Blockchain 4 Open Science & SDGS

Rachovitsa, Adamantia

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#Blockchain4SDGs

Report 2018

ABOUT THE WORKSHOP ORGANISERS

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The Data Research Centre of the University of Groningen/Campus Fryslân (DRC) is a centre of expertise in the field of data science and the interaction between society and technology. It functions as a co-creation space between researchers, students, and external stakeholders for research in all disciplines that connect to the domains of data science, artificial intelligence, internet of things, and Blockchain with real world implications.

The centre plays a crucial role for the Living Lab of Campus Fryslân and facilitates Data Science training and practice amongst all educational programmes of Campus Fryslân. It also facilitates collaboration with industry, non-profit, and governmental partners.

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Data Research Centre
University of Groningen
Campus Fryslân

Globalisation Studies Groningen

IN COLLABORATION WITH:

CENTRE FOR INNOVATION
Leiden University

HumanityX

The Institute of International Humanitarian Affairs

CONTRIBUTORS AND PARTICIPANTS

Adamanti Rachovitsa	Faculty of Law, University of Groningen
Ali Anwaar	University of Cambridge
Amaranta Luna	Campus Fryslân & NOHA, University of Groningen
Andrej Zwitter	Campus Fryslân, University of Groningen
Anna-Jorien Prins	Campus Fryslân, University of Groningen
David Michels	Queen Mary University of London
Dilek Genc	NOHA, University of Groningen
Egon Rijpkema	CIT, University of Groningen
Evan Yap Peraza	Tykn B.V. Leiden
Giulio Coppi	IIHA, Fordham University
Jonas Bulthuis	CIT, University of Groningen
Joost Herman	NOHA & GSG, University of Groningen
Jorn Poldermans	HumanityX, Centre for Innovation, Leiden University
Kate Dodgson	HumanityX, Centre for Innovation, Leiden University
Koen Hartog	Blockchain Pilots
Layne Vandenberg	Global Alliance for Improved Nutrition
Leslie Zwerwer	CIT, University of Groningen
Mathilde Boisse-Despiaux	Euroculture, University of Groningen
Melissa Amoros	HumanityX, Centre for Innovation, Leiden University
Oskar Gstrein	STeP, University of Groningen
Richard Adams	Cranfield University
Steven Gort	ICTU, Dutch Government
Taynaah Reis	Moeda, Brazil
Terry Ling	Moeda, China
Thomas Baar	HumanityX, Centre for Innovation, Leiden University

CONTENTS

BLOCKCHAIN4SDGS WORKSHOP: A FOREWORD

Blockchain is a novel technology that is rapidly reshaping the digital tools we use to conduct daily transactions. Blockchain has emerged as a disruptive technology, which has not only laid the foundations for all crypto-currencies, but also the field of smart contracts. The features of blockchain technology – decentralised and trustless ledgers recording transactions across a peer-to-peer network – create the potential to remove corruption by providing transparency as well as accountability. This could impact not only the financial sector, but also other fields such as supply chain management, digital identity, smart contracts and much more. The initiatives in which the technology is used to distribute and trace aid funding, provide and manage IDs in refugee camps, or create trustworthy land registries, are just a few examples of the utility of blockchain technology, but they also highlight the risks, such as to privacy protection. Opinions on the utility of blockchain technology are very mixed. Some are enthusiastic, others believe that it is merely hype. Blockchain has also entered the sphere of humanitarian and development aid. In order to explore, whether it is a hype or indeed a revolutionary new technology, the Data Research Centre and Globalisation Studies Groningen, invited experts from academia, government and practice to an interdisciplinary workshop on Blockchain for Sustainable Development Goals (Blockchain4SDGs).

The Blockchain4SDGs interdisciplinary workshop was held in December 2017 and brought together experts from the development and humanitarian sectors with experts on blockchain technology. Participants jointly explored the implications of blockchain – both its possibilities and limitations – in the field of development and humanitarian action and discussed how the technology could be used to address the United Nations' Sustainable Development Goals (UN SDGs). The one-day event included rounds of lightning talks during the plenary sessions, as well as roundtable discussions on different subject matters pertaining to the SDGs. The themes of the roundtable discussions were:

- Blockchain and humanitarian action;
- Blockchain and development;
- Blockchain, international peace and security;
- New approaches in Blockchain technology.

This report presents the results of those discussions. After an introduction to blockchain technology in the fields of humanitarian and development aid, this paper summarizes the individual participants' contributions to the Blockchain4SDGs Workshop. These contributions range from practise examples to theoretical and technological developments. The report also includes summaries of the themes raised during the round table discussions and final remarks.

The Blockchain4SDGs Workshop was in many ways a follow up of the Humanitarian Blockchain Summit, organized by Giulio Coppi at the Institute of International Humanitarian Affairs, Fordham University Forham University, NYC, on November 10, 2017. We would, therefore, like to thank our partners at the Institute of International Humanitarian Affairs for supporting the Blockchain4SDGs Workshop. Particular thanks also go to our colleagues Thomas Baar, Jorn Polderman, Kate Dodgson, Melissa Amoros, Evan Yap-Peraza and Dilek Genc for helping to organize the event and their substantial contributions to the content. We would also like to specifically thank Amaranta Luna Arteaga for her part in leading the organization of the workshop and for ensuring that everything ran incredibly smoothly on the day. Finally, Mathilde Boisse-Despiaux deserves her own special mention for supporting the content development of the Blockchain4SDGs Workshop from an early stage and for taking the lead in finalizing the workshop report.

Prof. dr. Andrej Zwitter
Dean, University College Fryslân
Director Data Research Centre

Prof. dr. Joost Herman
Director Globalisation Studies Groningen
President International NOHA Association

The Blockchain4SDGs interdisciplinary workshop was held in December 2017 and brought together experts from the development and humanitarian sectors with experts on blockchain technology.

BLOCKCHAIN, DEVELOPMENT AND HUMANITARISM

Andrej Zwitter[*] and Mathilde Boisse-Despiaux[*]

WHAT IS BLOCKCHAIN

In the last four years, a number of high profile incidents have highlighted the extent to which European consumer supply chains can be complex, opaque and susceptible to poor practice: the 2013 horse meat scandal, the 2017 contaminated eggs scandal, and the 2013 Bangladeshi factory collapse are to name just a few. Initiatives using blockchain technology such as *Fair Food*[1] – which traces the origins of coconuts sold in the Netherlands back to the farmers who produced them in the Philippines, while at the same time ensuring that people at the beginning of the supply chain receive a fair wage - give reason to believe that blockchain technology could lead to supply chains which are more straightforward, more transparent and more reliable in the future.

