International cooperation in the digital era

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Universiteit Leiden

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Mijnheer de Rector Magnificus, mijnheer de Decaan en leden van het bestuur van de Faculteit Wiskunde en Natuurwetenschappen, dames en heren hoogleraren, dames en heren van de wetenschappelijke en de ondersteunende staf, dames en heren studenten, en voorts gij allen die deze plechtigheid met uw aanwezigheid vereert,

Deze aanspreektitel vormt de brug tussen het verleden en het heden. De tekst wordt in het Engels uitgesproken.
Honourable Minister Mme Duncan-Cassell, Honourable Vice Chancellor Professor Dr Rungano Zvobgo, Honourable Commissioner Mme Zamina Malole, Dear distinguished colleagues and guests,

Introduction: The key question
International cooperation is rapidly changing. In the book *The New Digital Era*, Google-leaders Schmidt and Cohen identify how the increased virtual presence in cyberspace intersects with the current Westphalian order of nations, which underpins our modern political system (2013). These two 'gurus' of the digital era reason that what we know as a natural order of nations, may be profoundly affected by digital progress.

We can further observe that the interest in cooperation between nations is rapidly changing. Today, we even imagine a possibility that such cooperation, like unattended fire, could become extinct. If solid walls were built between nations, to protect the nation state, we may indeed preserve distinct nations, but we may also sacrifice international cooperation.

This raises the question: *How to cooperate in the digital era*? I will approach this question by looking at new opportunities in health care and finance. The first question I will address is what is international cooperation today, in the digital era. Secondly, I will identify the untapped possibilities of integrating digital solutions within it. Thirdly, I will aim to set out a theoretical framework to study this. Finally, I will set some contours for the future.

International Cooperation in the Digital Era
Let me begin with the first question, how does international cooperation manifest itself today?

Megatrends
To answer this question, I will take you back a few years to one of our university rooms, during a misty early spring day in the Netherlands. On 27 March 2014, we held a brainstorm meeting of the research network 'Globalisation, Accessibility, Innovation and Care' (GAIC). We had intense discussions as we all came from very different realities. The group consisted of my PhD students, Ria Landa and Jolanda Asmeredjo, and some colleagues, who work in elderly care in the Netherlands, delegations from Zimbabwe and Liberia, led by a medical doctor.

In an organised way, we identified megatrends that would affect health care delivery in different places in the world. We looked at demographics, which predict that the number of people over 60 years of age will double by 2050 and triple by 2100. Whereas globally populations are aging, in Africa 50% of the population are currently under the age of 18 (UNFPA, 2014; UNDESA, 2015). Demographics affect health care services, labour markets for health workers and economies, household expenditure and spending on healthcare and care services. (Vital Wave, 2016). Aging demographics are driving technological innovation around the globe. In Thailand, an elderly care robot 'Dinsow' has been developed to help the elderly:

Dinsow can not only keep track of your medication and video-phone your relatives, but can also exercise with you and even entertain you with its karaoke skills. (Reuters, 2016)

We discussed how aging is rapidly changing health care needs and service provision in our hospitals and care homes worldwide; how ICT and data-science help to address some of the challenges. We considered how these megatrends drive rapid social and cultural cyber-transformation.

'Cyber' - what does this word mean? Cyberspace, cyber culture, cyber dating! The word 'cyber' originates from 'cybernetics', a field of study that was established in the 1940s by an interdisciplinary group of specialists in fields ranging from biology to engineering to social sciences. The *cybertron* was the first machine to make use of raw data. With its etymology from the the Greek word *kubernan* 'to steer' (Oxford Dictionaries, n.d.; Dictionary.com; Unwin, 2014), the word 'cyber' means steering.

The Ebola crisis

The delegation from Liberia that attended the meeting was a medical team from Redemption Hospital in Monrovia, the capital of Liberia. In 2012, I had visited Redemption Hospital, which is situated in New Kru Town in Monrovia, and it was then treating the largest number of patients in the country. However, it was a far cry from the top-notch medical facilities that Liberia had boasted before the civil war, such as the amazing JF Kennedy Hospital located next to the beach in Monrovia, which was a much sought after facility for the entire region. The JF Kennedy Hospital still hosts the nurses training centre and enjoys the legacy of Liberia's heyday, with solid nursing in the best traditions of care for body and mind.

During our meeting we received an unexpected phone call. The delegation leader picked it up. Our animated discussion fell silent. In Redemption Hospital a case of Ebola had been identified. It was a fearful moment. Academics around the table searched for words.

Redemption Hospital is a clinic that operates basic facilities, providing free health care for a population that is among the poorest in the world. When you enter the gate your name is pencilled down in a book and you proceed to the waiting area, a room with rudimentary wooden benches. The hospital has a few sparsely-equipped wards, where there are usually several patients sharing beds due to overcrowding. In 2014, at the beginning of the Ebola crisis, the digital era had not reached this health facility. This was not a health facility ready to fight a major epidemic.

