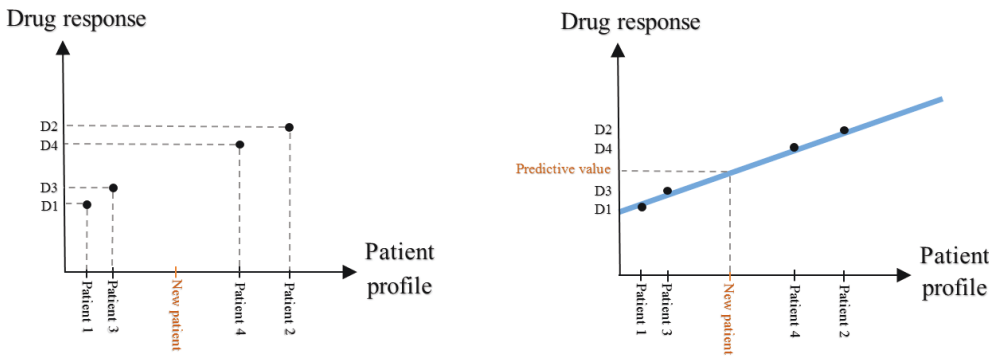


Fig. 2. An example of predictive healthcare.

**Example:** Suppose a hospital has recorded the medical history of four cancer patients. For one specific drug, the hospital has monitored the drug response for each patient. This information is shown in Figure 2 (left). The horizontal axis represents the patient’s medical profile. Those with similar profiles are close to each other on the axis (e.g., the medical profiles of patient 1 and 3 are very similar). The vertical axis denotes the drug response for each patient. For a new patient the hospital has gathered the medical profile; however, this patient has not tested the mentioned drug yet. Here the aim is to predict the drug response for the new patient given the information for these four patients. The graphic on the right in figure 2 presents a simple solution for the problem. The simplest approach is to learn a function (the blue line in the figure) that can map the patient profiles to the drug response. Afterward, the profile of the new patient can be used as an input to the function in order to obtain the predicted drug response.

Predictive analytics is not a new field, and the science and algorithms have been around for several decades. However, there are two main reasons why they have currently become very important: the availability of data and the arrival of smart technologies (see Section 3.2 and 3.3).

### 3 Challenges and Enablers Toward Health-Care Digitalization

Based on our review of the field and research on different trends in digitization, in this section we introduce some of the main subjects that will significantly influence the future of the health-care sector.

#### 3.1 Demographic Issues

Countries have difficulties in balancing the economics of their health-care systems

and being able to maintain basic medical services to all segments of the society. Issues such as the definition of an optimal retirement age and the development of liberal, public, or mixed health-care societal models are constantly being debated. Experts argue that already by the 2020s the health-care delivery system in Western countries will be fully digitized [13]. What sort of challenges lie ahead?

One of the most influential factors affecting the long-term sustainability of health-care systems concerns the dramatic change of the demographic pyramid [14]. During the last century, developed countries have experienced progressive change on how the working-age population has postponed or completely abandoned the creation of families due to changes in living habits as well as the effect of industrialization. To make matters more complicated, life expectancy has increased steadily over the years as well. Long-term care and welfare systems need to respond to these concerns as effectively as possible [15].

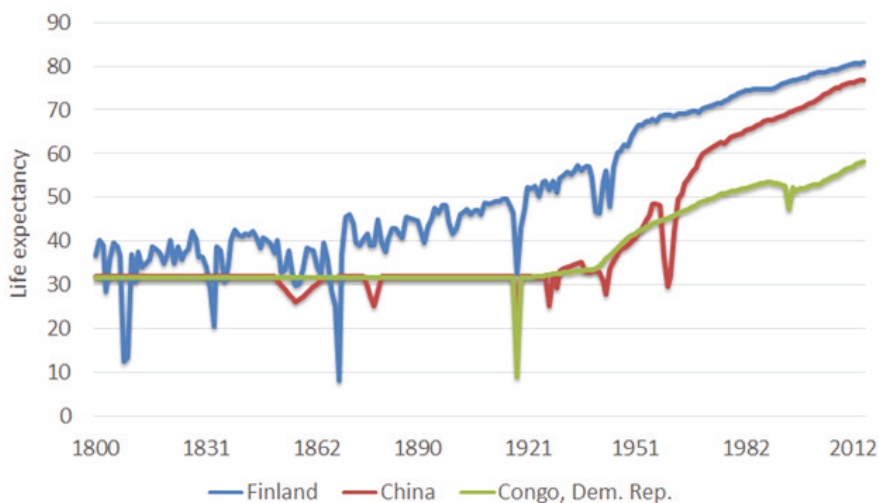


Fig. 3. Life expectancy comparison between Finland, China, and the Democratic Republic of the Congo (<http://www.gapminder.org>).

Trends in life expectancy and the fertility rate in Finland, China, and the Democratic Republic of the Congo are depicted in Figure 3 and Figure 4 respectively. As a representative example of the historical evolution of these two trends, in 1900 the average life expectancy in Finland was 43 years and the total fertility rate was 4.8 children per woman. The 2015 life expectancy in Finland was 81 years, and families had an average of 1.8 children per woman. The trend is similar in China. In 1900 the life expectancy was 33 years and the fertility rate was 5.5 children per woman. Today life expectancy in China is 77 years, almost at the level of Western societies, and fertility rates are at a similar level of 1.6

children per woman. Conversely, some of the African countries, for example, the Democratic Republic of the Congo, show cases of extreme poverty. In the Congo, life expectancy in 1900 was 31.6 years, and the fertility rate was 5.99 children per woman. Currently, life expectancy in the Congo has increased to 58.3 years, with fertility rates of 5.72 children per woman.

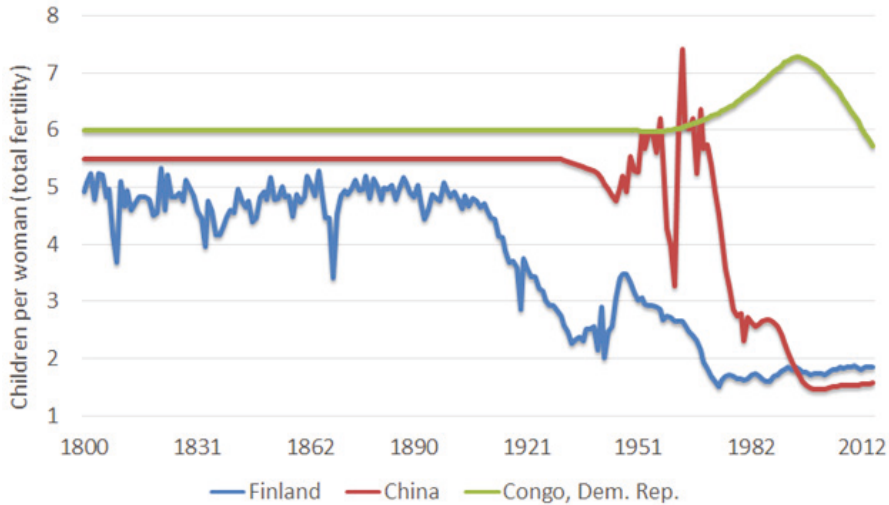


Fig. 4. Children per woman comparison, Finland, China, and the Democratic Republic of the Congo (<http://www.gapminder.org>).

Although trends differ among countries, the reality is that nearly all developed countries are aging as a result of low fertility, existing immigration policies, and longer lives. Historically, society’s progressive industrialization has had a positive impact on the creation of basic sanitation and health-care services. The development and implementation of human rights go hand in hand with urbanization. Scientific and technological developments have also helped create what we today understand as basic health-care delivery.

Future trends in morbidity (i.e., the incidence or prevalence rate of injuries and chronic diseases, such as cancer, fractured hips, strokes, dementia) and disability rates will be crucial determinants of societies’ abilities to meet the challenges of population aging [4]. The long-term projections of the Economic Policy Committee and the European Commission show that the pension, health, and long-term care costs linked to the aging population will lead to increases in public spending. Public spending on long-term care is also expected to increase substantially; it is projected to increase from 1.2% to 2.3% of gross domestic product (GDP) in the European countries between 2007 and 2060 [15]. As a consequence, the impact of this demographic prediction on the welfare state is a high-priority topic on the European policy agenda [14].

During the coming decades the profound changes in the population structure will force all countries to prepare and execute new ways of operating their health-care systems. In addition, the financial-crisis-induced austerity measures, such as restrictions on increases in health-care spending have had negative effects, especially for certain population groups [16]. What is even less encouraging is the equity gap among wealthy and less wealthy countries as well as the stratification of the society, dividing it into groups of wealthy people who have access to high-quality health-care services and into middle- and lower-class working groups that have difficulties in accessing the same services [17]. Figure 5 shows the effect of the GDP per capita on child mortality with a comparison of Finland, China, and the Democratic Republic of the Congo, which has the lowest GDP per capita on a global scale. To portray the difference between developed and underdeveloped countries, the x-axis in Figure 5 is in logarithmic scale.

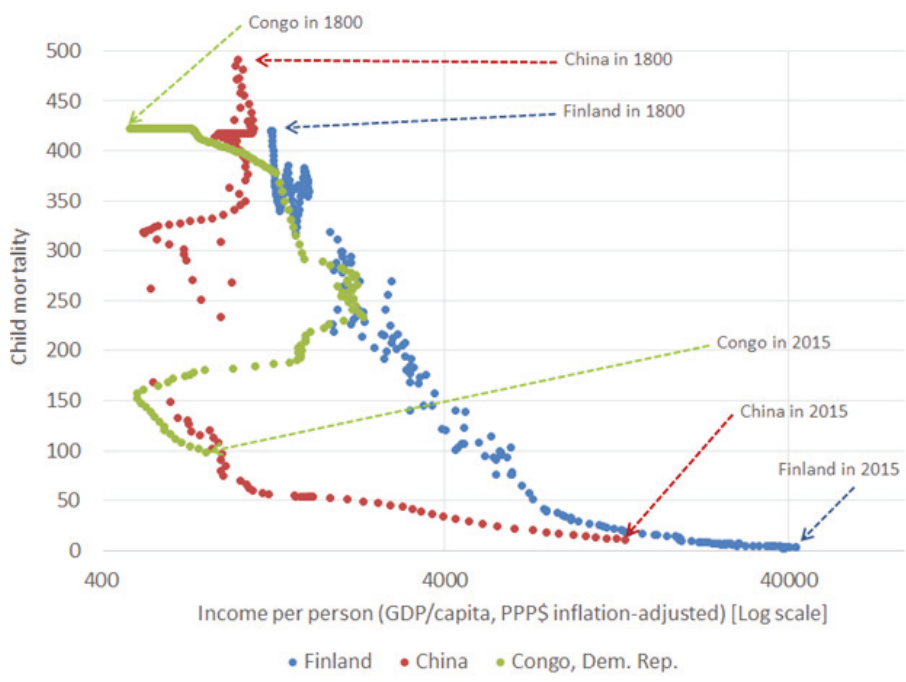


Fig. 5. Child mortality as a function of the GDP per capita, purchasing power parity adjusted (PPP\$)—a comparison between Finland, China, and the Democratic Republic of the Congo (<http://www.gapminder.org>)

The reason for such polarization in developed versus developing countries is grounded in the demographic challenge of an aging society, which is dramatically stressing the economic sustainability of existing health-care systems. The level of industrialization of different countries has an impact on the GDP per capita,

and therefore on the quality of healthcare provided to the population. A dramatic example of this is the Democratic Republic of the Congo, a country lacking in industrial infrastructure but extremely rich in natural resources, which have been exploited and corrupted for centuries due to commercial and colonial extraction.

EU countries have difficulties in balancing the economics of the health-care system, being able to maintain a welfare state at the same time, and providing basic medical services to all segments of the society. The truth is that national policies have not been able to develop an optimal system, and there are practical differences in terms of services provided to low- and middle-class groups and those that just a selected group of the population can access.

In this scenario, experts discuss the enormous potential for a new wave of digital technologies (e.g., electronic health records, remote patient monitoring, wearable sensing technologies, Big Data analytics, artificial intelligence, activity trackers, etc.) to improve many aspects of health-care systems in terms of productivity and patient health as well as economics of social care provision [18].

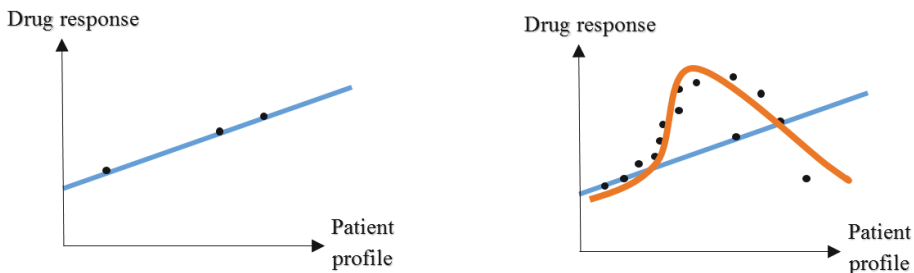
### **3.2 Big Data in Health Care**

The health-care sector has confronted big changes due to digitalization. Most of them are not clearly visible to ordinary patients, but the work of health-care professionals has changed tremendously during past years, and it will continue to do so as digitalization advances. One of the biggest improvements has been the digitization of data. According to the University of Iowa, Carver College of Medicine, the availability of medical data will double every 73 days by 2020. Other than the vast amount of data recorded in each hospital and health center in a digital or nondigital format, a big portion of data comes from the huge variety of health detector sensors, mobile phones, and wearables (see Section 3.3). The main question is, why are these data important, and how will such data change the health-care sector as we know it?

The first and biggest impact of data is in predictive health care. The accuracy of prediction methods directly depends on the size and quality of the data received. In other words, a machine can make good predictions if and only if it has a good understanding of the past and current states. In the example mentioned in Section 2, Figure 2, it can be inferred that by having more data about more patients, the system would be able to learn better models, which would increase the prediction accuracy. In that example, now assume that instead of having only the patient profiles of three subjects, the hospital has gathered the data for a large number of patients. The visualization of these data is shown in Figure 6 (right). It is evident from the figure that by having more and more data, the machine can



learn a better model to fit the data and consequently make better predictions about the drug response for new patients.



*Fig. 6. Prediction of drug response based on patient profiles. (Left) Only the medical profiles of few patients and their corresponding drug responses are available. (Right) With more data, the machine can learn more complex models (orange curve).*

As an example of how data are being used in practice, there are currently some initiatives in Finland that aim to unify separate patient record systems under one database and user interface. One of them, the National Archive of Health Information [19], has already been introduced to the public and partly adopted. Kanta Services includes electronic prescription, pharmaceutical database, patient data repository and My Health pages, and it is meant for use by health-care professionals, pharmacies, and citizens themselves. Other initiatives include the Una project, which seeks to define requirement specifications for a new health-care data system needed due to the ongoing Finnish health-care and social reform (“Sote”) [20].

Another direct use of data is in self-service health care (e.g., home monitoring of blood pressure or sugar level). Self-service health care in Finland is currently taking its first steps. The national Oda project (Omahoito ja digitaaliset arvo-palvelut, “Self-Care and Digital Value Services”) is developing online services that can, for example, define the illness by symptoms, estimate whether or not there is a need to go to a physician, and find out if there is any recommended self-treatment. The services have access to the patient health records in the national health record database, so the given answers are tailored for each patient personally. The online services have been piloted in the city of Hämeenlinna, where the procedure has been defined so that the patient gets an answer from a physician or nurse within three hours during the opening hours of the health center if the online system notices that there is a need for a professional opinion [21] [22].

Emphasizing the role of connectivity for collecting patient health data, increased popularity and easy access to Internet on a world scale can improve the current state of patients’ treatment and cure significantly. Table 2 illustrates

the top 12 countries from Europe and North America with a high rate of access to Internet and their health expenditure per capita (note that countries with a population of more than 1 million are selected). Even though we believe the benefits of Internet for the health-care sector are endless, the health expenditures among the listed countries in Table 2 are very high compared with most of the countries with less access to the Internet. Although it is clear that the living standards in these countries are improved over time and therefore this results in high health expenditures, we think deployment of the Internet can decrease the costs of health care dramatically while sustaining and/or improving the current standards.

*Table 2. Internet usage rate and health expenditure (from the World Data Bank and World Health Organization).*

	Country	Internet users per 100 people, 2014	Health expenditure per capita (current US\$), 2013
1	Norway	96	9715
2	Denmark	96	5680
3	Netherlands	93	6270
4	Sweden	92	6145
5	Finland	92	4449
6	United Kingdom	92	3598
7	Switzerland	87	9276
8	Canada	87	5718
9	United States	87	9146
10	Germany	86	5006
11	Belgium	85	5093
12	Australia	85	6110

As a notable example from Table 2, the United States, with \$9,146 in expenditures per capita in 2013, ranks third in health expenditures, after Norway and Switzerland, among the 12 countries. With 87 out of 100 people having access to the Internet and with several well-established information technology and communication device companies existing in the United States, this begs the question: is the United States effectively using these technologies for improving health-care solutions and decreasing the expenditures? Yet, despite all the attention that different successful best practices, such as in online retail stores (e.g., Amazon) and the entertainment industry (e.g., Netflix), have devoted to value

creation for their customers through the Internet, the health-care sector is not benefitting society as it should. However, in light of recent developments such as smartphone applications and smart wearables, there is a growing trend toward collecting and storing the data associated with the health states of individuals.

### 3.3 Smart Technologies

There are two main reasons the smart technologies will be one of the most important enablers of the digitalized health-care sector. First, everyone has or will have at least one smart device that has its own set of sensors and actuators. This device can be a smartphone, smart wear [23], a smart chip inside the body, or any other kind of futuristic sensor. In other words, there will be a way to monitor everyone. If we only consider the bright side, this means that it will be possible to monitor the health status of all humans in the world. Second, access to the Internet is a widespread phenomenon, and in theory it is possible to connect all smart devices together via the Internet. It may sound unbelievable that in only 15 years, the percentage of Internet users in the world has increased from 6.8% of the world population (414,794,957 people) in 2000 to 43.4% (3,185,996,155) in 2015.<sup>1</sup> What these numbers indicate is that by creating good infrastructures and regulations, it is possible to integrate all the generated data and use the data in real, preventive, and predictive health care.

Other fields of technology, such as robotics, have also contributed to health-care digitalization. For example, several surgeons can participate in the same operation from different locations with the help of video cameras, robot arms, and other technology. This kind of cooperation can be a life-saver for seriously ill or injured patients, and it also saves the time of surgeons because they do not need to travel to another hospital for the operation. When physicians are able to work in one location, because the digital technology brings the patients to them no matter where they are, the saved time and effort can be used for other patients. Collaboration among the physicians can also spread the word of new methods and practices and in that way keep up the physicians' expertise.

Another example is the smart screen, which can contribute in the change of health operating systems. In South Korea, the Bit Bang group visited the LG+ center for the Internet of Things for home appliances. One of the appliances was a normal-looking mirror that actually had an extremely small camera embedded in it. The mirror contained an application that analyzed the face of the person looking at it, and it was capable of telling the person about his skin features and

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<sup>1</sup> <http://www.internetlivestats.com/>.

mental mood. Although the things that the mirror revealed appeared not meaningful but mainly funny at the time, it seems that soon a human will experience similar screens that can play the role of an advisor or consultant. In another words, referring to a recently published book entitled *The Smarter Screen* by Benartzi and Lehrer (2015), sitting in front of computers for long hours can be considered as a great opportunity to provide applications that can support and monitor human health status [24]. It is not far behind the reality where, for example, your computer can start to tell you about the impact of visited websites or of the text you just read on your mental mood, blood pressure, or consumed energy. As a result, health-care systems can reap the benefits of digitalization to enhance the effectiveness of preventive and predictive health support.

In recent years, the health-care sector has experienced different types of technology breakthroughs for delivering high-quality care services while reducing the costs. One of the newest actions has been triggered by a joint collaboration of Apple and IBM for the support of the Japanese elderly. As is discussed by Herper (2015) [25], in this project, Apple is going to provide iPads, IBM will design software applications with the help of its Watson artificial intelligence machine, and the Japan Post will supply the data associated with the Japanese elderly population. Then the Japan Post will teach its elderly customers how to use the iPad and its health-related applications. In the future, health-related technologies, such as wearables, could be used for illness prevention [23].

### **3.4 Challenging the “Status Quo”**

Other than the mentioned three challenges/enablers, there are still several important subjects that require careful attention in the road to health-care digitalization. In this section, we briefly discuss some of them.

From a societal perspective, there are several different challenges in providing digitalized health care. On the one side there is the state legislation of services, much of it statutory, concerning the entire health-care sector. New digitalized health-care solutions may require new legislation due to patient security, responsibilities, patient data handling, and so on. It is a known fact that the legislation process in the Western societies, including Finland, is slow. The challenge in providing digitalized health care for the state and the legislation is to keep up with the pace of the new digitalized health-care solutions.

On the other side there is the human perspective, consisting of both the patients and the health-care professionals. The reaction of the patients is one of the biggest concerns in the health-care digitalization. A computer system diagnosing a patient itself without an intervention of a human may feel odd and even scary

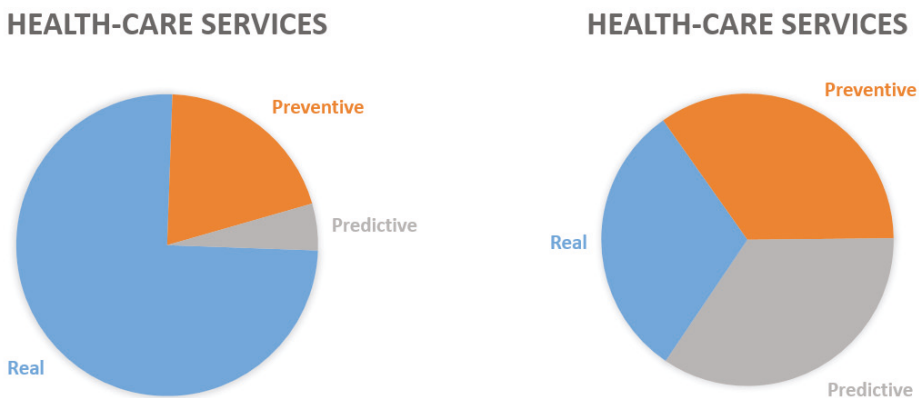
at first, but if thinking of how things are developing in Western society, more and more services are turning into self-services. Thus, people, especially the younger “digi-native” generations, are becoming used to communicating with all sorts of self-service machines. As an example, a computer replacing a physician in a routine flu diagnosis does not differ that much from computer-based passport control at country borders. Smartphone applications that can perform different types of measurements of a human body already exist, and it is anticipated that all sorts of self-diagnosis tools will be available soon. Many people belonging to older generations are against or afraid of the modern technology. Therefore, a more important question than whether patients are willing to use the digitalized health-care services is actually whether patients are able to use the services efficiently. Usability is crucial, yet challenging.

To give an example of deployment challenges that new technologies may face, we repeat the story that Lars Kåhre, the founder and CEO of Futudent, told to a Bit Bang class (spring 2016). Futudent has implemented a solution for dentists who want to film operations for, for example, archiving or patient education purposes, but according to Kåhre, many physicians are actually afraid of filming themselves working due to possible mistakes. Human nature leads to a tendency for us to hide our errors, and due to public criticism, a professional such as a dentist or physician is greatly affected by wrong decisions or bad work. Using technology that makes the everyday work of such professionals more transparent may scare many. Taking this a step further, what happens if a computer physician makes a mistake? A wrong diagnosis or a missing diagnosis can in the worst case be lethal. Human physicians make mistakes too, but they are responsible for their deeds themselves. Who is responsible for the computer? Is it the hospital or health center, and if so, the organization as a whole or a specific individual? Or is it the city or commune or state? What is the role of the manufacturer and software designer?

One essential part of the digitalized health care is personalization. As devices and services for collecting and analyzing health data evolve, personalization of the treatments and medication will become more and more common and eventually an everyday practice. Personalized health care will also include patient monitoring, either at a hospital or at home, so that a physician can see if the prescribed medicines have the desired effect or whether the medication needs adjustment. The objective of personalized health care is to make the patient treatment more efficient by finding the best treatment and medication for each patient individually, and more cost-effective by reducing the amount of trial-and-error treatments.

## 4 Unfolding Digital Health-Care Delivery

As mentioned earlier, current health-care delivery is mostly based on physician expert opinion and real and preventive measures to diagnose and help to find an answer to patient needs. In Figure 7 we estimate the following distribution, 75 percent of the health-care measurements are delivered in real time by case scenarios; preventive measures (e.g., vaccination) are also provided hand in hand in this current model, whereas predictive systems are not fully developed and start to emerge.



*Fig. 7. Health-care services now (left) and our vision of the future (right).*

Looking at the evolution of the technology for assisting the health-care preventive system (i.e., sensor ubiquity and exponential growth of health-related data), we envision that future health-care delivery will be more balanced. Predictive systems will be used together with preventive measures, and the need for real-time assistance will decrease substantially. Robotics, artificial intelligence, and other technologies are here to stay as an inseparable part of the medical innovations. As the other areas of science that have a close relationship with medical science (e.g., computer science, physics, chemistry, and psychology), keep developing, it is likely that we will see big or even revolutionary innovations in the area of medical science in the near future.

One of the foreseeable things is a new way to cure people from fatal diseases by replacing a damaged or malfunctioning organ with a new one, specifically tailored to and 3D printed for the patient. 3D bioprinting is currently an active and ongoing research area, and the results have already been promising [26]. The amount of detailed personal data collected from individuals is growing all the time, providing

an opportunity for extremely personalized health care such as the bioprinting of new organs. Taken to the extreme, 3D bioprinting might not only to extend the life of sick people, but it could also improve human life expectancy significantly.

Another interesting area is brain research. There is a joint, interdisciplinary attempt from researchers to build a so-called neuromorphic computer, a machine that learns like the human brain. Currently, mapping the complete human brain is too complex even for the state-of-the-art supercomputers, but the researchers believe that within a decade it is possible to get a much better understanding of how the brain works, which will help to gain new knowledge about brain diseases [27]. The next step after understanding the brain is trying to influence its behavior: storing, altering, and deleting memories; giving new skills and taking old ones away; and copying the information that the brain contains. When that is possible, we are not far away from the complete artificial human brain that can be totally controlled.

#### **4.1. Basic Health Care**

What would be the future prospects for everyday health care, then? It seems obvious that health care will focus more and more on preventive and even predictive care. Gene technology will enter the realm of everyday health care as the costs of reading the human genes keep coming down, and innovative cures for the expanding number of diseases are often based on genes. With gene technology, a growing amount of diseases can be prevented completely, and some others can be cured at the very early stage.

Because current health-care-sector structures are very inflexible and the field is strongly regulated by legislation, it is possible that despite the medical inventions and findings, the common health-care practices will not face any world-shaking changes in the next 10 to 20 years. With the increased use of different self-service tools for measuring, examining, and diagnosing, patients can get a diagnosis directly by describing the symptoms while sitting on the couch, or they can consult a physician after taking all the required tests at home by using the appropriate applications. This is already happening now in its basic form, but in the future the services will become more sophisticated and versatile. It could also be possible that if there are tests and examinations needed that require special skills or equipment, a self-driving examination/laboratory car would be sent to see the patient and take care of the tests. In some cases, drones could also do the work.

In the future, computers will play a much bigger role in finding and diagnosing diseases. Currently, although computer-aided tools are used in diagnosis, a human professional is the one who actually makes the decisions and orders treatment,

although these can be suggested by a computer. There are serious illnesses that can escape a physician's attention, especially at the early stage of the disease, unless the patient health data are analyzed by a computer. As advancement continues, more diseases can be recognized by data analysis, thus making the diagnoses more accurate and providing a patient with the correct treatment earlier. This not only applies to physicians and nurses, but also to the work of other health professionals, such as dietitians and physiotherapists. The more data the computer has about the individual, the more accurate comparisons with previous cases and analysis based on the state-of-the-art research data will be. This will help health-care professionals to find the source of the health problem faster and more easily.

The future computer physician or nurse will be able to make decisions for patient treatment on its own, but it will still take time until there are walking (or rolling), self-thinking robot physicians and nurses hurrying in the hospital corridors. The first type of a future physician is a human working in a close relationship with a computer that has extremely sophisticated analysis tools. Self-diagnosing computer physicians are possible to construct even today, and the more advanced they get, the more specific the diagnoses they will be able to make. One feature that really makes a difference between a human physician and an assisting computer physician is the ability to have a sensible conversation. In order to be able to work independently without human surveillance, a computer physician needs to have the ability to interview the patient like any other physician. The future computer physician will be able to do that, but the technology is not here yet.

In the wards of some hospitals, there are moving robot nurses and physicians that can roll to the bedside of a patient to perform small tasks and provide a video connection to a real human physician or nurse located somewhere in the hospital premises. In the future hospital, there could not only be self-thinking and self-moving robot professionals, but also personal bedside robot nurses that would make the patient feel as comfortable as possible, together with smart rooms equipped with smart furniture and versatile entertainment systems. Another possibility is to let a patient stay in a place he or she feels most comfortable. "Hospital at home" is a concept that has already been experimented with in some countries, but with the advanced innovations such as robot physicians and assisting technology, having hospital at home could really be an option for many patients.

Despite the technology hype, there is one crucial aspect of health care that has to be kept in mind. Health care is not only about providing a person a cure for a disease; it is also very much about a human contact, someone seeing and listening to you as an important individual. A computer will be "only" a computer for a long time, until the dawn of the cyborgs, when no one will be able to tell the difference between human and machine anymore.



## 4.2 Health Care Everywhere

As pointed out in prior sections, various devices controlled in different ways, including self-controlled devices, currently collect a huge amount of detailed health-related data, and they will collect even more in the future. The smartphone is currently the most used personal device in this regard. Wearables are expected to be the next big success after smartphones [23], and their ability to gather real-time health information is much better than that of smartphone applications. Therefore, if a person wants, he or she can soon be versatily “health monitored” 24/7 through his or her own equipment. Some would do this only for curiosity, and some for real health reasons, but some potential user groups could be elderly and disabled persons and patients at home, in which case the device would be connected all the time to a health service center for data monitoring. The amount of aging people is growing in the Nordic countries, which means that there will also be a growing amount of younger people who are constantly worried about their older family members coping at home. It would be a relief to the relatives to know that help will be there immediately if the real-time health data show such a need.

The idea of wearables can be expanded to anything that a person can wear. Not only to watches, clothes, or eyeglasses but also to jewelry, nail polish, and deodorant. Other types of personal health monitoring systems could be small chips fitted under the skin or inside an organ, a future scenario that is familiar from science fiction.

Not only portable devices but also our environment could monitor our health status. Entire houses are becoming more and more intelligent, with house control systems only further requiring the right types of health applications to measure selected metrics. The health application could contact a health-care professional or a friend or a relative, call for a shared self-driving car to get the unwell person to a professional, or call for an ambulance if there is an emergency. It could also happen that the house is quicker than the inhabitant in recognizing symptoms of, for example, the flu, and contact the pharmacy to order a home delivery of flu medication before anyone else. In a future world, deliveries will be carried out by drones or other unmanned vehicles. Continuous monitoring of person’s life at a very detailed level raises questions about the data ownership, privacy issues, and security. When a person’s life is in practice stored in a digital format, what are the consequences if the data disappear or are tampered with? What about ethics—are there any limits in monitoring people, or is everything allowed in the name of individual’s well-being? These all are fundamental questions that need to be solved as we move on to a more and more digitized and connected health-care system.

### 4.3 Future Scenario Analysis

In the book *Laws of Media* [28], published posthumously in 1988, Marshall McLuhan introduced a tetrad of media effects, four laws of media formulated as questions that can be used as tools when analyzing the effects of any technology. The four questions are:

1. What does it enhance?
2. What does it make obsolete?
3. What does it retrieve that had been obsolesced earlier?
4. What does it flip into when pushed to extremes?

When the possible future health-care scenarios presented earlier in this section are analyzed by using McLuhan's tetrad of media effects, the following answers are found:

**1. ENHANCEMENT:** Nowadays, most of health care occurs in real time, whereas in the future, health care will mainly concentrate on either preventive or predictive care. Due to sophisticated diagnosis methods, health problems will be discovered more reliably and at an earlier stage than before, many diseases even before they show any symptoms. This offers an opportunity for early treatment, and consequently for a quicker, easier, and cheaper recovery. Also, new treatment methods such as gene therapy and organ replacement by 3D bioprinting will support the focus of health care turning toward preventive and predictive care.

The new treatment methods will also provide a complete cure for serious illnesses such as cancer and HIV. When more and more illnesses can be cured and aged or damaged organs replaced by new ones, human life expectancy will improve remarkably. The science fiction fantasy of building an artificial human will be a little bit closer, as little by little medical science and other related science research will provide necessary building blocks.

**2. OBSOLESCENCE:** In the future health care world, many traditional methods used in health centers and hospitals will be obsolete. One example is secretary work, for which health-care professionals are currently forced to reserve a huge amount of time on a day-to-day basis. When there will be computers or robot secretaries taking care of the patient records and other paperwork, professionals will be able to concentrate more on patient work. Another example is the various health-state monitoring tests that take place in health center laboratories. Because most if not all monitoring tests will be advanced so that they can be easily and reliably taken at home, there will not be a need to come to the health center for testing.

The future health-care systems will not completely prevent wrong diagnoses or treatments, but they will reduce the possibility substantially. When the diagnoses become more accurate and reliable in the complicated cases as well, there will be less need for trial-and-error techniques in treatment methods.