Blockchain technology was initially created in 2008 as the underlying technology of the Bitcoin cryptocurrency.[2] It solved one particular problem of the digital economy: the double spending problem; or how to ensure that one and the same digital token (e.g. bitcoin) could not be spent more than once. It has gained momentum amongst the general public in the past few years, especially after appearing on the cover of *The Economist* in October 2015.[3] The Economist stresses the extraordinary potential of blockchain technology beyond its applications in digital currencies. Blockchain has subsequently been portrayed in many instances as a revolutionary invention, which could change the world as profoundly as the Internet has since the 1990s.[4]

[*] Dean of University College Fryslân and Director of the Data Research Centre, University of Groningen
[*] MA student, Euroculture Erasmus Mundus programme in European Studies, University of Groningen

However, somewhat understandably, most people still struggle to understand how blockchain works. Simply put, blockchain is a decentralised database, which stores a registry of assets and transactions across a peer-to-peer network. The term "asset" can be understood in manifold ways: not only as money, but also as ownership, custodianship, contracts, goods, and even personally identifiable information.[5] Although peer-to-peer networks already exist to exchange files such as pictures or songs, blockchain works differently in the sense that it does not duplicate the value which is transferred. Instead, the technology registers that a value has been transferred from one actor to another across a network.[6]

In essence, blockchain is a technology that lowers the uncertainty which we face when exchanging value. Whilst anonymity is often a core feature of blockchain technology; trust is not an issue as all members of the network hold a record of all transactions, making blockchain almost impossible to tamper with.

Moreover, blockchain functions without any central control system, and stores the transaction history in blocks of data that are cryptographically locked together. As it is replicated on every computer that belongs to the network, it is an immutable, secure and transparent record of all transactions that have ever taken place.[7]

On a more technical level, blockchain is based on a consensus mechanism, which principally relies on two elements: "hashing" and "proof of work" (alternatively "proof of stake"). Hashing means creating a fingerprint (a formula made of numbers and letters) of the data elements in the transaction message. It is a way of verifying the authenticity of transactions, thus allowing users to identify whether someone or something interfered with the data.[8]

Before a new transaction is added to the block, transactions need to be verified through "proof of work"; a mathematical puzzle which ensures that users do not cheat by knowing up-front who will validate the transaction. Solving this proof of work-puzzle is also known as "mining", and is performed by members of the network. Hence, all the computers compete to validate the transaction.[9] Once a block has reached its maximum capacity of transaction hashes, it is queued with previous blocks, which altogether form the blockchain.[10]

In essence, blockchain is a technology that lowers the uncertainty which we face when exchanging value. Whilst anonymity is often a core feature of blockchain technology; trust is not an issue as all members of the network hold a record of all transactions, making blockchain almost impossible to tamper with. This is the idea of a "trustless" technology. It also reduces the uncertainty of not having recourse if something goes wrong with transactions. Since blockchain enables one to trace every transaction from the beginning until it is validated and added to a block, users can see whether a mistake has happened, and where in the process it has occurred. Therefore, although societies traditionally called upon formal institutions such

as governments and banks to deal with such uncertainty, blockchain could render those institutions obsolete by enabling individuals to exchange value with technology alone, without the need for central third parties.[11]

In summary, blockchain technology, which is also referred to as "Distributed Ledger Technology", relies on the following characteristics. The technology is:

- *highly available,* as it requires only electricity, and a network of computers;
- *censorship proof,* as no single individual can unilaterally decide to dictate the content of the blockchain;
- *reliable,* as one can trust the blockchain in clarifying and transferring assets correctly;
- *open,* as no one is excluded from using the blockchain;
- *pseudo-anonymous,* as it identifies owners uniquely using individual pseudonyms, but real world identities do not need to be revealed.
- *secure,* as it prevents ownership from being manipulated, counterfeited or spent twice;
- *resilient,* as it can clarify and transfer ownership even under difficult conditions;
- *consistent,* as the chance of getting consistent results increases over time;
- *upstanding,* as it maintains its integrity as well as data consistency and ensures security on the level of individual transactions and the whole history of transaction data.[12]

Since 2015, some of the world's largest financial institutions have gathered in a consortium, coordinated by a start-up called R3Cev, to research and develop blockchain database usage in the financial sector.[13] Moreover, in January 2016, the British government published a report on how the technology could transform the delivery of public services and boost productivity.[14] In May of the same year, the European Parliament approved a proposal for a task force dedicated to monitoring the use of cryptocurrencies and blockchain technology.[15] Indeed, companies, national, and supranational entities are increasingly being forced to pay attention to the use of blockchain technology as its disruptive potential becomes ever more apparent. Its power is already being felt not only within the financial sector but also in other fields, such as supply chain management, digital identity, smart contracts, to name just a few.

BLOCKCHAIN FOR DEVELOPMENT AND HUMANITARIAN AID: IMPLICATIONS AND APPLICATIONS

In their article "Blockchain for Good?", Kewell, Adams and Parry differentiate between the intended use of an artefact (one which is built into its design), and the properties which it assumes, that ultimately allow for a different use of the very same artefact.[16] Following this line of thought, although blockchain was initially developed for financial transactions, there are already implications and potential applications in the fields of development and humanitarian aid. According to Kewell et al., when it comes to the distributed ledger technology, "to focus on a single application or specific use of the Blockchain is to overlook its significance for ethical impacts at the global level".[17] In fact, "Blockchain affordances" relate to the "discernment of what the software can do for sustainable development and environmental protection in parallel with an appreciation of what novel development could realize for vulnerable and impoverished communities."[18] Furthermore, the authors argue that there are discussions to be had regarding the practical and ethical considerations in relation to blockchain in the following fields: blockchain mining, the emergence of an Internet of values as opposed to the current Internet of information, supply chains, innovation in governance, sharing economy and financial inclusion.

Two of the most engaging notions they introduce are "coloured coins" and "qualified money": the idea that moral principles and ethics can be embedded in the code of the distributed ledger technologies and allow individuals to align their spending with their own values. The authors give the examples of the CarbonCoin, which was designed to engage the environmentally conscious community; and that of a block-

Although blockchain was initially developed for financial transactions, there are already implications and potential applications in the fields of development and humanitarian aid.

chain-based Islamic cryptocurrency, in which transactions are aligned with Muslim values, and which include an anti-radicalisation agenda. One can easily imagine donations that are digitally earmarked only to be used for certain services, or to reach certain communities. Thus, it is easy to see why authors argue that blockchain "may be a boon in developing or politically unstable economies."[19]

Nir Kshetri underlines the fact that blockchain technology can be applied not only in banking, but also in promoting transparency and reducing fraud and corruption. It could also reduce barriers and costs associated with property registration, promote efficiency in international business-to-business (B2B) trade, and increase access to trade and supply chain finance. At the same time, because the technology is completely digital and can be fully automatized, a wide range of costs can be reduced, resulting in enhanced efficiency within international payment systems, insurance policies, and risk management procedures.[20]

In terms of real-world application within the humanitarian and development sectors, blockchain is already being used to fight corruption, improve land tenure and property rights, create secure digital identities, and tackle gender inequality.