Assistance was offered from within the region. A senior surgeon, Dr Mutoro, from Mbarara University of Science and Technology (MUST) in Uganda, where I am incidentally a visiting professor, came to Redemption Hospital to assist during the Ebola crisis. Unfortunately, he died from Ebola on 2 July 2014, as a result of attempts to offer medical assistance to co-staff, leaving behind his wife and three children (Bwire, 2014). All-in-all, from the day we first heard the news, six months passed before the international community woke up to the emergency. In a damning article, Leigh Phillips argued that this was due to lack of money for 'poverty' diseases (Philips, 2014). In the science journal Nature, Médecins Sans Frontières (MSF) President and Leiden University Cleveringa Professor, Joanna Liu, reproached the international community for "lack of political will" (Liu, 2015). The Lancet published an editorial (Philips & Markham, 2014) calling for a response to the crisis. Together with Professor Van Ranst, I also called for action in Europe in an Open Letter (De Morgen, 2014).

By this time, most airlines had stopped flying to Liberia and the country was becoming increasingly isolated (Telegraph, 2014). On 18 September 2017, the United Nations Security Council adopted a resolution, which was the first resolution ever adopted on a health concern identified as a threat to international security (UN SCR 2177).

On 30 September 2014, the first case of a person who had contracted Ebola in Liberia was reported in the United States. This made the difference. On 16 October 2014, by Executive Order, President Obama deployed military to Liberia to help combat the epidemic (The White House, 16 October 2014). It was now clear that the problem could not be contained by closing borders but required cooperation, not isolation.

Leiden University received Liberian Minister Duncan-Cassell at the Africa Works Conference on 17 October 2014 to discuss the situation (African Study Centre, 2014, p. 14). The Dutch government and the European Union appointed special Ebola representatives. The fight against Ebola was now coined as an international emergency, receiving international humanitarian attention and financial support.

The Satellite company SES deployed a connectivity hub in Liberia, Sierra Leone and Guinea and brought facilities to enable data integration, earth observation and the mapping of epidemiological information, and to provide information to communities via a satellite TV channel (SES, 2014). New data science techniques were deployed, combining different sets of data "such as mobile phone data, diagnostic app data, social network data and advanced mathematical models". (Plaat, 2015: 11). Nonetheless, progress was slow and it remained difficult to pick up all new Ebola cases. The Philips Foundation moved to develop a device that could be employed on the ground to gather basic medical data from which individual Ebola cases could be picked up.

When the crisis ended in May 2015 over 10,000 people had died in the three most-affected countries, among whom 500 were health workers. Liberia was left with a fragmented and disconnected medical service in which a new Ebola crisis could emerge at any time. There was no longer a security interest to support a case for international cooperation, as the height of the emergency was over. Liberia returned to a normalised reality in which the fight against poverty-related diseases generally remains unprofitable and underfunded. Professor Liu expressed her concern over the situation: "The epidemic has left an already fragile health system in tatters" (Liu, 2015). She called for support to reinstate non-Ebola related health care. But under what conditions would health care in Liberia now be maintained? SES and other connectivity providers were leaving. The medical data collected during the crisis were held in data-clouds, out of reach of Liberians.

The company SES had brought in bandwidth, allowing aid workers to, temporarily, overcome connectivity problems. By buying the service, the international teams could overcome issues of legacy (caused by systems that are no longer up to date) and congestion (caused by latency and legacy). While the US military had provided security, international aid had provided the necessary finance and SES had provided connectivity, and, briefly, a digital health system was put in place. Now - as the crisis was subsiding - all of these conditions for digitally-facilitated health care were removed. None of the technologies and none of the data collected were available for ongoing use in Liberia, which was struggling to cope with the social and economic aftermath of the Ebola crisis, including serious health problems and a heavily diminished cadre of trained health care workers.

This did not remain unnoticed. The Ebola crisis put on the agenda a need for structural attention to primary health care to prevent such crises. In a recent official declaration, 54 African governments stated:

While the Ebola virus pandemic was contained and affected countries declared Ebola-free in the end, the experience has shown that the continent's health systems must be strengthened and have the capacity to respond to, better prepare for, and prevent pandemics and other public health crises. (TICAD VI Nairobi Declaration, 2016)

The technology providers had a similar perspective. A participant in a conference shared the following:

One of the things that came strongly out of the Ebola-response is that it is hard to develop systems during a crisis. […] One of the challenges is coordination. There are many separate solutions. During the Ebola response, it took 10 months for text messages to be implemented between Tech organisations. (Anon., 2015, *Pers. comm.*, Chatham House rules (private) conference, 7 October 2015)

A panel hosted by SES, discussing the aftermath of the Ebola crisis and the role of satellites in providing connectivity, concluded that a new business model was needed to improve the affordability of connectivity (Smits, 2015).

International Cooperation in the Digital Era is a disruptive practice. The digital solutions provide short-term remedies in times of crises, which are withdrawn once the crises has subsided. Long-term structural solutions are missing. In a plea for continued international cooperation, Joanna Liu from MSF argued for a structured approach to tele-medicine to establish a better-equipped health care system in low-income situations, which would make the world better prepared to stop crises from going out of control.

Integrating Digital Solutions through International Cooperation

So let me address the question: how can digital solutions be integrated sustainably in international cooperation?

