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Digitalisation and the children of the mainframe[1]

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Abstract. We are the children of the mainframe. From the early 1950s this smart machine glowed its alluring lights, zoomed its magnetic tapes, and worked hard a couple of megabyte memory worth millions of dollars. The mainframe computer created a foundation for the field of Information Systems (IS) educating IS professionals and researching how software and organisational practices could be designed and implemented, and what effects could result from such efforts. Nearly 70 years on, since the Lyons Electronic Office began in 1951, much has happened. The radical digitalisation and transformation of organisational and public service processes challenges not only perceived wisdoms amongst IS practitioners, but also within academia. This essay challenges the IS field on its fundamental ability to address the grand challenges associated with the digital transformation of societies, organisations, as well as the lives and livelihoods of individuals. The essay argues that the IS field will need to more explicitly address its assumptions rooted in the organisational mainframe. The IS field must transcend the mainframe heritage from our inception if it wishes to escape a pathological curse rendering the field unable to deal with the powerful synthesis of: wholesale digitalisation of society; the computerised distribution of human activities; and exponential scaling of computational capabilities.

Key words: Digital innovation, grand challenges, information systems research challenges, digital agility.

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1 Introduction

The developments since Lyons Electronic Office (LEO) in 1951 began running the first electronic mainframe application for business purposes seems incredible by any measure we may choose to apply (Caminer et al. 1998). The mainframe began a process of extensive automation and digitalisation of basic business processes, for example, enabling globally distributed supply-chains. Furthermore, technological and societal developments now see tiny user-friendly devices connected to powerful cloud services through fast global, local, and personal network technologies.

The field of Information Systems (IS) was born out of the mainframe era where these smart machines supported both the automation of workers' activities driving out the need for discretionary decisions, and informating workers about circumstances previously beyond the individual's reach and thereby rendering workers better able to make discretionary decisions (Zuboff 1988). As the decades have past, the IS field has developed and thrived, and due to its focus on synthesising technical and non-technical concerns, it has been argued that it is centrally placed to provide an important voice in the generative machine age of wholesale digitalisation (Yoo 2013).

Considering how the IS field deals with grand challenges, it does seem that challenges related to socio-technical phenomena find a much easier home within IS if they 'smell like a mainframe in the basement'. When the phenomena can be seen to display characteristics that immediately align with established perspectives and constructs based on assumptions of one organisation and one major technology embedded within, for example, Enterprise Resource Planning (ERP) systems, big data, cloud computing, supply-chain management, and knowledge management, to name a few (Sørensen and Landau 2015). While all of the above phenomena can be studied from a variety of perspectives, they also all allow for the choice of organisational-centric analyses where alternative perspectives may be less likely to gain foothold. Rather than seeking to define uniquely new constructs based on the identification of new socio-technical configurations, the newness is most often interpreted in the context of existing constructs and artefact categories. However, some of the contemporary configurations of technological innovations and human action do not fit well within such organisation-centric context. Digital infrastructures are not merely organisational artifacts but denote a new category of artefact (Tilson et al. 2010). Related, yet also distinct, the proliferation of digital platforms implementing multi-sided markets through matchmaking, also challenge the notion of an organization-centric analysis (de Reuver et al. Forthcoming; Eaton et al. 2015). The wide-spread global use of mobile telephony, along with the rapid growth of smartphones in all regions, the increasing use of various Internet of Things (IoT) technologies, for example in Machine-to-Machine (M2M) arrangements, also challenge our understanding of the dynamics and boundaries of socio-technical arrangements.

This commentary in particular highlights three grand challenges to the IS field that the examples above exemplify: 1) Digitalisation—the wholesale digitalisation of previously analogue aspects of life; 2) Distribution—a high degree of distribution of digitally connected socio-technical phenomena; and 3) Scale—the exponential scaling of computational capabilities. Sections 2-4 present these three challenges and exemplify each with an example of a current specific research challenge. Section 5 discusses the synthesis of these three grand challenges, and Section

6 rounds off the essay with a brief discussion of ways forward. However, the aim of this commentary has mainly been to analytically point out the issues rather than proposing some quick fixes that clearly do not exist.