**3. RETRIEVAL:** Artificial intelligence and robots will help to bring back the physician–patient relationship of the pre-Internet era that has so many times been longed for. Currently, busy physicians and nurses seldom have the time to get to know the patients and really concentrate on their issues as they would like to. In the future, professionals will have more time for the patients, so they will be able to prioritize patient needs.

**4. REVERSAL:** The future health-care scenario in a sense reverts to the family physician, who was always invited to patient’s home. Usually the physician was a distinguished confidant who knew all the family members and their medical history, perhaps for several generations. There are countries in which such a family physician system is still in use, but it is not nearly as common nowadays. In the future, the patient can get diagnosis and treatment at home in a growing number of cases, and the health-care computer system will know the patient’s and his or her relatives’ medical history extremely well.

Future achievements in the medical sciences will lead to effective treatment methods for currently lethal diseases such as cancer and HIV. However, gene therapy and organ bioprinting are examples of treatments that could be used in an unethical manner. Tampering with human genes—of either a born or unborn individual—in order to give the person selected skills or to create a “super-human” is a scary possibility. Offering rich people who are able to finance the treatments an extremely long life or near immortality with new organs and such is another unwanted future scenario.

#### **4.4 Economic Implications**

The costs of the future health-care system and even of the cures for currently common diseases are difficult to estimate because there are so many things that can and will change on the way to the predicted future. Personal devices and health-care applications, a digitized hospital environment, computer physicians, new treatment methods, new vaccinations for currently common diseases—all of these and many more aspects will affect the total costs of future health care.

One of the most interesting and also promising areas of future health care is the ability to cure currently incurable diseases. However, providing new treatment methods for the diseases is not cheap. First, the development research and related clinical testing takes several years, sometimes decades, and is very expensive. Second, the treatment method itself can also be expensive. For instance, gene therapy is proven to be a very effective treatment method for cancer. However, the costs for treating patients with ordinary methods is much cheaper than using gene therapy. This is due to the nature of the gene therapy: in many

cases the treatment is tailored individually for each patient, which naturally costs more than the treatment that is suitable for all. The challenge of the new treatment methods is to get the pharmaceutical companies interested in them and find ways to push the treatment costs down as much as possible so that they can be considered as true alternatives to the old treatments [29].

The visions for future health-care costs greatly emphasize the importance of preventive health care. As stated earlier, the distribution of health care is assumed to move toward preventive and predictive care. From the perspective of costs, this would be truly beneficial. In the 2009 publication “The Power of Prevention,” the National Center for Chronic Disease Prevention and Health Promotion of the United States listed the most common chronic diseases among American people, how much they cost for society, and how they could be prevented [30]. Trust for America’s Health estimated that if \$10 per person per year was invested in community-based programs that provide education in physical activity, better nutrition, and quitting smoking, it would result in a savings of more than \$16 billion in medical costs annually within 5 years. This means that every dollar spent in education brings back \$560 because of the reduced health-care costs [30]. The future of health care lies not only in sophisticated treatment methods and the digitalized health-care environment, but also in the better understanding of the human body and the nature of disease.

#### **4.5 Expert Opinions**

Experts argue that as soon as the 2020s, health-care delivery systems in the Western countries will be fully digitized [13]. The key factor for this transition is that health-care service users will move from passive health-care recipients to active health-care service consumers. Current empirical data and surveys conducted by Garret et al. (2014) [13] concluded that (1) nearly half of population and 79% of physicians believe that the use of mobile devices can help clinicians provide a better service. (2) Half of the physicians said that digital visits, or e-visits, could replace more than 10% of in-office patient visits, and nearly as many consumers said that they would be willing to communicate with their caregivers online. (3) Of physicians, 42% are comfortable relying on at-home test results to prescribe medication. (4) Of consumers, 28% already have a wellness or medical app on a mobile device. (5) Roughly two-thirds of physicians said they could use an app to help patients manage a chronic disease such as diabetes.

The trend of consumers actively using health-care applications will continue to grow in developed as well as in developing countries [31]. Experts argue that underdeveloped countries can also benefit from this trend. Data generated by

connected devices, online platforms, and digitalized medical records during live health-care check-ups will be used to predict macro-behaviors of health trends at a global scale. Scholars are discussing the new role of intelligence health-care informatics in the Big Data era and focusing their research on topics such as (1) Big Data, analytics, and health-predictive control modeling [32]; (2) artificial intelligence and decision support systems in medical diagnosis [33]; (3) telemedicine and home monitoring systems [34]; (4) network effects of social media and predictive epidemiology [35]; and (5) semantics and data integration [36].

### **Interview**

To highlight the importance of data in future health care, we interviewed Samuel Kaski, professor of computer science at Aalto University. He is one of the responsible researchers in the Data-Driven Decision Support for Digital Health (D4Health) project, funded by the Academy of Finland. The goal of D4Health project is to combine large medical datasets and prediction models, as well as to design user interfaces that support medical physicians in diagnosing diseases.

While digitalization has several important aspects, we focus on one dimension of it, namely the data. Hospitals have databases of patients and, in principle, physicians can use those to make better diagnoses and treatment decisions. However, due to their limited time this is usually possible only to a limited extent. Now the big question for data scientists is how to develop techniques that can improve predictions; for example, what would happen if the patient would be treated in a certain way. There are several challenges.

First, due to the nature of the problem, many of the statistical techniques that are needed do not exist yet. The second challenge is the privacy of the data. There is the big dilemma that most people would like to get better treatments, but at the same time, they would not like to release their private data. The question is can we implement such privacy controls that people would be guaranteed to lose only very little by sharing. The third one is how to incorporate prior (expert) knowledge in analyses, and how to accumulate the knowledge as new data come in. This also brings in the challenge of designing user interfaces for experts so that they can maximally benefit from the data.

Another interesting question in medicine is translational medicine, that is, how can medical (biomedical) basic research be translated to clinical practice. We would also like to ask the question from another perspective, meaning, how does the clinical evidence maximally propagate back to basic research in medicine. These kinds of research questions can hopefully be helped with data analysis and modeling.

## 5 Conclusion

The present study was designed to investigate the impact of digitalization on the health-care sector. At first glance it may seem that health care is left behind in the race toward digitalization. However, careful study of historical events in health care implies that it is actually taking the first concrete steps toward digitalization. Our study showed that there is an ongoing shift in health-care services from what is known as real health care toward predictive and preventive care.

We identified some of the main enablers and challenges of this transition. The first challenge (or enabler) is the change in the population pyramid of the developed countries. Due to the aging society, increase in life expectancy, and low fertility and death rates, these countries have had the problem of balancing the economics of their health-care systems. To this end, benefiting from machines and new technologies is inevitable to compensate the cost and lack of human supervision and real care. Furthermore, the digitalization of patients' data and data integration on a national scale have created potentials for using data analytics to improve the decision making and accuracy of diagnosis. In addition, smart technologies such as mobile phones, wearables, smart homes, and so forth have provided the necessary sensors and actuators to monitor the health status of everyone at all times. These starting steps will be the enablers of the future health-care system, which will mostly rely on predictive and preventive care.

We envisioned the future of digitalized health care in which machines take control over medical decisions. This is not far away from what is happening today, for example, with IBM's Watson. Nevertheless, in this paper we envisioned the benefits and also future challenges that deserve particular attention as we prepare ourselves for health-care digitalization.

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# *Digitalization Reshaping Conflicts— The Ordinary Citizen as the New Peacekeeper*

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**ABSTRACT:** *In this paper we explore how digitalization changes the nature of conflicts. Based on a theoretical foundation of conflict as a socially emergent phenomenon, we investigate how conflicts in the digitalized era emerge, how wars are fought, how digitalization changes the traditional forms of warfare, and the implications of the new digital battlefield where cyberwarfare is waged. We discuss two principal changes driven by digitalization. First, digitalization will make conflicts more ambiguous. Second, digitalization individualizes warfare. Based on these changes, we outline the emerging role of the individual as the modern digital peacekeeper, what government policies could be expected to drive a more peaceful world, and, finally, what business opportunities might arise.*

**KEYWORDS:** *war, conflict, peace, Heider's balance, digitalization, kinetic warfare, information warfare, cyberwarfare*

# 1 Introduction

Conflict has been an integral part of human activity since the beginning of time, with its origins in primal fights over food and opportunities to mate. Gradually societies emerged and grew, with their foundations in shared ideas about truth and morality. With the emergence of an organized society, also the nature of fighting evolved to wars for control of land and resources. Technology has played an integral part in the history of war, sometimes providing an unsurmountable advantage to one side of the conflict and sometimes preventing the escalation of war simply through its existence. With digitalization changing most aspects of modern life, the question is not *whether* but *how* digitalization changes the nature of conflicts and warfare.<sup>1</sup>

We argue that digitalization, despite its binary nature, challenges existing notions of war and peace through its creation of a *twilight zone* of conflict, where nations and other capable groups wage wars and fight battles in the shadows of the Internet. War is a distant concept for those who have lived their lives in peace, and although we argue that digitalization reduces violent conflicts and civilian casualties, the flipside of the coin is that digitalization offers the means for extending war into the homes and handsets of those seemingly living their lives in peace. In other words, where there has traditionally been a distance between the heart of a nation and the frontline where it is defended, digitalization puts every citizen on the digital frontline, and we are currently ill-equipped to defend our nations and ourselves.

Informed by established theories, we begin by exploring the nature of conflict through an explication of its foundations in truth and power, while illustrating key ideas and concepts through the examples of three recent conflicts. Building on these foundations, supported by literature reviews and expert interviews, we are able to evaluate how digitalization reshapes the two traditional regimes of warfare, information and kinetic warfare, and further, the implications of the emerging digital theater of war, where cyberattacks are conducted and cyber-defenses are erected. Based on our analysis, we offer conclusions on what capabilities nations and individuals need to develop to avoid becoming casualties of digital warfare and what business opportunities might arise.

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<sup>1</sup> We refrain from offering an explicit definition of the terms conflict and warfare here because one of our conclusions is that these terms, due to digitalization, are becoming harder to define. However, we predominantly discuss these terms on a national level, as “conflicts” between nations and “warfare” that is conducted or orchestrated by nations.

## 2 Conflict Is Rooted in Power and Truth

To create a more peaceful world, we need to venture into the *dark side*, in an attempt to understand how conflicts arise, what makes them sustainable, and how they are ended. For this we develop a theoretical framework based on the idea that conflicts are socially emergent phenomena. Based on the framework and the analysis of three recent conflicts, we then create a model for conflict design, which outlines how conflicts can emerge or, in the worst case, be orchestrated. This section forms a foundation for understanding the impact of digitalization on conflicts.

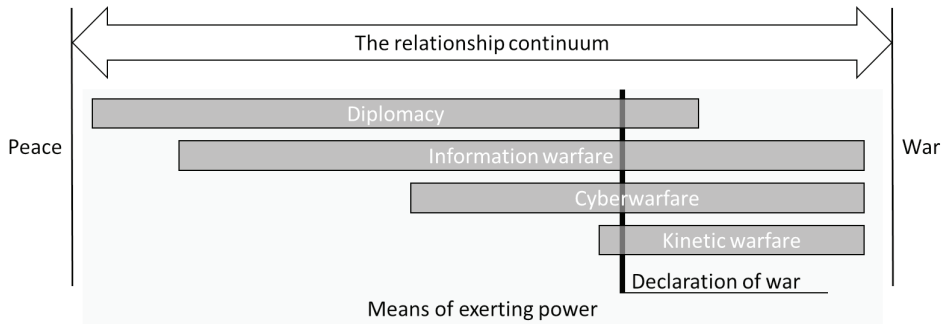
### 2.1 Conflict as a Socially Emergent Phenomenon

Truth is what unites and divides us. Societies are held together and defined by shared ideas of how things are and how things should be. This applies for any socially constructed group (within or between societies) offering a sense of belonging and unity to its members. Any diverging ideas, especially if they are relevant for the group, will create tensions within the group that can only be resolved through reaching a new consensus or through dissolving the original group and regrouping around the divergent ideas [1] [2]. As individuals, and as members of various groups, we have an innate need to protect our version of the truth (which we coincidentally see as *the* truth) by imposing our version of the truth on others, or by isolating ourselves from ideas that deviate from those of our own [3].

Truth is tightly coupled with individual and collective action because a difference in how things are and how things should be is what drives action. Accordingly, Foucault [4] argues that there is a tight relationship between power and truth, in which power shapes action through shaping the truth. “Power is everywhere and comes from everywhere”; power is what moves us and what shapes our lives as we know it [4, p. 63]. Thus, any instrument through which truth is disseminated is an instrument of power. On a complementary note, Emerson [5] outlines power based on dependence, which emerges from control of that which is valued by the other. Based on this, power can be defined as the extent to which it can overcome resistance by the other [5] (i.e., the other acting against his or her will). These ideas are essentially complementary because power can involve both controlling that which is valued and influencing what is valued.

Where truth is the foundation on which we stand and to which we relate ourselves, power can be used to sow the seeds for conflict. Conflict, which in economic terms is tightly coupled with the idea of scarcity (and, by extension, control of that which is valued), emerges when groups with mutually exclusive ideas of how things

should be set to act against each other in an attempt to reshape their future and to maintain the status quo, respectively. Minding that a conflict need not be armed, economic theory typically reduces conflicts to the idea of achievable benefits and expected costs [6], where war is seen as the continuation of diplomacy (Figure 1) in situations where benefits outweigh expected costs.



**Fig. 1.** *The relationship between groups—the new peace-war continuum.*

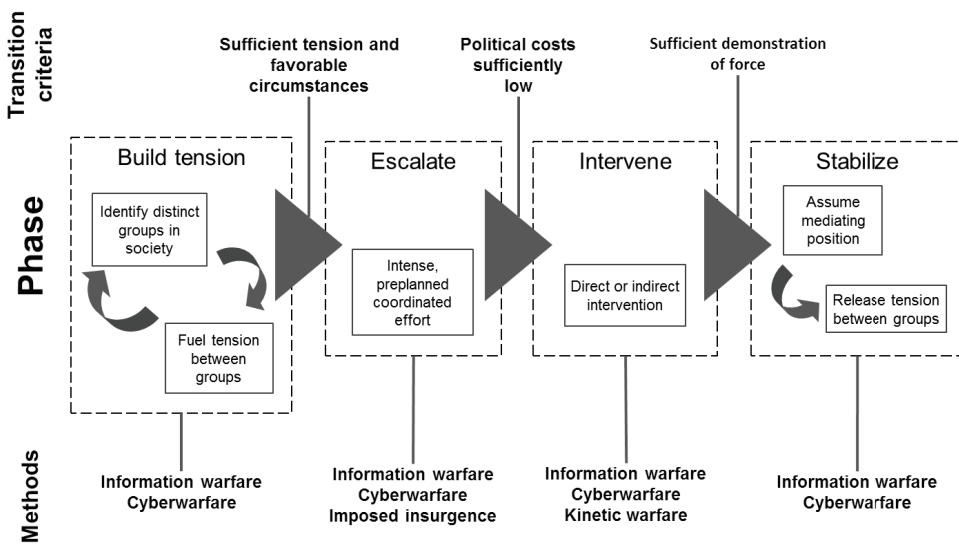
Imperfect information tends to drive conflict [6], typically through overestimation of expected benefits or underestimation of conflict-related risks. This has also been discussed from a behavioral perspective, where we tend to have a behavioral bias (e.g., in evaluating low-risk, high-impact events) that drives us toward conflict [7]. These biases have a crucial role in the relationship continuum (Figure 1) because they create a disequilibrium at the point where diplomacy crosses over to warfare, which is also captured by Rubicon theory [8]. The implication is that a conflict will have a tendency to escalate once a “point of no return” has been passed.

Finally, in discussing the nature of conflict, we highlight that the presented ideas are not limited to nation-states and their relationships. Groups, truth, power, and conflict can be found in business (cf. [9], [10]) and presumably, albeit probably, in a slightly different form in all areas of society. This highlights the layered nature of society, where we have groups forming and dismantling not only within the layer of nation-states, but also in cultural, economic, and religious layers, to name a few. Within the individual, truth spans across all layers, which means that it would be myopic to assume that these layers did not affect one another also on an aggregate level.

## 2.2 How to Design and Orchestrate a Conflict (in Theory)

We look at three recent conflicts through the social emergence perspective, as

outlined in the previous section. Based on the cases we deduct a four-stage model for how conflicts emerge and are resolved, from the perspective of a third party that seeks to gain from the conflict. This model consists of four stages: (1) build tension, (2) escalate, (3) intervene, and (4) stabilize. These stages are shown in Figure 2 and are elaborated in detail in this section. Further, we identify the transition criteria between the stages and discuss how the different forms of warfare are utilized in the phases. However, before discussing how each stage manifests itself in the cases, we briefly present each case: the 2007 cyberattacks on Estonia, the Russo–Georgian War in 2008, and the Russian intervention in Ukraine and the annexation of Crimea in 2014.



**Fig. 2.** *The design of a conflict.*

The case of the cyberattacks on Estonia in the spring of 2007 provides a reference point in the sense that it was the first intensive, large-scale, coordinated attack with the aim to paralyze societal functions [11] [12]. The attacks targeted political, economic, and communications infrastructure and were presumably performed or orchestrated by Russia in response to Estonia’s “anti-Russian policies.” The attacks culminated in pro-Russian protests surrounding the relocation of the Bronze Soldier statue, a memorial for Soviet victims of WWII. Although the attacks had little impact on Estonians, apart from the short-term disturbance they created, they further established cyberwarfare as a real threat and raised a question regarding the capability (and perhaps responsibility) of the North Atlantic Treaty Organization (NATO) to protect its member states in this respect [11].

The Russo–Georgian War in August 2008 was also attributed to worsening

relations between Russia and Georgia due to a pro-Western government. In August, pro-Russian separatists in Ossetia initiated attacks against Georgian villages, which provoked a Georgian counterattack, which in turn provoked a Russian intervention in the strategically important Caucasus region. Although the actual hostilities were accompanied by information-warfare and cyberwarfare actions targeting economic and communication infrastructure along with political and media sites on the Internet, there were also signs of hostile activities weeks prior to the military intervention [13]. The conflict arguably marked the first in history where the means of cyberwarfare accompanied those of kinetic warfare [14].

The Ukrainian revolution in February 2014 marked the fall of the pro-Russian Yanukovich regime and the rise of the pro-Western “Euromaidan.” The revolution sparked pro-Russian protests in the eastern Donbass region of Ukraine and the Crimean Peninsula. In the case of Donbass, the protests escalated to a war between the new Ukrainian government and pro-Russian separatists while Crimea was annexed by Russia. In this series of conflicts, the cyberwarfare components were similar to those in the other cases, but social media outlets were for the first time effectively leveraged for *reflexive control* [15]. From a Russian point of view, operations in this series of conflicts were so successful that “the West is currently playing catch up vis-à-vis Russia in [the information warfare] arena” [16, p. 87].

### 2.2.1 Build Tension

The first stage in conflict design is the *build tension* phase, in which natural tensions in society are identified and possibly fueled primarily through means of information warfare, but also complementary cyberwarfare. Societal tensions are natural and will in some cases build up where, for example, sustained oppression and discrimination exist. In all of our cases the tension was between pro-Russian minorities and a pro-Western government or majority. The extent to which tensions were intentionally fueled in our cases is unclear; however, according to Heider’s theory [2], the pro-Russian minority is in an unstable state, implying that it is bound to move either closer to the West or closer to Russia. In this case, if Russia wishes for the latter to happen, the logical action is to create tension between the Russian minority and the pro-West majority. The role of truth in this equation is well illustrated by the Estonian case, where the bronze statue for the Russian minority represented the sacrifices made by Russian soldiers in WWII, whereas the same statue represented occupation and repression for the Estonians [11].

Nations have societal tensions by default, and the role of information warfare in fueling tensions is manifested in the limitations on freedom of speech by het-

erogeneous countries such as Russia and China. Containing societal tensions and creating national unity is one of the reasons for having your own national search engine, social network platform, and messaging service [17]. Further, controlling information flows is an advantage that can be used for both sustaining peace and creating war [18].

The closing down of Google China is an example of this, and further, through being an example of how societal tension can be fueled through economic activity, it illustrates how different layers in society interact in the creating and defusing of conflicts. Social networks have made fueling tensions and targeting receptive groups easy and cheap (J. Aro, personal communication, March 17, 2016), offering the means for creating artificial tension. Once sufficient tension has been created, be it natural or artificial, and circumstances are favorable, the conflict can move to the escalation phase.

### 2.2.2 Escalation

Once the conflict-prone society enters a disequilibrium state, it needs to be “pushed” over the edge. In Estonia this was attempted through cyberattacks and seemingly orchestrated protests, which eventually failed to gain sufficient momentum. In Georgia the separatist attacks fueled the events, and in Ukraine it was violence against protesters. The Estonian and Ukrainian cases share the presence of murky agitators, which at least in the Estonian case were suspected to be criminal groups sponsored by Russia [11]. In all cases, but especially Estonia and Ukraine, activity on the information-warfare and cyberwarfare fronts intensified considerably during the escalation phase [11], [19].

Whether or not there is an orchestrating third party in our cases, it is clear that facilitated escalation requires a massive coordinated effort, which may be beyond the capabilities of other organizations than nation-states. Once the point of no return has been passed [8], the orchestrator may sit back and watch the events unfold as the conflict becomes self-propellant for a while. The orchestrator will at this time portray itself as an “interested power rather than a party to the conflict” [15, p. 7]. The growing violence will lead to increased international desire to end the conflict, and once the political cost of intervention by the orchestrator is sufficiently low, it is time to intervene.

### 2.2.3 Intervention and Stabilization

Whereas the Estonian case never escalated, the Ukrainian case saw both direct and indirect interventions, as Russia first indirectly and later directly supported

the pro-Russian separatists in east Ukraine and directly, albeit covertly, intervened in the Crimean Peninsula. In Georgia the intervention came too soon to gain international “support,” and the direct nature of the intervention made Russia a part of the conflict instead of the “interested stakeholder.” The implication of this was that Russia was not able to take a mediating position in stabilizing Georgia, and thus missed the chance to be the well-intending “peacemaker.” On the other hand, had Russia not intervened as swiftly as it did in Georgia, the Abkhazian and South Ossetian separatists would likely have been overrun. The purpose of the intervention is to demonstrate power to convince the other side that the costs of achieving victory are too great.

Once sufficient power has been demonstrated, the other side of the conflict should be ready to negotiate, and at this time the “interested stakeholder”—provided it has maintained its neutral appearance—steps in. If everything goes smoothly, the “interested stakeholder” now makes sure that the objectives it sought with the conflict are met, and it is perceived as the bringer of peace by the international community. In the case of the Ukraine, Russia continues to maintain the image of an “interested stakeholder,” with continued attempts to stabilize the conflict [20]. However, although there is evidence of continued information-warfare and cyberwarfare activities [21] [22], it is at this point unclear whether or to what extent Russia has deployed these measures to drive stabilization.

### 3 Digitalization Reshaping Traditional Realms of Warfare

In this section we look at how digitalization reshapes the traditional realms of warfare, information and kinetic warfare. We explore both realms in terms of historical developments, concentrating on the development of strategies in the realm of information warfare and on the historical impact of technology in the realm of kinetic warfare. We then analyze and discuss how digitalization affects the realm in question, in light of current and anticipated developments. Finally, we discuss what implications digitalization has for the nature of future conflicts in light of the anticipated developments in each realm.

#### 3.1 Information Warfare

In the context of *information warfare*, the *infosphere*—media channels—is where truth may get distorted or manipulated [23]. This section presents how information-warfare dynamics have taken place in the *infosphere*, a neologism



utilized to refer to the conceptual space where information is gathered, managed, and displayed according to power relations by, for example, government agencies and media companies. We discuss how information symbolizes power in conflict settings and how it is obtained and manipulated. We also explain the use of information to create different versions of one same event and shift perception in larger masses and discuss current management techniques used in detail. However, first we need to define what information is.

According to Hutchinson [24], the smallest unit is *data* and is “associated with the attributes of things; describes different states,” being physical, social, or political. *Information* is then “collated data in context...the set of data filtered by human within the bounds of the knowledge held by the human itself.” Finally, *knowledge is a human attribute*, it is the result of “information that an individual has interpreted in the light of experience” [24, p. 220].

### 3.1.1 The Brief History of Information Warfare: Shaping the Opinion of the Masses

*Information warfare* as a term first appeared in 1999 with the rise of information-centric warfare. It can be traced to the 1920s [25] [26], the moment information was first understood as a powerful asset; however, it was not yet linked to political objectives. In the Marxist-Leninist Soviet Union, the use of information to lead, change, or persuade masses for political purposes was a common practice [24]. The selection, concealment, or manipulation of information became a standard practice by the Soviet regime and part of its propaganda structure. The Soviets named the act of information deception *maskirovka* [24], meaning “to deceive, misinform, imitate, conceal, and simulate.” It involved any strategy or practice that could debilitate an enemy, even its own people.

During the Socialist times, ideological manipulation was a common practice, and anybody who dared to question the status quo was obliterated. The use of deception tactics was easily justified with such ideologies at play. Socialism defined itself as “moral and good,” whereas any potential threat was considered “amoral” and “unwanted”; the oversimplification of ideologies is a first step of many information-warfare tactics. Just as the Soviet Union managed to manipulate information through the previously described tactics, the German Nazi regime is also known for its propaganda and deception tactics during the war. In Germany in the 1930s, we find the ideal setting to describe what deception meant for the upcoming Nazi regime. In order to place its members as frontrunners in the upcoming elections, the Nazi Party developed elaborate propaganda campaigns. These strategies, later used during WWII, included *deception* as “attempts to

deliberately mislead and adversary regarding intentions and capabilities or to otherwise manipulate him through falsehood” [27, p. 5].

Deception tactics by the West occurred a little before the mass media appeared; however, it was around the 1990s, where media companies thrived with governmental support, that such tactics became pronounced. While the bond between media and government strengthened after the Vietnam War, social psychology and empirical research helped media become an essential tool of war. It was around the same time that information warfare was “reconceptualized” as *information operations* [24] because deception tactics are not exclusive to war. This new term encompassed a series of strategies designed to corrupt, disrupt, and usurp the decision-making capacities of any foreign or domestic opponent through information manipulation.

After the attacks on the World Trade Center in New York, news reporting changed drastically. News agencies could no longer do their job impartially, and thus society bore witness to the creation of a one-sided story (9/11). The meticulous media production included material selection, publishing, broadcasting, and dissemination of a story with a good plot, a climax, and a good finale, appointing the *media* the new “fourth front” where battles were fought [24].

### 3.1.2 The Impact of Digitalization on information Warfare

With the appearance of the commercial Internet, a renewed sense of democracy was born. On one hand, the Internet offers possibilities for freedom of speech and information flow. On the other, the same democratic power also poses a threat to nondemocratic regimes, often leading to the conclusion that “a free and unregulated Internet constitutes a threat to their survival” [28, p. 2]. The regulation of the Internet in some countries could be interpreted in many ways, be it for control purposes or commercial hegemony over domestic markets.

However, more than one type of information warfare is carried out over the Internet. Banning the free flow of information over the Internet is one strategy; other strategies take advantage of the information overflow. By deploying tactics of deception and manipulation, different political groups have created a new kind of war: *hybrid war* [29] [30].

This type of war has its own particularities because it relies on media manipulation and tactics such as “disinformation, lies and deception to influence target audiences” [31, p. 1]. The “soldiers” engaging in this type of warfare are trained in languages and are generally savvy in social media use. They actively participate in social networks, affecting debates with the aim of weakening government structures and diluting people’s trust [31]. A complementary activity in this sense is

online provocation—termed *trolling*—an old practice that has taken a new turn with the appearance of social media platforms.

Recent cases, such as the one of the Finnish reporter Jessikka Aro<sup>2</sup> investigating “troll factories” in Russia [32], have uncovered key aspects of this topic. Trolls access discussion forums to spread disinformation and agitate discussions, with the hope that contradictory arguments may polarize and fuel underlying societal tensions. Unfortunately, this also entails attacks on individuals, with the aim of intimidating or discrediting key opinion-makers (J. Aro, personal communication, March 17, 2016). Trolling is especially vicious with women, as intimidating victims with sexual threats and attacks on their public image being a common practice among trolls.<sup>3</sup>

Social platforms offer an open window to all segments of the world’s population, where memes go viral and posts are carefully tailored for different audiences and where trolls with bogus profiles harass anybody that may raise questions about their purposes or identities. These platforms have lax regulations on trolling, online harassment, and hate speech, hiding behind the argument of protecting the right to free speech. In consequence, ill-intent remains free of prosecution, causing victims grave stress and destroying their reputations and careers. At the same time, these platforms (e.g., Google, Facebook, and Twitter, to name a few) capitalize on the hostilities (J. Aro, personal communication, March 17, 2016).

The root of the problem lies in the Communications Decency Act of 1996, which in an attempt to regulate “pornographic or indecent material” states that “operators of Internet services are not to be construed as publishers, and thus not legally liable for the words of third parties who use their services.”<sup>4</sup> This created an environment where knowing the identity of a source (authentication) over the Internet is typically impossible. This in turn implies that anybody is “free” to post and comment anything and not be held accountable because it’s his or her right to remain anonymous. This is playing right into the hands of whomever who wishes to engage in information warfare because it enables anonymously shifting opinions with data that cannot be corroborated.

Digitalization has changed information warfare by removing the cost of *replication*. When social media platforms include and connect people, they give them the possibility to share content—to “pass it on.” The term *viral* was coined to capture the idea of pieces of information spreading like an epidemic disease. People

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<sup>2</sup> Prior to our interview with her, Jessikka Aro received the renowned *Bonnier Journalism Award* on her work related to the Russian troll factories.

<sup>3</sup> <http://eeas.europa.eu/press-media/subscribe/ecas-user-manual.pdf>

<sup>4</sup> [https://en.wikipedia.org/wiki/Communications\\_Decency\\_Act](https://en.wikipedia.org/wiki/Communications_Decency_Act)

posting pieces of—even if misleading—could reach more audiences through these platforms than ever before. The other side of the coin is that communication has never before been so accessible and low cost. The data produced and shared by users give away behavioral information that makes it easier to profile users and conduct effective information-warfare campaigns. Information in the age of social media has put the individual at the center of any debate or discussion as the *creator of information*.

### 3.1.3 How Digitalized Information Warfare Changes the Nature of Conflict

Information in digital form has been handled among nations for decades. The appearance of social media has made our involvement in worldwide conflicts discreet and more easily possible. Our participation in world conflicts may not be obvious to the individual; however, it does have an impact. The creation of consent through social media is easy, and in many cases the low-literacy level of this medium makes it easy for other parties to manipulate public opinion. The normal practices in these mediums are to destabilize—as in war-like tactics—or to facilitate communication among members of a group. On a national scale, heterogeneity in a population may be assumed as a norm—hence the need for controlled communications. The role of the individual has never been more important; knowledge and understanding of communication dynamics are crucial from this point on.

The game-changing attribute of social media is the accessibility of power groups to us and between our peers and us. The replication capacity of social media is taken as an exponential force for power groups. One could argue that depending on the level of social media literacy and political awareness, a group is liable for manipulation. Reputation of sources plays a big role in shaping public opinion. Reliable power institutions have leverage when shaping public consent; however, they are prone to misinterpretations and may carry heavy burdens when misinforming their audiences.

The bottom line is that information warfare has become a relatively cheap and effective way of advancing an agenda. When added to the national anonymity provided by individual-centric social forums and platforms on the Internet, information warfare has become a daily practice in some nations, as illustrated by the Russian troll factories.

## 3.2 Kinetic Warfare

Kinetic warfare refers to actively and directly applied lethal force in open-combat situations; more familiarly, it consists of *tanks and guns* or *boots on the ground*,

encompassing the use of armies, navies, and air forces [33]. In this section we briefly explore how technology has changed kinetic warfare and reshaped conflicts in the past. We then outline how digitalization has changed and continues to change kinetic warfare and what the future holds in this respect. Finally, we conclude the section by discussing whether and how digitalization affects the nature of conflicts.

### 3.2.1 Technology and Kinetic Warfare: Creating the Next Last Samurai

Technology was entangled with conflict and warfare even before the discovery of these concepts. With humankind's first understanding of the utility of tools, that utility was soon transformed into utility in combat. Therefore, technological innovations have always underlined the evolution of kinetic warfare; an edge in warfare gained through technological innovations has been always sought to trump opposition.

History has seen countless technological innovations that have changed the game of warfare, such as siege machines, which were designed to break the advantage of heavy fortifications during classical antiquity [34]. Similarly, the "Greek fire" of the Byzantine navy shifted the balances of eastern Mediterranean naval battles during the Early Middle Ages before appropriate counter tactics were invented [35]. Subsequently, gunpowder altered military traditions substantially both in the East and West as the emergent propellant weapons changed the nature of warfare for good. Even though adapting to new technologies in battlefields becomes a necessity for survival, new technologies obliterating traditional conceptions of warfare are not always welcomed with embracing arms. Military traditions and customs often have deeper ties to cultural identity than often realized on the surface. This particular clinging to traditions in the face of uncertainty was beautifully depicted in the 2003 movie *The Last Samurai*. In the movie, rebelling samurai refuse to give in to the modernization of their feudalistic traditions by defiantly charging against unconquerable gunpowder-powered opposition, themselves armed only with traditional Japanese swords, *katanas*.