Digital health for continuity of care

Decades of austerity programmes have undermined health services, especially at the community level, in many low-income countries. Decentralised facilities are understaffed and under-resourced. Population growth has exacerbated the inadequate ratio of health workers to patients. Hospitals in cities have taken over many of the functions of the health care system. This is inefficient and costly from a health-economic perspective. There is little if any prevention, diagnoses are belated and epidemics are detected too late.

In many countries, digital health is seen as a way to lift health systems back on their feet. There is a sense that a new approach is needed to replace broken and fragmented health systems, such as the system in Liberia, which caused the Ebola epidemic to spiral out of control. Possibilities for digital connectivity create space for a new vision of a connected cycle that can provide continuity of care. The Ministry of Health in Kenya defines e-Health as:

The use in the health sector of digital data - transmitted, stored, and retrieved electronically - in support of healthcare, both at the local site and at a distance. (Government of Kenya, 2014, p. 66)

E-Health can help create a connected and operational referral and diagnostic system in the context of the enlarged mobility of patients (*ibid.*, p 44), including cross-border movements. The policy distinguishes between: (1) patient-centred information; (2) pharmacy and medical supply chain information management; (3) financial information, including insurance and payments; (4) health workforce management and training; and (5) regulation (Ogara, 2012).

In Zimbabwe, the Ministry of Health promotes an e-Health strategy with a carefully formulated phrasing:

[...] new innovative programmes such as e-health are implemented to enhance and not to disrupt what has been working so far. (Ministry of Health, 2013, p.61)

The document incidentally notes that: "The item with the lowest availability was the computer with internet/email access" (*ibid.*, p.7). A noteworthy footnote.

The management of cross-border mobile communities requires specific attention. The need for the increased use of digital health services is also acknowledged by the Cross-Border Health Integrated Partnership Project (CB-HIPP) in East Africa:

Mitigation is critically important in cross-border areas, other corridor hotspots, and water-ways. These environments are dynamic, with frequent interaction between transport and other migrant workers and vulnerable resident populations [...]. Health services in these areas - HIV, tuberculosis (TB), sexual and reproductive health (SRH) in particular - are often weak, inaccessible, or unaffordable. (CB-HIPP, 2014)

Important as it may be, cross-border cooperation can be challenging, as countries have to overcome issues with different national governance of ICT and health systems and obstacles for interoperability of data analytics that should underpin e-Health. I will elaborate on this later.

In Zambia, a national Electronic Health Record system has been developed, called 'SmartCare'. SmartCare is an 'e-first' system, with health staff using computers to input medical information, replacing paper records. General data are reported centrally (Bailey, 2013). Each Zambian carries a SmartCare card with a chip. The chip carries all health information, with a copy of the information at the clinic. Epidemiological outbreaks can be detected and followed up with prevention programmes. Data can be studied regressively to understand causes of illnesses. Importantly, the computational programme is tailored to local realities and how these impact on expected outbreaks of diseases (*ibid.*). Developed locally under the authority of the Ministry of Health, the system is well suited to local circumstances, studied by my PhD, Gertjan Van Stam (2017).

An important feature of SmartCare is that it has been adapted to the resource constraints in Zambia where electricity remains unavailable to many. The use of SmartCare does not require access to the Internet. Touch-screen technology makes it easier for health-workers to use - although many health workers still trust paper more. The system is a distributed database system, which means that SmartCare data is held at each facility in a distributed design. The aggregate data are stored at health facilities.[1] The Zambia SmartCare Card proves that the fragmentation of referral systems can be leapfrogged through ICT, distributed and adapted to local realities and designed with local expertise.

The data derived from digitised health care can be mined to predict health risks and prevent outbreaks through data analytics, based on semantic features (Partridge, 2012). Big data analytics is the analysis of data based on autonomous data sources, able to collect and analyse information without relying on centralised control. An important element of such data analytics is the domain knowledge in the particular context of the data source and its contextualised interpretation, as well as the semantic connections between data in relation to their application. It is this knowledge that Wu et al. (2013) place in the inner circle of a working model for big data. Wu et al. (2013) identify how a generic analysis can be meaningfully constructed on the basis of patterns in the local mining activities, respecting the context of the localised data to discover local patterns: "By exchanging patterns between multiple sources, new global patterns can be synthetized by aggregating patterns across all sites" (Wu et al., 2013: 101). They propose the globalisation of big data analysis based on the explicit understanding and formulation of meaningful narratives in the local data.

Financial solutions for digital health care

In India a SmartCard for Health has been developed that specifically targets citizens living below the poverty line with little if any disposable income. The system is called the Rashtriya Swasthya Bima Yojana scheme (or RSBY). The scheme responds to the problem that especially those with very little income face when paying for health care services through out of pocket payments. In low-income situations, coping with health crises constitute some of the most significant financial burdens on families.

The scheme was put in place by the Ministry of Employment and Social Affairs (and later taken over by the Ministry of Health) as a social protection scheme to help low-income workers and farmers. Card holders can access health services for free by visiting any of the public or private health care facilities participating in the scheme to receive inpatient services (Slater, 2014). This social protection scheme was later merged into a health insurance scheme. It is an important improvement in health care as it combines financial support

with the digitalisation of patient's medical records and the transfer of medical data.