2 Digitalisation

The wholesale digitalisation of nearly all aspect of personal and professional life has accelerated the past decades with complex consequences for industrial, organisational and individual processes (Kallinikos 2007). This digitalisation challenges existing understanding of socio-technical phenomena and is a force to be reckoned with theoretically within IS (de Reuver et al. Forthcoming; Kallinikos et al. 2013; Tilson et al. 2010; Yoo et al. 2010). Assumptions that digital arrangements merely display similar dynamic characteristics as analogue counterparts are not tenable.

The technical process of digitising analogue content or data into digital counterparts has proven far from a placid and mundane activity. Exemplified by the music industry, digitising resulted in socio-technical and institutional changes where traditionally tight couplings, here between the storage formats, the processing technologies, and the distribution mechanisms, were loosened and thereby forcing a restructuring of the industrial vertical established over a long period (Tilson et al. 2010). The tight coupling between these three elements had seen the record labels securing their intellectual property rights through embedding music in vinyl LPs, cassette tapes, or digital CD discs, all to be distributed by physical record stores. The early digitisation of music onto CD discs paved the way for wholesale disruption when MP3 compression technology from Fraunhofer Institute, cheap storage technology, and fast Internet connectivity allowed for Peer-2-Peer (P2P) music sharing—first with Napster and since many others. At first consumers voted with their mice and took music without paying, then the industry recaptured some of the control first through paid first music downloads spearheaded by Apple, and subsequently advertisement-based free or paid-for music streaming from Spotify and others. The end-result has, however, been a significant shift in total revenue, and three major industry upheavals in a short span of years.

2.1 Computing in the large

The process of digitising comes with built-in possibilities for unbounded recombinability, re-packaging, and greatly increases the importance of data about data (meta-data). The emphasis on the specifics of digitality in socio-technical arrangements is important and will hopefully win ground within IS and beyond. The ongoing struggle for the IS field to deal with computing in the large relates intimately to the challenge of understanding digitalisation.

Computing in the large has received some interest beyond the IS community. For example: the study of how the Internet was established (Abbate 2000); the public value of infrastructures in general with some discussion of the Internet (Frischmann 2012); the control arrangements in Internet-based arrangements (Goldsmith and Wu 2006); a range of issues relating to the dynam-

ics innovation and law in digital infrastructural arrangements (Lessig 2000, 2002, 2006); centralised and decentralised control arrangements in the information industries (Wu 2010); the economics of networked information arrangements (Shapiro and Varian 1998); the changing of the control-generativity dynamics of the Internet (Zittrain 2008); and the design, dynamics and management of digital platforms serving the meeting of different stakeholders in multi-sided market arrangements (Evans and Schmalensee 2016; Gawer 2009; Gawer and Cusumano 2002; Parker et al. 2016; Tiwana 2014).

While management literature and beyond has dealt with infrastructures and platforms, the IS field is still attempting to address the question of what is particular about digital infrastructures and –platforms compared with their analogue and physical counterparts. The work by several IS academics and -groups have studied issues related to computerisation in the large, for example on: the institutional character and dynamics of information infrastructures (Ciborra et al. 2001; Hanseth and Lyytinen 2010; Henfridsson and Bygstad 2013); the institutional character of information (Kallinikos 2007); and digital platform dynamics (Eaton et al. 2015; Ghazawneh and Henfridsson 2013). There are, however, and abundance of challenges for the IS field to establish theoretical constructs and models. For example related to: How the dynamics of digital infrastructures differs from their analogue ones (Tilson et al. 2010), for example in terms of their generativity (Tilson et al. 2013); the specific characteristics of layered-modular architectures combining modular hardware components and layered software arrangements (Yoo et al. 2010); or how to understand what emerges as specific characteristics of platforms supporting multi-sided markets and highly distributed innovation arrangements when these platforms are digital (de Reuver et al. Forthcoming; Eaton et al. 2015). Yoo (2013) argues that the era of digital innovation management represents the opportunity of a golden era for the IS field. I agree, but it requires rapid and rigorous action!