The modern era also has witnessed drastic changes in kinetic warfare via technology. Inventions of submarines and torpedoes added a new dimension to naval battles; possible threats were no longer confined to coming from a visible range above the surface, but undetectably from below the surface. Even though the first submarine for warfare was deployed during the American Civil War in 19th century [36], proper countermeasures didn't come into existence until decades later during the WWI with the invention of depth charges and SONAR (sound navigation and ranging) [37]. Just as submarines added a new dimension to an established branch

of military, the navy, an invention added such a fundamental new dimension to warfare that an establishment of a whole new military branch was necessitated; thus the air forces were born. As with all new inventions, it subsequently took quite some time to master this new dimension, and hence the aircrafts evolved from zeppelins to planes to missiles and drones, while countermeasures evolved from dogfights to anti-aircraft guns to complex missile defense systems.

WWI also saw the advent of a comprehensive modern version of a new branch of dreaded weaponry: chemical weapons. WWII witnessed even more horrific weapons of mass destruction, nuclear weapons, which were used against Japan to end the war. The sheer force of these weapons of mass destruction was so indefensible that the best policy to counter them was to prevent the use of these weapons altogether. This policy later spiraled into a balance of terror, a suspended conflict otherwise known as the Cold War, in which nuclear strikes were prevented through the fear of retaliatory strikes. Subsequently, the weapons of mass destruction have been tried to control through international agreements.

Other weapons targeting individuals rather than masses of them, such as anti-personnel landmines, expanding bullets, and personnel-blinding lasers, have also been considered so horrific and difficult to counter that they too have been banned through international law [38]. Attempting to control means of war through multilateral agreements already has a lengthy tradition; chemical weapons and expanding bullets were banned in an international convention a decade before WWI [39], [40].

As we can observe from the evolution of military technology, new innovations provide opportunities for drastic shifts of balance in a conflict. However, the advantage gained through technology is only temporary because in each case there has been a countering action to nullify the advantage from new technologies. Some cases, though, have been deemed so horrific or difficult to counter effectively that the only countering measure has been through multilateral political agreements. A reaction to counter horrific military technology through political negotiations brings us to an interesting notion if we consider the view of war of revered military theorist Carl von Clausewitz [41]; in his view, it is means of politics brought to the extreme. From this perspective these multilateral political agreements are just attempts to use “softer” political means to control the Clausewitzian extreme means of politics. This methodological misbalance might be a contributing factor to why these multilateral agreements have a tendency not to fully live up to their expectations.

### 3.2.2 The Impact of Digitalization on Kinetic Warfare

In contrast to the discussion in the last section, digitalization is not a new weapon

that gets deployed in the battlefield. Rather, it is an ongoing development that has the potential to improve existing and to some extent enable new technologies of war. In effect, digitalization changes both how decisions are made in the battlefield and subsequently how and by whom (or what) the decisions are then executed. Digitalization has been going on for some time, which means that some of these changes date back half a decade, whereas others are newer to the battlefield.

The changes brought about by digitalization can be classified into four groups: (1) substituting humans in the battlefield to reduce or remove the risk of loss of lives, (2) substituting humans in the battlefield to overcome physical limitations of humans, (3) complementing human decision making through improving situation awareness and reducing complexity of tactical decisions, and (4) improving reconnaissance by facilitating better-informed decisions in the battlefield.

The first of these changes is exemplified in the robots operated by bomb squads in Iraq, with the dangerous task of disarming the improvised explosive devices (IEDs) used by the insurgents.<sup>5</sup> The risk aspect is best illustrated by a quote from a letter written by the team commander to the robot's manufacturer, following its destruction in the battlefield: "When a robot dies, you don't have to write a letter to its mother" [38, p. 21]. The risk aspect is also a prime reason for the growth in drone technology being deployed in Iraq and Afghanistan, where low-altitude reconnaissance flights such as the ones performed by the drones are notoriously dangerous for fighter jets.

The second change can be argued to have been ongoing for the last half a century, as any rocket or missile guidance system is essentially the means for overcoming the physical limitations imposed by a human "driving" the rocket (exemplified by the Kamikaze pilots in WWII). This development has in turn spurred digitalized defensive technologies capable of intercepting high-speed missiles and rockets,<sup>6</sup> which in a sense is about overcoming the reaction time of any human-based defenses. This development also highlights the important progression that for every offensive technology, defensive technologies or measures will also emerge.

The third and fourth changes are tightly coupled in the sense that digitalization essentially enables a new era of military intelligence and reconnaissance (exemplified by current drone applications), to a point where individuals can be targeted in the battlefield [42]. This is also important considering that conflicts will increasingly take place in urban areas [43]. Consequently, as the amount of available information increases, decision making is most effective with complementary

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<sup>5</sup> cf. <https://en.wikipedia.org/wiki/PackBot>

<sup>6</sup> cf. [https://en.wikipedia.org/wiki/Goalkeeper\\_CIWS](https://en.wikipedia.org/wiki/Goalkeeper_CIWS) and [https://en.wikipedia.org/wiki/MIM-104\\_Patriot](https://en.wikipedia.org/wiki/MIM-104_Patriot)

decision-support systems that reduce the complexity of the tactical decisions at hand [44]. Further interesting possibilities lie in strategic decision making based on Big Data,<sup>7</sup> which could potentially prevent prolonged conflicts [45].

Although improved reconnaissance could be argued to reduce civilian casualties, there are new risks involved (cf. [46]), as illustrated by the case of Daraz Kahn in Afghanistan, who was killed in 2002 by a drone when collecting scrap metal, simply because he was at the wrong place, was wearing the wrong clothes, and was tall enough to be mistaken for Osama bin Laden [38,: 397–399]. It is clear that the developments just described have their pros and cons, depending on the perspective, which leads us to the next question: How does digitalized kinetic warfare change the nature of conflicts?

### 3.2.3 How Digitalized Kinetic Warfare Changes the Nature of Conflict

From a historical perspective, advances in technology can often be associated with increased destructive power, typically failing to discriminate between enemies and innocent bystanders. In this sense digitalization can be argued to drive a positive development; for example, Singer describes it as “a way to reduce war’s costs and passions, and thus its crimes” [38, p. 393]. However, from the perspectives of cost and passion, we can also build counterarguments, which we examine here. Further, developments related to digitalization currently fall into a void in international laws governing warfare.

Digitalization reduces the cost of warfare. Although digitalized solutions can be argued to be costly in economic terms, the cost has to be evaluated against the impact the solution has. Drones have pushed the frontier of digitalized warfare for the simple reason that for the price of one F-22 fighter you get 85 predator drones, which are essentially better suited for the low-level reconnaissance and air-to-ground attacks that they perform [38]. In addition, digitalization drives down the political costs of war (which is an issue especially in war-waging democracies) through reducing casualties, in terms of both military personnel and civilians. In terms of economic theory, the reduction in cost would imply that the decision to go to war would be more tempting.

Further, digitalization effectively drives dehumanization of the battlefield. On one hand, this development may save lives by removing rage from the battlefield. On the other hand, along with rage, compassion is also removed, which becomes a problem considering that battlefield situations are seldom black-and-white is-

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<sup>7</sup> cf. <http://www.emergencymgmt.com/safety/Military-Use-Big-Data.html>, <http://www.defence-industries.com/articles/id/roleofbigdata> and <http://www.forbes.com/sites/teconomy/2012/03/12/military-intelligence-redefined-big-data-in-the-battlefield/#2715e4857a0b34f57048718f>



sues, and thus may not lend themselves to Boolean logic. Among other things, this raises the legal dilemma of who should be held responsible when an autonomous system conducts a war crime. Considering this, it can be questioned whether fully autonomous systems will ever be allowed by the international community [38].

## 4 Cyber Warfare and the New Battlefield

Computer networks have created a new domain for battlefields that are wholly existent within a realm of cyberspace. Even though cyberspace is not “real” in the same sense as our physical time-space domain, the damage conducted through cyberwarfare can become as real as wounds from kinetic battlefields. Cyberwarfare is usually considered to be a means of causing harm and disruptions through information and computer networks by nation-states [47]. The damage and disruptions can be caused through various types of cyberattacks, such as hacking, malware programs, and denial-of-service attacks. But what do these various methods really mean?

*Hacking* is an overall umbrella term for exploitations of existing vulnerabilities in the targeted computer systems to gain access for information gathering and/or causing damage.<sup>8</sup> Vulnerabilities in computer systems and networks come in many forms and shapes. The task of cybersecurity is to identify these vulnerabilities and fix them so they can no longer be exploited. Therefore, hacking and cybersecurity can be viewed as a constant cat-and-mouse game where one tries to beat the other; one trying to find new vulnerabilities to exploit and the other trying find those vulnerabilities to patch them up. If the mouse of the analogy (i.e., possible cyberattacker) is able to find a vulnerability, those first attacks possibly become the most dangerous because previously undiscovered and undisclosed vulnerability effectively reduce the reaction time of the defending party to zero. In other words, the defender must react to these zero-day vulnerabilities only after a discovery of a cyberattack, that is, after some damage has already occurred [48] [49]. Even when the cat of the analogy (i.e., the party ensuring the cybersecurity of a computer system or network) is able to discover a vulnerability first, the safety is not guaranteed. Because it takes a time to patch the vulnerability, the time frame from discovery to patching the vulnerability creates a window of exposure for possible perpetrators to exploit the vulnerability [49].

The methods to create and exploit possible vulnerabilities also vary. The software-based methods are often collectively referred as *malware* or *spyware*

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<sup>8</sup> <http://www.merriam-webster.com/dictionary/hacker>

depending on usage intentions; malware is software designed to cause damage and disruption,<sup>9</sup> whereas spyware is designed for gathering information.<sup>10</sup> Malware include software classifications such as *worms*, self-replicating malware programs that operate and conceal themselves independently among nodes of computer networks; *viruses*, similar to worms in that they are self-replicating malware programs, but different in that they require a host program upon which to attach to conceal themselves and spread further; and *Trojan horses*, malware programs that pose as legitimate programs but perform undesired or unknown actions within the computer system [50]. Trojan horses are often used as method to gain an access to a computer system and subsequently deliver other malware within the system, but there are also other methods to gain access.

*Social engineering* is an umbrella term to describe gaining access to computer systems by using what is typically the system's greatest weakness: the users [51]. Humans are notoriously prone to psychological manipulation, and the users and computer systems jointly create a cyber-physical unit, with the influence of one ultimately compromising the other. Even the most sophisticated firewalls—programs dedicated to monitoring communication between computer nodes and filtering out any unwanted traffic according to the security policy [52]—are useless against security errors made by legitimate users coaxed into performing unwanted actions, such as installing malware inadvertently into the computer network or accidentally disclosing private information and login details. The only option is to train the user base to be alert on any social engineering attempts, but this becomes once again a cat-and-mouse game because methods that could be used for psychological manipulation in various contexts exceed the imagination of a single individual in versatility. Consequently, a similar issue also persists in cyberspace; it takes only a single unique idea that no one has ever thought of before and sufficient execution to compromise a computer system or network.

Cyberattacks are not always aimed to gather information or cause physical damage. Depending on what the attack is attempting to achieve, *web defacement* is a very apt method in the context of information warfare. Web defacement—unauthorized access to a web server and alteration of the webpage content [50]—is an applicable tool for smear campaigns intended to discredit the opposing party, or for spreading propaganda.

Denial-of-service attacks can be used for discrediting too. Denial-of-service attacks can discredit the information system owner by giving an impression of poor service availability, but they can also be used to cut access for a critical

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<sup>9</sup> <http://techterms.com/definition/malware>

<sup>10</sup> <http://techterms.com/definition/spyware>

service at a crucial point of time. These attacks are often discussed in terms of distributed denial-of-service (DDoS) attacks, in which an information system is incapacitated by trafficking it with a horde of unnecessary service requests from multiple sources to deny any legitimate access to the system [50] [53]. The DDoS attacks differ from other denial-of-service attacks in the sense that the source of the attacks is distributed to multiple different computer nodes. This distribution is utilized to mask the perpetrators behind the attack. However, this distribution also makes the attack resource intensive, which is why *botnets*—robot networks of compromised computers—are often used for execution [48] [50].

Generally, at a national level, cyberattacking capability is considered to be very sensitive material, and thus it is extremely difficult to obtain disclosed detailed information about the offensive cyberspace capabilities of various nations. This is in contrast to the defensive capabilities, which can be characterized by at least a certain level of openness among nations [54]. This contradiction might be related to the resource intensity of cyber-defense compared to cyber-offense. Given the right chance, a cyberattacker can cause serious harm and damage with a very limited resource set (T. Kiravuo, personal communication, February 19, 2016) [54]. Basically, the minimum for attack is a capable person with Internet access and the right window of opportunity or exposure. Defense, on the other hand, requires vast resources for continuous proactive and reactive patching of the computer systems because one can never comprehensively predict who will attack, from which direction, with which motivations, what time frame or window of opportunity they will use, what methods and vulnerabilities they will be using (previously known or unknown) and whether there will be any traces left to learn from the attack for future protection.

Because it is difficult to obtain concrete information about nations' current cyberwarfare capabilities, we look at information available on historical cyber-events. We seek to better understand how nation-states have operated in the past to inform a discussion of how they will operate in the future in regard to warfare-like methods in cyberspace. Through contextual information related to these historical incidents we can also seek to explore underlying motivations for nations to use cyberattack methods, despite the fact that attackers are primarily using the veil of anonymity provided by cyberspace.

#### **4.1 A Brief History of Cyberwarfare: In Search of Motives**

The history of cyberattacks and hacking is often regarded as beginning in the 1980s, long after the emergence of the first computer networks in the 1960s or the first computers in the 1940s. Conversely, hacking of information and com-

munications systems has a very long history if we take a liberal interpretation and involve communication systems too; even as early as 1903 a public demonstration of a supposedly secure wireless telegraph device was disrupted with insulting messages broadcasted in Morse code in order to discredit the device and its demonstrator [55]. Naturally, a more famous case of early communication systems hacking is the deciphering of Enigma by Allied forces during the Second World War. Since then various methods have been used against different information and communication technologies, ranging from more innocuous phreaking<sup>11</sup> to more complex computer system hacking, which can be conducted either under benign or malicious motivations [56] [57].

Benign attempts to hack computer systems often refer to experts conducting penetration testing on computer systems to ascertain their security [57]. Benign attacks can be conducted internally by the organization controlling the system, or an external contractor can be hired to perform surprise penetration attacks to test system's security capabilities in a more realistic setting. In the cyberwarfare context, benign cyberattacks are very much analogous to methods of cyber-defense: a nation's internal attempts in trying to spot possible weaknesses in the system. Malicious cyberattacks, on the other hand, are, as the name implies, the attempts of an external party to break computer system security for malicious harm or personal gain [56]. This type of hacking is analogous to the offensive form of cyberwarfare.

To understand what motivations drive cyberattacks, we concentrate on the offensive methods. The emphasis is on the offensive because motivations of a defensive side are generally obvious—who would not want to protect themselves from harm and damage? Furthermore, without offensive methods, there would not effectively be a need to create defensive methods.

We approach these underlying cyberattack motivations by reviewing some of the major cyberattack incidents relating to cyberwarfare, information warfare, and kinetic warfare. The starting point of this review is the dawn of personal computing and the Internet in the 1980s because the emergence of these consumer technologies makes the comparison more analogous to the present day. The review contains 14 incidents that were selected to represent archetypical cyberattacks over the years and around the world, with an emphasis on the large and most discussed events that primarily involve nation-states as main stakeholders. The incidents are summarized in Table 1, after which a short discussion is provided about the importance of these incidents along with their relationships to one another and to the broader thematic context of this article.

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<sup>11</sup> *A practice of reverse engineering of telecommunication systems to evade high long-distance call charges; <https://www.techopedia.com/definition/4050/phreaking>*

However, we stress that definite details of cyberattacks are often hard to come by because cyberattacks fundamentally contain an aspect of concealment; the act of cyberattack is intended to leave the perpetrator unknown. Therefore, some of the reviewed incidents contain speculative information based on deduction rather than known facts. Consequently, readers are advised to make their own conclusions regarding the details and related conditions of each reviewed case, minding that some of the sources used may be politically biased.

Table 1. Major cyberattack incidents, 1982–2016

Event	Year	Method	Description	Sources
<b>Trans-Siberian pipeline incident</b>	1982	Trojan horse	A Soviet plan to steal appropriate technology from a Canadian company to build natural gas pipeline was intercepted by the Central Intelligence Agency (CIA). In collaboration with the Canadian company, a Trojan horse was embedded in the company's software to sabotage the Soviet plan. As a result, the pipeline experienced an explosion caused by the software tampering, making it effectively the first recorded case of Trojan horse in computing. However, the story has been disputed by Russian news reports and remains unverified by the CIA.	[58]–[60]
<b>LBNL hacking</b>	1986	Hacking	A West German hacker accessed the computer system of the Lawrence Berkeley National Laboratory in the United States by using a vulnerability in the contemporary e-mail system. Through the hacking, the systems of various American military bases were also compromised, and relevant information was sold to the KGB.	[61], [62]
<b>Morris worm</b>	1988	Worm	This self-replicating software program was intended to measure the size of the Internet. The worm utilized weakness of the UNIX system and ended up copying itself to the same computer nodes multiple times. This resulted, ultimately, in a slow-down rendering approximately 10% of the Internet servers beyond usable. NATO regards this as the first occurrence of a cyberattack.	[61], [63]
<b>Titan Rain</b>	2003–2006	Hacking, DDoS	A series of coordinated cyberattacks beginning in 2003 and lasting at least three years. The attacks targeted information systems all over the United States, but especially the information networks of U.S. military contractors. The perpetrators were suggested to be involved with Chinese military forces. However, no conclusive identity for the attackers could be defined apart from a belief of Chinese origin.	[64], [65]
<b>Estonian cyberattacks</b>	2007	DDoS	A cyberattack against websites of Estonian governmental organizations, key business organizations, and media and communication companies lasting more than a week and described as the second largest orchestrated cyberattack after the Titan Rain. The attacks were thought to have state-level backing from Russia, and the incident has been explained as being triggered by the then-ongoing Russo–Estonian political dispute over the relocation of a Soviet era war memorial in the Estonian capital. Despite the expansive nature of the attacks, Estonian services were described to manage quite well, reopening the disrupted services within hours to a few days. These cyberattacks were part of a larger operation to resist the relocation of the war memorial involving elements from political activism and information warfare.	[63], [66], [67]

<b>Red October</b>	2007–2012	Virus	A cyber-espionage virus, Red October, had been running all over the border regions of former Soviet Union for around five years before its discovery in 2012. It exploited e-mail attachments and web browsers, mainly in search of diplomatic information.	[63], [68]
<b>Georgian cyberattacks</b>	2008	Hacking, web defacement, DDoS	Concurrently with Russo-Georgian War over disputed border regions, Georgian government websites were hacked using web defacement tactics, and local servers were overloaded with a DDoS attack. Effectively this incident was recognized as the first time that a cyberattack was conducted simultaneously with kinetic warfare operations	[59], [63]
<b>Gaza war cyberattacks</b>	2009	DDoS	Cyberattacks were utilized as a part of means of retaliation against Israel's operations in the Gaza Strip. At least 5 million computers—apparently through foreign botnets—were used to bring down the Israeli Internet infrastructure, concentrating especially on governmental websites.	[63]
<b>Iranian Cyber Army attacks</b>	2009–2010	Hacking, web defacement	A group dubbed the Iranian Cyber Army executed a web defacement operation by disrupting a microblogging service, Twitter, and Baidu, the Chinese equivalent of the search engine giant Google, by redirecting the services to a page presenting Iranian political propaganda.	[63]
<b>Stuxnet</b>	2010	Worm, social engineering	Stuxnet was product of joint development by the United States and Israel intended to both gather information and sabotage the nuclear program of Iran. The worm enabled digital mapping of Iran's key nuclear facility and destruction of a sixth of Iran's centrifuges used for uranium enrichment—a key step for a functioning nuclear reactor and, alternatively, for a nuclear weapon. As an apparent unintended consequence, Stuxnet got loose from the intended target and ended up infecting computer systems globally and almost 60% of Iran's total computer base—most of which were completely unrelated to the nuclear program. Stuxnet combined different modes of cyberattack: espionage and sabotage. Also, it was the first time a rootkit <sup>12</sup> was used against zero-day vulnerabilities in programmable industrial control systems. The target was an offline computer system that required an agent, and possibly involving social engineering, to deliver the worm on a USB drive. Iran was claimed to have responded by attacking banking websites and networks in the United States. However, these claims remain inconclusive because Iranian officials have categorically denied their involvement.	[48], [69]–[73]

<sup>12</sup> A rootkit is a software program designed to access the administrative settings of a computer system, enabling alterations while masking the presence of the rootkit malware [71].

<b>Sony Pictures hacking</b>	2014	Hacking	<p>Sony Pictures Entertainment, an American subsidiary of the Japanese conglomerate Sony, was about to release its latest movie: <i>The Interview</i>. The movie poked fun at North Korea's supreme leader, Kim Jong-un, with the plot revolving around his assassination plan. North Korea viewed the movie as a form of information warfare designed for defamation. According to the Federal Bureau of Investigation (FBI), a hacker group affiliated with the North Korean government retaliated by launching a cyberattack to hack computer network of Sony Pictures and threaten its employees. The movie was subsequently delayed, re-edited, and later released without any further retaliation.</p>	[61]
<b>Ukrainian power plant cyberattacks</b>	2015	Hacking, unidentified malware, DDoS	<p>A part of the still ongoing Russo-Ukrainian conflict that also involved Russian annexation of the Crimean Peninsula from Ukrainian control. Just before Christmas 2015, parts of western Ukraine's electric grid were taken out remotely by using a malware program for both execution and wiping out traces of the perpetrators. The cyberattack was immediately followed up with a denial-of-service attack on the Ukrainian utility company's customer service to block out legitimate complaints. The power was out in the targeted region for several hours.</p>	[21], [22]
<b>Swedish cyberattacks</b>	2016	DDoS	<p>A denial-of-service attack was reported in Sweden on March 20, 2016. The attack targeted Swedish news media and was able to shut down the service of major Swedish news sites for several hours. The attack was evidently tied to an information-warfare campaign; the attacks began after an anonymous Twitter account posted a threat against the Swedish government and "media spreading untruthful propaganda." The origin of the organizers of the attacks is suspected to be based in Russia, according to changes in Internet traffic data.</p>	[74]
<b>Finnish cyberattacks</b>	2016	DDoS	<p>Similar to the Swedish attacks, a denial-of-service attack was directed against the websites of the Finnish Ministry of Defense, Parliament, and Social Insurance Institution in late March. However, the attack origin and motivations are yet to be disclosed, and no Twitter threats were reported.</p>	[75]



The review begins with an incident straight out of a spy novel involving espionage, counterespionage, and sabotage. The motive behind the Trans-Siberian Pipeline incident was obviously politically laden in an environment where two superpowers were frantically competing over technology and resources. The second incident, LBNL hacking, was very much in the same vein as the first one: two superpowers competing for resources or, namely, information. An added component to this equation was a private party, the West German hacker, who actually initiated the whole incident for his personal gain by offering and subsequently selling classified information to the Soviets. This incident can be viewed as the first espionage-oriented hacking as well as the first incident orchestrated by an external private party.

The Morris worm is interesting because it is listed as the first cyberattack incident in a NATO review [63] examining the evolution of cyberwarfare, even though the whole incident was actually a graduate student's benign attempt to understand a new phenomenon: the Internet. However, this incident illustrates the fragility of connected cyberspace infrastructure due to its scalability; even a benign survey attempt may have catastrophic consequences if fatal errors are made in the automation and replicability of the software and its dissemination. The Morris worm subsequently provoked an emphasis on cyber-defense; the first computer emergency response team (CERT) was established immediately after<sup>13</sup> and the formal governmental organization a decade later [61]. In Finland similar organizations were established in 1995 and 2014, respectively.<sup>14, 15</sup>

The first major incident of the new millennium was so extensive that it got a designated name, Titan Rain, from U.S. officials. The motives are difficult to decipher conclusively, but it seems to be a similar case to the first two, with powerful nations competing for information, in this case related to military technology, classified technology-creation structures, and cyberwarfare capabilities. Similarly, Red October was a massive espionage operation in cyberspace that targeted diplomatic intelligence instead of military intelligence. Despite the fact that the source of the Red October virus cannot be confirmed conclusively, a simple motive and source can be deduced based on the information that the main target was the diplomatic correspondence of former Soviet satellite nations.

In the Estonian DDoS incident, which we also refer to as one of our cases in Section 2.2, the perpetrator and partially the motive seem to be rather evidently deducible due to surrounding political conflict over the war memorial, which involved

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<sup>13</sup> <https://www.techopedia.com/definition/27371/morris-worm>

<sup>14</sup> <https://www.csc.fi/-/funet-cert>

<sup>15</sup> <https://www.viestintavirasto.fi/en/cybersecurity/ficorasinformationsecurityservices.html>

features of information warfare. The whole incident in cyberspace seems to be a part of the continuum of Russia exerting its power in multiple fronts over its neighbor in this political dispute. The Gaza incident is similar to the Estonian incident in its operational execution; DDoS was used as means of retaliation to discredit political leadership in the eyes of citizens by sabotaging some key institutional services. However, the difference is that in the Gaza incident the apparent perpetrator was the inferior party of the conflict, which needed to turn to an external party for rented botnets to conduct the DDoS attack. The Estonian incident is very similar to the Georgian incident, which we also discuss in Section 2.2, in which connection to the perpetrators of the conflict (Russia was conducting kinetic warfare operations within areas claimed by Georgia) and the motive of the attacks (web defacement and DDoS attacks were aimed to discredit the political leadership of Georgia among the citizens) were even more straightforward.

More classical cases of information warfare can be seen in relation to the Iranian Cyber Army incident and the Sony Pictures incident, although the operational logic is a bit different in these. In both of these cases private corporations and services were used for dissemination of information-warfare types of information. The Iranian Cyber Army targeted an audience as broad as possible by hacking private Internet platforms to spread its own propaganda, whereas the Sony Pictures incident was apparently a successful operation of scare tactics through means of hacking to prevent or dilute a more traditional form of information warfare, a movie, although the movie's origin was in a private company rather than in an adversary nation.

Stuxnet was in many senses a remarkable piece of malware that was beyond the scope of regular hacker groups (T. Kiravuo, personal communication, February 19, 2016), a fact that was later disclosed and confirmed in relation to U.S. elections. This disclosure enables a unique view on this incident by confirming the political motives of the United States to sabotage the Iranian nuclear program. The operation echoes the similar Cold War era motives and operational tactics seen in the Trans-Siberian Pipeline incident as well as the unintended consequences of autonomous, self-replicating malware, such as the Morris worm.

The Ukrainian power plant incident is a similar energy-related sabotage operation and interesting in the sense that it established an apparent capability of some parties to have remote access to control and harm societally important industrial facilities, the impact of which can be further cultivated by delaying the reporting of the incident through DDoS attack. Although the true motive is once again difficult to determine due to lack of conclusive information, it is easy to associate this incident with the ongoing conflict in the Ukraine.

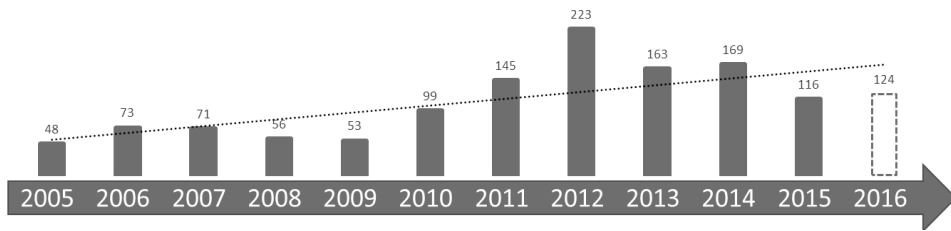


Fig. 3. Development of hacking events 2005–2016<sup>16</sup>

As if to exemplify how cyberattacks are becoming more frequent and common, during the writing process of this article we experienced two DDoS attacks in Scandinavia in March 2016. In Sweden the websites of media were targeted, whereas in Finland the target was national institutions' websites. The Swedish attacks were clearly more information-warfare oriented because related threats were made over an anonymous Twitter account and media institutions were targeted. However, the true motives behind these attacks remain murky at best, but some speculation can be deduced from the surrounding conditions, ranging from practical testing of cyber-defense capabilities or information-warfare-campaign-related recent developments regarding these Nordic nations' relationship with NATO. Interestingly, because the targeted systems were able to recuperate quickly, the media discussion also was blown off very quickly, as if to exemplify the commonness of these type of incidents nowadays. Figure 3 illustrates more generally this increasing tendency of malicious use of cyberspace by showing the development of reported individual data-breach incidents in the United States conducted via methods of hacking and malware between 2005 and 2016. The trend of increased number of cyberattacks is not radical but clearly visible from the figure's linear trend line.

Consequently, it is rather obvious what we can learn from the history of cyberattacks. As time has progressed, the motives and the understanding and capabilities to execute methods tied to cyberwarfare have evolved accordingly. This is to some extent a result of the evolution of underlying technologies, and to a greater extent about accumulated knowledge and understanding of how to apply the technology in increasingly complex socio-technical systems. More and more stakeholders can participate in cyberattacks as well as be subjected to them. There also seems to be an increasing tendency of the coevolution of cyberwarfare methods with information warfare; there is a seemingly increasing ten-

<sup>16</sup> The data were collected by a nonprofit organization in order to mitigate possible figure inflation reported to the cybersecurity companies for marketing purposes. The figures for the year 2016 show only a simple approximation of projecting the first quarter's results over a whole year; <https://www.privacyrights.org/data-breach/new?title>

gency to target the public opinion to sway political opinions one way or another, as has been evidenced by web defacement and discrediting DDoS campaigns. As a result, cyberattacks have become ever more frequent, complex, and versatile in terms of execution and application.

Part of this development has been driven by a “private sector”; criminal organizations have increasingly begun to exploit possible vulnerabilities in cyberspace, which has provoked nation-states to react in terms of defense, but also in terms of attacking capabilities. For example, China has been accused of exploiting private organizations’ capabilities against the United States, and Russian ties to private botnets in relation to the Estonian and Georgian incidents are nearly undeniable [48]. Consequently, cybercrime accounts for the majority of recorded cyberattack motivations, along with hacktivism. Conversely, cyber-espionage and cyberwarfare are merely marginal compared to cybercrime in the reported incidents.<sup>17</sup> However, these statistics only cover detected cyberattacks, which may differ vastly from statistics also involving the undetected attacks. Nonetheless, it is not just criminal private organizations that nations tend to source for cyberattack and defense knowledge and know-how; there are indications that developed nations utilize legitimate cybersecurity companies for operations such as acquiring cyberwarfare-related information and resources from the deep end of the dark web or purchasing services that enable the breaking of the cybersecurity settings of individual consumer products (T. Kiravuo, personal communication, February 19, 2016) [76].

Currently, there is no indication that there would be anything reversing this tendency of increased utilization of cyber-methods as an extension of political power and control. Zero-day attacks are reportedly becoming increasingly common [49] as unknown security threats keep emerging from increased complexity within and connectedness among the systems. However, cyberattacks are largely point-like operations that do not often last longer than couple of days because CERT organizations are usually quick to react, subjugating the attacks and collecting hints and traces about the attacker’s origin. Therefore, it is not all doom and gloom in terms of cybersecurity because also the defensive methods have evolved accordingly, with quick-response capabilities in developed nations. Complexity in cybersecurity and requirement for quick response have even mandated a push among nations toward openness and collaboration for better cybersecurity [54]. However, despite quick-response capabilities, zero-day vulnerabilities still enable seemingly unnoticed, long-lasting cyberattacks. Titan Rain lasted at least three years without clear disruptions to American society

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<sup>17</sup> <http://www.hackmageddon.com/2016/01/11/2015-cyber-attacks-statistics/>

[64], and the cyber-espionage virus Red October had been running all over the border regions of the former Soviet Union for at least five years before it was discovered [63]. Consequently, these long and quiet operations usually aim for information gathering rather than for disruption and damage.

The increased use of methods in cyberspace in relation to warfare also raises questions about the future. How will the methods and utilization of those methods continue to evolve, and, especially, how will they evolve in relation to traditional warfare? Will we enter into era in which we will see these cyberwarfare methods escalate into a full-blown cyberwar in the future?

#### **4.2 Will Cyberwarfare Substitute Kinetic Warfare?**

It has been debated whether cyberattacks are acts of war or, rather, acts of cyberterrorism. Because they are typically not traceable to any identifiable entity, often the real scope and extent of the cyberattack operation is left at least partially veiled, and ultimately the victims are left guessing whether there will be a follow-up of any sorts [76]. In a longer time frame the cyberattacks seem more like point-like operations of aggression for which normally no particular modus operandi can be applied because the underlying motivations are only rarely possible to tie conclusively to other operations of actual military aggression. Furthermore, conceptually it would seem impossible to annex parts of other nations just by using cyberwarfare methods; for that you need boots on the ground (T. Kiravuo, personal communication, February 19, 2016).

The whole concept of cyberwarfare has been disregarded as fitting insufficiently into the totality of war. Von Clausewitz characterized war as an instrumental act of power to coerce an opposition under the political will of the offensive faction. This act of power is a possibly prolonged violent means-to-end operation to extend the political actions to extreme measures [41]. Conversely, the acts of cyberattacks can be viewed merely as modern, sophisticated versions of sabotage, purposeful action to incapacitate economic and military systems; espionage, an act of infiltration to obtain secured and undisclosed information; and/or subversion, premeditated effort to harm the credibility of an established authority or public order [54].