Good results have also been achieved with social cash transfers, which are transferred to clients through mobile phone payments. Mobile phone money transfers are commonplace in Sub-Saharan Africa and a vast portion of the economy is involved in person-to-person (P2P) payments via mobile phone networks of families and friends. Financial transactions in the health services economy can benefit from digital-payment platforms, which have the potential to incite innovation and spur growth (Van Reisen et al., 2016). The digitisation of payments, transfers, and remittances is revolutionising the financial and IT systems through the penetration of mobile money. A more data-driven, customised approach to linking health services, mobile health and mobile payments is one way of increasing finances for health.

Remittances and mobile money
International cross-border mobile money transfers from migrants to relatives in low-income countries are already three times the volume of all official development aid. These remittances reach the beneficiaries directly, sent out of love, compassion and care, helping in crisis situations, especially health crises (UN, 2014). The volume of money sent by migrants to their families in developing countries is annually over US$ 400 billion. (World Bank, 2016a: pp. iv-v). The importance of remittances can be seen today in rural towns and village centres where almost entire economies are running on mobile money. Remittances form a social protection system (Mawere & Van Stam, 2016), rapidly replacing official international aid:

It will be interesting to see how this changes development aid. I have long thought that development aid […] is not very efficient (large waste of resources) and also creates dependency [...]. Remittances put the power and the money back into local hands. (Anon., *personal communication* with MVR, 16 February 2017).

Apps and services providing a product over the Internet carry culturally-embedded values of care within communities. Old financial systems, such as the hawala system (in which a community has a collective relationship to a range of financial transactions through which money is transferred), are transforming into ICT-based networked financial transaction systems. The digitisation of money enables more financial fluidity among members of a group within and across borders and continents, profoundly changing the nature of international cooperation.

Customised services and sensitive data
Remittances help improve health care delivery in low-income settings (Van Reisen et al., 2016). This is explained by the increased availability of financial resources for health. However, expectations also change; remitters sending money home expect a better standard of health care for their relatives (Van Reisen et al., 2016). Digital financial solutions can be tailored to health care: direct mobile payments for health services; health vouchers or insurance schemes; transaction security for health service providers; interoperability between different banked or unbanked providers; and the facilitation of cross-border transactions and services (Van Reisen et al., 2016; Bissyandé, 2016). This is also good for the economy. Our NWO-funded research, led by my former PhD student Dr Nakazibwe, showed that a combination of cash transfers and mental health services led to a significant improvement in economic performance (EWP-U, 2017). In another study, which we have just been awarded by NWO, my PhD-student Selam Kidane will research the use of ICT to administer treatment for post-traumatic stress to refugees who have escaped violent situations and who can be reached through mobile phones (Van Reisen, Kidane & Reim, 2017). The use of ICT for mental health allows for a highly-customised and targeted approach that can be contextualised to suit the different realities where it is administered.

Mental health care, health care and financial information are sensitive data. In technological innovations in the discussed settings, most of the data traffic takes place among mobile phones. The architecture of connectivity systems in developing countries is vastly different from industrialised countries, which requires security systems that are tailored to those realities. Is such data traffic safe? Proposing a combination of techniques of cloaking and encryption, Ahmat, Bissyandé and Magoni (2013) provide detailed technical methods for the P2P security of digital transactions (as well as block-chain technology for mobile payment platforms, proposed by Bissyandé, 2016), thereby fully recognising the mobile basis of development and innovation of technologies and adapting security techniques to these. I am looking forward to working with Bissyandé and my PhD-student Gertjan van Stam on developing such techniques, adapted to local realities.

In conclusion, digital solutions can be integrated in more sustainable approaches to international cooperation. E-health is being integrated in health policies combining solutions of connected care and diagnostics and linking health care to financial solutions powered by mobile money. The rapidly increasing international remittances show that the digital era is driving change in international cooperation towards people-to-people aid.

A Conceptual Framework for International Cooperation in the Digital Era

Let me now turn to the third question of this inaugural address. What would be a useful framework to theorise international cooperation in the digital era?

Moore's Law

The idea of progress in communication technology is often presented as global and universal. Van Oortmerssen, compares the evolution of the Internet to that of an organism. An organism can see, hear, and locate; it can also think and act. It can improve on all of this and develops exponentially (Van Oortmerssen, 2009). The breakthrough of a computer winning a game of 'Go' was significant because the machine had to learn to strategize based on artificial intelligence created by computing across various systems. The demonstration illustrated the capacity of machines as self-thinking organisms based on such computational techniques. The next bold steps envisaged is machines or systems that can 'care' or, rather, that are technically capable of responding to emotions and can be programmed as 'caring' machines (NOS, 2016) and such systems may be programmed to express 'intuition' (Van den Herik, 2016) and address ethical questions (Van den Herik & De Laat, 2016). Once such capabilities are engineered, they will become universally available. Van Oortmerssen describes the Internet as an intelligent organism providing an external layer of intelligence around the Earth, in which the speed of transportation of information is much faster than in the human nervous system (Van Oortmerssen, 2009; see also Van Bussel, 2009).