Hundreds of millions of dollars are currently lost to corruption every year, and blockchain is now being used to trace aid funding in order to stem the flow of corruption.[21] The Start Network, a consortium of international aid agencies, which uses blockchain technology, was created to deliver effective aid to the people affected by crises.[22] In fact, blockchain has implications for supply chains in general; for example, the company Provenance uses blockchain to track materials and products in a transparent and secure way.[23]

Distributed ledger technology has also been applied to land tenure and property rights. Traditionally, governments keep records of land properties, but these registries can be lost or manipulated, and owners may not have written proof of ownership. Successful initiatives include the BitLand digital registry created in Ghana in 2015, as well as other applications in Georgia[24,25], and experiments conducted in both Honduras[26] and Sweden[27]. At present, 90% of the land on the African continent remains unregistered; and in India landlessness is arguably a more powerful cause of poverty than caste or illiteracy. Consequently, argues Kshetri, blockchain technology offers a tremendous opportunity for addressing insecurity, corruption and misuse in the field of land registration.[28]

Digital identity is also a topic in which blockchain technology is uniquely useful. According to Kewell, Adams and Parry "identity […] will underpin the digital future and lies at the heart of realising the potential of DLTs (distributed ledger technologies)."[29] Among other initiatives, the government of Estonia has implemented an e-residency scheme through blockchain, which allows individuals to electronically record their marriage, birth certificates, business contracts, or access services regardless of their residency status.[30] Similarly, in 2015, the AID:Tech company used a blockchain-enabled system to provide refugees, who lived in a camp in Lebanon, with digital identities which were connected to vouchers to buy consumer goods.[31]

The technology might also be used to tackle issues affecting women who live in developing countries. The digital identity applications of blockchain are being used by the UN Office for Project Services (UNOPS), the organisation has launched a pilot project in Moldova to protect children and young women from being illegally trafficked.[32] In addition, other initiatives using blockchain allow women to access micro-loans or enable secure money transfers among female entrepreneurs.[33]

As demonstrated, blockchain technology has potential applications within many domains beyond the financial sector. Furthermore, smart contracts will help improve supply chains for development and humanitarian projects. As we have indicated, some initiatives have already been implemented; others are still in an early, ideational stage. However, the possibility of creating an immutable ID record may be both a promise as well as a curse, as contracts are automatically executed, this might initially lead to very rigid processes without the human margin of appreciation so often necessary in volatile emergency scenarios. This is one of many concerns and limitations concerning blockchain technology.

CONCERNS AND LIMITATIONS

Although the distributed ledger technology has been described as disruptive and revolutionary, it is not a panacea to all of the world's problems and is not without its limitations. There are several concerns that are important to consider. Firstly, blockchain is a high energy-consuming technology. Whilst attempts to reduce the energy costs already exist, blockchain will always require servers and computers to process transactions. Therefore, in countries where the Internet is frequently shut down, where there is poor energy infrastructure, and where brownouts are common, DLT rapidly reaches its limits of scalability.[34]

Moreover, blockchain is often referred to as an open-structure by design. Consequently, privacy and data protection remain a concern, particularly when it comes to identity registries and other blockchain databases in which personally identifiable information is processed.[35] There certainly are potential solutions to these issues, such as zero-knowledge proofs. However, the extent to which they can be reasonably implemented within blockchain technology remains an unanswered question.

Beyond privacy concerns, there are also considerations regarding data ownership, the misuse of data, and the right to be forgotten.[36] Since blockchain provides an immutable, and decentralized ledger, this may be a problem if data needs to be permanently purged or changed.

In addressing these concerns, the development of blockchain is held back by the absence of a legislative framework. The participants of the Blockchain for Good conference advocated for a federated model: "a guiding hand to set the vision and principles to enable the success of the blockchain for the greater good." Inspiration for such a framework might come from the Linux

Privacy and data protection remain a concern, particularly when it comes to identity registries and other blockchain databases in which personally identifiable information is processed.

Foundation, which provides standards for Linux; or the Internet Corporation for Assigned Names and Numbers: a non-profit organisation which is responsible for managing the addressing system globally.[37] A legal framework certainly appears to be necessary for blockchain to reach its full potential in the fields of development and humanitarianism, or indeed within any other sector.

In essence, this leads to four criteria that determine the suitability of blockchain technology for use within the fields of development and humanitarian affairs:

1. Is decentralization through distribution, and built-in trust through transparency, a necessary feature of the new technology?
2. Does the digital ledger, as a core of the new technology, need to be immutable?
3. Do benefits outweigh the development and scaling costs of the new technology?
4. Do the features of the new technology comply with humanitarian principles and professional codes of conduct?

If the answer to any of the above questions is a NO, then blockchain is not the technological solution to the problem.

HUMANITARIAN BLOCKCHAIN SUMMIT FINDINGS

Jorn Poldermans *

The Humanitarian Blockchain Summit hosted by the Institute of International Humanitarian Affairs (IIHA) at Fordham University in New York on November 12, 2017, brought technology experts, scholars, and humanitarian practitioners together for dynamic discussions about the future of Blockchain technology within humanitarian operations, and in pursuit of the United Nations Sustainable Development Goals.

Blockchain technology holds great potential for improving these operations – whether it is used to transfer cash to disaster victims, coordinate the delivery of supplies, streamline humanitarian financing, or make humanitarian projects more gender-inclusive.

The summit was designed for those interested in using blockchain for tangible humanitarian impact. Breakout sessions focused on overcoming challenges to using blockchain, as well as identifying the best ways to develop humanitarian-friendly blockchain platforms. The sessions also included collaborative exercises and presentations regarding how some organizations are currently using blockchain.

More than 250 humanitarian workers, United Nations officials, governmental and public sector representatives, technology experts, and academics convened at the Summit to explore the vast potential of blockchain technology, and grapple with its associated challenges.

* Innovation Fellow at the Institute of International Humanitarian Affairs and HumanityX, Leiden University

The Blockchain for Humanity Initiative will provide ongoing actions for further discussion and engagement with like-minded institutions and practitioners concerning the application of Blockchain technology for humanitarian action.

HUMANITARIAN BLOCKCHAIN SUMMIT OBJECTIVES

The summit prompted participants to recommend policies for using blockchain for humanitarian action through:

- highlighting a range of piloted and pioneering blockchain initiatives for humanitarian action;
- facilitating the ethical adoption of humanitarian blockchain solutions in response to technical, legal, and governance challenges facing the humanitarian sector;
- bringing together people from various sectors to foster new partnerships, encourage technical collaboration, and explore non-traditional funding sources;
- curating existing open-source tools used in humanitarian blockchain services; and
- building a digital community of developers interested in impacting humanitarian assistance.