Although wars fought solely in cyberspace seem implausible, methods of cyberwarfare may spark (kinetic) military counteroffensives, as manifested in a 2014 statement of the NATO secretary general outlining a policy in which NATO will respond with military countermeasures against anyone conducting a large-scale cyberattack against NATO members [77]. Further, methods of cyberwarfare will be increasingly utilized as part of military operations. Sabotage, espionage,

and subversion have their “real-life” wartime counterparts in covert sabotage operations behind enemy lines, gathering of military intelligence by any means necessary, and wartime propaganda to affect opposition morale. Therefore, cyber-tools have become a part of the offensive and defensive military arsenals of nation-states, in effect becoming complementary tools of hybrid warfare.

On the other hand, from a resource point of view, cyberwarfare is interesting in the sense that it has completely different dynamics of offense and defense compared with kinetic warfare. In kinetic warfare there is a long-standing heuristic or rule that an attacking force should be at least three times the size of a defending force [78]. This makes offensive actions much more resource intensive compared with defensive actions. Thus, cyberwarfare is interesting in relation to kinetic warfare because it turns these resource dynamics completely around [54]. In cyberspace, defense demands more resources and surveillance because an attack can come from any imaginable direction—there are many times more defensible dimensions in cyberspace than the three in real life. Given the right window of opportunity, an attack can in theory be executed by a single skilled individual with a computer (T. Kiravuo, personal communication, February 19, 2016).

Because the different forms of warfare can be expected to coevolve and merge to some extent, it can be hypothesized that warfare will increasingly be conducted as focused, point-like operations. A resource view would support this tendency, considering how costly actual kinetic war is. More sophisticated military technology would enable military organizations to conduct more effective operations based on rich intelligence data. Furthermore, depending on their extent, quick point-like operations could also be easier to deny in cases where political costs are high.

### **4.3 On Turning a Country’s Military and Infrastructure Against Its Citizens by Means of Cyberwarfare**

As outlined in Section 3.2, digitalization is also driving developments in kinetic warfare, implying that also the military machines of the future are at least in theory susceptible targets of cyberwarfare. This may bring increasingly scary scenarios in which automated weaponized systems become compromised and disabled, or even turned against their original users. However, considering the destructive capability of connected and (at least partially) automated machines of war, they will also likely be one of the most difficult pieces of technology to compromise using the tools of cyberwarfare. Consequently, a future where entire armies are “hijacked” and turned against their “masters” is not likely to materialize (T. Kiravuo, personal communication, February 19, 2016).

We have already witnessed conflicts where national infrastructure (com-

munication and power) is brought down by means of cyberwarfare. However, it remains to be seen whether the means of cyberwarfare will be deployed not only to disrupt, but to physically harm civilians or military personnel. A worst-case scenario in this respect could be, for example, if a chemical facility handling airborne toxins is attacked (T. Kiravuo, personal communication, February 19, 2016). Having malware, such as Stuxnet, designed to cause widespread damage instead of mere disruption is a scary prospect.

This notion that anything that is connected to the Internet could in theory be hacked highlights the risks with the current development of the Internet of Things<sup>18</sup> (IoT). Whereas having your refrigerator hacked would not pose a serious threat to your life, having your car hacked could lead to fatal consequences, an issue that already exists [79]. Considering this, it is alarming that security is lagging behind in the current IoT development (T. Kiravuo, personal communication, February 19, 2016).

The bottom line is that we are currently building more and more complexity into our technological systems, with the number of connections growing exponentially. This development impairs our ability to comprehend the great whole and to understand how it works [80], making it hard to foresee what the future of cyberwarfare holds and how it will complement information warfare, kinetic warfare, and politics in the future.

## 5 Discussion

Digitalization redefines warfare by both enabling new forms of warfare and by changing existing forms of warfare. Although digitalization can be argued to promote both peace and war, it could also be argued to make the distinction between the two harder. Further, digitalization also makes it harder to distinguish between friend and foe and soldier and civilian. In this section we discuss these perspectives, starting from the perspective of nation-states and moving to the perspective of the individual. We then present policy recommendations for promoting peace in the digitalized world, and round off by discussing possible business opportunities in promoting peace.

On the bright side, digitalization can be argued to drive a more peaceful world, with fewer conflicts and fewer civilian casualties, as imperfect information has traditionally been seen as a driver of conflict. Digitalization promises more informed decision making also with respect to warfare, preventing conflicts from

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<sup>18</sup> For more information, see [https://en.wikipedia.org/wiki/Internet\\_of\\_Things](https://en.wikipedia.org/wiki/Internet_of_Things)

escalating and possibly also shortening the ones that have escalated, by providing conflict parties with a more accurate view of the costs, gains, and risks of initiating and prolonging military engagements. Further, modern technologies of war will develop in precision, enabling a higher accuracy in military operations and in turn implying less civilian casualties compared with nondigitalized warfare.

On the dark side, digitalization can be argued to drive down the costs of warfare, in effect lowering the threshold of going to war. This is not only limited to monetary costs, where, for example, drones perform the work of fighter jets with greater accuracy at a fraction of the cost, but also political costs, as robots are blown to pieces instead of soldiers, resulting in a repair or replacement order at the manufacturer instead of a mourning family that blames the government. Digitalization also enables cyberwarfare, which enables aggression with virtually no risk of being held accountable in front of the international community (again implying low political cost). Respectively, in the battlefield, the digitalization of the machines of war has also to some extent led to the detachment of morale from action, where lives are ended through a click of a button some 5,000 miles away as a result of intelligence based on mobile location tracking data.

Social media use has triggered a renaissance of democracy, and mobilizing the masses for causes they care about has never been easier. At the same time, social media use has evolved into a formidable weapon in information warfare, where trolls and bots behind fake accounts shape public opinion easier and cheaper than ever before. For the apt and able nation, an organized information-warfare campaign (possibly accompanied by well-targeted cyberattacks) allows the ability to turn foreign citizens against one another and their governments, or to secure a favorable outcome in seemingly democratic election, both of which have already seen their first successes.

As a result of digitalization, the distinction between war and peace is diluted as conflicts transform from finite, high-intensity physical engagements to continuous low-intensity warfare, with less physical damage but similar ultimate outcomes. As a result, the declaration of war becomes an obsolete concept, and along with it international agreements related to warfare and rules of engagement. It is also the new norm that the identity, let alone the nationality, of perpetrators will remain unknown and open for political speculation.

In all three discussed dimensions of warfare, digitalization enables targeting individuals and using individuals to perform acts of war without their consent or knowledge. Modern weapons of kinetic warfare combined with intelligence from the digital infrastructure enable the targeting of key enemy individuals for precision strikes. The trolls of information warfare will target and ruthlessly pursue opinion leaders in an attempt to degrade their credibility and silence



them through verbal abuse. Cyberwarfare relies on incautious individuals to deliver payloads, granting perpetrators the keys to cripple a nation. In the coming sections we discuss how the individual, policymakers, and business can together promote a more peaceful world, by making societies resilient against the emergence of a conflict (Figure 4). With the individual having a key role in the defense of modern society, we begin by discussing what is required from us, as we, whether we want it or not, can no longer choose to be innocent bystanders.

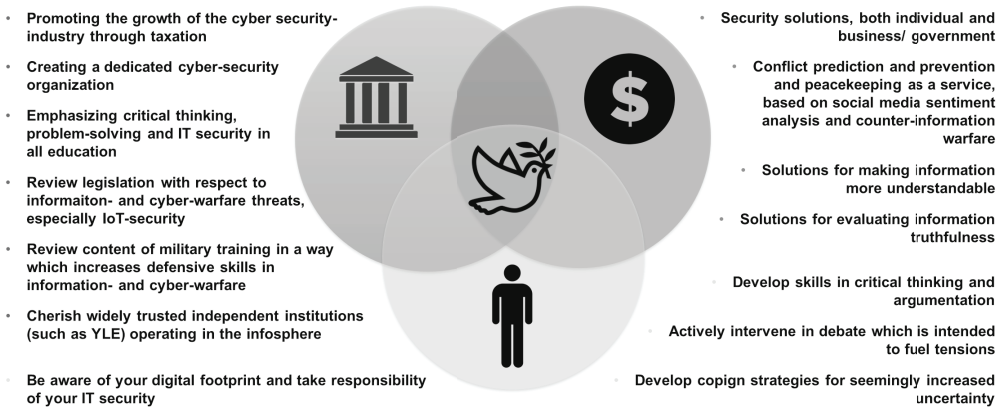


Fig. 4. Building peace.

### 5.1 The New Peacekeeper

Considering how conflicts emerge or are created (cf. Section 2.2), the key to sustained peace is in defusing inter- and intrasocietal tensions before they mount to the point where escalation becomes possible. Sustained peace, which is created through defusing tensions, is, however, relative in the sense that although there is no conflict-related violence or kinetic warfare, there may still be attempts to fuel tension through information warfare and cyberwarfare. If tensions should grow to the point where escalation is possible, conflict may still be prevented as long as the voice of reason overcomes that of aggression, which may be challenging considering human nature [7] [8].

The growing prevalence of digital social platforms and forums puts the ordinary citizen in the position of a peacekeeper. Defusing societal tension requires both skills and courage from the individual. Because tensions are created through falsifying or distorting truth, skills in critical thinking and argumentation founded on healthy criticism against presented truth are required. These are skills that can be developed, and they require us to be aware of what our truth is founded on and to frequently test that foundation for weaknesses. We also need to be aware

of who affects that foundation (e.g., what journalists writes the news you read and whose status updates fill your Facebook feed) and what agendas they may have. Further, whenever our version of the truth is challenged, we must accept the challenge and explore the views of others with an open mind—discussion with those who have a different opinion does not create conflicts, but isolation from them might. Finally, when witnessing rhetoric that is intended to fuel tension and aggression, it should be considered our responsibility to the civil society to intervene, however unpleasant it might be.

It can be argued that the truth is the only victim in information warfare; however, there is some collateral damage because attacks are also made on opinion leaders, journalists, and key decision makers. As individuals we may also need to develop coping skills and strategies for assaults against our online personas, be they from bullying classmates or online trolls with more sinister motives. Although this problem may be remedied through legal solutions, the individual solution is to create a psychological distance between the real and the online self (J. Aro, personal communication, March 17, 2016). Although distancing may be a good solution when being assaulted, paradoxically, distancing can also be used for evil because it provides us with the means to do and say things that we would not normally do, in essence causing social networks to be partly dehumanized or desocialized.

Considering the risks related to cyberwarfare, the individual is also the first, and sometimes the last, line of defense. We need to be aware of our digital footprints and develop a genuine interest for the technology that we use. Tech-savvy, as a positive term, should be reserved for those who understand how technology works; being proficient in using the latest gadgets and apps is not enough and can be downright dangerous without an understanding of the potential back-end risks involved. The necessity of understanding how social media platforms work is also understated, in the sense that we may currently be somewhat oblivious to the consequences of our shares and likes, which may be insignificant until the “wrong thing” goes viral. Further, the emerging IoT society creates additional pressure to understand technology because the scope of applications is growing rapidly, with security currently lagging behind.

The bottom line is that although the societal climate may have remained unchanged, campaigns of information warfare will make society seem more unstable and tense than it actually is. Due to the low cost of waging information warfare with current platforms and legislation, we need to (for now) accept this and develop coping strategies. And although we discuss the legal tools for reducing acts of destabilization later in the article, we first need to discuss the fundamental question of how to limit the abuse of free speech without limiting free speech itself.

## 5.2 Should There Be Freedom of (Hate) Speech?

Freedom of speech is a stated basic human right [81], article 19, and something that we tend to take for granted in Western democracies. The International Covenant on Civil and Political Rights [82], article 19, further specifies that freedom of speech also contains responsibilities, and that, consequently, freedom of speech can be restricted by law where it is “(a) For respect of the rights or reputations of others [or] (b) For the protection of national security or of public order [ordre public], or of public health or morals.” In other words, we tend to forget that freedom of speech bears with it the responsibility of not causing harm to another or society by that speech.

This taps into an ongoing philosophical debate with long traditions on when speech can or should be considered harmful.<sup>19</sup> Much like the free market is actually regulated, in ways that have become so obvious and institutionalized that they have been excluded from the idea of a free market itself (such as regulating child labor), free speech is also regulated. Even in the most liberal democracies we regulate free speech in terms of, for example, pornographic material and other “obscenities” or information “protected” by privacy, confidentiality, or copyright. As a further example, some countries that we may perceive as leading advocates of free speech have legislation against Holocaust denial. In this light, the question is not whether free speech should be limited, but how.

The anonymity of online discussions is problematic because it effectively disconnects rights from responsibilities by removing accountability. Nevertheless, hate speech and personal attacks against key opinion makers should be removed from the discussion, through the means presented in the following section. Further, because any direct incitement to violence is banned, so should any indirect incitement be banned, exemplified by the recent public debate surrounding immigration, in which immigration critics wished for proponents of multiculturalism to be raped. Wishing that someone be the victim of a crime should be allowed within the freedom of opinion, but banned in terms of freedom of expression, solely on the basis that a third party could seek to grant that wish.

Considering that freedom of speech can be limited when in the interest of national security, we may also need to take a more humble approach against repressive regimes. That is, where the individual in free societies carries the responsibility for defense against information warfare, the governmental defense against information warfare (whether the threat is foreign or domestic) is founded on limiting free speech. Although we maintain that freedom of speech is a universal

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<sup>19</sup> For the main points in this debate, see: [https://en.wikipedia.org/wiki/Freedom\\_of\\_speech](https://en.wikipedia.org/wiki/Freedom_of_speech)

human right and desirable considering the future of all societies, we argue that limitations on free speech should be lifted gradually and with care, as too-fast actions in this sense may fuel societal tensions and drive conflict escalation. Next, we discuss what policy measures can be taken to maintain societal stability and defuse tensions.

### **5.3 Policies for a Peaceful World**

Continuing the previous discussion, conflicts can be prevented, controlled, or limited to some extent through proper legislation. Regarding kinetic warfare, one question arises above any other, and that is whether machines should be allowed to make autonomous decisions of life and death in the battlefield. This question holds several problems (cf. [38]), mainly relating to accountability, current opinion on which indicates that autonomous killing machines might be deemed by the international society as too horrible to unleash upon humanity. However, in this field (as in the others discussed next) technology is currently evolving faster than legislation, with the potential to create temporary voids and gray zones that are then tested in precedent conflicts.

The anonymity of cyberwarfare (as well as cybercrime) is challenging in legislative terms because establishing the identity of perpetrators may not be possible. Although accountability is problematic, acts of cyberwarfare and cybercrime are already punishable by law. The question, then, is whether accountability should be extended to unknowing/unwilling accomplices who enable perpetrator access to critical systems. In effect, the question is whether the citizen or the software engineer (or both) should be held accountable for neglected cybersecurity. This question is especially relevant in the emerging IoT society, as we are essentially surrounding ourselves with connected devices that could potentially kill us (T. Kiravuo, personal communication, February 19, 2016). Negligence in many other walks of life leads to prosecution (however unintentional it may be), which would make it seem as if we are simply waiting for the first real case to materialize before taking legislative action on this point. Cyberattacks also typically fall in to a gray zone between an act of crime and that of war, which creates a need for a dedicated institution working against this threat, in tight cooperation with both military and law enforcement.

In the arena of information warfare, anonymity again poses challenges with establishing accountability. However, because information warfare is waged through commercial platforms, the obvious leverage point would be to hold platforms accountable for the crimes and acts of war that they (again unintentionally) facilitate. This approach would seem harsh, but then again it does not

seem fair that, for example, Facebook is earning money on hate speech and information warfare. Alternatively, some kind of legal plugin for platforms could be devised through which authorities would gain a stronger moderating presence, manifested through solutions such as the social media police or virtual restraining orders.

Where legislation offers a short-term, reactive solution, policies for education offer a long-term, proactive solution against information warfare and cyberwarfare. As digitalization begins to affect a growing share of the population, it will be essential to start training the peacekeepers of tomorrow at a young age. Critical thinking, argumentation skills, and digital security should be on the educational agenda before a citizen goes online for the first time. This means that these subjects should be taught beginning at kindergarten and throughout life. The more capable citizens are in defusing tensions, the less likely it is that the society in question could be escalated into a conflict state. Further, as mentioned in the discussion on the individual's role in preserving peace, critical thinking and argumentation skills are essentially about exploring truth. Considering this, it should be noted that the presence of a trusted, nonpartisan, nongovernmental media institution should be considered a major stabilizing factor in society. In this sense institutions such as YLE need to be cherished.

Finally, we note that the changed nature of conflicts also calls for adapting military service to the new circumstances. Although kinetic warfare will still remain at the core of escalated conflicts (implying that military as such will not become obsolete in the foreseeable future), the evolving impact of information warfare and cyberwarfare in the early stages of a conflict warrants placement of these subjects on the military training agenda. A separate question, then, is to what extent offensive tactics in these domains should be taught.

## 5.4 Profiting from Peace

It is well known that wars are a profitable business; government expenditures last year alone amounted up to \$216 per every human on the planet<sup>20</sup>. According to our analysis, digitalization drives down the costs of warfare, both economic and political. This is not to say that weapons will generally become cheaper, but rather that the increase in military power due to digitalization could be argued to be greater than the increase in cost. However, there are also profitable opportunities in building and sustaining peace, which we concentrate on here.

As uncertainty and an underlying sense of insecurity become the new normal,

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<sup>20</sup> [https://en.wikipedia.org/wiki/List\\_of\\_countries\\_by\\_military\\_expenditures](https://en.wikipedia.org/wiki/List_of_countries_by_military_expenditures)

new business ideas can be developed to cope with insecurity and hence prevent the social instability that precedes conflict escalation. We have already observed the first initiatives that empower users to become critical and to detect, report, and correct inaccurate or false information online. There is an opportunity in data visualization and analytics systems to make information more easily digestible and less susceptible to distortion and selective presentation. Further, there are opportunities to make the digital footprint palpable, through illustrating how information spreads online in terms of speed, patterns, concurrences, and corruptibility. Tools that help users make sense of the meta-information online (e.g., to dig backgrounds on hosts) are also potentially good development opportunities.

Further opportunities lie in personal online security, which is already a need; future business ideas could focus on profile protection and cyber-police and cyber-detective services. Education programs that concentrate on problem solving and critical thinking are already reality.<sup>21</sup> Open-access information will become more prevalent, and as verification tools become standard features in our browsers and applications, our sources for reliable information will be open and contemplated within our rights. Institutions responsible for the content in our infosphere will carry the heavy duty of truthfulness and will need tools capable of massive analytics and protection of large amounts of data.

Finally, we see that developments in technology and analytics will enable conflict prediction and prevention services, in which social networks and forums are scanned for sentiment changes and manipulation attempts. As mentioned earlier, methods for information warfare can also be used for defusing tensions and stabilizing society. The value of such a service would be immense for nation-states and international crisis and aid organizations, considering the economic, political, and humanitarian consequences of conflicts. However, preventive and predictive services are typically difficult to sell because building your value proposition on the concept that something will not happen is far more challenging than basing it on the idea that something will happen.

## 6 Conclusions

Digitalization changes how war is waged to an extent that leaves war itself in need of a new definition. In kinetic warfare this change is progressing slowly, but the realm of information warfare has effectively evolved beyond recognition

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<sup>21</sup> *Master programs on critical thinking focus on teaching skills for the future users and the understanding of their valuable participation in the infosphere; <http://dmlhub.net/research/>*

within the last decade. Further, in cyberwarfare, digitalization has created a new battlefield and a new form of war that, along with the emergence of the Internet of Things, offers expanding opportunities in terms of targets. War becomes more ambiguous than ever before, with digitalization underpinning developments that make it harder and harder to distinguish between war and peace, friend and foe, and soldier and civilian.

Digitalization drives down the costs of warfare, both economic and political. In terms of economic theory, this would make war a more feasible option, implying that due to digitalization we will see more conflicts in the future. On the other hand, the anonymity associated with information warfare and cyberwarfare implies that conflicts are less likely to escalate to armed confrontations because low-intensity continuous warfare may become the new normal. These viewpoints add up to the conclusion that although digitalization in the long run brings a more peaceful world in terms of less armed conflicts, it also creates a more unstable world, with societal tensions rooted in diverging ideas about truth and imbalances in power being continuously fueled.

This trend was visible in the recent conflicts studied for this paper, based on which we deducted a four-stage model of how future conflicts will emerge and be resolved. Based on this model, armed conflicts will predominantly take on the appearance of civil wars, and thus they will emerge where there is sufficient societal tension to eventually escalate to an armed conflict. This development can be driven and facilitated by a third party through means of information warfare and cyberwarfare, which may then achieve its objectives through direct or indirect intervention and subsequent stabilization of the situation. This model highlights that sustained peace depends on preventing conflicts from ever reaching the escalation phase, implying that the key to peace lies in defusing societal tensions. Based on this, we have highlighted the role of the *ordinary citizen* as the peacekeeper of the digitalized era.

Societal tensions, rooted in discrepancies in truth and power, are natural and even necessary considering the capacity of society to renew and reinvent itself. The difference between war and peace is merely a difference in how these tensions are handled, and social media forums have placed the individual on center stage. Preserving peace is thus increasingly dependent on every citizen's skills in critical thinking and argumentation, complemented by the civil courage to intervene when tensions are being fueled. Further, defense against cyber-threats also is increasingly dependent on individuals minding their personal information technology security and that of their IoT devices.

Policy decisions can support and facilitate the new role of the individual as the first line of defense. The educational reforms discussed in this paper are mainly

concerned with supporting the individual in becoming a more proficient peace-keeper and reviewing the role and content of military training. In terms of the legislative reforms, we discussed how freedom of speech should be maintained while promoting responsibility for what is said, and to what extent the individual should be accountable for neglect of information technology security. We also discussed economic opportunities that facilitate peace, such as security and information verification services. Further, there seem to be interesting prospects for selling peace as a service through the use of information warfare to defuse tensions instead of fueling them.

The bottom line is, however, that digitalization as such brings neither peace nor war, and it can be assumed to drive development in both directions. Although a future where fully automated, robotized armies are sent into the battlefield might be feasible in terms of technology, we need to ask what sort of geopolitical, cultural, and humanitarian situation could trigger this; it would seem incomprehensible that a nation would care so much for its citizens to send in robots on their behalf, but so little of their enemy that it would send in robots against them. The moral of this argumentation is that technology will never be aggressive, but rather a tool for human aggression. We conclude this article in the same way as Peter Singer concludes his book *Wired for War—The Robotics Revolution and Conflict in the 21st Century* [38, p. 436]: “Sadly, our machines may not be the only thing wired for war.”

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# *Disrupting the Water Industry*

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**ABSTRACT:** *In this paper we assess how digitalization can affect the role and operations of municipal water and wastewater utilities. We discuss ways through which the industry could be digitalized, focusing on the effects of digitalization on water and wastewater networks in particular. We assess the impacts of digitalization on stakeholder relations and analyze a case utility's business model as exemplary for the Finnish water and wastewater industry. The fact that water and wastewater utilities are natural monopolies affects their development strongly—they are the only actors with sufficient power to implement digitalization. Therefore, the drive for change needs to come from the utilities themselves. The strongest motivation for adopting new digital technologies lies in cost savings due to optimization of various asset management practices and advanced network control. Also, new revenue streams could emerge from new services offered by the utilities. We introduce seven business model innovations that digitalization could make possible.*

**KEYWORDS:** *Asset management, business models, digitalization, water industry, water and wastewater networks.*

# 1 Introduction

Water and wastewater utilities form one of the cornerstones of modern urban societies. Their core operations and service offering have remained very much the same throughout decades. Just as digitalization has rapidly changed many other industries, one can expect changes to take place in the water sector as well. In this paper, we seek to present some of the new possibilities digitalization offers to the water industry. We see that there are potential benefits that digitalization could offer and present our vision on how these could be realized. We present the basis of digitalization in this context, analyze the drivers for and barriers related to its adoption, and assess what would motivate water and wastewater utilities to drive these changes. We analyze the current business model utilities have and assess how digitalization affects the key stakeholders and their position. Finally, we introduce business model innovations that digitalization would enable and that could benefit both utilities and customers as well as society.

## 2 Municipal Water and Wastewater Networks

Water and wastewater systems form a part of the critical infrastructure of urban societies. They are both similar to and different from other vital infrastructure systems, such as roads, electrical networks, and gas and district heat pipelines. A notable difference is that although digitalization has already transformed many of the other infrastructures, such as electrical networks, the water industry is not yet strongly affected by this development.

Some of the earliest water distribution systems conveyed water gravitationally from the mountains to the citizens of ancient Rome through aqueducts. A modern water distribution system supplies water to end users through a pressurized pipe network in which the pipes form loops, a tree-like structure, or a combination of the two. Wastewater systems collect wastewater from water consumers through a collection system that typically forms a tree structure leading to a wastewater treatment plant located at the tree “root.” There, wastewater is treated before being discharged into natural bodies of water. In our analysis, we concentrate on municipal water and wastewater networks, thus leaving the water and wastewater treatment processes outside the scope of our study. We limit our study to these public networks, but discuss also household water metering, which offers potential benefits both to utility managers and individual water consumers.

Network assets together with treatment plants form the physical assets that water and wastewater utilities own and operate. Of these two asset groups,

network assets typically form some 80% of the total financial asset value. The operational environment and conditions where water and wastewater utilities function vary greatly in different parts of the world. Also, the amount of water consumed (and thus, wastewater produced) varies a lot. The average water consumption of a Finnish household is some 155 liters per person per day [1]. For comparison, Table 1 shows the average water consumption for four countries, selected to highlight the differences between the countries where the coauthors of this work come from.

*Table 1. Water consumption in selected countries.*

Country	Water consumption, liters per person per day
Germany	121
Finland	155
Taiwan	273
Canada	327

Table 1 shows that, on an average, Germans consume somewhat less water than Finns [2] and Canadians clearly the most [3], while Taiwan [4] falls between Finland and Canada in terms of water consumption in households.

The core services related to these systems are typically provided by water and wastewater utilities, which in many countries, such as in Finland, are partially or fully publicly owned, but can also be private, such as, for example, in England and Wales. The ownership and governing of the networks have an effect on, for example, what kinds of factors are experienced as drivers and barriers for change in the industry. The operational environment differs also in terms of the sufficiency of freshwater resources available. In many countries and regions, there is at least occasional lack of freshwater resources and therefore a need to save water. However, unlike one might expect, this is not always reflected in the water consumption figures of those regions. In spite of the fact that there is a need for saving water, authorities and water utilities have not always found effective ways for reducing water consumption, and this is an area where digitalization would offer new opportunities.

In our daily lives we mainly interact with water and wastewater systems through our use of water for different purposes of various levels of vitality. Typically, we may not think about these networks at all, or only in situations where something goes wrong—for example, water or wastewater flooding on the street due to a failure or a house being flooded due to a pipe breaking inside. These oc-

casions can lead to both severe structural and environmental damage as well as considerable costs. In fact, water can be considered a bigger danger to properties than the more obvious danger of fire. Finnish insurance companies paid some €140 million for water damage to properties in 2011, whereas compensation for damage caused by fire totaled “only” about €120 million in the same year [5]. Sensors, data, and analysis could help in preventing and reducing such damage. Water utilities could have a role in this as well.

## 2.1 Digitalizing the Industry

Little has been reported on the status of the water sector with respect to digitalization and the Internet of Things. Often, the water sector is referred to as a conservative field of industry, which practical experience also supports. Our understanding of the water sector is that, currently, there is a lot of potential for both collecting more data on the status of the network assets and utilizing the data more extensively, as is already done in fields that have been faster to adopt new advances, such as marine industry, for example. The adoption and use of devices and services already prominent in many other industries are still largely missing from the water industry. For example, one of our interviewees, Björn Ullbro [6], described how they at Wärtsilä offer a so-called “virtual engineer” service for power companies. This means that a person working at a power plant, possibly on the other side of the planet, can contact an engineer at Wärtsilä’s office to consult on a problem. Both wear a head-mounted camera and are able to see the same things on the screen as the other one does. Even though this kind of technology exists and already is in use elsewhere, it seems rather radical in the context of water and wastewater utilities, where the use of tablet computers can still be considered somewhat extraordinary.

High quantities of measured performance and advanced analysis of large datasets (“Big Data”) form the core of Internet of Things [7]. This, in turn, is linked to digitalization through the fact that only data in digital format can effectively be combined and analyzed. Networks typically can be considered data scarce, especially when one takes into account the geographical extent these networks have, which can be hundreds or thousands of kilometers per utility. Currently, in a good case, static datasets such as information on asset types, materials, dimensions, and installation years are stored in the utilities’ information systems. Online measurements are far less common in water and wastewater networks. Additionally, an essential aspect is often missing, namely, the connectivity between different datasets and between the data and actual network items. We claim that many improvements could be achieved through a more active approach to data utilization.



Devices that could be installed to get a better understanding of the networks include, for example, pressure and vibration sensors, online water consumption meters, flow meters, and water quality measurement devices. Water and wastewater networks are placed underground, which can make installation of extensive sensor networks both expensive and slow: If a utility starts installing new pipe materials readily equipped with sensors sending information on pipe condition, it may take hundreds of years before the whole network is covered by these new sensors. However, as measurement devices become cheaper and data collection and analysis commonplace, the amount of online information on the network can easily be multiplied. Even a relatively loose sensor network can improve the understanding of the network functioning compared with current systems. Additionally, installation of sensors can first be limited to places where they can be installed aboveground and in locations that are the most critical to get maximal benefits.

Another way to start collecting more data is by installing online water meters in households. These so-called smart meters measure water consumption on an hourly basis and send the consumption data to the utility. Most electricity meters in Finland are already smart meters due to 2009 regulations requiring at least 80% of electrical meters to send online data by 2013. Deployment of smart water meters would provide benefits similar to those in the energy field, where the smart grid has been under active development since 2007, after being first defined in the Energy Independence and Security Act in the United States [8]. In a modification of the definition of the smart electricity grid given by the International Energy Agency [9], the smart water grid could be defined as “a water network that uses digital and other advanced technologies to monitor and manage the transport of water from all sources of supply to meet the varying demands of end users.”

We see that an essential factor affecting the speed of changes in the sector is the fact that water and wastewater utilities are natural monopolies. This has implications for both the adoption of new technologies and the emergence of new services in the industry. Therefore, we next discuss the special features of natural monopolies.

## **2.2 Water and Wastewater Utility—A Natural Monopoly**

Markets in which a single organization can supply a good or service to all customers at a lower price than could two or more organizations are commonly referred to as natural monopolies. These markets demonstrate strong economies of scale, where a single organization can produce any amount of output at the lowest average cost. With an increasing amount of organizations supplying the product

or service, the output per organization is decreasing while the average cost increases for all organizations [10].

A city's water and wastewater supply system is the textbook example of a natural monopoly; to start with the distribution of water, the organization needs to build an extensive network of pipes, requiring significant investment. However, after the initial high investment costs to establish the water network, costs created by the use of individual customers are negligible. The marginal cost is determined by the individual customers' water use, which is a variable cost related to water and wastewater consumption. Compared to the fixed costs of building and maintaining the piping network, it is negligible and recouped directly with every liter used. Thus, serving the first customer creates as much marginal costs as serving the next. In consequence, the average cost sinks with each additional customer. Now, if two or more organizations were to compete, each would have to build its own piping systems, which would ultimately drive up the average cost of water and wastewater services.

Natural monopolies tend to represent the important infrastructure necessary for modern life; accordingly, they are often nationalized or strongly regulated [11]. Changes in the market structure and the regulatory decisions that might drive these changes are highly political. Nevertheless, over the last century many of these natural monopolies have been opened up for competition and undergone considerable changes in their industry structure and business models; the postal, telecommunications, railway, and electricity industries are some of the most prominent examples. In all of these cases, regulation has first been loosened to open the market for new actors. These changes have often been driven by political and societal pressures for increasing efficiency. In many cases, this was enabled by advancements in underlying technology. For example, the cost of various technologies has decreased and made it possible for organizations other than the utility to run the operations. Opening up the water and wastewater industry for competition might drive the adoption of digitization. Nevertheless, this would require that new actors are willing to appear and that society considers this sensible.

### **3 The Current Business Model of the Finnish Water and Wastewater Industry**

To fully understand what the digitization of the water and wastewater industry could mean, we need to have a general understanding of the sector. For this, we apply the business model canvas to the Helsinki region's water and wastewater services. The business model describes the offering, activities, and resources

an organization employs in creating value for the organization and its partners. Hence, the application of the business model canvas to the Helsinki region's water and wastewater services provides a broad understanding of how the organization works, what activities it engages in, and how its activities are connected through interactions with important stakeholders. Based on this understanding, we can more clearly demonstrate ways in which digitalization can create value for the organization and its partners. The business model consists of a customer value proposition, profit formula, and key resources and processes [12].

Fig. 1 shows the business model canvas [13] applied to the water and wastewater services in the Helsinki region. The business model would look similar for many other Finnish municipal water and wastewater utilities.