One could argue that the Internet also has memory and that its construction is created on legacies of the past, just as we create today based on our memory and understanding of yesterday (Rothberg, M., 2009). The Internet evolves on the basis of such legacies and artificial intelligence is constructed within the structures provided by legacy. If this is so, then engineering cannot be just a universal exercise, but must be seen as a localised exercise defined in time.

In this lecture I have given examples of applications in digital health, digital finance and customised care in low-income settings. A particular feature of such settings is the reliance on mobile phones (Donner, 2015). Technical creation takes place around this reality in the form of engineering that is adapted to such local realities. However, these innovations rarely receive international recognition or acclaim - they are not registered as 'progress'.

So what is progress? Moore's Law is widely accepted as the benchmark of exponential growth every 18 months (Cardinal, 2015). Schmidt and Cohen state that:

As adoption of these tools increases, so too will the speed and computing power. Moore's law, the rule of thumb in the technology industry, tells us that […] a computer in 2025 will be sixty-four times faster than in 2013. (Schmidt & Cohen, 2013, p. 5)

Hruska concludes that "After 50 years, Moore's Law has become cultural shorthand for innovation itself" (Hruska, 2016). Hruska sets out how the original parameters of identifying costs and innovation have become imminently more complex than the simple calculation of costs and transistors, on which Moore's law is based:

Now it serves as shorthand for better battery life, higher boost frequencies, [..] sharper screens.. (Hruska, 2016)

Parameters for progress are complex and highly context dependable, and progress depends on what the infrastructural context allows, such as the availability of electricity, capacity of internet connectivity and the nature of the devices utilised.

ICT for Development (ICT4D) and the unintended effects of digitalisation

In the field of international development, progress is often measured along the one variable of GDP per capita. In ICT progress is measured by Moore's curve for exponential growth. ICT for Development (ICT4D) refers to its mission as reduction of poverty (Adera et al., 2014). Poverty is associated with lagging behind (World Bank, 2016b), being a rear-runner, some refer to it as being backward (Lechman, 2015: 21). Cooperation in ICT4D aims to facilitate rear-runners to catch up with the frontrunners, to realise greater equality and to reap the broader development benefits from using digital technologies (Heeks, 2014; World Bank, *2016b*). The problem is this: catching up on an exponential growth curve is pretty difficult to do; mathematically it is impossible.

It is no wonder, then, that the part of the digital industry that aims to help develop digital equality has become disillusioned. ICT4D Professor Tim Unwin expresses his disillusionment with the ICT4D paradigm as follows:

The idea of 'development' itself has become a vehicle through which the technological interests of the private sector in particular, but also those of governments and civil society, can be further propagated. Expansion in the use of ICTs has thus become the primary focus of attention (D4ICT²), rather than the development outcomes that might be facilitated by ICTs in the interests of the poor and marginalized (ICT4D). This is scarcely surprising, given the long history of the use of technologies to serve and maintain the interests of the rich and powerful. (Unwin, 2016)

Unwin seeks to explain the failure in terms of the interests underlying the spread of technology and the unintended effects that can be provoked by ICT. Unwin indeed suggests that ICT has exacerbated the marginalisation of people living in poverty and enhanced existing unequal power structures in and between countries (Unwin, 2016).

I have also pointed to the need to include in research an appreciation of the unintended effects of the deployment of digital tools. Examples include the activities of unscrupulous criminal trafficking gangs, which have used modern digital tools to facilitate the trade in human beings (Van Reisen, Estefanos & Rijken, 2012; 2014; Brandpunt, 2016). Using mobile phone communication to extort ransoms from family members of hostages while they are being tortured is a practice that has arisen virtually simultaneously in Latin America, Asia and in Africa, a trade estimated to have a value of at least 1 billion USD (cumulative count since 2009) (Van Reisen & Rijken, 2016; Van Reisen et al., 2017; Van Reisen & Mawere,

2017). In addition to this specific example, other more general illicit money transfers are also facilitated by ICT (Mawere & Van Stam, 2016).

System diversity

There is a need for a more refined theorisation with which we can understand progress in the digital era. There are a range of critical parameters which impact on digital progress in different places, including cost and affordability, the availability of electricity, latency, legacy and congestion, in addition to social and political contextual features (Matthee et al., 2007; Mulozi, 2008; Saif et al., 2007; Van Stam et al., 2012; Mpazanje et al., 2013; Zheleva et al., 2013; Parks, 2014). Nussbaum (2011) and Sen (1999, 2009) have proposed that progress can be measured by the capabilities people can enjoy. However what we need to explain is that, as societies develop in different directions, the underlying architecture of technological, political, social and cultural systems change the order of things (Foucault, 1966), including an understanding of what constitutes progress.

If we want to measure or understand digital progress we need to include the context-specific parameters. We can project this as functions with more complex sets of parameters in time as sequences, or iterations of functions. For example, an iteration of a function $f_a(x)$ from the start value x=s would be as follows:

$s, f_a(s), f_a(f_a(s)), f_a(f_a(f_a(s))), \ldots$

where *a* stands for some parameter. These iterative steps of functions are often used in computer science. They can also represent moments in the time. Remarkably, such series have unexpected mathematical characteristics. Depending on parameter value a, these series may explode into infinity, it can find a stable (or unstable) equilibrium, it may circulate repeatedly around some finite number of states, or it may implode. For some functions the series evolve into chaos, erratically jumping through space to never revisit any previous state ever again. Such functions are called fractals (Mandelbrot, 1977).[3]

Fractals can help explain the connections in dynamic systems and mathematically clarify how systems may evolve. Fractals allow us to see step-by-step the features of a connected system of underlying parameters. Fractal theory can also help us understand how these steps might develop over time. Hence, fractal theory may provide tools for understanding some dynamic aspects of the digitalisation of society.