Following the Blockchain Summit, the IIHA launched the Blockchain for Humanity Initiative alongside the Centre for Innovation at Leiden University, the University of Northampton, and the University of Groningen. The Blockchain for Humanity Initiative will provide ongoing actions for further discussion and engagement with like-minded institutions and practitioners concerning the application of Blockchain technology for humanitarian action.

LIGHTNING TALKS SUMMARIES

HOW BLOCKCHAIN WORKS

Anwaar Ali[*] and Dave Michels[*]

Anwaar Ali and Dave Michels provided a lightning talk on how blockchain works, as part of their ongoing research into blockchain technology at the Microsoft Cloud Computing Research Centre (MCCRC). The MCCRC is a virtual research centre in which technology lawyers and computer scientists collaborate to conduct cutting-edge research on challenges in cloud computing at the intersection of technology and regulation. The MCCRC was launched in April 2014 with generous financial support from Microsoft. It is a collaboration between the Cloud Legal Project at the Centre for Commercial Law Studies, Queen Mary University of London (CLP) and the University of Cambridge Department of Computer Science and Technology.

In 2017, the MCCRC researched the implications of blockchain technology. This included the legal and regulatory issues around the use of blockchain technology, as well as the difficulties that may arise when blockchain tokens are used to represent off-chain assets. The research also covered the emerging field of Blockchain-as-a-Service. Their working papers can be found on the following website: http://www.mccrc.eu/.

Ali is a PhD Researcher in Computer Science at Cambridge University and Dave is a legal researcher with the CLP. Together, they provided a short introduction to blockchain technology. The presentation covered two topics. First, it addressed the two main technologies that create a persistent, tamper-evident ledger of transactions. Transactions are grouped into blocks, which are linked through hash pointers that provide proof of the integrity of the transaction data. Public key infrastructure is then used to establish the identity of the participants to the transactions.

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[*] PhD Researcher in Computer Science at Cambridge University

[*] Legal Researcher at the Centre for Commercial Law Studies, Queen Mary University

Second, the presentation covered the two main methods of storing a blockchain. One option is to store the ledger of transactions centrally, with a Trusted Third Party (or TTP) that holds the master copy. The TTP updates the ledger by adding blocks of new transactions. In this case, participants need to trust the TTP to maintain the ledger accurately. An alternative is to store the ledger in a distributed manner, across a peer-to-peer network. In this case, there is no single master copy – every node stores a copy of the ledger. Such approaches use what is known as a 'Consensus Protocol' to ensure that all nodes update their copies of the ledger consistently.

Their 'Blockchain Demystified' working paper provides a more detailed explanation of how blockchain technologies work and can be deployed in various ways to create blockchain applications with different features, including distributed and centralised platforms. It further analyses the technology's implications for law enforcement, private law (including contracts, companies, and securities), and EU data protection law. The purpose of this paper is to help legal and other professional advisors understand blockchain technology in general, so they can tailor appropriate advice; and to alert users of blockchain technology to the current legal uncertainty and associated risks.[38]

ACTIVITIES OF BLOCKCHAINPILOT.NL

Koen Hartog *

In 2017 blockchainpilot.nl concluded the final round of thirty-five blockchain pilot projects for Dutch governmental organisations. A huge amount has been learned, and a high quality informal blockchain network has been established within the Dutch government. More than a dozen of the participating organisations have started developing working prototypes. In 2018 and 2019 a range of pilot projects will continue to be developed, and the first larger-scale projects for governmental blockchain services are due to be launched. 2018 will be the year of scaling up.

2017 was also the year of international collaboration. Multiple presentations and meetings took place in Dubai, Israel, Belgium, San Marino and New York to spark interest in international collaboration on blockchain projects. In November the first blockchain mission for governmental organisations was launched in Singapore. During this mission, more than twenty government representatives met with their Singaporean counterparts to discuss potential synergies between Dutch and Singaporean blockchain projects. Follow up visits for 2018 have been scheduled.

2018 will be an exciting year, more projects will move from the drawing board to implementation, and governmental organisations will move on beyond the proof-of-concept phase. Furthermore, Blockchain.nl aims to launch it's first international projects, beginning with Singapore followed by further blockchain missions to the US and Korea.

In order to share our experiences and to strengthen international networks, two books on blockchain developments in the public sector are due to be published. The first, in collaboration with the Belgian government, examines blockchain projects within the public sector both in Belgium and the Netherlands. The second is being written by the UN and a consortium of Dutch legal experts which focuses on the legal aspects of blockchain.

Finally, work continues to promote open source development of blockchain services/applications for the public sector together with the IT Foundation of the Dutch government (ICTU).

* Programme manager, blockchainpilot.nl

BLOCKCHAIN 'OVERSIGHT'- POTENTIAL PARALLELS TO THE SURVEILLANCE DISCUSSION

*Oskar Josef Gstrein**

Who should be carrying out 'oversight' on blockchain systems? Should there be something like external oversight at all? Blockchain technology seems exceptionally self-sufficient and trustworthy. All users of the system can validate the authenticity of the chain independently, and it seems unlikely – if not impossible – that one user could be capable of manipulating the system. However, the foundations of this trust are "total transparency" and the authenticity of the values in the chain.

What if the technology has problems, or too few actors control too many resources? In other areas of technology regulation – like the regulation of systems used to carry out governmental surveillance – those who study the field demand oversight of the processes from multiple institutions. This includes the executive, judiciary and legislative branch of the state as well as the general public. Can the oversight of blockchain technology be left to technological and conceptual safeguards alone?

Most likely, we should not be relying solely on the integral characteristics of the system itself, but also have additional, external (non-technological) oversight mechanisms in place. Traditionally, governance structures do not typically require all community decisions to be reached by complete consensus. Instead, they also include mechanisms to allow for the implementation of majority decisions, even when such decisions go against the will of some participants within the system. This leads to considerations about whether a system like blockchain, which is frequently used for applications which are decentralized and used by specific communities of people, can only work if it is used in very specific scenarios. The governance of blockchain

> If this technology is to be deployed on a larger scale, with a significant impact on society, it requires mechanisms for accountability.

technology, and the oversight of its implications for wider society, is still an open field with many unanswered questions.

Another important area for consideration, is complete transparency, which is integral to blockchain technology. Transparency is recognised to be a particularly useful and efficient characteristic of the technology when assessing its suitability for administering monetary transactions, or guaranteeing the authenticity of goods within a supply chain. In these scenarios, this particular feature represents a useful mechanism to ensure accountability within public and/or private administration. However, it also raises concerns if the information stored is sensitive, or if it requires customised levels of access for different users. For example, in the current digital age, the fundamental human right to privacy is increasingly dependent on mechanisms which enable us to manage and restrict the dissemination of data. It is not only important to know whether, which and how personal data is being used, but also equally important to ensure controls with regards to data dissemination, analysis, and the length of time it can be stored.