3 Distribution

Characteristic for some of the most potent socio-technical challenges to the IS field is a shift from localised systems to distributed arrangements, for example, of open digital infrastructures, or in more controlled arrangements of digital platforms. Computing has of course, in some sense, always been distributed since the first electronic computer became more computers located across the Globe. These were, however, not both distributed and connected. The context for much of IS research is the organisational processes located within the physical boundaries of one organisation. The increasingly finer and finer granularity of devices and activities that at the same time are both highly distributed among individuals, across locations, between organisations, and elsewhere, yet locally, and globally interconnected, marks a shift. The core-understanding of an organisational unit at the centre of our attention is challenged by the need to focus on understanding complex dynamics emerging from distributed, yet computationally enhanced and interconnected phenomena. In such arrangements, it is important to not assume homogeneous behaviour but rather to be open to recursive processes of distributed pragmatic actions by independent, yet interconnected, agents who engage in large-scale coordination at arms length through technology.

3.1 Computing in the small

The widespread diffusion of mobile and ubiquitous information technologies has emphasised the need for research to seek theoretical discourses that assumes decentralised connectivity. Computing in the small has transformed highly distributed work contexts as well as everyday being across any context to loci of distributed connectedness where the ontology before to a greater extent could divide computing life into dwelling and work (Bassoli 2010; Yoo 2010).

Extensive work within sociology, social geography, and communication studies has explored what has been characterised as "The Mobility Turn" or "New Mobilities Paradigm" (Sheller and Urry 2016; Urry 2000, 2007, 2008). A series of important monographs and anthologies on the sociology of the mobile phone and mobile communication explore, for example: Rituals and routines (Ling 2008); technological ubiquity (Ling 2012); impact on language (Baron 2008); maintaining social networks for underprivileged in developing countries (Horst and Miller 2006); and SMS messaging (Harper et al. 2005). Characteristic for most of this work is generally the lack of specific technological assumptions beyond mobile voice communication and SMS messaging. Countering this is the extensive interest in framing social phenomena. At the other end of an imaginary socio-technical scale, the Human-Computer Interaction (HCI) field, and the part of the IS field close to HCI, have explored the design of mobile information technology with little interest in theorising the socio-technical relationships—with a few notable exceptions, such as Dourish's (2001) book on ubiquitous interaction.

Within a mainstream IS agenda, very little work has been done with a singular perspective on mobile information technology, in terms of both mainstream journal publications (Sørensen and Landau 2015), or in terms of monographs (Sørensen 2011). There has been no shortage of calls for action, most notably led by Lyytinen and Yoo (Lyytinen and Yoo 2002; Lyytinen and Yoo 2002; Lyytinen et al. 2004; Yoo 2010). Yet, these calls to arms have so far largely been ignored within IS with a decline in interest since 2006 (Sørensen and Landau 2015). The IS field hAS failed to establish a lasting theoretical narrative related to the wide-spread mobile information technology and associated practices and ways of organising (Sørensen 2011), or indeed engage in a rigorous debate on why there is none to be found. Within IS the mobility turn failed to turn up!

4 Scaling

The computational capabilities of digital technologies based on the Von Neumann Architecture has increased exponentially the past 50 years in accordance with Gordon Moore's prediction. Moore predicted that the number of components in a specific size integrated circuit would double every 18 months. This doubling has occurred around 34 times since the prediction was made in 1965. It has been argued that this exponential growth of both computational capabilities is now beginning to yield services of a significant different kind than previously, and that the extent, complexity, and sophistication of such services goes beyond our previous imagination (Brynjolfsson and McAfee 2014). This development has contributed significantly to contemporary computational solutions to problems, which a decade ago seemed impossible to crack. As an

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example, the Simultaneous Location and Mapping (SLAM) problem was for a long time sought solved, thus seeking to bridge the gap between robot capabilities and those of small children; i.e.; mapping a new location in order to avoid bumping one's head (Wikipedia 2016). A simple solution was subsequently produced using the Microsoft Kinect consumer games peripheral (Anderson 2010).