<p><b>Key Partners</b></p> <ul style="list-style-type: none"> <li>Construction companies</li> <li>- infrastructure for new buildings</li> <li>- upgrades for old infrastructure</li> <li>Government</li> <li>- certification</li> <li>- regulation/lobbying/advisory</li> <li>Suppliers of equipment</li> <li>- supply for new builds and modernizations for maintenance/repair (pumps, control software, customer service software)</li> <li>Service contractors</li> <li>- Maintenance companies</li> </ul>	<p><b>Key Activities</b></p> <ul style="list-style-type: none"> <li>Supply side</li> <li>Wastewater collection</li> <li>Wastewater treatment</li> <li>Water treatment</li> <li>Water distribution</li> <li>Infrastructure maintenance</li> <li>Customer facing</li> <li>Billing</li> </ul>	<p><b>Value Propositions</b></p> <ul style="list-style-type: none"> <li>Clean, high-quality water supply</li> <li>Collection and treatment of wastewater</li> <li>Reliable supply 24/7, 365 days a year</li> </ul>	<p><b>Customer Relationships</b></p> <ul style="list-style-type: none"> <li>Water consumers</li> <li>Via monthly billing</li> <li>Via mail or e-billing</li> <li>Via occasional repairs</li> </ul>	<p><b>Customer Segments</b></p> <ul style="list-style-type: none"> <li>Water consumers</li> <li>Individual households</li> <li>Housing companies</li> <li>Industrial customers (businesses, factories, etc.)</li> <li>Public customers (schools, hospitals, offices, government buildings)</li> <li>Towns</li> </ul>
<p><b>Cost Structure</b></p> <p>Fixed costs</p> <ul style="list-style-type: none"> <li>Infrastructure construction, modernization, and maintenance</li> <li>Maintenance equipment (maintenance vehicles, etc.)</li> <li>Software licenses</li> </ul> <p>Variable costs</p> <ul style="list-style-type: none"> <li>Water treatment costs (energy consumption, chemicals)</li> <li>Salaries</li> </ul>	<p><b>Key Resources</b></p> <ul style="list-style-type: none"> <li>Physical resources</li> <li>Water reservoirs</li> <li>Infrastructure</li> <li>Organizational resources</li> <li>Knowledge</li> <li>Experience</li> <li>Patents</li> <li>Customer base</li> <li>Human resources</li> <li>Employees</li> <li>Business relationships</li> <li>Government relations</li> </ul>	<p><b>Channels</b></p> <ul style="list-style-type: none"> <li>Physical water and wastewater infrastructure</li> </ul>	<p><b>Revenue Streams</b></p> <ul style="list-style-type: none"> <li>Initial charge for connecting to the network</li> <li>Base charge depending on property type</li> <li>Billing: Freshwater (price per liter X consumption)</li> <li>Wastewater (billed freshwater amount)</li> </ul>	

Fig. 1. The business model canvas [13], filled out for the water and wastewater industry in the Helsinki area as it is now.

### 3.1 Customer Value Proposition

The customer value proposition (CVP) answers the question, “What is the job the offering performs for the customer?” In other words, it describes what it is that the organization offers its customers. Following the business model canvas logic of Strategyzer AG [13], this can also be split into the value proposition (the job performed) and customer segments (the customers served). Hence, CVP considers the value that is created for the customer.

In our analysis the customers live in municipalities, as water and wastewater services outside of population centers often are provided in a decentralized manner. Given our interest in digitalizing water and wastewater networks, we therefore concentrate on the business model in city regions. What the water and wastewater utility in the Helsinki region provides to its customers is the delivery of drinking water and the collection and treatment of wastewater. From the customers’ perspective this means that drinkable freshwater comes out of the taps whenever they are opened, 24 hours a day, 7 days a week. The used water is then collected through the wastewater piping system. Customer segments are individual households, housing companies, industrial customers (businesses, factories, etc.), public customers (schools, hospitals, offices, government buildings, etc.), and sometimes also municipalities. All these customer segments are provided with the same freshwater delivery service. The wastewater retrieval and treatment is also available to all customer segments, with the exception that if an industrial water consumer creates heavily polluted wastewater, this cannot be treated centrally at a wastewater treatment plant but must be treated locally by specialized service providers.

### 3.2 Profit Formula

The profit formula is further broken down into revenue streams and cost structure [13]. This part of the business model considers the various aspects that generate income or cause costs for the organization—the net value of revenues minus costs represents the profit. Accordingly, the profit formula looks at how value is generated for the organization.

In a typical case, revenue streams consist of the usage rate, basic rate, and connection fee. The usage rate is composed of water consumption and wastewater removal. Consumed freshwater is billed at the price per liter times liters consumed. This remains constant regardless of the volume consumed. Accordingly, the more that customers consume freshwater, the higher is the amount they are billed. Customers are also billed for the second part of the usage rate, wastewater

disposal and treatment. In Finland the billing is based on the assumption that wastewater quantity equals water consumption, and only water consumption is measured. The water price per liter is typically the same for all customer segments. The cost structure is divided into fixed costs that do not vary with the volume of freshwater delivered and wastewater collected for treatment and variable costs that do vary according to the volumes of usage. Fixed costs include network and other fixed assets; piping infrastructure construction, modernization, and maintenance; maintenance equipment (maintenance vehicles, etc.) to realize maintenance activities; and other equipment such as software licenses. Variable costs are mainly water treatment costs to prepare freshwater that is to be delivered to customers and to treat the wastewater customers return after use. A large part of these costs stems from energy consumption for the water treatment and pumping and the chemicals required for treatment. Another source of variable costs is employees' salaries.

### **3.3 Key Resources and Processes**

After having defined what is offered to whom (CVP) and at which revenues and costs (profit formula), key resources and processes next focus on how the offering is delivered. For this, Strategyzer AG proposes to consider key partners, resources, channels, and customer relationships (key resources) and activities (processes) [13]. The assessment of key resources and processes demonstrates the how the CVP and profit formula are operationalized. Thus, the assessment shows how the offering can be provided and purchased by the customers and how the different other partners figure into the offering delivery.

*Key resources* can be divided into physical, organizational, and human resources. Physical resources are water reservoirs and the physical piping infrastructure that transports water from the reservoirs to the households. It needs to be noted here that the water and wastewater utility operating in the Helsinki region owns the piping network up to the property line of the individual household, housing company, or other actor. The piping from there onward, all the way to the tap, and from the sewer pipes back to the property line, are owned by the customer. At the entry into the customer's property, there is a water meter. This water meter, located inside the property, is owned by the utility. This meter records the water consumption, and customers are billed based on the records. The right for the utility to have such a meter inside properties, or vice versa, the responsibility of the customer to allow this, is defined by Finnish regulations. Since 2011 each individual household in new apartment buildings has been obliged to have a water meter in every flat, and today these meters must be installed into old apart-

ment buildings as well when the plumbing is renovated. As for the organizational resources, another component in key resources, they span the operational and technical knowledge of providing these services and the company's experience, intellectual property, and customer base. Because the water and wastewater industry is a natural monopoly, the customer base is a particularly valuable resource because there is no risk of customers switching to another provider—they are a “safe asset.” Human resources are any employees of the utility. The experience of the employees makes them a particular source of value creation. Moreover, good ties with business partners and the government can also be valuable resources.

*Key partners* are typically construction companies for building the infrastructure for new neighborhoods and upgrades for old infrastructure; the government for certification and legislation; equipment suppliers for equipment such as pumps, control software, or customer service software; and service providers, for example, for maintenance.

*Key activities* are managed on two levels. First, on the supply side the Helsinki water utility engages in freshwater treatment, water supply, wastewater collection, and wastewater treatment. Fulfilling these also requires maintenance of infrastructure and facilities, which is an important and high-cost activity. On the customer-facing side there is the billing activity.

*Customer relationships* are limited to the delivery of services (supply side) and billing (customer facing). The channels over which the supply-side services are delivered are the physical network assets. Customer-facing billing activities are managed through traditional paper billing by mail and through e-billing via online banking.

## 4 Stakeholder Analysis

Stakeholder analysis helps us to explore the parties affected by digitalization in the water industry and foresee potential benefits and challenges related to digitalization. As such, the literature has been rather vague on the exact meaning of “stakeholder,” and over 25 different meanings have been presented [14]. In this work we consider stakeholders as those parties that can affect or are affected by changes, and we further classify them based on the power they have in the water industry, the legitimacy of their claims, and the urgency of their needs [14].

To our knowledge, there is no academic work on the stakeholders of water and wastewater utilities. To present a generic overview of this field, we explore literature on the allocation and management of natural resources (e.g., [15]) and infrastructure planning process (e.g., [16]). Prell et al. [15] studied sustainability man-

agement in national parks. They identified eight stakeholder categories involved in the sustainability work: the water companies, recreational groups, agriculture, conservationists, grouse moor interests, tourism-related enterprises, foresters, and statutory bodies. Similarly, Jonsson [17] examined actors involved in water pollution. He identified agriculture, local authorities, point-source polluters, and recreational interest groups as stakeholders. Lienert et al. [18] identified administrative and political bodies as critical stakeholders, including various local operations people from the organizations involved in water management (i.e., water supply and water management). Similarly, the Helsinki Region Environmental Services Authority, the local water operator in the Helsinki region, describes its stakeholders as municipalities, technical departments in municipalities, the ministry of the environment, the raw water tunnel operator, supply and technology vendors, and customers [19]. Based on our review of the stakeholder connections, we focus our analysis on the following stakeholder groups:

- Water consumers
- Owners of real estate
- Regulatory bodies
- Water and wastewater utilities

The model is rather simplistic, summarizing it to users and regulators. As Moss [20] suggests, in reality the situation is more complicated because different mediatory actors emerge. However, we limit ourselves to conducting this simplified analysis only, not accounting for potential mediatory actors.

We classify each stakeholder further based on the power, legitimacy, and urgency aspects of the different stakeholders and map the potential changes for their interests caused by digitization [14]. Here, power refers to the opportunity of an actor to make someone else do something the actor wants to be done [21]. Legitimacy refers to the rightfulness and acceptance of actors' decisions [14]. Urgency refers to the degree to which stakeholder claims require immediate attention [14].

#### **4.1 Water Consumers**

The individual consumer (end user) has little to no impact on the day-to-day operations of the utility company. The lack of impact is due to lack of any opportunities to customize the offering per user; the water and wastewater services are mass produced for everyone connected to the network. Indeed, the only cases where customers can influence the setup of the offering is in a situation when they for the first time are connected to the network through a newly built con-



nection. However, even then the legislation defines the context rather strictly in Finland [22]. Indeed, there has traditionally been very little interaction between the water consumer and the utility.

In the context of digitizing water and wastewater networks, the impacts experienced by the consumer may seem rather small, such as an increase in the average level of service. However, adoption of new technologies can empower consumers to, for example, monitor their water consumption more closely; sometimes building automation already provides detailed digital information on the water consumption of the building. However, the most substantial benefits of digitalization often emerge only when reconsidering the business and operating processes and the organization more closely [23]. Examples of more radical changes in processes and organization could be, for example, the circular economy and new models for water storing in-house. These can bring more power to the end user, but are not outcomes of digitalization in the network [24]:

*If you look at the circular buildings in Holland...they have a kind of [secondary] loop water system, where they are collecting rainwater to flush toilets...maybe they are only using the fresh water for drinking...*

*Applying [smart] energy grid approach to water...similar to Tesla walls<sup>1</sup>...may ask “do you want water cheaper” and then you would have only minimum water access during certain times of the day.*

Before discussing the urgency of water consumer requirements, we acknowledge that there are different types of requirements that have different levels of urgency. Urgency can be high if the requests relate to service delivery, such as the quality of water or problems in the piping. At the same time, other requests, such as those related to environment or pricing, may be given less urgency. We suggest that as a local monopoly where customers do not have the possibility to switch the operator, the customers' various demands may not be considered as vital.

Furthermore, digitalization may influence how consumers perceive the urgency of their demands. Aspects with high urgency are related to service delivery, and they can be automated through improved digitization. Therefore, the water utility can react to the needs before the end users see any problems. Even while this demonstrates how the consumer needs are in the core and are served, the

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<sup>1</sup> Tesla walls are batteries for the home that provide additional reliability for solar panels; they can power the house even if solar energy is temporarily unavailable. In the case of water, this would mean similar short-term storage facilities for each building, allowing short-term disconnection from the water and wastewater infrastructure.

consumer remains unaware of actions taken. Therefore, the consumer—while receiving a higher quality of service—is less aware of the efforts made by the utility or by the local network infrastructure owners to maintain this service.

Finally, in addressing the legitimacy of consumer demands, we must first ask what type of demands consumers can make related to water and wastewater services. As we addressed earlier, the consumer has little power overall in the functions of the network operations. Because water and wastewater services are a mass-provided utility, we argued that digitization is expected to have only a minimal effect on the power-making capability of the customer. Therefore, if the ability to make demands is almost nonexistent, we cannot measure the legitimacy of those demands.

## **4.2 Owners of Household Plumbing**

As explained previously, the water network consists of municipal infrastructure owned by the water utility and the household plumbing inside buildings. The ownership of the latter belongs to the owner of the real estate, which can be the water end user living in the flat or someone else. Real estate owners have power over the consumers. The real estate owner can control how the plumbing is set up, and consumers are not allowed to modify this. However, various regulations must be followed in the installation [22]. Thus, the power of real estate owners is limited by regulations. A good example of this relates to the mandatory per-household water meters, which are required in new buildings. These are installed but not necessarily used for billing purposes due to additional costs related to reading the per-household meters [25]. This said, the real estate owner does not have strong power over the water utilities. As discussed, the water utility has a natural monopoly, and the chances of challenging the water utility are rather limited.

Similarly to water consumers, real estate owners may have requests, both urgent and nonurgent, regarding day-to-day operations. For example, the owner may have complaints about water quality, which is something that the utility may need to react to. (In Finland the utility is responsible for water quality until the point where the household connection starts. Depending on the circumstances, water quality problems may relate to either the municipal network or household connections and plumbing.) However, mostly the real estate owners have a position similar to the consumers: they do not have urgent needs regarding the municipal infrastructure.

We argue that compared to the consumers, the real estate owners have a slightly higher ability to make demands of the municipal water and wastewater utility. The water delivery from the water supply to the consumer is the sum of

the activities of the water and wastewater utility (municipal infrastructure) and (various) real estate owners, (responsible for household plumbing). The exact nature of the demands depends on the service agreement between the local infrastructure owner and the water utility, and this legal framework also defines the legitimacy of each demand.

The impacts of digitalization on the real estate owners are not enormous. Sensors in the water and wastewater networks can provide more detailed information, which may even serve to benefit the owner of the household plumbing. This information allows just-in-time maintenance. However, this technology does not change the relationship between the water consumers and real estate owners, as their relationship is dominated by the ownership of the infrastructure. Similarly, the household plumbing is outside the municipal network; thus, even if sensors inside houses could provide valuable information for the water utility, most likely the utility would solve its critical information needs in some other way than collecting data from real estate owners. Therefore, we do not see that digitalization would significantly change the relationships between real estate owners and other stakeholders.

### **4.3 Regulatory Bodies**

Regulatory organizations clearly have the power to make demands regarding water and wastewater infrastructure. For example, in Finland, the regulators also set limitations on various operational details, such as the required flow of water in showers [22]. The current regulation focuses on physical elements, but regulation can be extended to cover digital systems as well [26] [27] [28]. For example, the algorithms and data formats can be regulated for “interoperability purposes.”

However, the power of regulation is challenged through digitalization. Today major digitalization players, such as Uber and Airbnb, work “in the gray area of legislation,” or, more simply stated, they disrupt existing rules and benefit from modest reactions from regulatory agencies [29]. We, however, argue that these type of global disruptions are not likely when examining infrastructure services. Infrastructure services require physical “hardware” and cannot just be delivered through a software solution. This may challenge the ability to disrupt them in ways similar to other modern industries. Therefore, we argue that there is only a slight possibility that the regulatory power would decrease in the future.

However, digitalization can change the legitimacy of regulations. Citizens may have new expectations regarding regulations. Various trends, among them digitalization, drive changes in the 21st century, characterized by rapid and fundamental changes in the operational environment and operation logic of vari-

ous industries. However, public administration and regulatory authorities have thus far been maintaining the status quo in their reactions. This behavior can decrease the legitimacy of those actors because it is easy to argue that “they don’t understand the new world” and thus challenge the validity of their claims. If this trend takes place, we argue that there can also be a decrease of the legitimacy of regulators in the water industry. Already now we can see small changes in the regulatory environment. The current policy documents have discussed leaner operational models in administration, which may decrease the role of regulation overall (“kokeilukulttuuri”) [30].

We argue that the legitimacy of regulatory organizations’ demands is not specific to the water industry; rather, legitimacy reflects the society at large. If the public administration is commonly considered to be legitimate, we assume that also specific regulations related to water are considered legitimate. Similarly, the demands from regulations are dealt with urgently. We base this argument on the power the regulatory stakeholders have; they may force operators to take action if they are not satisfied with the current situation.

#### **4.4 Water and Wastewater Utility**

In this work, we have chosen to view changes from the utility perspective. For example, the business model canvas was developed reflecting this perspective. To understand the implications of digitalization on the utility, we examine how the role of the utility as one of the stakeholders might change, in the same way as for the other stakeholders identified previously.

The water and wastewater utility that owns and operates the municipal water and wastewater networks also has ultimate power over this network—naturally, constrained by regulations. The water and wastewater utility chooses where and how to invest in maintenance and other operations and decides on different service fees. However, the water and wastewater utility does not have full control over the service delivery because the final part of the network that serves the consumers is owned by private real estate owners.

Even though the water and wastewater utility has a significant role for the infrastructure, the demands made by the utility may not be considered urgent. For example, changes in the regulation based-requirements for water and wastewater operations or attempts to change consumer behavior in the form of campaigns may not be considered urgent. However, management decisions by the utility itself can rapidly be reacted to.

Finally, we argue that the legitimacy of the requirements depends on the public perceptions of those demands. Many “routine” operations, even though

inconvenient, can be considered legitimate because they are a part of the core operations related to maintaining the network. The challenge may, however, emerge in cases where the demands are not considered as being caused by core operations. Digitalization of operations would allow more precise estimation of network status, which will give more power and legitimacy of the demands to the water and wastewater utilities.

Although having more data from sensors and appliances benefits the utility, costs are also related to running and maintaining them. Can the investments needed for digitalization be justified through potential cost savings in the future? If not, the expenses of digitalization can create a legitimacy deficiency and distrust in the management of the water utility. This can have negative effects on the position of the water utility.

Even with these remarks, we have chosen to focus on water and wastewater utilities and their opportunities in digitalization. We consider—using modern jargon—water and wastewater utilities platform companies. These utilities own the core infrastructure and have opportunities to access data and modify the service delivery. Therefore, if the networks are more strongly digitalized, we argue that water and wastewater utilities should be the ones to drive the change. First, the water and wastewater utility is the core, the operator. Challenging these utilities would require building different water distribution systems, which has high costs. Thus, water and wastewater utilities have been given a natural monopoly in the area where they operate. Second, we believe that other stakeholders may approach digitalization from a disadvantaged position. If digitalization is not coordinated, the outcome may be noncompatible digital interfaces, such as each building having its own platform. Similarly, digitalization may be pushed in a way or cause demands that are not in the interest of all stakeholders. For example, the per-household water meters in Finland are an example of a regulation-led operation that was not successful.

## **5 Optimization of Operation—Motivation for Change from the Utilities' Perspective**

Our view is that the water and wastewater utility is the core operator in digitalizing the networks. From the utility's perspective, the motivation for change is to improve its operations related to technical efficiency, smooth workflows, and economics. The improvement of the management and maintenance is considered important at utilities, and digitalization could assist in this. For example, our interviewee Tommi Fred [31] noted that digitization will offer improvements to asset management.

The costs of maintaining and renovating the networks are huge. For example, some 5 billion euros are spent annually in Europe alone to renovate existing wastewater networks [32]. Optimizing the spending of this money could be improved through digitalization. This means optimization on various levels, such as asset life span, optimization of maintenance activities, and operation and control of the networks in an energy-efficient way. Potential benefits also cover reduction of environmental problems and risks related to network failures. To see these opportunities, it is important to consider the current issues and solutions in the water industry. In this section, we investigate the motivation for change from the utilities' perspective.

### **5.1 Existing Asset Management Practices**

Water and wastewater networks are located underground, and thus activities such as preventive maintenance pose special challenges. Traditionally, the most advanced methods of asset management have relied largely on retrospective analysis of data on asset condition information and asset attributes, possibly combined with environmental datasets. These methods have enabled characterization of the deterioration behavior of different pipe groups based on, for example, pipe age, size, and material. Deterioration models have been built to model pipe deterioration over time and predict the chance of having a failure. Physically based deterioration models are robust because they explicitly combine all of the factors that lead to failure. However, they require a high quality and availability of data, which often is only available for large water mains for economic reasons [33]. Also, statistical models can be applied to predict failures and to identify factors affecting failures [34]. Although these modeling approaches are capable of providing a lot of new insight into the life span of network assets, they also have deficiencies regarding both their predictive power into the future as well as the spatial and temporal resolution that can be reached by using them. By analyzing large amounts of historical data on pipe failures, it has been possible to estimate how the average structural condition of different pipe groups evolves. This has already improved the asset managers' tasks compared with earlier decades, where the structural condition of most underground pipes was practically unknown. However, so far it has not been possible to predict the condition of individual pipes, let alone receive information on it online.

Maintenance of water and wastewater networks is an essential task for the utilities. To ensure the quality of water and to minimize risks related to, for example, drinking-water contamination, asset management requires continuous optimization [35]. In many countries, water and wastewater assets are poorly

documented, arguably because at the time of construction the philosophy was to “build and forget”; pipes were built, buried, and left unattended [36]. Also, it can be assumed that the power in analyzing the asset data has not been understood until relatively recently. Even today, there are often limited systematic recordings of asset condition but no linkages between maintenance data and the inspections undertaken [35] [36].

## 5.2 Improvements to Expect

It could be argued that most of the approaches aim at cost reduction and advanced support for making decisions related to asset management. Digitization offers new possibilities for asset management in the water industry. One of our interviewees, Björn Ullbro [6] of Wärtsilä, described digitalizations with the slogan “From sensors to sense-making.” The first step in advancing “sense-making” would indeed be installing sensors that send signals and thus create data. Currently, the number of installed meters or sensors in the networks is still very low, especially when considered in the context of the industrial Internet. The main assumption is that in the digitalization era there are plenty of these datasets and, on top of those, efficient algorithms that analyze those signals. These together lead to a value-adding element, which can mean increasing the benefits to the user or lowering the cost to the provider, as discussed further in the next section.

Fenner [36] summarizes three requirements for an efficient asset management system. Even though the reference is from the year 2000, the points are still valid. Modifying his list, we state that the requirements are as follows:

1. *Reliable data:* Data quality needs to be confirmed regarding all the datasets, whether they describe network assets, measurement, or spatial data.
2. *Standardization of information:* The data must be easily transferrable to the formats used by hydraulic modeling products, and data should be standardized because decision support systems need to be able make use of existing information.
3. The decision on the *method for collecting information:* New technological developments continuously extend the capability of collecting data. However, new measurements alone will not solve the fundamental problem that the datasets must be combined to make the actual decisions on, for example, inspections and renovations.

One of the promises that digitalization offers, again according to our interviewee Björn Ullbro [6], can be formulated as “asset management made easy.” The Internet of Things (IoT) offers new potential not only for online system control but also for long-term asset management. Once the utility has data with sufficient quality and

quantity and the platforms working for efficient utilization of the data, the decision support for managing the networks can be dramatically improved. The utility will benefit from improved asset management through a reduction in the cost of maintaining networks and the risk related to network failures.

Interaction between the utility and the customer has traditionally been very limited. This could change if water consumers get applications where they could send information to the utility on, for example, water quality issues, as was suggested by our interviewee Tommi Fred [31]. Crowdsourcing related to collecting environmental information for public use has been implemented in projects such as Smart Citizen [37]. In this project, crowdsourcing was enabled by distributed IoT devices and a “Smart Citizen Kit” consisting of sensors that measure air composition, temperature, humidity, light intensity, and sound levels. Anyone can obtain the measurement device, install it, and join the network. The device will then share the data and geolocation. Smart Citizen is a crowdsourced environmental monitoring platform, which illustrates how digitization could also facilitate the interaction between end users and the service provider.

### **5.3 Future Prospects and Related Challenges**

It is reasonable to expect that with accurate data on the status of different parts of the system, it will be possible to detect failures and malfunctions at an early phase. Extensive online monitoring will enable fast reactions to pipe failures and thus reduce unwanted consequences. Methods for detecting anomalies in network functioning have been proposed by, for example, Romano et al. [38]. Also, examples on optimizing the network operation online already exist (see, e.g., [39]). As more and more data are collected over decades, it will be possible to make more solid conclusions about, for example, the durability of different materials than before. Similarly, failure prediction might become an option; as the spatial and temporal resolution of failure modeling rises, failures could eventually be predicted at even the pipe level. Similar products designed for end users have appeared on the market (see [40]) but have not been widely applied. Active detection is a huge change compared to the current situation, where the condition of pipes might be inspected, for example, once in a decade and where the water consumers are often the ones to inform the utility about a failure.

There are still challenges to be overcome before radical changes can take place in the industry. Many of the challenges that water utilities face with respect to digitalization are similar to those faced by other fields of industry: how to handle lots of data and make conclusions based on the data, how to present a clear synthesis of a huge amount of data, and how to convey an overall picture of



what is happening to the water professional [6]. In addition to these tough but practical challenges, there are also other issues to overcome before digitalization can really bear fruit. One of these is information security. Water infrastructure is critical to the society, and therefore information security needs to be considered when starting to apply IoT solutions. However, in our opinion, this is a fact experienced by many industries, which inevitably will start taking advantage of IoT to some level at least, so solutions for this can be expected to be found.

In line with digitalization, new kinds of expertise are needed in the industry related to data analysis and software systems. This could also be one of the factors that eventually make the change possible. It is likely that utilities will have so much data to deal with that they need help with data processing. This is a completely different need than what the utilities mainly struggle with currently. Those service providers that can best answer the need of this type will have a chance to flourish. Also, on the utility side, there will have to be a shift in core competencies from traditional water and wastewater engineering toward data analysis and information technology, even if these are actually carried out by third party. The activities utilities will focus on will not only include the mechanical, but also the analytical tasks, and not only the operational, but also optimization tasks.

## **6 Business Model Innovation in Natural Monopolies?**

In regular, nonmonopolistic markets, digitalization has caused severe disruptions over the last years (e.g. advertising or publishing [41]). These fundamental changes within these industries are largely due to the specific characteristics of the digital economy; exactly measured data can be transmitted instantaneously an infinite amount of times without creating marginal costs [2]. These industry upheavals have been caused by business model innovations by companies such as Amazon and Google. The lesson learned from these large-scale industry reconfigurations is that organizations, if they are to capitalize on the opportunities digitization can provide, ought to reconsider their business model.

So far, few digitalization efforts have been made in the water and wastewater industry. The reason for this might be found in the early life-cycle stage of the IoT and sensor technology in industrial operations [7] and in the current relative uncertainty about its exact value for and implementation in the water and wastewater industry. The use of IoT and sensor technology for industrial Internet solutions inherently carries the precise, real-time, and extensive measurement of operations, regardless of whether operations are to be analyzed or (partly) au-

tomated [7]). By measuring the performance, use, and maintenance of water and wastewater delivery, an immense wealth of digital data can be created. Using this data to further develop the business to better meet internal and partner needs does not require utilities to switch into the software business. Rather, as Iansiti and Lakhani [42] propose, it means considering how the current business can be improved by making use of this additional insight: How can the water and wastewater utilities leverage their current business through digitalization initiatives?

Currently, the water industry is a highly regulated industry and a natural monopoly. The utility feels no external pressure to develop the business model, nor are there external pressures to use more efficient operational methods such as IoT-enabled industrial Internet solutions. One option would be to increase external pressures; the government could open the industry for competition. Although this could promote technical innovations, there are also considerable risks associated. Water is widely considered to be a human right [43], and thus the networks form a part of a country's vital infrastructure. In consequence, the provision of quality water and wastewater services should not be driven by a purpose to create financial profit, but at a self-sustaining level for the purpose of supplying the service. In our analysis, we concentrate on the possibilities of disrupting the industry without privatizing the utilities. Change can come about in a number of ways and does not always require a change in dominant actors.

The alternative to opening the industry through external governmental pressure is for the water and wastewater utility itself to reinnovate its business model. Within the given regulations, the utility could tweak the details of its operations. Fig. 2 shows the business model of the water and wastewater services in the Helsinki region as it is currently (in black), with added new alternatives for future business innovations (in blue, and their effects on other parts of the canvas in green).

Keeping in mind the role of water and wastewater service as a critical piece of a nation's infrastructure, the ultimate goal of our suggestions is to optimize the value of the water services to all stakeholders. In other words, rather than limiting our thinking to the utility's interests alone, we consider which innovations could be valuable to customers, the greater public, or society at large. Which business model innovations could increase the value of water services delivery for all stakeholders, without reducing the value to the water company?

<p><b>Key Partners</b></p> <ul style="list-style-type: none"> <li>Construction companies</li> <li>- infrastructure for new buildings</li> <li>- upgrades for old infrastructure</li> </ul> <p>Government?</p> <ul style="list-style-type: none"> <li>- certification?</li> <li>- regulation/lobbying/advisory</li> </ul> <p><b>BMI 7: would make governments even more important partners</b></p> <ul style="list-style-type: none"> <li>- BMI 5: governments might invest in this self-monitoring app</li> <li>- BMI 7: setting daily consumption limits and coordinating of tax payment</li> </ul>	<p><b>Key Activities</b></p> <p>Supply side</p> <ul style="list-style-type: none"> <li>Wastewater collection</li> <li>Wastewater treatment</li> <li>Water treatment</li> <li>Water distribution</li> <li>Infrastructure maintenance</li> </ul> <p>Customer facing</p> <p>Billing</p> <p><b>BMI 3: Water flow monitoring, automatic shutdown service in case of leakage</b></p>	<p><b>Value Propositions</b></p> <ul style="list-style-type: none"> <li>Clean, high-quality water supply</li> <li>Collection and treatment of wastewater</li> <li>Reliable supply 24/7, 365 days a year</li> </ul> <p><b>BMI 2: Differentiated pricing model</b></p> <p>Price water according to peak and low hours</p> <p>Consumers could lower their water bill</p> <p><b>BMI 4: Additional service to house-owning customers for condition monitoring</b></p> <p><b>BMI 5: Mobile app/web service that shows exact consumption</b></p> <p>This could incite people to use less water</p> <p><b>BMI 6: Platform offerings</b></p> <p>e.g., Amazon dishwasher tablet order</p>	<p><b>Customer Relationships</b></p> <ul style="list-style-type: none"> <li>Water consumers</li> <li>Via monthly billing</li> <li>Via mail or e-billing</li> <li>Via occasional repairs</li> </ul>	<p><b>Customer Segments</b></p> <ul style="list-style-type: none"> <li>Water consumers</li> <li>Individual households</li> <li>Housing companies</li> <li>Industrial customers (businesses, factories, etc.)</li> <li>Public customers (schools, hospitals, offices, government buildings)</li> <li>Towns</li> </ul>
<p><b>Key Resources</b></p> <p>Physical resources</p> <ul style="list-style-type: none"> <li>Water reservoirs</li> <li>Infrastructure</li> </ul> <p>Organizational resources</p> <ul style="list-style-type: none"> <li>Knowledge</li> <li>Experience</li> <li>Patents</li> <li>Customer base</li> </ul> <p>Human resources</p> <ul style="list-style-type: none"> <li>Employees</li> <li>Business relationships</li> <li>Government relations</li> </ul> <p><b>BMI 2 to 6 make data an asset, as it is used for new services</b></p>	<p><b>Channels</b></p> <p>Physical water and wastewater infrastructure</p> <p><b>BMI 3 and 4 would create further contact points</b></p> <p>Letters, emails, webpage for information about new services and the management of these service relationships</p>	<p><b>Revenue Streams</b></p> <p>Initial charge for connecting to the network</p> <p>Base charge depending on property type</p> <p>Billing: Freshwater (price per liter X consumption)</p> <p>Wastewater (billed freshwater amount)</p> <p><b>BMI 7: Price hikes for high consumption</b></p> <p>Consumption price steps according to daily and weekly consumption e.g., first 90 liters a day/person as base price each additional liter per person +10%</p> <p><b>BMI 2 to 6 would create further revenues from the services offered</b></p> <p><b>BMI 7: Punitive tax for over-consumption</b></p> <p>The government could levy a tax for consumption beyond 90 liters per day per person</p>	<p><b>Cost Structure</b></p> <p>Fixed costs</p> <ul style="list-style-type: none"> <li>Infrastructure construction, modernization, and maintenance</li> <li>Maintenance equipment (maintenance vehicles, etc.)</li> <li>Software licenses</li> </ul> <p>Variable costs</p> <ul style="list-style-type: none"> <li>Water treatment costs (energy consumption, chemicals)</li> <li>Salaries</li> </ul>	<p><b>Revenue Streams</b></p> <p>Initial charge for connecting to the network</p> <p>Base charge depending on property type</p> <p>Billing: Freshwater (price per liter X consumption)</p> <p>Wastewater (billed freshwater amount)</p> <p><b>BMI 7: Price hikes for high consumption</b></p> <p>Consumption price steps according to daily and weekly consumption e.g., first 90 liters a day/person as base price each additional liter per person +10%</p> <p><b>BMI 2 to 6 would create further revenues from the services offered</b></p> <p><b>BMI 7: Punitive tax for over-consumption</b></p> <p>The government could levy a tax for consumption beyond 90 liters per day per person</p>

wFig. 2. Business model canvas [13] with innovations. (BMI = business model innovation.)

## 6.1 New business models

We found seven potential business model innovations (BMIs). Not all of these BMIs are equally applicable to the Finnish market. When considering these innovations, water companies' interests, customers' needs, and the government's intentions need to be considered. The development of any of these innovations requires initial investments and continuous support; for this, they need to be aligned to the different stakeholders' interests.

### 6.1.1 Modifications of the Existing Business Model

Digitalization can help water and wastewater utilities drive performance of their operations, either through cost optimizations or incentivizing optimized consumption by a new pricing model.