In conclusion, one cannot refute that there is an urgent need for more discussion and exchange

* Post-doc researcher, Faculty of Law, University of Groningen

of ideas with regards to the implications of the wider application of blockchain technologies. If this technology is to be deployed on a larger scale, with a significant impact on society, it requires mechanisms for accountability. Governance and 'oversight' through technological means and conceptual safeguards, can only be one element in a complex setup of checks and balances, which must ultimately be able to stand the tests of societal legitimacy.

AN OVERVIEW OF THE DISCIPL CONCEPT

Steven Gort[*]

ICTU launched the Discipl concept in 2017 to boost open source innovation for a digital society architecture, utilizing distributed ledger technology. Discipl consists of a vision, inspired by the writings of Miki Kashtan, in which society progresses towards a highly automated economy of abundance. It focuses on automated fulfilment of people's needs at zero cost. To become such a society, the idea is to focus on a path to zero cost by adhering to a manifesto which stipulates that solutions must be free to use, open source, highly automated, and easily reproducible/deployable. Those solutions also fit in the so called Discipl Pattern, a form of e-democracy which focuses on conflicting needs resolution using a mix of artificial intelligence and human guided convergent facilitation. To support the development of such solutions, ICTU has now introduced Discipl Core which will be an implementation of a Discipl Pattern supporting application-programming interface (API), and which is based upon a Self-Sovereign Identity and Verifiable Claims API.

An initial version of this API, with a binding to the IOTA foundation platform and its Masked Authenticated Messaging extension feature (used in public mode), is currently being used for the first time by the municipality of Haarlem. The IOTA platform is what makes Discipl solutions possible now. This project is also a step towards a Self-Sovereign Identity in combination with Personal Data Sources. In fact, within the current project, users have better control of their own data, to the extent that a central register for third parties is not required. That is because citizens as prosumers (both consumers and producers) are all that is needed to fulfil the requirements of the system in an intelligent and peaceful manner.

In 2018 an ever-increasing number of projects at the local, national and even international level are waiting to advance Discipl Core and the Discipl Community, with improved and extended functionality. ICTU will also collaborate with Miki Kashtan, as well as other partners, to define and and implement a more detailed version of the Discipl Pattern in more detailed version.

The first blockchain projects launched in September 2016 considered several technologies but only began to take shape in February 2017, when the work, 'Reinventing Government Track' was sponsored at the Dutch Blockchain Hackathon. In April 2017, Discipl was conceptualised, and as of September 2017, it began to operate as an open source ecosystem for further innovation of public services. In addition to its open source dimension, other fundamental properties of the ecosystem are currently under development such as social scalability and public-private cooperation.

BLOCKCHAIN 4 OPEN SCIENCE & SDGS

Mando Rachovitsa[*]

Open Science 4 SDGs

Open science – namely more openness with regards to educational resources, access, methodology, reproducibility and data – is fundamental to realising the SDGs. Science is a universal public good, and it can be a game-changer when addressing global problems. This is exemplified by the critical roles that the production and

[*] Data whisperer" at ICTU, Dutch Government

[*] Assistant Professor of Public International Law, Faculty of Law, Groningen University

diffusion of science (scientific outputs and processes) play in the transfer of knowledge and technology[39]. Sadly, linguistic, financial and bureaucratic gatekeeping ensures that too much of today's science is not open to all but is restricted to those with power. To realise a world with more open science, and to reap its benefits throughout the SDGs, innovation and reform is needed. Some examples include: the need for decentralised ways to acquire, manage and analyse open data in disaster management (resilient & sustainable cities under SDG 11); the need for new research and development (R&D) models for innovation, as well as knowledge & tech transfer for the production, and delivery of. delete availability and access to safe, quality and affordable medicines and vaccines (SDG 3); or the need for technologies to provide clean water and sanitation, affordable and clean energy, and mitigate (the adverse effects of) climate action (SDGs 6, 7, 13 and 9)[40].

Blockchain 4 Open Science

Blockchain technology and its core operational principles, including decentralisation, transparency, immutability and the ability to be permissionless, can encourage, support and enhance open innovation and open science[41]. Crucially, this openness must involve access to not only the scientific results, but also to the scientific process. Blockchain can potentially inform the research cycle in a holistic fashion pertaining to the following (non-exhaustive) areas/issues:

- **Open source:** fostering transparency in experimental methodology and the collection of data.
- **Open data:** improving the availability and re-usability of research data via the use of blockchain. Data sharing practices contribute to avoiding the duplication of work and research. Moreover, data sharing allows for experiments to be reproduced and replicated (more easily), making scientific work more reliable (addressing the reproducibility crisis issue).

> Science is a universal public good, and it can be a game-changer when addressing global problems.

- **Open access:** permitting and ensuring public accessibility and transparency of scientific communication (e.g. published research work; scientific/technological products).

Managing & analysing data

Blockchain has the potential to create a universal research ledger as a living project. Such a research ledger sustains open science workflows (e.g. in a form of an open lab or an open notebook/document) in real time, on a global basis. This will encourage and maintain research and other multi-stakeholder partnerships across different countries/continents. This in turn may have a positive impact in three ways. Firstly, by prioritising the scientific problems that need to be addressed as per the real needs of developing countries; secondly, by solving complex problems; and, thirdly, by expediting the creation of relevant scientific knowledge.

New models to incentivise R&D

Ideas are being explored as to how blockchain can provide the technological means to create novel ways to credit scientists/researchers for their respective scientific work. This inevitably entails revisiting the role of the dominant and established intermediaries in the scientific/research process (e.g. publishers, public funding bodies, corporations and other private actors). Questions also need asking about certain ideas relating to assessing the originality and sound-

ness of scientific work (or work-in-progress) on a peer-to-peer basis; finding new peer-to-peer reputation/reward mechanisms among researchers; evaluating impact factors in a decentralised way.

Blockchain, as an immutable, record-keeping, decentralised database, can keep track of all nodes' contributions to a publication, or to the design and creation of a technology. Blockchain can identify authorship rights, and automatically assign/match these rights to the nodes' contribution within the chain. This may take place by designing and concluding smart contracts, without the need for a centralised intermediary. Smart contracts can also implement automatic licensing and non-disclosure agreements. Blockchain's plasticity may also support, if needed, the design of different access and control regimes for different nodes. For instance, in order to abide by privacy requirements with regards to health data, smart contracts may set conditions on how and by whom this data will be accessed and analysed. It is also possible to design a contract that enables users to automatically "view" a restricted or limited selection from a dataset, thereby addressing any privacy concerns.

It remains to be seen whether blockchain will be adapted to simply meet the needs and requirements of the existing system, or whether it will be used to create and sustain transformative ways of doing science.