A few important observations can be made about fractal theory.

A slight variation of the starting value of a fractal can provide very different results. This can help us explain why negative unintended effects of the deployment of digital tools in some areas might develop into fast and unexpected exciting innovation, whereas deployment in other localities might be catastrophic and imploding. This phenomenon is referred to as sensitivity to initial conditions. A small variation of the starting position can account for a very different pathway.

Fractal theory also helps us understand change. Systems that seem stable can suddenly transform into a completely different system through a minor intervention. I have studied this in the context of change in social systems, where one event can completely alter the whole system (Van Reisen, 2009). It allows us to understand that a very small change can provoke fundamental system transformation, or even collapse. This can be seen in social reality, and it can be well explained in mathematical terms.

Fractal theory helps us better understand system diversity of digital societies (Van Reisen, 2016b) and how international cooperation interacts with it. If we do a mind exercise and imagine the start of the digital era as a level playing field at time zero. Minor differences in local parameters may lead to radically different development paths in various parts of the globe. For instance, the persistent problem of latency in large parts of Africa has created a digital system that is not dependent on broadband, but which instead relies on mobile

phone technology. In reality starting positions are not the same, and the parameters of digital progress are diverse. This then creates conditions in other continents that are different from those in the West. This provides a new and different starting point, which will influence future technological engineering in response to emergent domestic demand. Rather than to follow the exponential curve based on Moore's law, other continents go their own way along a radically different path of development and subject to a different set of functional laws, but just as exciting in terms of engineering (see for instance: Johnson & Mikeka, 2016).

International cooperation in the digital era

Cooperation does not mean pulling others up on a rope along the curve of exponential digital progress. Cooperation is the task of carefully building bridges between the different societal and technical systems, determining stability or fragility under the challenging digital onslaught of the Westphalian equilibrium. A better analogy might be that cooperation means feeding the system from within, from the roots of the tree, so that every branch receives the nourishment and sustenance to produce fruit. In the case of Liberia, smaller, permanent, long-term, and more inclusive interventions on the ground would have prevented Ebola from spinning out of control and, in its aftermath, would have helped to strengthen the country.

A theory of system diversity provides an alternative basis for thinking about cooperation in the digital era, aiming to bridge different realities. Localisation then matters. Those engineering within the systems do so knowing the patterns that keep the system in equilibrium. Interventions from outside the systems may disturb the equilibrium of systems that are stable. International cooperation should be informed by respect for the internal integrity of different systems. Any intervention needs to be carried out with respect for and understanding of the potential dangers posed by unintended effects, as well as the risk that it may create instability. Local engineering is capable of recognising local parameters and developing solutions suited to these.

Human beings have their own way of understanding their own society. This is called epistemological sovereignty and it means human beings have an agentic ability to interpret their world within their own context and to act on the basis of this understanding. It is the prerogative of human beings to shape their own society, as well as the relationship of their society to others (Buskens & Van Reisen, 2017).

In a theory where stable systems are rare, heritage and tradition count as tested foundations of what may constitute systems in equilibrium. In Africa and Asia, old fractal patterns appear to have governed the geography and its outlay for a history longer than Europe's - not to speak of the United States; these are tested patterns that have provided stability in difficult times (Eglash & Odumosu, 2005). Support and respect for the institutions that underpin those patterns, which have proven to be stable, are important components of international cooperation. In terms of engineering, this means that the legitimate authority in foreign systems, and the boundaries set by legitimate authorities, should be respected. International diplomacy in the information age requires sensitivity to the heritage that defines societies (Van Reisen, 2016a).

Digitalisation has already greatly undermined the current system of nations, as the 'imagined community' (Anderson, 1983) is no longer the exclusive prerogative of the nation state, but extends beyond and across borders (Van Reisen & Gerrima, 2016). Kutsal Yesilkagit (2016) demonstrates how identities of globalised virtual communities, through glocalisation may compete with national identities, straining the public administration of nations and groups of nations. The digital era may place great strain on international cooperation, as the stability of internal systems and the equilibrium between systems are challenged.

International cooperation in the digital era therefore needs to be cognisant of the multiple factors that determine how societies change and how solutions match the particular circumstances of a society. International cooperation is the policy of navigating carefully between the distinct layers of various systems that exist in the international community, recognising the legitimacy and leadership of domestic, local and traditional authorities.

Near-future Developments

I would like to end by pointing to some exciting near-future developments which will have a deep impact on how we will cooperate.

The open science cloud of FAIR data

Our world will increasingly be a virtual world expressed in data. The European Open Science Cloud, established by the European Commission under leadership of Barend Mons, is a bold endeavour to establish a common data protocol, which will form the basis of an open Internet of Data. The data protocol is called FAIR. Under this protocol data will be findable, accessible (under well-defined conditions), interoperable and reusable (FAIR) (Wilkinson et al., 2016).