#### *BMI 1. Sensor- and analytics-based asset performance improvement processes*

This BMI helps water and wastewater companies to drive internal cost savings. By employing sensors to collect real-time data on the condition of the existing piping infrastructure, the companies can better analyze the need for maintenance. Moreover, the analysis of this data might show operational stress levels in different areas of the system, which might give an indication of where in the infrastructure operational inefficiencies are located. This way, operational and maintenance costs can be minimized.

The BMI demonstrates a high implementability—it requires the water company to install additional sensors in its own system; hence, there is no external resistance to this BMI. In the first phase, the existing datasets coming from, for example, SCADA systems could more actively be taken into use for condition monitoring and analytics. Additional sensors could be installed at critical locations based on an analysis of where they provide the most benefit.

The value of this BMI lies in a reduction of operating and maintenance costs for the water and wastewater utility. The costs of installing the additional sensors might be quickly offset by the cost savings resulting from a more efficient maintenance and operations planning and the reduction in severe failure consequences.

#### *BMI 2. A differentiated pricing model for peak and low hours*

This BMI would serve the water company by helping to reduce operational costs or to reduce investments on extra capacity in networks with capacity problems. When a lot of people use critical pieces of the municipal infrastructure at the same time, the network is strained. The water infrastructure has certain limits

in its capacity to transport water and wastewater at any time during the day. At peak hours (i.e., mornings before work and in the evenings), much higher flows are pumped through the system than average. By incentivizing users to use water at some low-use hours rather than at peak times, this strain on stressed parts of infrastructure can be relieved. We have seen this BMI in the energy industry, where electricity prices vary depending on the time of the day. A similar model could be applied to the water industry. By raising peak-time prices, customers who do not have to use their washing machine or dishwasher during these hours could be incited to use water at different times. Although this is unlikely to influence whether customers use the shower in the morning, other activities that can be rescheduled without problems can be taken care of outside of peak hours. This would enable the water company to optimize its operations and prevent problems caused by varying use.

Considering the water companies' market power and the customers' lack of alternative providers, this BMI is highly implementable. In case the water and wastewater utility decides to implement this pricing model, other stakeholders need to accept this. This would require having online information on the water consumption in properties, which is technically fully possible even now but requires installation of online meters in properties throughout the network. Similar changes in recording electricity consumption have been made in the electricity industry.

For the utility, the value of this BMI lies in reduced operational costs and a lower need for new investments in capacity. Once consumers are incentivized to consume less water during peak hours, the strain on stressed parts of infrastructure is relieved. Whether the water and wastewater utility decides to implement this BMI depends on whether the utility judges the potential cost savings or the initial, possibly adverse reaction by the public to be more relevant.

### 6.1.2 Key Activity Extensions

In addition to changes in the existing business model (i.e., operations optimization and pricing), there are several opportunities for new offerings.

#### *BMI 3. Automatic shutdown service in case of leakage*

This BMI speaks to customers and can create additional revenue streams for the water company. With real-time monitoring of water consumption, leaks can be spotted early on before they cause a lot of damage. The granularity of the service will depend on the quality of data that can be collected on-site; in the case of the currently existing online metering devices that have to be installed in new flats,

consumption data points can be sent, for example, every 30 minutes. If customers were to agree to install additional sensors (e.g., not only on the branch pipes leading to individual households but also distributed across different taps), the detection of leaks would take place with a higher accuracy. For instance, regular water usage patterns could be constantly compared against current patterns, and in cases of large discrepancies, the customer could be contacted (e.g., by automated email or SMS) to ask whether this excess usage occurs on purpose. Once such an unwanted leak is identified, the water company could cut the connection to the property. This service could be offered at a monthly rate to customers or possibly subsidized by, for example, insurance companies.

The implementability strongly depends on customer acceptance levels to (a) grant authority to the water utility to cut the water supply in the case of unusual water usage patterns and (b) update older meters to online meters or install additional sensors. Yet, considering the annual damages caused by water leakage, acceptance should be somewhat forthcoming. In Finland, annual costs caused by water damages lie at 140 million euros (6). Hence, providing a means to lower the likelihood of the occurrence of water damage should be welcomed by house owners. Moreover, insurance companies should be interested in this. Once a critical mass of users is reached, insurance companies might come into action and start offering cheaper premiums for those households that subscribe to such a leakage-prevention service.

The value of this BMI lies in damage prevention for property owners and insurance companies, as well as higher convenience for tenants. Even when covered by insurance, water leakage causes considerable financial damages to property owners. Moreover, tenants might not have to pay for water damages, but they will be inconvenienced at the very least. Last but not least, insurance companies pay more for fixing water damages than for fire damages [5]. Hence, the prevention of water leakage should create value for all three groups, and the water and wastewater utility might generate additional revenue streams for the service.

#### *BMI 4. Condition-based monitoring algorithm service to property owners*

This BMI enables house-owning customers to more conveniently monitor the condition of their household plumbing. The water and wastewater utility could sell a set of sensors to customers, who then install them on their various taps and drains. These sensors then send data to the water company for analysis. The customers then subscribe to a monthly fee-based service that alarms them automatically when maintenance is required at any of their piping infrastructure parts. Customers no longer need to go through the hassle of manually checking

the condition of their pipes, but will be notified in case there is a problem. The maintenance of their own assets is made much easier and more convenient. This is also of interest for the utility company because it provides an additional stream of income.

The implementability depends on the customers' willingness to install additional sensors, share the sensor data with the water and wastewater utility, and pay for the analysis and notification service. Pricing, as with all of the other previously mentioned BMIs, should be a key factor for implementability—it should be high enough for the water and wastewater utility to break even and low enough for property owners to be willing to pay for the additional service.

The value of this BMI lies in the provision of an easier way for house owners to monitor the condition of their taps, drains, and bathroom/kitchen piping. Until now house owners have to manually monitor the condition of these. With the new service, data are collected automatically by sensors, the data are analyzed automatically, and the house owners just receive a message if a problem is detected. Hence, the house owner is notified to investigate what might be the problem and which actions should be taken.

The other innovations were found to be interesting for the water industry more broadly, but less appealing in the Finnish context.

*BMI 5. A mobile app or web service that allows customers to check their daily water consumption per tap*

This BMI would provide additional value to the customer and could potentially provide additional revenue streams for utilities. We are living in a time of quantification—people are interested in understanding their everyday lives. By adding additional sensors or simple meters to the household taps and drains, customers would be able to see their exact water usage. This might appeal to environmentally conscious consumers who are looking for ways to save water. On the basic level, this service could be free of charge and coupled with a small booklet on reasonable consumption levels. On a fee level, this service could be coupled with an analysis of the consumption rates over time, analyzing changes and comparing the customer's consumption to the average consumption rates in Finland. Also, hints on how to save water could be given. Moreover, in the paid version, this service could be developed to additionally inform customers about, for example, water quality at any point in time.

The implementability of this BMI hinges on the willingness of customers to (1) install additional sensors and meters on their taps and (2) pay for the associated additional services.

The value of this BMI would lie in increased information about consum-

ers' own water consumption, and potentially later also water quality and other factors. On the one hand, this responds to a growing desire of consumers to be aware of their daily actions and the effects of these actions. On the other hand, the insights thereby created can give hints to consumers on how to modify their consumption habits and the values this would create. Water saving would be the most evident application, yet, especially in areas with fluctuating water quality, an automated indication of water quality could also be valuable to consumers. In Finland, this would for the most part just serve the consumers' desire to be better informed, or "quantify themselves." Whether consumers would be willing to install sensors or pay for the services is questionable. However, if these sensors have been installed for other reasons (e.g., BMI 3 or 4), the development of this additional service might be not a big investment for the water and wastewater utility. In this sense, this added feature could also motivate customers to install the necessary sensors and meters for BMIs 3 and 4.

#### *BMI 6. Platform offerings*

This BMI argues that the sensors and the data collected thereby can be used outside the water and wastewater utility's scope. Third-party developers and companies can create new customer experiences based on knowledge of water consumption, preferably per tap (see BMI 5). Such data can be used, for example, to estimate consumption of detergent and thus remind the user to act when the detergent is about to run out. Water consumption patterns could also be integrated into reality mining [44], where various sensors are used to predict human behavior. They may provide additional insights into what is happening inside a house. Thus, we argue that the data produced by the sensors should be considered as offering value that can also be extracted outside the water and wastewater utilities.

The implementability of these innovations is not yet very high. Although there may be substantial interest for any of these solutions, they require a lot of development to build and connect the platforms needed for their implementation. In addition to developing the internal data platform, it needs to be connected to other commercial platforms to enable service offerings. For this, commercial platforms need to be interested, and customer acceptance (particularly in terms of data security and privacy) needs to be figured out. Last but not least, the revenue models need to be defined—how much revenue is the water and wastewater utility or an alternative service provider to receive for connecting customer orders to commercial suppliers?

Also, this is the least straightforward BMI in terms of value creation. Although its implementation would increase the convenience for consumers (e.g., washing detergents would be delivered automatically before the previous pack is used up),



it would require many other developments to take place first. As of now, it might not be very convenient to have a separate delivery of washing detergent arriving to the home independent of other grocery deliveries. However, if the IoT develops to a status where fridges can automatically order new food items, this order could be coordinated with washing detergent orders. Thus, the value as of now might be diminutive, yet this might hold great potential for the future.

### 6.1.3 Pricing and Supply Innovations for Driving Water Savings

Water savings can be driven through various digitalization-enabled actions, such as price hikes initiated by the water and wastewater utilities or regulatory bodies, punitive taxes lobbied by governments on excessive water use, or the interruption of the water supply once a government-set limit is crossed. In the Finnish context these are not very implementable, mainly because there is no need for water savings beyond the current levels. However, they may be very interesting for water-scarce regions.

#### *BMI 7. Incentivize consumers to use less water*

Customers can be incentivized to consume less water, and the initiative for this can lie with different actors. The water and wastewater utility could increase the price per liter after, for example, 100 liters per person per day; the government could introduce punitive taxes past this point, or, in cases of severe water scarcity, the water supply for excessive users could be turned off after the limit of 100 liters per day and per person has been reached. The 100 liters per person per day is not a set limit, and can of course be set freely by government in water-scarce areas according to the local conditions. The World Health Organization (WHO) has estimated that a domestic consumption of 100 liters per day is enough to ensure health and related hygiene, and that is the reason why we also apply this number in our example [45]. Moreover, these options have to be negotiated and implemented in collaboration between the local water and wastewater utilities and the local government. In some contexts, it might be beneficial to incentivize water saving through application of price reductions for consumers whose water consumption remains under a given level.

This BMI could be interesting for water and wastewater utilities or governments interested in saving water. If there is a desire to reduce water consumption, adjusting the prices per liter (or, alternatively, a punitive tax as set by the government) is a good solution. As prices rise, customers will consider whether they really need the additional water use. The water company would achieve a higher price per liter; even if customers were to consume less water, the increase

in water prices might keep the revenue stable. A more drastic solution would be to not just increase the water's prices per liter or add a tax, but to entirely cut off water supply after set limits have been reached. Especially in cases of severe drought and affluent consumers, the costs of water might not be enough to dissuade excessive consumption. For example, in California certain households are using about 45,000 cubic meters of water per year, approximately equal to the consumption of 210 persons per year in that area [46].

What the versions all have in common is the need to have an online metering device installed at every household. This is especially true for cases where the regulation is intended to limit daily consumption levels at least for some parts of the year; this is something that cannot be done using annual billing, even when billing is based on actual consumption. Having an online meter is the standard for all newly built houses in Finland; however, most of the older apartments are not yet using new metering technology. Currently, there are no published plans to make a replacement of legacy meters mandatory. Because there is generally no lack of water in Finland, the implementability of the water-saving BMIs in Finland is rather low. Thus, neither the government nor activist groups should have an interest in this solution. However, this solution is based on the technology required also for the other BMIs introduced here. Hence, this might be an exportable idea to water-scarce areas. Once the technology (i.e., hardware, software, and algorithms) is ready, this know-how could easily be in high demand in water-scarce regions, in which it will be highly valuable to governments trying to regulate individual household water consumption.

Now, whether the water utility is the right stakeholder to implement all of these BMIs is uncertain. It might well be that some of these BMIs would better be implemented by other companies, either existing ones or even new startups. However, regardless of who eventually provides these services, they could be of great value to water utilities, customers, the government, and society at large.

## 7 Conclusions

Digitalization has disrupted many industries, even those that traditionally have had a monopoly in their field. In our analysis we have outlined several ways in which water and wastewater utilities and their network infrastructure in particular could be reformed by digitalization. We identified changes in the fields of network asset management, network control, and business models. We approached these from the perspective of how the current stakeholder positions might change in line with digitalization.

On a practical level, digitalization entails installing new devices, collecting and analyzing data with them, and building platforms that enable improved use of data and better decision making. The main driver for most water utilities is to improve the management and maintenance of their networks and reduce costs. The quality of data is essential, and the quantity of the datasets can be increased gradually. The reliability of data, standardization of information, and effective decision support are the key elements for a data-based asset management system.

We found that the physical core of the service—water supply and wastewater removal and treatment—cannot be affected by digitalization. In this respect, the water and wastewater infrastructure differs from, for example, electricity grids, where the physical aspects play a lesser role. Due to the monopolistic nature and the physical aspect of the key offering, we found that the utilities themselves will have to be the ones to drive the change; other stakeholders have only limited possibilities to do so.

Because water is vital to human life and also a human right, a general acceptance for changes is needed in the society for changes to actually take place. For example, we found that effective leak-prevention services could be provided to water consumers with higher-resolution data on household water consumption. The prerequisite for this, however, is that people generally must allow for their water consumption data to be collected and analyzed by the utility or a third party or that this is required by regulation.

We analyzed the impact of digitalization on the stakeholders in the water sector, these being water consumers, real estate owners, regulators, and the water and wastewater utilities themselves, and came to the conclusion that we do not foresee changes in the stakeholder network. Also here the assessment showed that for changes to take place, the infrastructure owner must drive the change.

We also studied what kinds of new business model innovations (BMIs) could be introduced in the sector. Although none of our innovations can be expected to fully revolutionize or entirely disrupt the industry, they provide avenues for increasing the value of the service for the largest group of stakeholders possible without “stealing” value from any other stakeholder. In general, the BMIs we introduced are value-creating—they enable customers to optimize their water consumption and water utilities and to optimize their operational and maintenance costs for the piping infrastructure.

The implementability of suggestions for new BMIs vary depending on the context; whereas BMIs 1 and 2 depend only on the utility’s internal interest in whether to implement them or not, BMIs 3 through 6 depend also on customer acceptance and customer demand. First, customers would have to accept the placement of additional sensors in their homes (or several of those for BMI 3).

Second, the demand would have to be high enough so that there are customers willing to pay for the additional services. BMI 6 requires extensive connectivity between different networks: Customers need to configure their online shopping account (e.g., Amazon) with their water meter, and an automated order agreement needs to be arranged. Moreover, how would the revenue-sharing and payment be configured between the customer, the online ordering platform, and the water and wastewater utility? In spite of these questions, we know that the details can be solved. Our goal in this article is to demonstrate potential paths for increasing the value of the water and wastewater industry, and these BMIs give an initial, but by no means complete, view of different alternatives.

Also, BMIs 1 through 6 are highly applicable for the Finnish context, whereas BMI 7 is primarily of interest in water-scarce regions. Although all of the BMIs concentrate on water saving, the interest for saving water varies across contexts. In Finland, water savings and leakage prevention translate into cost savings. This may also hold true in water-scarce contexts, but there the issue is also water saving itself because water is a scarce, valuable resource. In water-scarce regions, water savings also translate into a fairer distribution of a scarce resource across society.

Most importantly, some of the innovations could be initially tested, learned, and developed in richer countries with further developed water and wastewater systems, and then tested-and-proven solutions could be exported and applied to other countries. In countries where water-related infrastructure needs to be built or modernized, it might actually be easier to implement sensor-based solutions than in systems that are already built and in use.

Challenges are present in relation to many aspects of digitalization. Realizing the platforms, algorithms, and data management needed for getting the full benefits of digitalization will take some time and effort. Most importantly, issues related to information security will need to be solved before new technologies can be implemented. In spite of the challenges, we feel that digitalization offers benefits and opportunities worth striving for.

## **Interviewees**

- Tommi Fred, Department Head, Helsinki Region Environmental Services Authority
- Björn Ullbro, Director, Wärtsilä Services East Asia
- Ken Dooley, Sustainability Group Manager, Granlund

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# *Digitalization: Unlocking the Potential of Sharing*

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**ABSTRACT:** *It is evident that digitalization and development of different digital platforms have been a key enabler for sharing in a larger scale. Examples of sharing platforms can be found in hospitality, food, transport, logistics, and even expertise. However, digitalization has also played a key role in the monetization of the sharing transactions, which has led to the formation of the “sharing economy,” with examples such as Uber and Airbnb. Bringing money into the equation changes the nature of sharing into a service provision and access economy driven by monetary rewards, which then again is aligned with expectations of service and quality. We argue that sharing platforms and schemes solely motivated by monetization come with a cost and fail to capture the massive true potential of digitally enabled sharing that enables altruistic, communal, and reciprocal interaction between people.*

**KEYWORDS:** *Sharing, sharing platforms, sharing economy, access economy, trust*

# 1 Introduction

A day doesn't go by without us hearing the words sharing economy in some technology news article, usually with an emphasis on how disruptive the phenomenon is and how it is going to completely change the world as we know it. Every day a new startup pops up with claim of being the Uber for some service or applying some well-known scheme for other cases of "sharing." The word *sharing* in this context is so instilled that no one questions anymore what is it that we truly share while we are renting our belongings or acting as a temporary cab driver for some stranger. Light and Miskelly (2015) point out that this is a clear case of "share washing," where the language of sharing is used just to promote new modes of selling [1].

Belk (2010) finds that sharing is closely linked to trust and bonding, unlike economic exchange [2]. Sharing is fundamentally nonreciprocal and characterized, for example, by social links to others, networked inclusion, and the unimportance of money, and thus needs to be separated from gift giving and commodity exchange. Belk further differentiates between the cases of sharing as sharing in or sharing out. He defines *sharing in* as analog to selfless altruistic sharing within a family or inner circle without expecting anything in return. Conversely, sharing out is signified by the dispensing of wealth or belongings with humanly feelings. It is quite clear that there is no place for economy in the genuine notion of sharing.

It is safe to claim that at this point in time the "sharing economy" is mostly about digitally enabled peer-to-peer rental and exchange of commodities and services, yet the concept itself is not about sharing at all. It misleadingly combines "sharing," a word with an altruistic connotation, together "economy," which represents monetary opportunism. As alternative concepts for the phenomenon of sharing between peers, other terms are presented as well, such as *collaborative consumption*, *peer-to-peer economy*, and *trust economy* [3].

Collaborative consumption is defined by Hamari et al. (2015) as obtaining, giving, or sharing the access to goods and services between peers, which is compatible with our definition of sharing [4]. Hamari et al. state that in the past, consumers' desire to support ethical consumption was run over by economical and institutional reasons [4]. Nonetheless, with the rise of the digital era, consumption through sharing, like collaborative consumption, is made easy and efficient, and thus can be easily addressed. Collaborative consumption is based on several factors: access over ownership, use of online services, and monetary and nonmonetary transactions, for example, sharing, trading, and renting.

All in all, it is evident that there is no point in denying the benefit of collabora-



tive consumption as opposed to individual consumerism where people keep buying new things and can easily come to own stuff they do not need or use most of the time. Collaborative consumption offers somewhat of a sustainable solution for underutilized assets [5]. A trend around these areas is that we see platforms monopolizing networks. For example, Airbnb has become a virtual giant monopoly in networked hospitality, majorly populated by people who seek to monetize their empty rooms or spaces, as opposed to its marginal sharing counterpart Couchsurfing, a niche for the bold and eccentric.

Nevertheless, we are seeing millions of empty rooms or empty car seats accompanying lonesome human beings. Apparently, money fails to fill certain voids and make our lives easier in some aspects. Excluding the special case of information, digitalization is yet to touch and enable sharing as we know it in a big way. In digitally enabled sharing, there is a huge potential value waiting to be achieved by bringing together those who need what we can offer to *share in* or *share out*. Sharing, small or big, helps us extend our individual selves and reach out to become part of something bigger than ourselves, filling those voids that money and consumerism tend to increase.

An idealistic view proposes that the true joy of sharing comes from knowing that we can do something good to reduce our consumption and footprint. We can go against the toxic pattern of consumption and waste that is central to the socio-economic paradigm in which we live. By sharing, we can challenge the status quo and be part of a movement for change, and if enough people join that movement, it can realize positive change in society.

In this paper, we investigate whether the synergy around the *sharing economy* and *digitalization* will also expand itself into more true sharing. Firstly, we look at three major cases of consumption to learn more about the nature and challenges of a *sharing economy* as opposed to *sharing*. Then we look into where the technology is leading us and what the future might possibly look like.

## 2 Sharing in Depth

Technology has helped us to make sharing cheaper and easier than ever. The shared assets range now from homes and cars to different commodities and to dining and entertainment as depicted in Figure 1 [3]. Here, we focus on three exciting areas: hospitality, mobility, and food; these are large entities that represent most categories of physical sharing today [6].

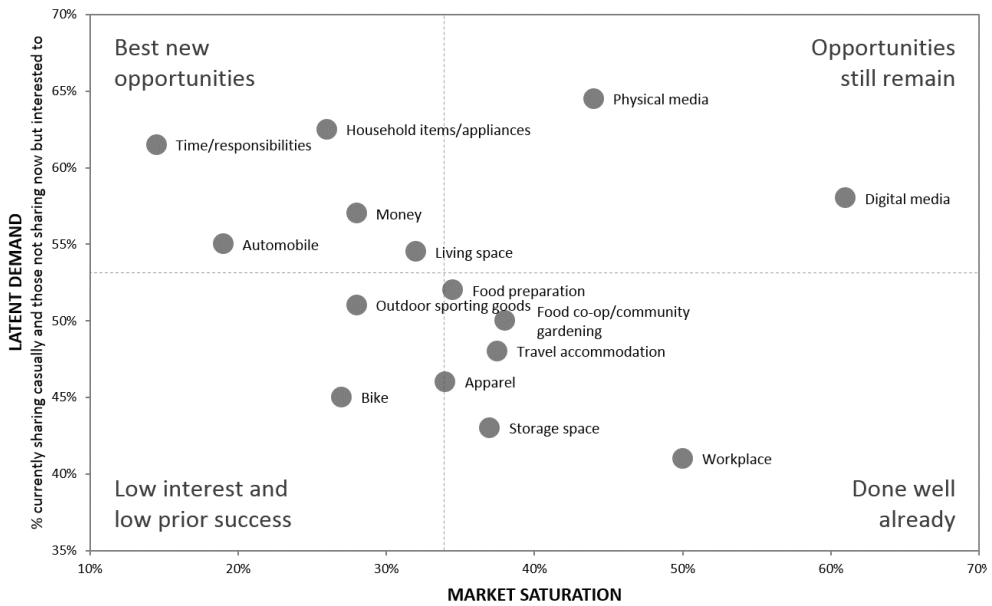


Fig. 1. Adapted from Latitude (2010) [6].

## 2.1 Hospitality

Hospitality sharing is nothing new and existed long before the penetration of the Internet. Servas International, for example, founded in 1949, is an international nonprofit network of hosts and travelers [7]. Along with the emergence of global connectivity, a number of online hospitality sharing platforms have been founded, including Hospitality Club in 2000 [8] and Couchsurfing in 2004. Currently Couchsurfing is by far the more significant hospitality sharing platform, with 12 million members in 200,000 cities, and so it will be the focus of this study.

Couchsurfing allows users to create profiles describing their travel experiences, their worldview, and why they want to participate in the community [9] [10]. For security, customers provide a small credit card donation to verify their identity, receive postal confirmation to verify their address, and receive a simple text confirmation to verify their phone number. Once established, they select their status as to whether they can accept guests, want to meet people, or cannot accept guests. When traveling, surfers can search for users in their destination city and contact them to request to stay. Success in requests rests on finding people with whom surfers identify a genuine connection and writing an interesting and unique request. In addition to accommodation sharing, the Couchsurfing community arranges local groups and regular events where travelers and locals can meet and interact in an informal environment.

In the context of sharing hospitality, the main costs are in terms of time and privacy. In order to host surfers, hosts need to be available for arrival and to spend some of their free time with their surfers. When allowing a stranger into their homes, they somewhat open up their lives and sacrifice some of their privacy and security. Indeed, opening your home is an act that many private people consider too intimate.

The platform has a number of security mechanisms for verification of a user's identity. Not least of these mechanisms is the opportunity to leave reciprocal feedback on surfer and host experiences. Although this feedback system was traditionally somewhat nonsecure, it has recently evolved into a double-blind nonretractable system that ensures honesty and removes the possibility for tit-for-tat arguments that might discourage users from leaving negative feedback.

Rosen, Lafontaine, and Hendrickson develop the concept of belonging and trust in a globally cooperative community [11]. As captured in Couchsurfing's mission statement, the key benefit is on a societal scale, where the sharing experience stimulates tolerance and creates a global community. In terms of individual users, Geiger and Germelmann (2015) explore the reciprocal versus nonreciprocal sharing benefits [12]. The primary benefit to the individual users sharing accommodation is in a social sense. Couchsurfing states that the values of the community are sharing your life, creating connection, offering kindness, staying curious, and leaving the world better than you found it [9] [10]. From these values, two clear and distinct benefits to participating in Couchsurfing emerge. First, it is about meeting new and interesting people, cultural exchange, and teaching and learning. The second key benefit that emerges is the intrinsic fulfillment derived from helping another like-minded individual—simply put, the joy of giving. A third benefit is being part of a community of like-minded people who are united in their efforts to make the world a more open and inclusive place. These benefits are well described also by Kocher, Morhart, Zisiadis, and Hellwing (2014) [13].

From the company's inception up until 2011, the Couchsurfing community was an entirely voluntary organization. The platform development relied solely on the voluntary contribution of its members. In 2006, for example, there was a massive database crash that resulted in much of the platform being irrevocably lost. After this crash, platform maintenance and development was organized through "Couchsurfing collectives," voluntary groups of members who would gather and work on development in their free time. In 2011, the nonprofit organization Couchsurfing International was liquidated and sold to the for-profit corporation Better World Through Travel, later renamed to Couchsurfing International Inc. The community reacted negatively to its perceived "sellout" of what had been built on the voluntary contribution of its members.

Couchsurfing International Inc. prohibits the request of payment from Couchsurfing hosts. Indeed, it considers this a violation of the company's safety policy and seeks to take action against any users attempting to extract money from the transaction. However, it is recommended that surfers bring along a small gift, offer to help around the house, or even make dinner for the host. Simple politeness suggests that there should be some kind of give and take in the sharing transaction.

It becomes clear from the history of the Couchsurfing platform that without some level of monetization it can be exceedingly difficult to develop and maintain an online platform of this scale. This is particularly the case when the number of users grows into the millions, as was so dramatically pointed out to the community in the database crash of 2006. On the one hand, the capitalization of Couchsurfing was an essential step to enable the investment in servers and hiring of professional developers. However, the Couchsurfing community grew to 5 million members in 100,000 cities as a nonprofit voluntary entity. After the "sellout" there was a massive backlash from the users who felt that the community was stolen from them. Thus, what started as a pure and true sharing community has now been transformed into a sharing economy, which, after all, is not about sharing but rather the monetization of micro-rental transactions. The future of Couchsurfing is uncertain, but it is clear that the venture capitalists who have invested in the platform are eagerly awaiting a significant return on their investment.

The story of Couchsurfing raises many questions relating to sharing and monetization. For example, is monetization the only path to scaling this kind of sharing community, or can there be another way?

## **2.2 Mobility**

People are most interested in sharing items that are not in constant use and have high barriers to buy as well as high burden of ownership, such as high costs [6]. Thus, consumers' attitudes and behavior toward driving and cars have been and are changing as we speak. Different solutions, such as applications, allow us, for example, to share cars, and ridesharing has actually become a trendy concept everyone is buzzing about. In the developed world we have already seen a decline in driving and young people's desire to own a car during the past years and a growth in the demand for sharing [14].

Looking back, peer-to-peer carpooling has actually been a recognized form of transportation for decades. These arrangements have traditionally been community-based operations, organized by nonprofits or subsidized through governments. In the earlier stages, connecting drivers with passengers was

largely dependent on word-of-mouth as well as bulletin boards. Later, with the rise of the Internet, these systems started to take on online forms, with many of the operating models developing into online ridematching [15]. Now, with constant Internet exposure and different digital devices all around us, the transfer of information and connecting people with similar needs occurs in a very agile way via different devices and platforms, wherever and whenever.

An example of a modern-day carpooling technology company is BlaBlaCar, a trusted ridesharing community with 25 million members in 22 countries [16]. The French company classifies itself as a “marketplace that connects drivers with empty seats to passengers looking for a ride.” This means that the company does not employ any of its drivers; rather, the idea is to connect people who are traveling the same long distances. In other words, the drivers take on riders for the trips they are already planning to take.

What is the motivation for the members to join and operate in the BlaBlaCar community? It has been argued that the company’s success has been largely dependent on launching in geographical areas where the public transportation is crowded or inefficient, and where the costs of driving are high, such as Europe [18]. Cohen and Kietzmann (2014) found out that engaging in carpooling is not motivated by the driver’s aim to make an actual profit out of the participation, but rather the desire to reduce the costs that owning and driving a car generate [19]. In addition, other key drivers have been identified to include low interest rates and improving economic status [14]. Tuttle (2011) argues as well that main driver seems to be money savings because carpooling’s popularity has been identified to rise with the rise of gasoline prices [20]. Interestingly enough, BlaBlaCar’s operating rules actually state that, unlike with other players in the field such as Uber or Lyft, the drivers do not, and cannot, aim at making profit with the sharing; they can only receive money for covering petrol and road tolls [18].

Nonetheless, looking at BlaBlaCar, one can still consider that the operations are based, at least partly, on the monetary win-win-win combination provided for all parties. The driver, rider, and company all get economic benefit out of the engagement and participate in some kind of monetary transaction. However, mobility sharing also has other crucial benefits for the participants, such as convenience, travel-time savings, and reduced commute stress [15]. In addition, the good feelings related to contributing to reduced traffic and pollution [19], energy savings, decreased demand for parking [15], and increased interaction between people [21] are also benefits that have been identified. Frederic Mazella, the founder of the BlaBlaCar service, stated to Shah at Forbes that the rewarding factor with BlaBlaCar is actually the possibility to share and help one another; the members “share good moments; they share life, basically” [21].

BlaBlaCar's underlying goal is to challenge the existing models of traveling and make moving people more social, convenient, and cost-efficient, even on short notice [16]. Ultimately, if this mission succeeds, it would result in reducing the amount of solo riders, the rate of car ownership, and the use of public transportation. Many government officials have actually been said to support BlaBlaCar and openly state that the company operations generate many benefits, such as reducing traffic [22].

BlaBlaCar may be conquering Europe with its long-distance ridesharing service, but Zimride and Rdvouz are trying to lead the way in the United States, and Liftshare operates within the UK market. In addition, emerging business models demonstrate that another trend is to challenge the more traditional carpooling model. The market share of new disruptive ridesharing businesses focusing on profit-driven peer-to-peer (P2P) ridesharing has grown significantly in recent years. Companies such as Lyft and Uber have entered the market without scrutiny, and more often than not neglected collaboration with local authorities, leaving different stakeholder groups wondering if they only aim at profit maximization. The fundamental dissents and conflicts have been said to possibly pose a threat to the longevity of these businesses [19]

Unlike BlaBlaCar, Uber and Lyft are challenging the taxi scene, at least when looking at their original operating models. However, it is important to note that in some countries Uber and Lyft have now expanded their operations to carpooling-style versions called Lyft Line and UberPool [23]. This is an indication that there is a high market demand for peer-to-peer pooling services not focusing on driver profit generation.

On top of different forms of ridesharing, car sharing is another growing form of mobility sharing. According to Belk (2014), independent and tight-knit small communities with shared vehicles have been found successful [24]; an example is Göteborg's neighborhood-based car-sharing organization Majorna, with 29 cars and 300 members. This kind of operation can be still managed by the people themselves, yet some members worry about the growth of the community because then they will not have the opportunity to know all members. Scaling this idea, Zipcar is a car-sharing community operating online worldwide. Nonetheless, Eckhard and Bardhi (2015) elaborate that via the market-mediated sharing made possible by Zipcar, unlike community-driven Majorna, the members do not find the reciprocal obligations between each other that traditionally appear with sharing [25]. Actually, the members have difficulties in trusting the peers in the network, and instead they trust more the "big brother"-like company behind it all. Thus, participation is based on selfish and/or pragmatic reasons, rather than selflessness or the desire to contribute to the collective good [24]. This makes us

question whether people's altruism and company participation can fit into the same sentence.

## 2.3 Food

According to Stevens and Gilby (2004), reciprocal food sharing is a form of reciprocal altruism in which an individual animal gives up the food it has foraged to another individual [26]. Food sharing has been observed in a wide range of animals, and it does not only happen between members of the same family but among non-kin individuals as well. In an era where roughly one-third of the food produced in the world for human consumption every year—approximately 1.3 billion tons—gets lost or wasted [27], the sharing of food that would be wasted is critical to fight world hunger.

For example, British households throw away 20% of the food they buy, and more is thrown away even before it reaches supermarkets [27]. The increasing concern about waste-food management, in combination with the high level of acceptance and penetration that digital technologies have in developed countries, has enabled the appearance of digital platforms for altruistic waste-food sharing.