Taken for granted? (or caveats)

When discussing Blockchain, in general, and Blockchain 4 Open Science in particular, we take certain factors for granted. For example:

- fast and reliable Internet access;
- sufficient processing power to verify blockchain transactions;
- awareness of how blockchain can be relevant/useful;
- skills to use blockchain;
- potential limitations in practice to anonymity;
- security issues (e.g. 51% attacks);
- (cloud) storage; and
- effective inter-operability across different blockchains via implementing open standards.

Some of these issues concern aspects of the digital and knowledge divide which persists across different parts of the world. If these underlying issues are not effectively addressed, it is likely that blockchain technology, and its use/non-use, will simply reinforce and further pronounce global inequalities.

Finally, blockchain technology opens the door to new ideas and possibilities, communities and practices. At the same time, however, the technology has also been designed within the context of the established mindset of society and scientist; that is, the current status quo. Given the variations in the implementation of blockchain's underlying principles, it remains to be seen whether blockchain will be adapted to simply meet the needs and requirements of the existing system, or whether it will be used to create and sustain transformative ways of doing science.[42]

CREATING AN ONLINE KNOWLEDGE PLATFORM FOR 'BLOCKCHAIN FOR GOOD'

Kate Dodgson *

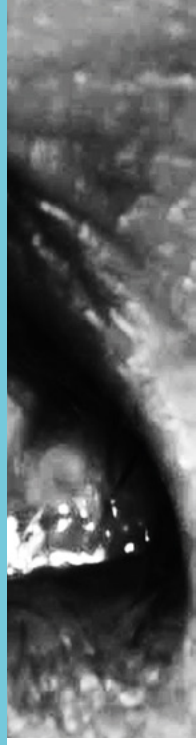
In her talk, Kate Dodgson pitched the idea of 'Blockchain for good'; an online knowledge platform to facilitate collaboration between universities, companies and organisations. The platform would contain a wide range of use-cases with which the contributors are already familiar, including neutral and unbiased assessments and critiques of the extent to which these initiatives are developed, their strengths, and areas for improvement.

The purpose of this platform would be for humanitarian organisations, charities and universities to have a one-stop-shop for all blockchain related, humanitarian information. Currently, information relating to use-cases of blockchain is scattered and incomplete. This platform would thus allow researchers and practitioners to better navigate the blockchain scene. In line with this idea, HumanityX has already created a proposed structure as well as various templates for chapters.

The audience were asked whether they were interested in participating in this project, and also whether they had suggestions regarding funding, structure and content. Participants reacted positively to the idea and suggested that the best way to maintain this platform would be to have it online and updated regularly. It was also mentioned that further publications (such as whitepapers) could come from this project.

This idea of creating an online knowledge platform on blockchain technology and its use-cases will be pursued by HumanityX in 2018. In particular, whether funding can be secured, and whether a structure and participants can be confirmed. Discussions will then commence regarding maintenance and contributions.

* Consultant and project manager, HumanityX, Centre for Innovation, Leiden University



ROUNDTABLES REPORTS

Breakout sessions of the humanitarian blockchain track involved discussions around the natural volatility of humanitarian situations, and what technological innovation in these contexts could mean; as well as the lack of standards pertaining to humanitarian-technology partnerships.

BLOCKCHAIN IN HUMANITARIAN ACTION

Giulio Coppi[*] and Dilek Genc[*]

Key themes raised during the plenary and breakout sessions of the event

The key theme raised during the one-day event concerned how blockchain-based systems can have an impact on humanitarian action, development aid, and the peace and justice sectors. Breakout sessions of the humanitarian blockchain track involved discussions around the natural volatility of humanitarian situations, and what technological innovation in these contexts could mean; as well as the lack of standards pertaining to humanitarian-technology partnerships. Confusion over development aid and humanitarian action was palpable and required building a shared understanding of the specific conditions and challenges facing humanitarian actors.

This was possible during the breakout sessions, where discussions mostly pointed in different directions. Some of these included the idea that emerging technologies, and especially P2P/distributed systems, can be a vector for local empowerment and ownership of the solutions proposed. Given the specific vulnerabilities generated or aggravated by violence and conflict, developing a design and implementation framework based on data ethics and protection is also of absolute importance. Additionally, international partners have an important role to play as facilitators, especially when local conditions are often too sensitive to allow fort a safe "clinical trial" phase for humanitarian solutions. Their involvement, however, should be the ultima ratio instead of the default model.

[*] Humanitarian Innovation Fellow and Adjunct Professor at Fordham University

[*] PhD candidate in International Development, University of Edinburgh

Current and potential innovations brought by Blockchain

Current innovations in the humanitarian blockchain space include projects by UN agencies such as the World Food Programme, as well as other more development-oriented pilots by start-ups. These include financial transfers on blockchain systems (through tokenization) or the creation of digital identities and financial histories. Other potential blockchain innovations in humanitarian action may include more transparent supply chain management, climate change mitigation through forecast-based financing, or the streamlining of humanitarian funding. While a small number of these are in testing stages, ost of them are remain very conceptual. Current scalability issues plague blockchains, hindering the expansion of the technology within humanitarian aid.

Core reflections which have emerged during the breakout sessions: "Pilotitis"

So far, most of the projects observed have suffered from the "pilotitis", a syndrome that has afflicted humanitarian innovation for many years now. This tendency finds strength and legitimacy in two assumptions:

- Smaller is safer;
- Low-budget short-term leads to full-budget long-term.

So far, empirical observations seem to suggest that both these ideas are wrong. Most pilot projects remain linked to a specific team or context, and never become mainstream tools within an organization's portfolio. Moreover, most projects are conditioned to a specific grant or investment and do not include any automatic follow up/ scaling up options. Consequently, most projects remain alive only for the time that the pilot is scheduled to run.

We are observing the same pattern with DLTs/ blockchain solutions, with a notable aggravating factor: they are imagined as replacing entire systems, not to integrate existing solutions or replace minor functions. Their whole premise is based on the idea of replacing current networks with entirely new, revolutionary processes; any form of duplication would make the idea itself inherently redundant.

Current Blockchain pilots employ a "watered down" version of the technology

While humanitarians are not exactly the most tech-friendly public, the case of blockchain and other "emerging or bleeding edge tech", is admittedly peculiar. These solutions are in such an early stage of development, that their core developers are still trying to figure out how and why how and why to select and build certain features of the system, and how to develop similar alternative platforms of their own. Humanitarian blockchain technology should consider all risks intensively. All potential risks associated with blockchain technology require intensive consideration. It is vital that all new technology is tested in an ethical manner, with minimal risk to beneficiaries. However, small-scale pilots or

All potential risks associated with blockchain technology require intensive consideration. It is vital that all new technology is tested in an ethical manner, with minimal risk to beneficiaries.

programs defeat the purpose of this technology itself. DLTs such as blockchain could make the greatest contribution in situations such as that in Yemen, where there is a profound lack of physical asset liquidity, and a severe humanitarian crisis exacerbated by external factors (such as the embargo). Humanitarian experimentation in situations where other (well tested) options are present should rule out blockchain for now.