For international cooperation this protocol will be important. While personal data will be protected, parts of the data can be entered by algorithms for aggregation purposes, which will cause a revolution in the life sciences. Data are owned by the producer of such data, while the FAIR Data protocol enhances the possibility to share data for analysis of personal health and science.

The objective of the FAIR project is to build an Open Science Cloud as a public good that everyone can benefit from and participate in (European Commission, 2016), which is not limited to a particular discipline. Based on their own initiative in each country or region, Open Science Cloud nodes can be established (cf. also CDISC). With local partners, we are working to establish nodes in East Africa, India and in West Africa, including Liberia. I am convinced that the future of the digital era will be transformed by international cooperation through FAIR Data in which local nodes give value to it, while maintaining their ownership over the data.

In this address I have reflected on international cooperation in the digital era. We can consider the unique transformative capacities of societies to engineer and progress in ways that make sense to people in their own context. Such transformative capacities will be based on the different pathways developed from each unique societal history. My plea is to consider a new model for international cooperation, which seeks to build bridges, that seeks to understand progress from various contextualised interpretive frames.

Each human being is looking for a life in dignity based on the history that brought him to where he is in a specific location at a particular point in time. Refugees from Syria and Eritrea, survivors of human trafficking, and those that were affected by the Ebola crisis, deserve caring attention, empowering them to find their own tools to address their problems. Let me finish this lecture with the words of President Johnson-Sirleaf of Liberia, from the foreword of the book that we published at the height of the Ebola crisis in October 2014. She said:

As human beings, we are not fighting to die, but to live. We invoke the spirit of communities, of all men, women and children of Liberia, of Africa and of the world to stand together. If we care about our communities we can resolve conflict, overcome the hardest challenges and rebuild our peace. (Ellen Johnson Sirleaf, 2014)

In the spirit of commitment to cooperation and dedication to peace for our communities, I am honoured and privileged to accept the chair 'Computing for Society' at Leiden University.

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I thank my mum - grateful for her sharp mind - and my family, for their love. I really miss my dad.

The research that has personally affected me most, is the study into the human trafficking of Eritrean refugees. The bewildering effects of digitalisation and the unbearable cruelty of the trade in human beings has been a most shocking and troubling realisation. I am grateful for the friendship I receive from Selam, Meron Daniel, Zack, Eyob and so many others. I admire how you keep moving forward fearlessly, with perseverance and determination. Thanks to the deep web, information is shared, as is the longing for better days,

when we will make an evening stroll or see a movie in Cinema Emperio, the day when we will meet as one family in Asmara.

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Ik heb gezegd.

References

Adera, E.O., Waema, T.M., May, J., Mascarenhas, O. & Diga, K. (2014). I*CT Pathways to Poverty Reduction Empirical evidence from East and Southern Africa.* Practical Action Publ. Warwickshire.

Africa Study Centre. (2014). *Annual report.* African Study Centre, Leiden University. Retrieved from: https://openaccess.leidenuniv.nl/bitstream/handle/1887/33449/ASC%20Annual%20Report%202014-Interactive.pdf;jsessionid=DAFE8E024046726A97B0174C41901E89?sequence=2

Ahmat, D., Bissyandé, T. & Magoni, D. (2013). *Towards securing communications in infrastructure-poor areas.* Conference Paper. AFRICOMM.

Anderson, B. (1983). *Imagined communities.* Verso. London.

Anon. (2015). *Conference London.* Confidential notes (Chatham House rules).

Bailey, C. (25 July 2013). Zambia: Making the 'SmartCare' Transition to electronic healthcare records. Retrieved from: http://www.pedaids.org/blog/entry/zambia-making-the-smartcare-transition-to-electronic-healthcare-records

Bissyandé, (2016). Proposal. Unpublished.

Brandpunt (2016). Mobiele mensenhandel uit Eritrea. 19 April 2016. Retrieved from: http://www.npo.nl/brandpunt/19-04-2016/KN_1678978/WO_KRO_3753626

Buskens, I. & Van Reisen, M. (2017). Theorising agency in ICT4D: Epistemic sovereignty and Transformation-in-Connection. In: Mawere, M. (ed.) *Underdevelopment, Development and the Future of Africa.* Langaa RPCIG: Bamenda, pp.394-432.

Bwire, J. (2014). Ebola kills Ugandan doctor in Liberia, 2 July 2014. *Daily Monitor.* Retrieved from: http://www.monitor.co.ug/News/National/Ebola-kills-Ugandan-doctor-in-Liberia/688334-2369720-format-xhtml-aup69pz/index.html

Cardinal, D. (14 April 2015). Moore's Law at 50: Its past and its future. Retrieved from: https://www.extremetech.com/extreme/203031-moores-law-at-50-its-past-and-its-future

Cross Border Health Integrated Partnership Project (CB-HIPP). (n.d.) Brochure. Retrieved from: https://www.fhi360.org/sites/default/files/media/documents/FHI360_CB-HIPP.pdf

CDISC. (undated) Intro to what we do. Retrieved at: https://www.cdisc.org/about/what-we-do

Dechesne, F. (2017). Personal communication to author. Unpublished.