The German platform Foodsharing.de is a nonprofit organization that aims to connect those who have edible goods with those who need or want them [28]. Foodsharing.de is not only used by those with low income but also by many others interested in consuming products in good condition that would be otherwise thrown away. By using a food-basket concept where you can put food to give away into baskets, Foodsharing.de has been able to organize 10,000 volunteers in 1,000 establishments. The platform has been able to save 3 million kilos of food in the 3 years it has been in operation.

In the United States, 40% of the food produced is lost in the journey from farm to fork to landfill [27]. In order to reduce the wastage of food that has not even reached distributors, the California-based Cropmobster offers a different spin on food sharing: the website allows farmers to post excess crop that would otherwise be sent to the compost, and volunteers sign up to collect it for further distribution to charities [29]. By leveraging social media and instant alerts, “Cropmobster is able to spread the word quickly about local food excess and surplus from any supplier in the food chain, get healthy food to those in need, help local businesses recover costs, prevent food waste and connect the community in new and fun ways” [30]. Cropmobster has had rather impressive results so far, with over 1 million food servings saved, which translates into over 2,000 pounds of products saved.

LeftoverSwap is an app that allows users to offer their leftovers to people who have signed up to be notified when there is food available in their area [31].

LeftoverSwap seems to be having some acceptance issues. However, Dan Newman, co-founder of LeftoverSwap, claims that “People are just getting comfortable sharing their bedrooms through companies like Airbnb. But I think there’s a large part of the population that want to do their best to share the resources we have” [29]. Other examples of altruistic food-sharing platforms with similar operating models are Olio and Ratatouille. Olio is an app that allows neighbors and establishments to create networks to share food that would otherwise be wasted. Ratatouille helps people to find someone who will take their extra food.

An interesting newcomer is the Finnish app Froodly, a “food rescue app,” which enables consumers to find supermarket products that have still-fresh discounts around Finland [32]. Froodly developers claim that their users can save from 30% to 70% when shopping for food and beverage items. The Froodly model goes “beyond reducing prices, it can also reduce food waste and ensure that this good food finds hungry bellies.” Table 1 summarizes the food-sharing platforms discussed thus far.

				
LeftoverSwap	Foodsharing.de	Olio	Froodly	Cropmobster
LeftoverSwap allows users to “offer your leftovers to locals, who sign up to be notified when there’s free food to be had in their area”	Foodsharing.de “connects those who have edible goods to give away with those who want them”	Olio is “a free app which connects neighbors with each other and with local shops and cafes so surplus food can be shared, not thrown away.”	“On Froodly’s food rescue app, you can find all of the great supermarket products that have still-fresh discounts around Finland, allowing you to save 30-70% when shopping for your favorite food and beverage items.”	“Cropmobster is able to spread the word about local food excess from any supplier, get healthy food to those in need, prevent food waste and connect the community in new and fun ways”

Table 1. Altruistic food-sharing digital platforms.

Sponsorship-based or government-owned digital food-sharing platforms can survive without having to monetize their services. However, for all other cases, service monetization seems to be the only way to operate. Beyond altruistic food sharing, moving forward in the platform evolution curve are the applications that allow people not only to share their food but to create a social experience out of it. These platforms have thrown away the altruistic nature of reciprocal sharing in order to implement operating models that allow monetization of food sharing as a social experience by, for example, offering professional chef services or complete meals cooked by locals in many cities around the world.

MealSharing.com [33] was the first successful service that implemented the concept of meal sharing as a social experience [34]. Whether someone is a tourist looking for typical local food or someone looking for new ways to interact with people, MealSharing.com offers a service similar to Airbnb that allows its users



to find home-cooked meals everywhere and meet strangers at the same time. The revenues of Mealsharing.com are unknown, but its success is undeniable—it has spread to 450 cities around the world.

EatWith is a growing leader in the meal-sharing startups. EatWith founders started their social experiment startup in Israel and Spain, but now they have expanded across the United States, Europe, Brazil, and other parts of the world [35]. EatWith is designed for locals to have new experiences in their own cities. Hosts maintain a profile with ratings and reviews, posting each event with a complete menu, meal time, group size, type of cuisine, and description of hosting style.

Information about the economic performance of meal-sharing apps is not available, and it is clear that the meal-sharing business has not disrupted the restaurant industry. However, such platforms are becoming an additional source of income for many. Regular users of platforms like MealSharing.com and EatWith are able to make a few hundred dollars each month in addition to their regular income. Yet, the majority of hosts on social dining platforms are not making their living from their dinner parties (food costs tend to make up about 30% of each meal, and the websites generally charge a 15% commission). There are notable exceptions, though. Some hosts have reported monthly profits of between \$3,750 and \$5,000 per month [36].

Economic success is not always guaranteed for meal-sharing startups. Kitchit, Eatro, and KitchenSurfing are examples of failed attempts to make the meal-sharing experience available to everybody. These platforms had two things in common. First, all of them offered professionally trained chefs and cooking services delivered to the user's household on demand. And second, they all stopped their operations in 2016 after "the realities of their business left them no choice but to conclude this chapter" [37]. Maybe it was that they all shared a business model doomed to fail, or maybe it is just that the social experience element was not sufficiently exploited. The reality is that despite their positive results (Kitchit.com, for example, reported over 100,000 booked meals through its system), they could not keep up with their operation costs.

More interesting than the economic impact of meal sharing is the potential it carries for urban food systems and communities. First of all, meal sharing creates time and space for people to connect offline in the most traditional way possible, over food. For guests who would otherwise be consistently eating out, eating home-cooked food on a regular basis usually means a lower intake of salt and fat, improving health. There are also implications for food waste and the ability to build more resilient communities through increased social connections [38].

Food sharing can reduce waste and increase buying power. Food sharing can also develop a sense of community creation. Food is a common denominator and an incredible tool to bring people together, and this seems to be a huge first step

toward addressing the multitude of challenges we face in urban environments. It's really not about limiting ourselves to digital platforms and solutions, but about social engagement and how food is a common denominator [38].

Table 2 summarizes the meal-sharing platforms just described.

 <b>Meal Sharing</b>	 <b>EatWith</b>	 <b>Eatro</b>	 <b>Kitchen Surfing</b>	 <b>Kitchit</b>
<p><i>"With over 500 hosts in 80 cities around the world and its strongest presence in Italy and France. Meals, barbecues and cooking classes are among the gastronomic experiences found on the platform."</i></p>	<p><i>"An open marketplace of alternative and exotic dining experiences in houses across the globe"</i></p>	<p><i>"Food sharing minus the leftovers. To be precise, it features home chefs who can offer their goods for delivery to customers in their neighborhood."</i></p>	<p><i>"Kitchensurfing sends a professional chef to your home once a week to cook dinner for you and your family."</i></p>	<p><i>"the Kitchit Marketplace, empowered diners to connect with chefs via a peer-to-peer platform and create custom events."</i></p>

*Table 2. Meal-sharing digital platforms.*

### 3 Motivators, Enablers, and Problems of Sharing

Now that we have examined three different cases of sharing, or collaborative consumption, with some level of success, we will now examine some of the common factors that influence the individual's tendency to share. What motivates sharing, and how are the current platforms resonating with these motivations, and thus fostering maximum adoption? Conversely, what disincentives exist, and how can the platforms reduce or eliminate them? Whereas motivators and disincentives are personal, enablers and barriers are the systematic elements of platforms, which are crucial to maximize user adoption and clearly will impact the traction of digitally enabled sharing in society.

#### 3.1 Disincentives and Motivators

Sharing is not without its flaws, which may deter people from engaging in sharing or hinder their desire for it. These disincentives include the lack of flexibility and convenience, which, for example, with mobility sharing are traditionally linked to owning and driving private cars. For both hospitality and mobility sharing, some people might be deterred from sharing due to the potential intrusion into one's personal space and time, where aversion to social situations might be a particularly significant barrier in the case of an introverted personality. Another clear disincentive relates to concerns over one's personal security [15]. In addition, aversion to being exploited can be a strong disincentive, as has emerged in the culture of hospitality sharing. This could either take the form of being taken

advantage of by so-called “freeloaders” or being exploited by platforms that attempt to extract profit from the sharing transaction or leverage the sharing community to generate profit by utilizing personal data or generating advertising revenue. Thus, we next examine what the main driving forces behind collaborative consumption today actually are and how they motivate people to overcome the barriers associated with sharing.

Hamari et al. (2015) found that taking part in collaborative consumption can be motivated by many factors, ranging from sustainability to enjoyment as well as economic gain [4]. Looking at this more closely, it seems reasonable that collaborative consumption easily be motivated by individualistic reasons because it results in saving money, eased access to resources, as well as free-riding. Yet, traditionally, collaborative consumption has been characterized to be based on the commitment to do good for society, from peers to the environment, through sharing and helping others. Nonetheless, the Hamari et al. study (2015) findings suggests that consumers’ perceived sustainability is an important driver because it generates positive attitudes toward collaborative consumption, but economic interest is a stronger driver for participating [4]. Building on this notion, this can result in some users engaging in sharing due to altruistic reasons, whereas others may be only interested in enjoying this goodwill or taking advantage of it. In the abstract, according to Hamari et al., this situation can endanger the sustainability of collaborative consumption [4]. However, there are numerous sharing scenarios where the economic benefit is of little consequence, and in these cases people engage in sharing because of enjoyment and social interaction. Altruism seems to be a big motivator because it adds an ethical dimension to sharing. For example, never before we have produced as much food as today, yet there has never been as much hunger in the world. The vast majority of food waste can be eliminated completely or used to feed the hungry, to feed animals, or to create new soil or energy. Altruistic food sharing seems to be an effective way to reduce food waste.

A key incentive for sharing is the feeling it generates of being a part of a like-minded community of individuals who are united under the desire to make positive change, which could arguably be presented as both a selfish and an altruistic motivation. At the core of community is the connection created in the sharing transaction that brings the greatest value, especially in the case of Couchsurfing. Experienced Couchsurfers would argue that the time and effort expended in the search for hosts often can far outweigh any economic savings presented by a free accommodation for a night or two, but the connections made, lessons learned, and horizons broadened can have a long-lasting positive impact on both the host and surfer. A similar argument can be made for driver and passenger in car sharing, and in the case of meal sharing chef and guest.

Another clear motivation for sharing is the concept of reciprocity, that is, giving to another in the expectation of receiving something of similar value in the future. However, this expectation may well be considered selfish and outside of the altruistic sharing mentality, especially if the return is expected from the same person. Thus, crowdsourced reciprocity, or a feeling of “what goes around, comes around,” is proposed to be core to the community. Indeed, sharing reciprocity could be argued to be at the birth of tribal society, based on the sharing of responsibility, risk, and reward to make the individual more safe and secure within the collective.

An article in *The Guardian* (2015) explores the perspective of a veteran Couchsurfer who also participates in Airbnb [39]. The writer has extensive experience both as a Couchsurfer and a host, and as an Airbnb customer and provider. The author expresses a strong preference for “hosting” Couchsurfers rather than “serving” Airbnb customers: “There is something more authentically nomadic about Couchsurfers—they are putting themselves out there at the whim of human kindness in a way most of us stop doing as adults.” He continues, “Put simply, the exchange becomes more human when money is taken out of the equation. The experience transcends the humdrum and can transport me back to the time when I too was a free solo traveler surviving off the kindness of strangers.” He describes the experiences of being an Airbnb provider with a feeling of sacrificing his home and in its place providing a serviced apartment. The author concludes, “I prefer the nature of the exchange that makes me feel like I’m part of a global community of people looking for meaningful travel experiences outside the mainstream, capitalist economy,” and in this point he eloquently illustrates that the value or compensation taken from participating in Couchsurfing is far more than money ever could provide.

### **3.2 Barriers and Enablers**

Trust, convenience, and communal behavior with a feeling or sense of belonging push consumers into favoring sharing [3]. Trust creation is an interesting aspect during the era of Web 2.0, and how to learn to trust strangers we meet online is one of the biggest questions of our time. According to PwC, our trust in our peers has not drastically changed; only 29% of the surveyed consumers felt increased trust in people in comparison to the past [3]. Even so, generating trust has been facilitated through technology, and for many people the Internet actually has been said to promote trust [17]. The PwC (2015) study suggests that consumers are so willing to try new applications these days that they are simultaneously becoming increasingly trustful through establishing relationships tied to social sentiment and user communities [3]. Yet all in all, it could well be that as consumers are getting more familiar with the concept of sharing among strangers, the ability to

trust will naturally grow, similar to what occurred with online shopping, where the mistrust was first high and now is perceived to be business as usual [18].

Many of the current sharing communities are founded on online platforms that include different reputation and peer-rating systems as well as, for example, GPS tracking or even background checks. As we saw in the Couchsurfing example, a three-fold verification method is employed that includes identity verification via credit card, phone number verification via text message, and postal verification of address, which can provide users with a comfortable level of security as to a counterpart's identity. The referencing system applied in this case uses a double-blind format and allows users to give experience feedback in which the nature of their interaction—whether it be as surfer, host, friend, or acquaintance—is also verified through the platform. Other platforms require members to register with their name, picture, and possibly preferences, and with BlaBlaCar, for example, after the trips the member profiles are then complemented with peer-to-peer ratings [16]. Peer reviews actually are increasingly seen as arbiters of quality [3]. BlaBlaCar founder Mazella highlights that because the users are strangers to each other before the rides, for the model to work, it is crucial to provide and receive enough information on the “matched” people beforehand [21]. In addition, the high social media connectivity around the globe allows people to take action into their own hands and check up on each other via Facebook and other channels [17].

Changing practices around food and its waste can be a challenging mind-set to shift, but technology is one possible way to facilitate reducing the amount of food we throw out. The act of food sharing is considered by many to be controversial, and just because it is free does not mean that people will find it easy to give away or accept. Dr. Jeremy Farr-Wharton, from the Urban Informatics Research Lab in the QUT School of Design, has looked at the use of technology to promote food sharing and found that more people are willing to share their unwanted food compared with those who are willing to accept unwanted food. According to him, this hesitation stems from a concern of trust and comfort. The act of taking food is dependent on trust, and the act of giving food is dependent on comfort. Dr. Farr-Wharton noted, for example, that some people said they would feel awkward going to someone else's house to retrieve a shared food item, and others said they would only take items that were well packaged or in cases where they trusted the person sharing. Optimal trust and comfort occurs between family and close friends and is likely to work best within a known community of sharers. According to Dr. Farr-Wharton's study, housemates are more likely to share with housemates but less likely to share with neighbors. Also, if a trusted person promotes food sharing among an unknown community, a person is more likely to share food. For Dr. Farr-Wharton, the next step is to further research how tech-

nology could be used to promote food sharing within the confines of what people find acceptable [40].

As described previously, the Couchsurfing community gained significant traction while being a nonmonetized platform with voluntary contribution to maintenance and development from its core members. However, the platform crash of 2006 highlighted the need for a more systematic maintenance of the platform. The fact remains that to develop, maintain, and scale a platform to many millions of users, some capital investment is required. The monetization of a platform enables efficient development and maintenance of the web services or applications, the marketing of these services, provision of customer or technical support, and the ability to attract new users efficiently. Even though companies might have socially responsible goals, it is still evident that they engage in the sharing business because they seek to profit from acting as the middlemen between sharing individuals. We need to note that the presence of companies also provides possibilities because these new forms of sharing via different digital solutions require capital investments. Nonetheless, this setup has also been known to pose limitations for altruism and pure goodwill hunting, as we learned from the Zimride case. Because scaled global sharing operations with a mass of community participants are often run by companies providing the easily accessible online tools, it turns the provision of sharing platforms into a service in and of itself. It follows that some revenue and even modest profit is perhaps reasonable for platform providers. The question arises of how to extract this revenue from an altruistic sharing community. There then comes a critical balance where the platform needs to extract some revenue from the sharing community, as an enabler of the platform development, without exploiting the community. This feeling of being exploited would surely arise as a barrier.

Platforms aside, when the individuals involved attempt to extract profit from the transaction, they move outside the true altruistic nature of sharing and toward the sharing economy. Many of the sharing platforms take measures to prevent this, and individual attempts to profit from sharing would likely be highlighted in peer-to-peer feedback. On the other hand, the sharing economy not only encourages this kind of pseudo-sharing, but considers it a key part of the business model. This case of pseudo-sharing includes profit motives, absence of communal thinking or feeling, and expectations of a direct principle of reciprocity. This again results in people's increased selfishness and actual mistrust among peers and limits the kind reciprocity [24]. Surely this mentality would emerge as a significant barrier to those who share for the "right" reasons.

Another large problem is the still-lacking regulations related to sharing [17]. Governments and legislators with traditional and very bureaucratic processes

have difficulties in keeping up with the disruptive operating models that technology allows us to develop. Also, strict regulations are developed to protect individual consumers from corporations' dominance, yet what happens when the transactions increasingly occur between two individuals? Interesting questions have already risen, for example, around taxation as well as insurance and liability issues.

As an enabler of sharing, the development of the community feeling is an essential component. Again returning to the Couchsurfing example, there are numerous events and activities that connect participants and generate this community. The platform is keen to market its own impact, constantly updating the number of users, cities, countries, and events. Ridesharing might be able to develop this feeling by highlighting the environmental impact of its platform in terms of CO<sub>2</sub> emissions saved; similarly, food-sharing platforms might quote their impact in terms of kilograms of wasted food saved.

For platforms to resonate with individuals who are ready to share for the right reasons, they must satisfy the simple equation that the user benefit is greater than the effort and/or risk. Here is where digitalization plays a key role realizing the convenience of sharing, amplifying the community aspect, and providing the trust mechanisms needed to enable sharing on a mass scale.

## 4 Future of Digitally Enabled Sharing

### 4.1 Future Scenario

In the waking of an early Saturday morning, the sun is shining bright as long-postponed vacation plans start bubbling up from the back of Matti's head. The need for a break is making itself felt much stronger than ever as he pets his beloved, always hungry cat Savu's head. He rushes out of bed to proceed with his morning routine of feeding Savu and cleaning the usual mess he creates. Then he pours a cup of coffee to get on with the actual design phase of his 3 months in Japan. He fires the app and checks his "vacation abroad" template to confirm that it has all the items that need sorting out. He has his flat with a hyperactive cat, car, bike, and summer cottage. Check, check, and check. He simply puts his destination and the date in mind into the app. Matti also appoints his closest friend Antti as a local contact and manager of his shareable assets. A couple of days later, Matti's phone makes a happy sound. A girl named Hanako, who happens to be a cousin of Matti's Japanese coworker Taro, proposes that she and Matti should exchange flats. She also assures him that she is a cat whisperer as a mother of miniature tigers herself. Hanako also kindly states that she can use the bike to explore the vast forests and lakes of Finland. Matti accepts the offer more than happily. A month later Hanako arrives at Helsinki after

she hosts Matti in Tokyo for a few days. Fascinated by the beauty of the nature in her first days, Hanako fancies a kayak trip, which she has yet to experience for the first time. She fires the app and puts in her intention. It turns out that one of Matti's close friends, Jukka, a big-time kayaking guy, sees her interest because Hanako and Jukka belong to same inner circle now, as the app recognizes. Meanwhile, Antti handles the renting of Matti's car and summer cottage because he has the keys, in return for much-needed handsome cash, as Matti went on a shopping spree for souvenirs in Japan.

## **4.2 Trust, Reputation, and Community**

Trust lies at the heart of all kinds of relationships. In particular, trust must be well understood in the context of collaborative consumption or sharing in/out. Slee (2013) depicts trust as a problem of asymmetric information between the trustor and trustee [41]. The trustor cannot directly assess the trustworthiness of the trustee but infers it via signs of trustworthiness. These signs correspond to a notion of secondary trust, which is a signaling problem when an untrustworthy opportunist might seek to mimic it in order to deceive the potential trustor. So as a result, an effective and desirable sign must be easy for trustworthy to produce but hard and costly for the opportunist to fake.

In a sense, reputation can be perceived as a sign for trust similar to the word-of-mouth phenomenon that happens naturally in reality and is as strong as the sources. It might be a considerably strong sign of trust in a closed, well-connected community. Yet reputation is not perfect in the sense that it might be easily manufactured in a loosely connected large online environment. Consequently, it is not as strong if generating fake reviews is easy. Also, platform-specific online reputation systems suffer from various issues. The effectiveness of reputation based on feedback and reviews heavily depends on the motivation of the reviewer, and hence is prone to be biased. For example, a review in a form of service quality feedback is already biased from the perspective that the reviewer decided to buy the service, which would not reflect the potential opinions of nonbuyers. On the other hand, it might be the case that nonbuyers might not have the incentive to provide feedback at all. Slee's findings exemplify this issue; an inspection of 190,129 BlaBlaCar ratings revealed that 98.9% were rated as 5 stars. Yet another issue with platform-specific reputation systems is that the platform's incentive is not to provide assurance/trust per se but a sense of trust to facilitate more transactions and maximize the platform's business potential. This thus brings the question: Can we base our trust on such data provided by a for-profit organization?

Furthermore, Finley (2013) points out that trust is a multifaceted concept com-



posed of expectation and risk in which individuals optimally negotiate these by a thorough process of rational decision making [42]. The process as such in this context is far from being feasible compared to the decision utility at hand. Thus, an effective means of providing trust must be able to circumvent the environmental complexity of modern society. In this respect, Finley provides definitions of two types of trust: particularized and generalized. Particularized trust refers to the type of trust that is established upon extended reciprocal interaction within a circle of close social proximity, whereas generalized trust is more of an abstract attitude or standard estimate of trustworthiness, or giving “benefit of the doubt,” which is more relevant in the context of collaborative consumption with certain protections in place.

According to Slee [41], reputation is only one mechanism toward the solution of the trust problem. Other typical mechanisms are listed as reciprocity in long-term relationships, regulations, professional qualifications, voluntary industry certifications, independent rating agencies, individual firm commitments, and so forth. Sharing economy platforms try to harness other mechanisms to improve their and peers’ trustworthiness, especially by creating a sense of community to influence reciprocity and increase the effectiveness of their reputation systems. Yet the sense of community does not scale well with the growth of the user base, and hence fails to do so.

Airbnb, as a lead in this respect, remedies its reputation system by further integrating social graphing into the situation. The users can see explicit reviews and comments of their social connections, which logically translates into certain weights in overall trust assessment as potentially more reliable opinions. Moreover, Airbnb introduces all sorts of verifications on photos and IDs, with the service levels essentially turning the so-called sharing platform into a full-fledged service business, as it has already reaped the benefits of “share washing.”

On the other hand, on smaller scales, new sharing economy startups try to facilitate the formation of communities around their business models in order to achieve critical mass for their businesses to pick up and become sustainable. As discussed, the sense of community does not stick well with such for-profit business models. The most prominent scale achieved in communal spirit we observe is in the example of Couchsurfing, where people host each other in a somewhat reciprocal nature. Customarily, Couchsurfers bring small gifts of symbolic value to their hosts or perhaps help them with certain chores as an immediate show of gratitude. Yet the whole process is based upon what Lampinen, Lehtinen, Cheshire, and Suhonen (2013) point out as indirect social exchange, where social exchange is seen as a fundamental human social behavior [43]. Additionally, from the perspective of hosts, this is a clear case of sharing out in Belk’s terms. Hosts have full autonomy in choosing their guests as they see fit, but the community

culture in place favors those who are reputable as hosts and guests, which is in line with the notion of indirect reciprocity.

Moreover, Lampinen et al. document a case of local online exchange called Sharetribe (Kassi) to provide an in-depth analysis of indirect social exchange and online–offline community formation [43]. Sharetribe is an online exchange system to facilitate sharing of information, goods, skills, or help within a group of local users (e.g., campus area). Extensive interviews with the users revealed that the indirect nature of the exchange raises feelings of indebtedness, which translate into a sense of community, eagerness to contribute, and minimization of efforts required in exchanges by helping each other. The online–offline, face-to-face nature of the exchange seemingly fosters a form of particularized trust.

In another study, Ikkala and Lampinen (2015) look into the dynamics of an online–offline community based on a shared identity [44]. The members of the community are all single parents with similar problems. In vision, the community network was intended to help meet such goals as discussing emotions and thoughts with peers, gaining knowledge regarding parenting, sharing material resources, and fighting the isolation associated with single parenting. The study revealed the importance of strong, solid ties with other members for social support and peer-to-peer exchanges of goods and favors to happen. Nevertheless, certain low-risk, direct, one-off exchanges did not require such extensive trust. The network members were rather reliant on well-established connections within the network to engage in risky exchanges such as organizing childcare or carpool school rides. The identified central dilemma was the initial time investment and social commitment needed to gain connections and access to resources.

As discussed, community formation suffers from multifaceted challenges and does not scale well with growth. The required trust for the nature of exchanges seems to be the primary factor that limits the size of the communities, and high-stake exchanges are only possible through well-established relationships. Clearly, in such a situation, the growth of sharing, social exchange, and collaborative consumption cannot depend on platform-imposed communities but rather hyperlocal communities based on personal identity and networks that can make trust establishments more feasible.

### **4.3 Platform Ecosystem**

Wagner, Kuhndt, Lagomarsino, and Mattar, (2015) report that the creation of a critical mass of users with positive network effects is seen as the most essential challenge for the success of sharing economy business models [45]. Other high-importance challenges follow, such as changing consumer habits, access

to products or service, establishing trust between users, and effort for arranging transactions.

So far in this ecosystem, every single sharing economy initiative has been struggling to develop its own platform-specific solutions to these challenges, whereas their inherent focus should lie in improving their value propositions, business models, and user experience. Currently, we are increasingly seeing third parties starting to give trust as a service as Figure 2 depicts a potential trust profile in such. This particular situation signifies the incarnation of a possible platform ecosystem where the discussed challenges will be solved by separate parties.

### 4.3.1 Trust as a Service

Botsman and Rogers (2011) think that trust is the new currency in collaborative consumption, especially for micro-entrepreneurs who are looking to monetize their assets [5]. Yet the problem of platform-specific reputation systems stands as a barrier for people to take ownership of their own reputations. It's quite inconvenient for people to not be able to harness their reputations from other platforms. Traity is a third-party trust provider that tackles this exact problem by letting people aggregate their reputations from different providers [46].

Traity further aggregates social network connections and credentials of people to further assess their trustworthiness into three classes, bronze, silver, and gold, with details about what makes the person in question trustworthy.

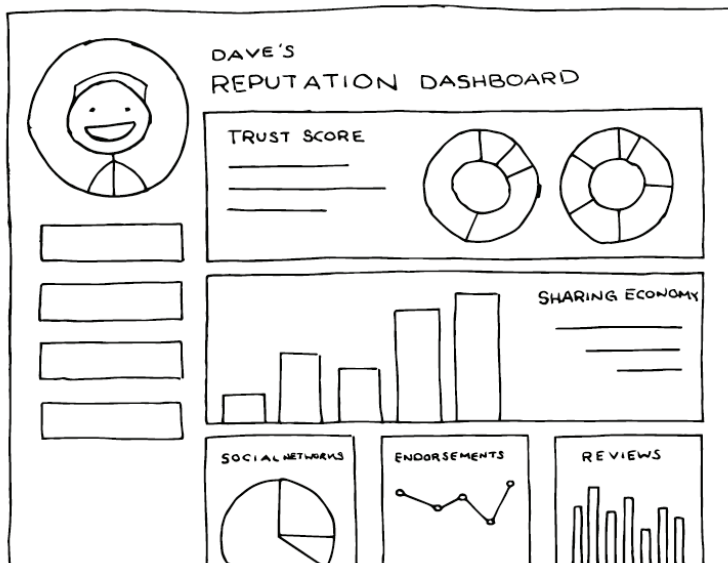


Fig. 2. Future of online reputation [46].

Similarly, TrustCloud, another trust provider, claims to offer not only trust as a service but also satisfaction [47]. TrustCloud provides trust scores along with satisfaction guarantees, acting as a referee on disputes to lift these challenges from sharing economy initiatives' shoulders.

Third-party trust providers have the potential of clearing the issues with platform-specific reputation systems. Nonetheless, the kind of trust that can arise from a system at such a level can be seen as mixture of generalized trust and slightly particularized trust, which is usually sufficient for major peer-to-peer exchanges and collaborative consumption.

The type of trust desired for social exchange and sharing needs more scrutiny in a way that it should provide us the chance to extend our inner circle. As in the example of our future scenario, where Matti clearly needs someone whom he can not only trust with his house but also his pet. These trust platforms have the potential to evolve in those directions via building on the transitive nature of trust along with social proximity features. Moreover, as a by-product, these platforms can enable liberation of platform-specific communities and mobilization of personal connections in further sharing opportunities.

#### **4.3.2 The Digital Experience**

The PwC (2015) study claims that price is likely to be a factor for consumers [3]. Nonetheless, as sharing becomes more and more popular and developed, seamless experiences are predicted to determine consumer choices. We do not want to waste time or efforts in processes, but rather want to focus on the outcomes. Thus, digital solutions that enable simple and seamless transacting will increasingly continue to play a crucial role on this journey.

Makkonen (2011), the creator of Sharetribe, also points out the big problem of fragmentation in platforms, where hundreds of small niche platforms with very specific sharing models suffer from never seeing critical mass [49]; hence, their only way out from the bottom of this pit is to collaborate.

Within these different initiatives, most of them are dealing with the same asset, which leads to an unreasonable ecosystem. From the perspective of the consumers, the cognitive load of starting to use one platform deters them. This situation creates an impossible user experience. The proposed solution is to run this ecosystem via open application programming interfaces (APIs) and ultimately provide access to services using a set of search engines for matching demand and supply to provide a plausible user experience. Although there are good enough incentives for small initiatives to do so, networked monopolies that are already well established, such as Airbnb, Uber, and so forth, have no interest in such. Consequently, the ex-

pected growth of this kind of collaboration is slow but inevitable. Yet, as discussed, third-party trust providers might give a boost in this respect.

Already at this phase we are seeing visionaries such as Swadmap and CompareAndShare poised to become search engines for all sharing. However, the time does not feel right, as we see Swadmap is yet to launch [50], and CompareAndShare already closed its doors [51].

## 5 Conclusions

Technology and modernity have transformed the way we are living our lives. And along with the economic growth, individuals are becoming more independent and self-sufficient, with sharing and peer support becoming an option rather than necessity. People opt to live alone, travel alone, and enjoy the new freedom they can afford. However, just because something becomes affordable does not and should not mean that it is the way to go. The newly found individualism and consumerism certainly do not help in the making of a sustainable world. Society needs to rediscover the culture of sharing not because of the physical needs, but to create more of the glue that will build the future of humanity.

So far the hype around the so-called sharing economy has been mostly driven by the business interests of a number of startups, such as Airbnb and Uber. However, as we have discussed, sharing models tailored for monetization can only capture the small part of the potential of digitally enabled sharing. The true sharing, as we have done with our families, friends, and tribes for thousands of years in the history of humanity, is yet to benefit from digitalization. The authors think that a seamless user experience is the future of all sharing, where flexibility exists and different cases are handled transparently by an ecosystem of platforms. Ultimately this newly found ecosystem will most likely be the one to enable a plethora of social exchange and sharing in/out, along with for-profit counterparts.

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# Appendices

# 1. The Bit Bang People

## FACILITATORS

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**Ormala, Erkki** – Professor at the Department of Management and International Business. He has a PhD in Engineering from Helsinki University of Technology. He is a former Vice President of Nokia Corp. Ormala has chaired the assessment of the EU R&D Framework Program and the association of the European Digital Industry, DIGITALEUROPE. He is a member of a European Commission initiated high level advisory board on the future of the European media.



**Neuvo, Yrjö** – Research Director. He has a PhD in Electrical Engineering from Cornell University. He is a former CTO of Nokia Corp. He has worked as a National Research Professor at Academy of Finland and a visiting professor at University of California, Santa Barbara. During his academic career he produced 30 doctors. Over the years he has been actively promoting industry-academia cooperation. He has been awarded 4 honorary doctorates.



**Kuikka, Meri** – Social media researcher, doctoral candidate in Information Systems Science. MSc (Information Service Management) and BSc (Business Technology) from Aalto School of Business. Current research topics include social media strategy for organizational use and challenges related to social media use in organizations.

## TUTORS

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**Elischka, Synes** – Austrian, MA. A PhD student at the Film Department, Aalto School of Arts, Design & Architecture. *Research topic:* Immersion in Film: Toward and empiric basis of audience engagement. *Other interests:* DIY, bicycles, snowboarding, making movies in 2–3 days all around the world.



**Hakala, Jussi** – Finnish, MSc. A PhD student at the Department of Computer Science, Aalto School of Science. *Research topic:* Perceptual and affective effects of stereoscopic imaging technologies. *Other interests:* Science fiction, road cycling, chillies, and Indonesia. Professional interests include visual media technology, experiment design, and futures research.



**Kuo, Vincent** – Taiwanese / South African, MSc. A PhD student at the Department of Civil and Structural Engineering, Aalto School of Engineering. *Research topic:* Management of tacit engineering knowledge using pattern recognition and semantic inference. *Other interests:* Poetry, journalism, languages, jazz.



**Pinjamaa, Noora** – Finnish, MSc. A PhD student at the Department of Information and Service Economy, Aalto School of Business. *Research topic:* Media content creation and distribution on social platforms. *Other interests:* Dancing, jogging, hiking, yoga and good coffee.

## PARTICIPANTS

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**Boz, Eren** – Turkish, MSc. A PhD student at the Department of Communications and Networking, Aalto School of Electrical Engineering. *Research topic:* From Quality-of-Service to Quality-of-Experience in mobile networks. *Other interests:* Cycling, music theory, musicianship, psychology, philosophy, outdoors, skiing.