BLOCKCHAIN AND DEVELOPMENT

Evan Yap Peraza [*] *and Thomas Baar* [*]

There is increasing interest in the potential of blockchain technology to confront humanitarian challenges and support sustainable development. The hype around blockchain is driven by high expectations around the potential applications of the technology. However, critical reflection concerning the unanticipated impacts and limitations of blockchain in these contexts has been limited.

Together with experts from various backgrounds, we reflected on the value of blockchain technology. Taking into account the key characteristics of the distributed ledger technology (i.e. the fundamental architecture behind blockchain technology), we attempted to define its potential applications. It was recognised that inflated expectations around the potential of this technology, often lead to misconceptions of what actually defines its essence. Clearer definitions are therefore needed in order to guide a dialogue around its potential value and applications.

While certain features of blockchain technology are often considered to be absolute and intrinsic, the participants to the Blockchain4SDGs workshop indicated that it is critical to realize that characteristics such as decentralisation, transparency, and immutability should be understood as outcomes of intentional choices in developing these technological architectures.

While certain features of blockchain technology are often considered to be absolute and intrinsic, the participants to the Blockchain4SDGs workshop indicated that it is critical to realize that characteristics such as decentralisation, transparency, and immutability should be understood as outcomes of intentional choices in developing these technological architectures.

This allows stakeholders to recognise that intentional choices must be made around the design of such systems in order to ensure the blockchain product fully realises the designer's objectives. Rather than taking the technology in itself as the starting point, a discussion should start with addressing the central challenges and contextual considerations.

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[*] Marketing and Content Developer, Tykn B.V. Leiden

[*] Project manager, HumanityX, Centre for Innovation, Leiden University

The participants argued that a more guided dialogue is needed to support stakeholders to make more informed decisions around the potential of blockchain technology. A clearer understanding of the potential benefits (and limitations) of various design considerations, would enable actors to access their potential, and decide whether their investment would provide sufficient value.

Similarly, a more careful reflection on the vast quantity of investment and experimentation currently taking place within the humanitarian and development sectors, would allow stakeholders to increase their understanding, and share best practices. As documentation on projects is often scarce, there is limited knowledge on their focus, progress, success and failures. Pilots seem to dominate in an environment in which there appears to be a lack of frameworks for evaluating and disseminating their outcomes. This is true not only for innovation around blockchain technology, but also for innovation in these environments in general. Therefore, it is considered critical that further monitoring and evaluation guidance is developed for the early stages of exploration and experimentation with new technology trends, in order to improve knowledge sharing and development around the potential of new technology trends, such as blockchain.

The participants concluded that it was critical to build a repository of ongoing initiatives focused on leveraging blockchain for humanitarian applications and sustainable development. A reference framework such as this should support stakeholders in this sector to make more informed decisions as to whether to invest in the development of the technology, as well as how to design its architecture to meet their demands.

NEW APPROACHES TO BLOCKCHAIN TECHNOLOGY

Kate Dodgson [*] *and Mathilde Boisse-Despiaux* [*]

Key themes raised: Blockchain use-cases

Blockchain technology, also called "distributed ledger technology," is best known in relation to cryptocurrencies, it has however implications beyond the financial sector alone. To this end, during the Blockchain4SDGs' "New approaches in Blockchain technology" roundtable, participants pinpointed Blockchain-based initiatives which tackle some of the United Nation's Sustainable Development Goals. Put differently, participants highlighted specific Blockchain uses-cases which fit within the workshop's overarching themes of development and humanitarian action. The Blockchain use-cases mentioned during the workshop can be classified under the following categories: money transactions, supply chain, and data collection/ management.

In relation to financial transactions, involving both cryptocurrencies and fiat money, the participants mentioned use-cases which belong to two sub-categories, namely:

1. Micro-financing, micro-loans, transfers without bank accounts;
2. Humanitarian and development aid disbursements, remittances, cash-based aid directly to beneficiaries or inter-organisation.

The case of MOEDA characterises well the first subsection of microfinancing. MOEDA is a cooperative banking platform that enables altruistically minded donors to finance small entrepreneurs, often living on different continents. On the blockchain-run platform, donors give sums in cryptocurrency, which are then distributed to the selected beneficiary in the form of fiat money loans.[43] Similarly, but without such an obvious altruistic aim, the company Everex also has a micro-financing activity administered using blockchain.[44]

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[*] Consultant and project manager, HumanityX, Centre for Innovation, Leiden University

[*] MA student, Euroculture Erasmus Mundus programme in European studies

In relation to the second sub-category of financial transactions using blockchain, participants thoroughly analysed the World Food Programme's "Building Blocks" initiative. In fact, since early 2017, the World Food Programme (WFP) has been running a pilot through which ten thousand refugees living in a camp in Jordan received cash-based transfers enabling them to purchase food.[45] The benefits of using the blockchain for this purpose are, among other things, to save money which would otherwise be spent as bank transactions fees. Another asset is that the humanitarian programme's beneficiaries' personal details do not need to be disclosed to any other entity than the WFP itself.[46]

In addition, participants discussed the implications of blockchain in relation to supply chains – which was pointed out as the strongest of use-cases. What's more, for this category also, there are two sub-sections: goods tracking and humanitarian/disaster relief logistics.

When it comes to tracing the origin of goods, numerous start-ups and companies have begun using blockchain technology. For example, Provenance started by recording tuna supply chains, and is now working with other products;[47] Everledger is using blockchain to avoid trading in blood diamonds;[48] FairFood tracks coconuts from their production in Asia to their consumption in the Netherlands, also insuring that growers receive a fair payment;[49] and Fairphone traces the use of cobalt in the production of phones.[50]

Furthermore, the distributed ledger technology can also enable humanitarian organisations to trace both aid money and logistics. One of the cases is that of Disberse – a company which manages and monitors humanitarian aid services through blockchain.[51] On one occasion, Disberse for instance enabled a British NGO to deliver aid funds to girls' schools in Swaziland without any transaction fees. The savings on transaction fees were so significant, it meant that the donor could fund the education of an additional three students for one year.[52]

Additionally, participants highlighted use-cases related to data collection, data management, and registration. The blockchain-based initiatives that were most often mentioned deal with identity. In this regard, Estonia is the first country to have placed its citizens identity details and created an e-residency in blockchain.[53] ID2020, for its part, is addressing the SDG 16.9 by aiming to provide a digital identity to the 1.1 billion people worldwide who do not have an officially recognised identity, and who are thus unable to benefit from some of the most basic rights – healthcare, education, or voting among other things.[54] Similarly, BanQu creates economic identities for refugees who lack official ID documents so that they can more easily prove their identity when applying for jobs or loans.[55] Moreover, participants once again mentioned the WFP's Building Blocks programme as well as the Finnish Immigration Service's initiative that gives asylum seekers a prepaid credit card, including a unique digital identity stored on a blockchain.[56]

Furthermore, participants highlighted the use of the distributed ledger for land registry titles by the Georgian, Ghanaian and Swedish governments,[57] or uses related to health records, and beneficiary registration. Lastly, and with a less direct link to the SDGs, some participants had heard of blockchain uses by the music industry, electricity supplies, and with sensors that measure pollution levels.