4.1 Humans, robots and work

The grand challenge of understanding the increasing computational capabilities relates to a number of challenges. Some of these can be clustered in terms of humans, robots, and work, where much public debate is concerned with the grand challenge of technological developments of robotics, artificial intelligence, and self-service resulting in fundamental reconfigurations of the labour market. The future of humanity in general, and of work in particular, under extensive digitalisation, artificial intelligence, and robotics has been explored by a number of authors and commentators. This work has for example explored: The ability to control technology with super-human intelligence (Bostrom 2014); the role of human effort under highly digitised and automated technology arrangements (Brynjolfsson and McAfee 2011, 2014); the appropriateness of extensive reliance on automation (Carr 2014); and the future role of professionals when expertise is being unbundled (Susskind and Susskind 2015).

The IS tradition has a complex relationship to this development from a past of Artificial Intelligence (AI) super-optimism more than super-intelligence. In my view, underwhelmed by the reality of the hype surrounding AI and expert systems in the 1980s, IS researchers do not seem to embrace the fast computational land grabs and translate these into revised understanding of our field. It is essential to not remain on the side-line but to engage both critically and constructively in the debate of computer agency, robotics, and automation, as indeed many researchers and commentators from outside IS has done.

5 Synthesis of three concerns

While the three grand challenges above; Digitalisation, distribution, and scale, each represent both a formidable challenge and new opportunities for the IS field, phenomena that are the results of combinations of the three denotes our main challenge. The solitary organisation has traditionally been the stable unit of analysis and source of empirical data within IS research. However, even when studying the organisational arrangements with information technology in the context of one organisation, the technologies and processes will increasingly be linked together across boundaries external to the organisation linking tiny sensors, distributed customer and employee handheld smart devices together with customer apps, business services, and back-end systems—all connected through globally distributed networks and cloud services. However, the stable organisational laboratory of the IS field (Braa and Vidgen 1999), is also being challenged by different socio-technical arrangements, such as digital platforms (de Reuver et al. Forthcoming), and digital infrastructures (Tilson et al. 2010). The IS field will, therefore,

need to theoretically frame its discourse broader than in terms of the single organisation's use of a limited set of information technology (see Figure 1).

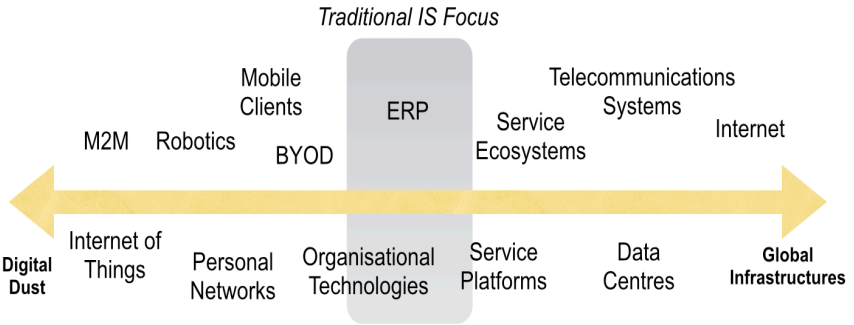

Figure 1. Illustration of the need for the IS field to engage in the investigation of sociotechnical phenomena at greatly varying levels (Sørensen and Landau 2015, p.167)

The complex interactions spanning from a motion tracker on someone's arm, over this data being combined with other digital behaviour patterns, and feeding into global auctions for the person's attention, or indeed informing how this person will be presented with other essential digital services. Such digital dynamics raise much broader questions, for example, of individual privacy, ownership of data, the distribution of effort and rewards, the societal regulation of such global digital processes, and the general marketisation of individuals, in what has be characterised as surveillance capitalism (Zuboff 2015). There is, within IS, a need to transcend the constructive narrative and seek to engage critically in the broader analysis of societal impact and choice (Aanestad 2016). As an example, the largely uncritical discussions of the 'sharing economy' has so far optimistically talked about removing friction, but not considered the broader framework of capital flows and subsidisation that has facilitated some of these services to outcompete incumbents, or indeed the wider consequences in terms of a race to the bottom of the work force (Morozov 2016).