**Ceps, Katharina** – German, MSc. A PhD student at the Department of Management Studies, Aalto School of Business. *Research topic:* The effects of digitization on inter-organizational relationships. *Other interests:* Yoga and gym, cooking, languages, travelling.



**Chen, Hung-Han** – Taiwanese, MA. A PhD student at the Media Department, Aalto School of Arts, Design & Architecture. *Research topic:* In-Between-Ness: A Practice-led Study Rooted in the Concept of Affect in Bergsonian Metaphysics. *Other interests:* Photography.



**Dae, Pedram** – Iranian, MSc. A PhD student at the Department of Computer Science, Aalto School of Science. *Research topic:* Probabilistic Modeling for Contextual Information Retrieval. *Other interests:* Playing the piano, going to gym.



**Dou, Jinze** – China, MSc. A PhD student at the Department of Forest Products Technology, Aalto School of Chemical Technology. *Research topic:* Fractionation of willow biomass for combined production of fibers, chemicals and energy. *Other interests:* Jogging, basketball.



**Flores Ituarte, Iñigo** – Spanish, MSc. A PhD student at the Department of Engineering Design and Production, Aalto School of Engineering. *Research topic:* Additive Manufacturing in Design, Production and New Product Development processes. *Other interests:* All kinds of sports (e.g. tennis, table-tennis, badminton, football, basketball) Enjoy going to the beach in summer and to ski during winter. I love meeting my friends and spending time with my family.



**Haka, Jaana** – Finnish, MSc. A PhD student at the Department of Biotechnology, Aalto School of Chemical Technology. *Research topic:* Recombinant antibodies for sensitive detection of food allergens. *Other interests:* In regard to my extracurricular activities I play violin and act as a leader of a string orchestra. I also like playing tennis and travelling.



**Laakso, Tuija** – Finnish, MSc. A PhD student at the Department of Civil and Environmental Engineering, Aalto School of Engineering. *Research topic:* Applying data analysis and risk management approaches to support sewer network maintenance decisions. *Other interests:* Music, playing the violin, handicraft, gardening.



**Larnemaa, Anne** – Finnish, MSc. A PhD student at the Department of Information Systems Science, Aalto School of Business. *Research topic:* Examining how digitalization revolutionizes the user/customer experience. *Other interests:* Traveling, sports like gym and yoga.



**Matveinen, Juho-Ville** – Finnish, MSc. A PhD student at the Department of Industrial Engineering and Management, Aalto School of Science. *Research topic:* Strategic, Systemic, and Contextual Enablers for Digital Service Systems. *Other interests:* Weightlifting, video games, tech & computers.



**Mc Caffrey, Colm** – Irish, MSc. A PhD student at the Department of Radio Science and Engineering, Aalto School of Electrical Engineering. *Research topic:* Low power to fully passive wireless sensing systems: Enabling the emerging IoT. *Other interests:* Guitar, Karate, Rugby (referee), cycling, running, couch-surfing, traveling.



**Nelimarkka, Matti** – Finnish, MSoc.Sc; BS. A PhD student at Department of Computer Science, University of Helsinki and researcher at the Helsinki Institute for Information Technology HIIT, Aalto School of Science. *Research topics:* Exploring and designing live participation systems, social computing and computational social science. *Other interests:* cats, coding.



**Noorizadeh Abdollah** – Iranian, MSc. A PhD student at the Department of Civil and Structural Engineering, Aalto School of Engineering. *Research topic:* Operations Management in Construction. *Other interests:* Running, football, group reading.



**Nykänen, Jussi** – Finnish, MSc. A PhD student at the Department of Information and Service Economy, Aalto School of Business. *Research topic:* Consumer Switching Behavior on Mobile Service Platforms. *Other interests:* Football, movies, video games, swimming, squash, history.



**Öhman, Mikael** – Finnish, MSc. A PhD student at the Department of Industrial Engineering and Management, Aalto School of Science. *Research topic:* Developing Smart Industrial Services - A Business Re-Engineering Tool for the 21<sup>st</sup> Century. *Other interests:* Nature, Archipelago, Cooking, Economics, Downhill skiing, Jogging.



**Partanen, Timo M.** – Finnish, MSc. A PhD student at the Department of Industrial Engineering and Management, Aalto School of Science. *Research topic:* Impact of Organizational Learning to the Timing of Technology Adoption. *Other interests:* Travelling, football.



**Rodriguez-Kaarto, Tania** – Mexican, MA. A PhD student at the Department of Media, Aalto School of Arts, Design & Architecture. *Research topic:* Finnish Language Acquisition for specific purposes through visual means. *Other interests:* Family, reading, cooking, movies, running, knitting, hand-crafts.



**Santillán Martínez, Gerardo** – Mexican, MSc. A PhD student at the Department of Electrical Engineering and Automation, Aalto School of Electrical Engineering. *Research topic:* Predictive online simulation systems. *Other interests:* Literature, music, travelling, beer.



**Takala, Pyry** – Finnish, MSc. A PhD student at the Department of Computer Science, Aalto School of Science. *Research topic:* Natural language understanding with deep neural networks. *Other interests:* Sports (kayak, volley, floorball, climbing...), some reading.

## 2. *Guest Lecturers*

- Anssi Vanjoki, Lappeenranta University of Technology
- Erkki Ormala, Aalto University
- John Zysman, UC Berkeley
- Jussi Hinkkanen, Fuzu
- Lars Kåhre, Futudent
- Lauri Kivinen, YLE
- Martti Mäntylä, Aalto University
- Pasi Hurri, BaseN
- Per Stenius, Reddal
- Sari Baldauf, Vivaio
- Sirkka Heinonen, University of Turku
- Tatu Koljonen, EIT Digital
- Tero Ojanperä, Vision+
- Tiina Alahuhta-Kasko, Marimekko
- Timo Ali-Vehmas, Nokia
- Timo Kiravuo, Aalto University
- Timo Vuorensola, Spaceboy
- Tuomo Pietiläinen, Helsingin Sanomat
- Valteri Halla, Valhalla Consulting
- Yrjö Neuvo, Aalto University

### 3. Course Literature

- Bit Bang – Rays to the Future.* Yrjö Neuvo & Sami Ylönen (eds.) 2009. Helsinki University of Technology.
- Bit Bang 2 – Energising Innovation, Innovating Energy.* Yrjö Neuvo & Sami Ylönen (eds.) 2010. Aalto University.
- Bit Bang 3 – Entrepreneurship and Services.* Yrjö Neuvo & Sami Ylönen (eds.) 2011. Aalto University. *Bit Bang 4 -Future or Internet.* Yrjö Neuvo & Elina Karvonen (eds.) 2012. Aalto University.
- Bit Bang 4 –Future or Internet.* Yrjö Neuvo & Elina Karvonen (eds.) 2012. Aalto University.
- Bit Bang 5 – Changing Global Landscapes – Role of Policy Making and Innovation Capability.* Yrjö Neuvo, Erkki Ormala & Elina Karvonen (eds.) 2013. Aalto University.
- Bit Bang 6 – Future of Media.* Yrjö Neuvo, Erkki Ormala & Meri Kuikka (eds.) 2014. Aalto University.
- Bit Bang 7 – Future of Energy.* Yrjö Neuvo, Erkki Ormala & Meri Kuikka (eds.) 2015. Aalto University.
- The Second Machine Age.* Erik Brynjolfsson & Andrew McAfee (2014). W. W. Norton & Company.

## *4. Study Program in Seoul*

### **Sunday, January 24<sup>th</sup>, 2016**

- 09:15 Arrival in Incheon by AY 041
- 11:00 Check in hotel Fraser Place Namdaemun Seoul
- 11:30 Lunch
- 13:00 Presentation given by Sungchul Chung, Ph.D from UST
- 15:30 Back to hotel and free evening

### **Monday, January 25<sup>th</sup>, 2016**

- 07:30 Departure from hotel
- 10:00 Visit ETRI and presentation given by Kyoungyong Ji, Ph.D
- 12:00 Lunch
- 14:00 Visit KAIST tour and Q&A session given by Songcheol Hong, Ph.D.
- 16:30 Visit Cargotec Korea, contact person: Heikki Ranta, CEO
- 18:30 Check in New Vera Hotel  
1027 Gagyeong-dong, Heongdeok-gu, Cheongju

### **Tuesday, January 26<sup>th</sup>, 2016**

- 06:30 Departure from hotel
- 10:00 Visit Wartsila Korea
- 11:30 Lunch
- 13:00 Visit GS-Hydro
- 16:00 Visit Fanuc Korea
- 17:30 Local restaurant, courtesy of Fanuc Korea  
(Korean Chicken Soup, Samgyetang)
- 22:00 Arrival in hotel

### **Wednesday, January 27<sup>th</sup>, 2016**

- 08:45 Departure from hotel
- 10:00 Visit Mando Central Research Center
- 12:30 Arrival in hotel and lunch
- 14:00 Visit LG U+ IoT @home experience center
- 16:00 Visit Nokia Networks
- 18:30 Arrival in hotel



### **Thursday, January 28<sup>th</sup>, 2016**

- 08:30 Departure from hotel
- 10:00 Visit Design Factory in Yonsei University
- 11:30 Lunch
- 14:00 Visit Samsung D'light Experience Center
- 15:45 Arrival in hotel and prep time for the reception
- 18:30 The reception to be held by Finish Ambassador's residence
- 21:00 Arrival in hotel

### **Friday, January 29<sup>th</sup>, 2016**

- 08:45 Departure from hotel
- 10:00 Visit SSKU Carbon nanotube research laboratory.  
Tour and presentation given by Seongju Lim, Ph.D.
- 12:00 Presentation and Luncheon with the members of  
Finland Chamber of Commerce.
- 14:30 Cultural Activity
- 17:00 Arrival in hotel and rest for an hour
- 18:30 Internal wrapping-up dinner at Sanchaehyang
- 20:30 Arrival in hotel

### **Saturday, January 30<sup>th</sup>, 2016**

- 07:10 Departure from hotel
- 08:40 Arrival in Incheon International Airport

## *5. Seoul Study Tour Reports*

Sunday, January 24<sup>th</sup>, 2016

### **Presentation given by Sungchul Chung, Ph.D from UST**

Dr. Sungchul Chung from the Science and Technology Policy Institute gave us a picture of the history of South Korea's trip from a developing country to a prosperous giant in technology. Back in the beginning of 1960's, South Korea's Gross National Income was 87\$, whereas today it is some 28 000\$. South Korea was able to change its economy from an agricultural society in the 60's through a duplicate imitation phase in the 70's and 80's to a hightech industry which it is today. The next step and at the same time a great challenge for Korea is to find its way to a flourishing 'Creative innovation economy'.

Dr. Chung explained us that Korea's development in recent decades has been influenced by various factors. The country is poor in natural resources and therefore cannot base its economy on top of those. South Korea has faced a war with North Korea, which was supported by the neighbouring country China and Soviet Union. Another neighbour, Japan, used to govern Korea as its colony. As a result, Korea chose a strategy where they focused on technology development, they aimed at international markets and wanted to keep economically independent of big countries. They deliberately exposed their technologies to international competition and supported companies that had succeeded on international markets.

The current challenge for South Korea is to create a strategy where they could become what was described as the 'Creative knowledge economy'. Some of the traditions in Korean society do not support this, since the Confucian tradition is a very hierarchical one and also creative thinking has not always been the focus in teaching but rather absorbing new knowledge.

Monday January 25<sup>th</sup>, 2016

### **ETRI visit and presentation by Kyoungyong Ji, Ph.D**

ETRI is government owned research organization, which consists of six laboratories: SW content research laboratory, IT convergence technology research

laboratory, components & material research laboratory, broadcasting & telecommunications media research laboratory, communications & internet research laboratory and future research creative laboratory. ETRI is one of the 14 government owned applied and advanced research organizations; and among the 48 government research institutes and think tanks.

ETRI is an applied research organization to bridge the basic and commercial research together. Their tasks include development of the technology and product development. Furthermore, they support technology transfers and diffusion of the technology. Furthermore, the ETRI expertise is used in the technology policy discussions and government roadmaps; together with other other government institutes and the business. ETRI also aims to fostering ICT expertise in Korea, having large alumni network in core positions in industry and government. The overall future goal is a “super connected society”, where IoT plays a key role. The aim is to support software platforms in the further to further.

ETRI used to provide IP transfer service for big companies such as Samsung and LG but the government now encourages them to support SMEs to create more workplaces. Their main focus currently is to serve small and middle size companies in Korea since the government noticed the importance of diversity in Korean economy. The SMEs can either support ETRI and join a project they have or they can buy the outcomes of the research projects. Based on analysis, they observe that only 28.3% of SME companies are conducting R&D, but very few have skills in this area. It is the result of the fact that most of the top talents prefer enterprises rather than SMEs when they graduate. ETRI supports researchers to setup SMEs and conduct collaborative research with SMEs. It was even mentioned that if an ETRI researcher starts a new company but that fails, the person can return to work at ETRI.

### **KAIST tour and Q&A session by Songcheol Hong, Ph.D.**

The KAIST Institute consists of research center and coexists with the KAIST University. It provides the university a multidisciplinary platform for collaboration and as an institute, has more research orientated approach with larger projects. These institutions are temporary, setup for specific purposes and collect various projects around that purpose. Fundingwise, they work mostly with direct government funding, thus aligned with the government policies. The research on coverage focuses on internet of things, smart sensors and fusion of these technologies to enduser applications. Current research topics include e.g. smart agriculture, and smart healthcare. Projects they have had or are working on include electric buses that charge when on the road.

One of the researchers demonstrated the use of an application they are developing, an interactive “panel” system consists by a touch screen and a smart phone. The user utilizes the ambient sensor on the smartphone to detect the contents on the touchscreen by placing the front face directly on the touch screen. The screen will flick to hint the phone the index of the data on the screen and the smartphone can then download the content or conduct further interactions with the touch screen.

In their laboratory, we also see researches on the arrangement of 5G antennas. They build several prototypes that test the efficiency of different antenna layouts. There are 26 researchers working in the institute and the funding comes both directly from the government as well as enterprises such as Samsung and LG. The 5G antennas experiment seems to be a cooperation between the institute and manufacturer of the 5G cellstation.

## **Cargotec Korea**

Cargotec Korea is a small assembly factory for the HIAB division (cranes) with 90 employees. They provide assembly and support for these cranes mainly in the Asian markets. Cargotec has already focused on data collection from their systems. It’s because they are now facing strong competitions from Russian and China. For example, they have data collected for 15 years from cranes in the field, used to optimize future products. In the long term, the goal is to become intelligent cargo handling in the digitalized world. Currently the data analysis group of 20 persons is located in Sweden.

The Korea factory has its special products and the R&D for those is done in Korea. This supports the transformation from product company to a digital company, emphasise the role of software and services in the future. The strategy is to outsource the manufacturing, maintenance and even assembling works and focuses more on data analyses and services. The Harbour business is already being digitised, Hamburg being the first harbour in the world to be fully automated.

Digitalization will move the direction of business more towards services and customer satisfaction and these are also the things Cargotec will be focusing on. The challenge for the company will be how to really provide new value to customers and to show how connected and intelligent solutions improve customers’ processes. However, good examples were provided from forest industry on how automation can improve the efficiency of the process. A key issue is who will be the system integrator. As IoT solutions are based on software, the software platform provider is likely to be a key role player in this development.

Tuesday January 26<sup>th</sup>, 2016

**Wärtsilä Korea**

Driving three and half hours from Seoul toward southeast, we arrived to Wärtsilä center in Busan. After warm welcoming program, Mr. Oh, Scott Sejeong, a country general manger, gave us a presentation about the shipbuilding industry in South Korea. He discussed about a number of different topics that in the following we cover some of those. To begin with, it is mentioned that high quality and performance of the shipbuilding and offshore companies placed South Korea in a superior position in the world in this industry. The cluster of companies (e.g., Hyundai, Samsung and Daewoo heavy industries) in this filed offer their products and services which lead to high competitive market environment. For example, regarding the companies in which have high market share, Hyundai heavy industry supports half of the South Korean shipbuilding activities. Emphasizing on the role of Hyundai in the market and value of collaboration for offering better products in this industry, Wärtsilä Hyundai Engine is the joint production of these companies. Moreover, while Wärtsilä's competitors endeavor to obtain more market share from service sector, Wärtsilä with its different solutions has a better position in the market. According to presentation, currently Wärtsilä is the most complete marine solution on the earth by offering merchant, offshore, cruise and ferry, navy and special vessels. For example, 369 million Euro was the marine solutions revenue for 2015 in South Korea.



Digitalization in shipbuilding industry was another topic of this session. The optimization and efficiency in oil and maintenance are considered among key drivers of digitalization in this sector. This part was more interesting for us in which has raised a variety of questions such as whether in the future it would be possible to have a ship without crew while passing through ocean? Or whether crew are interested to uncover all the records of speed and pressure on engine throughout the trip to external party? After presentation, we had the chance to go and take a close look at very large ship engines in of the company's warehouses. You can imagine the size of engines how big and powerful should be in order to move those ships and megaships. After having lunch at Wärtsilä, we leaved to visit GS-Hydro as another industrial company operating in Busan area.

## **GSHydro**

GSHydro is a Finnish company, established in 1974, providing nonwelded piping systems for extreme conditions throughout the world. The founder of the company was Göran Sundholm, who invented a method to connect pipes with flanges without any welding. The parts of the piping system can be prefabricated to a high degree, which reduces both installation and maintenance costs significantly. Nonwelded pipes are also leakfree and clean. Today, GSHydro is owned by a Swedish private equity company Ratos, and it has its own subsidiaries in 17 countries and cooperates with several partners around the world.

At our visit to GSHydro in Busan, we were first taken to a meeting room in a main building. Our hosts welcomed us all, and started with an introduction of a company and its products. We were told that GSHydro has invented three flange technologies: 37° Flare Flange, 90° Flare Flange, and Retain Ring Flange systems. We were shown a video, which explained how the flanges are made and pipes connected in different cases. Later, in a factory tour we saw in practice how the pipe ends are prepared for the flange systems with special machines, and how the pipe connections are made.

During our visit we learned that GSHydro provides its customers a total offering from engineering services and a complete set of nonwelded piping system products to documentation and pipeline maintenance solutions. About half of the customers are offshore, one third landbased and the rest marine. In Korea, the major customers include Maersk Drilling, Seadrill and Ocean Rig in the offshore side, Huyndai, Ssangyong Motor, RollsRoyce and Cargotec in the landbased side, and Samsung, DSME and Huyndai Heavy Industries in the marine side. The customer cases introduced to us included oil platforms, oil drill vessels, tankers, navy vessels, pulp and paper industry, and automotive testing. As a part of

its maintenance services, GSHydro has invented Smart Care Hose Management system. An RFID is attached outside the hose, and it can be read with a handheld reader or by using an internetbased software. The RFID contains e.g. the technical data and critical class of the hose, and a maintenance log. The information can be used for example in maintenance planning in order to avoid a sudden breakage which can cause revenue loss as well as a risk for personnel and the environment. The maintenance system is expendable also to hard installations like pipe lines.



*Smart Care Hose Management System RFID attached to the hose, and examples of flange connections.*

## **Fanuc Korea**

The Fanuc Company is originally from Japan. Currently a global company, they are the forefront of innovation, focussing their activities in automation sectors, such as Computer Numerical Control (CNC) systems for machine tool industry, laser systems, Robot systems and RobotMachines systems. Other technologies include machine tools for purposebuilt machines for wire cut Electron Deposition Machining (EDM), electric injection moulding, milling, turning, twin turrent machines punching machines and grinding operations. Korea division headquarters is located in Changwon, defined as a service territory from the company operations perspective. The visit tour started by a formal corporate presentation of Fanuc activities globally and then focussing on the activities in Korea. In numbers, Fanuc was founded in 1958, currently has 5261 employees globally with an annual revenue of approximately \$6010 billion. Korea activities are focussed mainly as a service and sales office, having a role in the assembly of CNC equipment for local manufacturers as well as providing technical assistance and training to local industry. The reason for this is that all major engineering, design and manufacturing operations are still centralized in Japan. After the corporate presentation of the company, the factory tour included a visit to some of their showrooms for industrial robots, manufacturing systems and CNC applications. The view of the factory presented a quick picture of the Japa-

nese “lean manufacturing” spirit. All working areas were clearly delimited and marked for the different steps in the production workflow. It seemed that every single operation followed a predefined workflow to minimize waste and increase productivity at maximum. The operation director also mention how they are facing currently some challenges that restructuring of the employment workload as they were suffering at the moment a decrease on the customer orders. Nevertheless, Fanuc production systems and specially CNC systems are market leader in a global scale. Covering 80% of market share in the supply of CNC and automation systems for machine tools.

## Wednesday January 27<sup>th</sup>, 2016

### **Mando Central Research Center**

The Mando Corporation is one of the largest original equipment manufacturers (OEMs) and suppliers to many major automobile companies in the world. The company was established in 1962 at a time when most companies still imported components from other neighboring countries. To this day, the company has exhibited phenomenal growth, and is set to further secure its position as the leader in technology.

“Highest technology is the only determining factor.” Monica Minkyung Kim, R&D Strategy

In total, the company has approximately 10 000 employees around the world in 23 manufacutring sites and 13 R&D sites. As a Korean company, the local market provides the largest share of its revenue, amounting up to around 55%. However, the company has plans to improve their sales abroad to maximize their overseas revenue.

Research and development was previously decentralized but in 2012 Mando built a new global R&D center in Seoul that integrated these different sites under one roof. This improved the response time to OEM demands and requirements, created a communication-friendly environment, maximized R&D capacity, and increased work efficiency. In the spirit of open innovation, the R&D center consults universities, researchers, government institutions, and companies in order to codevelop solutions.

Innovation in the new Mando R&D center makes use of the communication-friendly environment that encourages cooperation and knowledge sharing. As part of this, the company aims to create events where the whole company can discuss and share ideas, views, and opinions. It is recognized, for example, that regular em-



ployees might have been working for 20 or 30 years, constantly building up their expertise, but without any means of sharing that expertise. Hence, it is important to have forums for sharing this tacit knowledge with younger R&D engineers.



### LG U+ IoT @home experience center

One of Korean major telecommunication providers, which has focused its attention on five major services of navigation, shopping, music, game, and IPTV (Internet Protocol television). LG U+ offers a variety of mobile services.

Recently LGU + focused their strategic resources on Home IoT system and they formed an exhibition centre in Yongsan called IoT@Home, which is the section that we visited. The 'IoT@Home Platform', connected with a wireless application in your mobile phone it is possible to remotely control lights, room communication solution, is known to let a smartphone user access IoT-based home services anytime, anywhere. At first glance it may seem that there are lots of fascinating IoT services in IoT@Home. To give some examples, just by using temperature, plugs and door locks, check the electricity usage, detect intrusion using window sensors, or feed your pet while you are away from home.



However, if we look at each individual service by itself it seems that it is not that groundbreaking as one may expect from the huge hype surrounding the IoT. During this tour, the main question in our head was that “is this really the whole potential of IoT in everyday life, or is it just the beginning?” I guess future Bit Bangers will know the answer.

## **Nokia Networks**

Nokia Networks is the only foreign LTE infrastructure supplier to all three LTE operators in Korea, one of the most advanced and demanding markets. LTE, an acronym for LongTerm Evolution, commonly marketed as 4G LTE, is a standard for wireless communication of high-speed data for mobile phones and data terminals.

Andrew Cope, the head of Nokia Networks in Korea, described that after Nokia sold its mobile and devices division to Microsoft many people considered it as the end of the company. However, the truth is that Nokia is a changing company and not a failed one. After the sale of its mobile devices division, Nokia started to focus on its profitable network equipment division, Nokia Networks. Andrew mentioned that Korea is a key location for 4G technology that really needs IoT. This is because people in Korea are aging, they are connected, the country has no natural resources, and people have a good attitude toward technology in general. Furthermore, the government sees and supports IoT, which makes Korea a perfect hub for Nokia mobile networks. The company at the moment is working on four main areas: connected cars, connected industry, digital health, and virtual reality. It seems that there are lots of research about 5G IoT for the Olympics in Korea. Andrew thinks that the technology is there, however, the business model is still missing. In Iot case, companies have a vision but they do not know how to execute it.

Thursday January 28<sup>th</sup>, 2016

## **Design Factory in Yonsei University**

Our tour to the Design Factory covered several topics, ranging from the Design Factory concept, to student life, the nearby Songdo smart city, and even cultural differences between Korea and Finland. Our hostess Meri was a Finn who graduated from Aalto in 2014. She had studied at Design Factory in China already earlier, and moved to Korea in March 2015, and was likely on a 1+1 year term in Korea. Her task was to train students and faculty to understand how DF and multidisciplinary works.

The Design Factory in Korea was established in 2015, and important partners / financiers include for instance Kone, LG and Cisco. The Factory had a lot of interesting facilities, including equipment for practicing 3dprinting and laser cutting. A typical DF student would study information and interaction design, culture and design management, or creative tech management. Approximately 40 students would participate yearly, and the curriculum includes a mandatory capstone project. The DF concept has been recently introduced to high school students also, getting students to realize that anyone can design, and giving students confidence in their skills. At the core of DF Meri thought was mentoring and open-mindedness. An example project included an egg that could be put in the washing machine that measures water temperature, cleanliness etc., notifying your phone when you need to change something. Another example was a project airconditioning that would avoid overheating by detecting when no one was in a room.

In addition to DF, our discussions covered student life in Korea. The university had about 30 40 thousand students, about 5 thousand on the campus we visited. It was interesting to see the differences to Finland: a curfew, and separate living areas for boys and girls. Also, students were required to pay tuition (about 16 thousand per year), and the campus was mostly for freshman, i.e. most students would move out after their first year. The area was the Songdo smart city, a new area built over the past 10 years, with an investment of 35bn dollars. The intention in the area was to make a smart business hub, and as the city was close to the airport serving also Seoul, it was advertised that you could reach 1/3 of world's population within 3 hours.

Finally, we covered cultural differences between Korea and Finland. Meri perceived that it was harder for students to work together, as they were measured 'on the Gaussian curve', i.e. the grades of an individual would depend on other grades also. Dominated by the giants like Samsung and Hyundai Korean culture did not appear very startup friendly (especially compared to recent atmosphere in Finland), though the tide might be turning in the coming years. Funding would be challenging: there would not be that much state funding, personal or family money would need to be involved, and the unemployment benefits would not be good. Korean students would be also more worried about getting a job, as the pressure from family and society was high. In terms of creativity, Meri did not see much difference between Koreans or Finns.

## **Samsung D'light Experience Center**

Samsung D'Light, is named by a word play of course referring to delight while attempting to refer to itself as a digital lighthouse illuminating the future. The experience centre began with users entering some basic information and being

tagged with with passive UHF RFID bands. These bands were used to identify users at a number of stations in the tour. What most people probably don't realize is that UHF RFID has ranges in excess of 10m. Depending on the quality of the tag antenna and sophistication of the reader network it is feasible to track users location as they browse the store. This would be an ingenious method of determining which technologies are most of interest.

The tour continued through a number of stations where the devices proposed to measure such qualities of the users like imagination and intuition based on very scarce user input. Technologies on display here included large scale LCDs, surround audio, cameras and kinect (interestingly a microsoft device). A few cleverly designed and amusing experience stations were presented however in terms of technological innovation there was nothing of great interest here.

On the second floor more devices were presented from the basic IC building blocks (silicon processors and memories) to small scale IoT base stations to full application based solutions. Of particular interest was Samsung's initial steps into the sports and wearables industries but closer inspection revealed nothing groundbreaking here either. From the services perspective an interesting demonstration was given of a classroom service for teacher/pupil interaction. While it looked to have potential the clear learning value over traditional methods was not well established. Other services shown included secure payment systems utilising the S6's fingerprint recognition sensor. Freely exploring the centre allowed us to interact with the new S6, the smartwatch and check out other flagship devices like the smart TV. One impressive demo was the virtual reality headsets build with an S6 and some plastic goggles.

Overall the Samsung D'Light Experience Center was a disappointment. It was clear from the first moments that it was a rather gimmicky distraction from the fact that Samsung really don't have anything groundbreaking in their technology portfolio, or perhaps they do and are keeping it top secret. The questions from the curious bit bangers were coming hard and fast and becoming increasingly technical and probing. However the host was unable to address even the most basic of technical questions, and of the few she did comment on some of her answers were misinformed. Comparing this to Apple's Genius salesperson program, Samsung has much to learn in how it presents itself.

## **Reception at the Finnish Ambassador's residence**

We were warmly welcomed to Korea and to the ambassador's residence by the Ambassador Matti Heimonen and his wife, Second Secretary Heini Korhonen and Trade Commissioner Yoonmi Kim as well as other Team Finland members.



One of the main tasks of the Embassy is to promote Finnish political, economical and commercial relations with the Republic of Korea. Thus, we were very lucky to be invited and to be able to hear and understand the Korean culture also from the “local” Finnish perspective.

The atmosphere during the night was joyful and the visit was filled with interesting conversations that covered similarities and differences between Finnish and Korean societies. Conversational topics in small groups ranged from the educational system to work culture and worklife balance and from class differences to gender equality. The visit truly deepened our understanding of the local way of living and doing business, especially in comparison to Finland.

On top of everything, the food prepared by the Finnish cook was excellent and will surely be remembered.

## Friday January 29<sup>th</sup>, 2016

### **SSKU Carbon nanotube research laboratory**

This institute is part of the Sungkyunkwan University in Suwon City, Gyeonggi province. The main aim of the centre is to understand the physics of low dimen-



sional structures —find new thresholds for sensitivity and spatial resolution in nanomaterials— to find new applications and multifunctionalities for future technological applications. Among their main goals they:

- a) Develop research on multifaceted physical properties of nanostructures in search of new thermoelectric, carrier dynamics and spatial resolution amid other properties.
- b) Foster interdisciplinary and multidisciplinary research with the creation and cross collaboration of research groups that root on the fields of physics, chemistry, biology, material science and engineering.
- c) To foster research, doctoral and basic level studies with summer and winter schools, undergraduate collaboration and international internships.
- d) To disseminate knowledge onto the local industry with training programs, lectures, seminars and workshops.

The institute has close to 100 overall researchers —from which 60 are international students from China, Vietnam, Russia, India, United States and Japan— and is strongly committed to the future of education in undergraduate level too. They envision for the upcoming decade a holistically integrated educational model that will give middle schoolers a glimpse of professional life in the science field; they also have plans on how to help local researchers built an international profile for better exposure.

### **Presentation and Luncheon with the members of Finland Chamber of Commerce**

We were warmly welcomed by the FINNCHAM (Finland Chamber of Commerce and Industry in Korea) and the Finnish Ambassador. The FINNCHAM works for promoting and supporting the Finnish based companies to develop well in Korea, and also they were very interested and highly valued our visiting.



Firstly, the chairman of FINNCHAM Heikki Ranta introduced the representatives from their member and highly welcome us, then Professor Erkki shortly introduced the framework and importance of our course. There is no doubt that our presentation ended by large amount of questions from the FINNCHAM side, the questions mainly focus on the learning points of the students, Prof Yrjö also replenished and answered most of the questions.

Then all the groups shortly pitched the book chapters of Digitalization. The lunch truly deepened our impression of the Korea food.

## Cultural Activity

We ended our official program with a piece of cultural activity, as we visited the Gyeongbukgung Palace situated in the heart of Seoul. Gyeongbukgung is arguably the greatest of the five royal palaces situated in Seoul, restored to display traditional Korean architecture dating back to the 14th century. Originally built by king Taejo, founder of the



Joseon dynasty, the palace has served as the home for kings of the Joseon dynasty and their government. Our tour included several of the main buildings in the palace area, including the king's main residence (Gangnyeongjeon), the Queen's residence (Gyotaejeon) and the throne hall (Geunjeongjeon), with its impressive ceiling sculptures portraying golden dragons. Further sights included the Gyeonghoeru pavilion in which state receptions were held, and the Hyangwonjeong pavilion, both built on artificial islands.

Architecturally the palace offered interesting details such as the Japsang figures intended to protect building inhabitants from evil spirits, and the fireplaces under the royal residences intended to keep the floors warm. The palace also mirrored many aspects of Korean culture and heritage, still clearly visible today's social sphere. On one hand the Confucian heritage in terms of social hierarchy was reflected in the rank stones lining the path to the throne hall, and the slightly bigger gate leading the Gyeonghoeru which was reserved for the king. On the other hand, the history of the palace also reflects the sad history of Korea, as the palace has been destroyed twice in connection to Japanese invasions (1592 and 1910), and has only recently been restored to its former glory.













Aalto University

**This book** is the 8<sup>th</sup> in the Bit Bang series of books produced as multidisciplinary teamwork exercises by doctoral students participating in the course **Bit Bang 8: Digitalization** at Aalto University during the academic year 2015–2016.

Digitalization has brought great opportunities for economic growth, productivity gain and job creation in our societies, and will change the way industry will operate. Bit Bang 8 addressed the topic of digitalization from the perspective of its economic, environmental and social sustainability. The course elaborated on the interconnectedness of these phenomena, and linked them to possible future scenarios, global megatrends and ethical considerations. How will digitalization shape our future? How can we prepare can prepare our societies to respond to these changes?

Working in teams, the students set out to answer questions related to the digitalization and to brainstorm radical scenarios of what the future could hold. This joint publication contains articles produced as teamwork assignments for the course, in which the students were encouraged to take novel and radical views on digitalization.

The Bit Bang series of courses is supported by the Multidisciplinary Institute of Digitalisation and Energy (MIDE). Previous Bit Bang publications are available from <http://mide.aalto.fi>.

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