Potential of the Blockchain technology and possible improvements

During the roundtable discussions, the participants recognised the potential of blockchain technology in various fields: from making governments and companies more transparent nd accountable to citizens; to fighting against fraudulent products such as counterfeit medicines, which are easily accessible on the Internet.

As written above, distributed ledger technology is often used to monitor supply chains, and use-cases in this field were described as some of the strongest and most successful. With regards to tracking goods, participants also suggested that it would be interesting to develop the use of QR codes and radio frequency identification (RFID) tags on products whose supply chains are stored on blockchain, as it would be a way to make consumers more informed and involved.

The participants further highlighted the relevance of blockchain technology for the European Union (EU) and other large aid donors, who are often keen to earmark their aid funding to know how money is spent. Moreover, the EU at times calls upon conditionality to distribute money to third countries. Some participants suggested that smart contracts could be used in conjunction with aid conditionality. In other words, beneficiaries would have to fulfil criteria specified on smart contracts in order to receive funds.

Debates and discussions around the challenges facing the Blockchain technology

When asked which criteria the blockchain technology should be evaluated upon, participants answered that their organisations and companies should have a specific purpose for using the technology. Indeed, there is currently a hype around blockchain technology, and it is sometimes used where it is in fact not necessarily needed.

Additionally, various participants made it clear that safety should be a criterion and an intrinsic dimension of blockchain technology – underlining for instance, that putting individuals' religious or ethnic affiliation on a blockchain which stores identification details could be problematic.

Subsequently, a discussion on the right to redress emerged. Indeed, given that distributed ledgers are immutable, how could a registry be purged once someone has been judged, and has paid for his or her wrongdoings? There are indeed many discussions around the right to be forgotten in relation to blockchain technology. Yet, one participant pointed out that although it is near to impossible to erase data once it has been recorded on a blockchain, blocks can still be added in order to "explain" some information.

Another ethical dilemma which one of the participants brought up, is that blockchain experts, and companies running projects using blockchain, often process large sums of money. However, when it comes to the development and humanitarian sectors, the "guinea pigs" of those experts and companies are powerless people – thus leading to the ethical dilemma of companies making profit from people suffering and in need.

During the roundtable discussions, the participants recognised the potential of blockchain technology in various fields: from making governments and companies more transparent and accountable to citizens; to fighting against fraudulent products such as counterfeit medicines, which are easily accessible on the Internet.

Participants also highlighted potential reputation and public relations challenges. The first being that blockchain technology is associated by some sections of the public with cryptocurrencies' dark reputation as means of acquiring illicit products (e.g drugs and weapons) and services (ransomware, blackmail).[58]

Another perception held by the general public is that 100% of aid money should go directly to beneficiaries. Although this idea is inaccurate, given that a significant part of aid money is used for logistics, some companies using blockchain feed this illusion in order to appear more attractive. Moreover, a challenge that was underlined on several occasions is that companies using blockchain in order to trace goods, often struggle to incentivise producers and people along the supply chain to add data to the blockchain once the product has left their hands.

Lastly, a question was raised regarding the use of blockchain with regards to identity management, following-up on an incident that the Estonian government had experienced a few weeks before the workshop took place. After discovering a security flaw that could result in identity theft, the Estonian government froze and replaced hundreds of thousands of ID cards containing personal details stored on a blockchain.[59] The Baltic country of just 1.3 million inhabitants stressed that there had been no evidence of hacking, and was able to replace the ID cards, but would a country with a much larger population such as Germany, or China, or even a humanitarian system with similar number of beneficiaries, have been able to respond to such an incident?

Overall, the workshop, which brought technology experts together with humanitarian action scholars and practitioners, led to fruitful discussions. Indeed, the participants were able to pinpoint a wide array of blockchain use-cases relating to the UN SDGs, indicate some relevant criteria to improve the technology, and highlight various challenges.

SUMMARY AND FINAL REMARKS

Blockchain is already being used to fight corruption, improve land tenure and property rights, create secure digital identities, tackle gender inequality and more. As such these initiatives contribute to the realization of the UN Sustainable Development Goals in innovative ways. There is further huge potential in blockchain technology, including possible applications within the humanitarian sector.

The Blockchain4SDGs Workshop explored the implications of blockchain – both its possibilities and limitations – in the fields of development and humanitarian action and discussed how the technology could be used to address the SDGs. The expert workshop looked at the ways blockchain is currently being experimented with and explored further potential applications.

Experts highlighted ethical considerations and requirements that underpin work within the humanitarian and development sector. The important question remains as to whether this new technology complies with already established humanitarian principles and professional codes of conduct. The issue of data privacy, for example, would need to be addressed before the technology could be used within complex, volatile contexts. The stakes are high. Any use of the technology must uphold the principle of "do no harm".

The experts considered it critical that further monitoring and evaluation guidance be developed for the early stages of development and experimentation with new technologies, in order to improve knowledge sharing and development around the potential of new trends and opportunities, including blockchain. The participants also concluded that it was critical to build a repository of ongoing initiatives which focused on leveraging blockchain for humanitarian applications and sustainable development. A reference framework such as this supports stakeholders in this sector in making more informed decisions based on recognised best practices and needs for improvement.

When asked which criteria blockchain technology should be evaluated upon, participants answered that their organisations and companies should have a specific purpose for using the technology. Indeed, there is currently a hype around blockchain technology, and it is sometimes deployed unnecessarily. Rather than taking the technology in itself as the starting point, a discussion should start with addressing the central humanitarian and developmental challenges and include contextual considerations.

In short, blockchain technology offers great potential. However, it is still in such an early stage of development that its advantages and disadvantages are not yet fully understood. Moving forward will require:

- well-selected implementation choices;
- clear ethics guidelines; and
- common monitoring and evaluation frameworks.

Only then can blockchain move beyond the current hype and realise its full potential as a technology that can bring significant, sustained, system-wide improvements to the humanitarian and development sectors, that will lead to a meaningful and measurable impact upon the Sustainable Development Goals.

Prof. dr. Andrej Zwitter
Dean, University College Fryslân
Director Data Research Centre

In short, blockchain technology offers great potential. However, it is still in such an early stage of development that its advantages and disadvantages are not yet fully understood.

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EDITORS
Thomas W. Lowe
Laura P. Kaye
Amaranta Luna

CONTACT
Data Research Centre
drc@rug.nl

Globalisation Studies Groningen
gsg@rug.nl