6 Ways forward

What are then some of the constructive ways forward for the IS field to meet these immediate challenges? The first step is to realise that while the challenges facing the Information Systems field may be formidable, similar challenges are facing other fields. Researchers within management studies have also pondered the impact of digitalisation, for example the understanding of a digital workforce requiring new competencies (Colbert et al. 2016). Eisenhardt et al (2016) argues that: "Grand challenges require novel ideas and unconventional approaches to tackle their complex and evolving mix of technical and social elements" and advocate inductive methods as an essential part in framing and formulating theories when covering radically new ground,

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and as a way of ensuring "rigor without rigor mortis" (Eisenhardt et al. 2016, p.1119ff). The challenge can in particular for the IS field, be framed by Pasteur's Quadrant of research being practical applicable while at the same time informing a theoretical discourse (Stokes 1997; Tushman and O'Reilly III 2007).

Perhaps the mainframe perspective can be described as the main organising vision within the IS field (Swanson and Ramiller 1997), or even more broadly as the prevailing paradigm for our field (Kuhn 1962)? The great strength of our field has in the past been to establish itself around the 'mainframisation' of the World and to study this and educate generations of IT managers, consultants and other categories of organisational members. The field has also managed to develop with the changing socio-technical configurations the past decades, but it can sensibly be argued that it still lacks a sufficient academic agility (Sørensen and Landau 2015) to rapidly engage in an academically rigorous debate on the relative merits of various new and old theoretical constructs as means of explaining rapidly emerging phenomena. The field will need to help inform digital entrepreneurs seeking to establish radically new re-combinations of technologies, business models and stakeholder communities.

The path to increased academic agility (Sørensen and Landau 2015) within the IS field can have many contributing and interconnected elements, most of which are already present but which may need to be applied more strategically. Issues and opinion articles are not only good ways of calling to action and outlining new challenges, both in the main part of journals, but also as editorials. Considering the level of citations of a number of such commentaries the past years, this also seems to have an interest within the community. However, the main challenge for the community is to source high-quality full research papers formulating and exploring new theoretical constructs. Editorial strategising combined with the operational sourcing and development of contributions expressing new ideas are essential elements. Special issues of good journals can be a very good way of focusing such efforts. However, it may be difficult to source sufficient high quality submissions for an entire special issue if an area is too immature and insufficient work has been done by a number of research groups.

If indeed the IS field is contracting and concentrating on a few general journals and conferences, then there is increasing responsibility placed on those editing these to ensure a vibrant academic debate linking reality to the ivory tower discourse. It may be essential to redefine traditional incentives in order to ensure that the field pushes further to the edges and produce a broad range of output considered high-quality from highly detailed analysis of essential cases to purely theoretical assertions—as a way of breaking traditional modus operadi of a tight link in each paper between an organisation-centric empirical case and a theoretical framework emerging from this or sought proven by the case (Grover and Lyytinen 2015). Collaborative grants with industry in engaged scholarship (Van De Ven 2007) and action design research efforts (Sein et al. 2011), can perhaps further strengthen the development of the field's academic agility? There are within IS good examples of how close collaboration between advanced organisations and research groups can foster new and interesting perspectives.

It seems obvious to me that first and foremost, more discussion is required, hence this debate article with responses from others. However, also followed by more immediate action!

Notes

1. This commentary is based on the joint IFIP8.6/SCIS7/IRIS39 keynote address, August 7th, Ljungskile, Sweden.

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