De Silva, M.J. & Ryan, G. (2016). Global mental health in 2015: 95% implementation. *The Lancet*, 3 (1): 15-17, January 2016. Retrieved from: http://thelancet.com/pdfs/journals/lanpsy/PIIS2215-0366(15)00567-2.pdf

Dictionary.com (2016). Cyber Monday and the Origin of the Word "Cyber" (27 November 2016). Retrieved from: http://blog.dictionary.com/cyber-monday-cyberspace/

Donner, J. (2015). *After Access. Inclusion, Development, and a more Mobile Internet.* MIT Press. Cambridge Massachussets.

Eglash, R. & Odumosu, T.B. (2005). Fractals, complexity, and connectivity in Africa. In: G. Sica (ed.) *What Mathematics from Africa*? Monza, Italy: Polimetrica International Scientific Publisher, pp. 101-109.

European Commission. (2016). European Open Science Cloud: 11 October 2016 - first report from the High Level Expert Group. Retrieved from: http://ec.europa.eu/research/openscience/index.cfm?pg=open-science-cloud

EWP-U. (2017). Interim report. Unpublished.

Freedom Du Lac, J. (13 October 2014). The U.S. military's new enemy: Ebola. Operation United Assistance is now underway. *Washington Post.* Retrieved from: https://www.washingtonpost.com/news/to-your-health/wp/2014/09/30/the-u-s-military-forces-fighting-the-war-on-ebola/?utm_term=.24198df4a563

Foucault, M. (1966). The Order of Things. Routledge. London.

Government of Kenya. (2014). *Kenya Health Policy 2014 – 2030. Towards attaining the highest standard of health.* Ministry of Health. Retrieved from: https://www.afidep.org/?wpfb_dl=80

Government of Zambia. (2013). *e-Health Strategy 2014–2016.* Republic of Zambia. Ministry of Health. Retrieved from: http://www.moh.gov.zm/docs/ehealth.pdf

Government of Zimbabwe (2016) *The National Health Strategy. Equity and quality in health: Leaving no one behind: 2016–2020.* Retrieved from: https://www.unicef.org/zimbabwe/National_Health_Strategy_for_Zimbabwe_2016-2020_FINAL.pdf

Haikin, M. & Flatters, G. (2017). Digital Development: What is the role for international NGOs. *Oxfam Discussion Paper.* (February 2017).

Heeks, R. (2014). ICTs and Poverty Eradication: Comparing Economic, Livelihoods and Capabilities Models. *Working Paper 58.* Centre for Development Informatics. Manchester Centre for Development Informatics. IDPM, University of Manchester, UK.

Hruska, J. (16 April 2015). Moore's Law is dead, long live Moore's Law. *ExtremeTech.* Retrieved from: https://www.extremetech.com/extreme/203490-moores-law-is-dead-long-live-moores-law

Johnson, D. & Mikeka, C. (2016). Malawi and South Africa Pioneer Unused TV Frequencies for Rural Broadband. *IEEE Spectrum.* (29 August 2016) Retrieved from: http://spectrum.ieee.org/telecom/internet/malawi-and-south-africa-pioneer-unused-tv-frequencies-for-rural-broadband

Johnson-Sirleaf, E. (2014). Foreword. In: Van Reisen, M (ed.) *Women's Leadership in Peace Building. Conflict, Community and Care.* New Jersey: Africa World Press.

Kidane, S. & Van Reisen, M. (2017). Collective trauma from Sinai trafficking: A blow to the fabric of Eritrean society. In: Van Reisen, M. & Mawere, M. (eds) *Human Trafficking in the Digital Era. The Ongoing Tragedy in the Trade of Refugees from Eritrea.* Bamenda: Langaa. RPCIG, pp. 317-345.

Lechman, E. (2015) ICT Diffusion in Developing Countries. Towards a new Concept of TechnologicalTake-Off. Springer. London.

Liu, J. (5 August 2015). Disease outbreak: Finish the fight against Ebola. *Nature.* Retrieved from: http://www.nature.com/news/disease-outbreak-finish-the-fight-against-ebola-1.18109

Mandelbrot, B. (1977) *The Fractal Geometry of Nature.* Freemann and Comp. New York.

Matthee, K., Mweemba, G., Pais, A., Van Stam, G. & Rijken, M. (2007). Bringing Internet connectivity to rural Zambia using a collaborative approach. In *IEEE/ACM International Conference on Information and Communication Technologies and Development* (ICTD2007), Bangalore, India, IEEE (2007).

Mawere, M., & Van Stam, G. (2016). Pillage, plunder and migration in Africa. On the expatriation of riches and remittances. In: Mawere, M. (ed.) *Development Perspectives from the South. Troubling the Metrics of (under)development in Africa.* Bamenda: Langaa.

De Morgen. (2014). Richt een Ebolafonds op en stele en Europese Gezant aan. (Open Letter, 24 September 20124). Retrieved from: http://www.demorgen.be/opinie/richt-een-ebolafonds-op-en-stel-een-speciale-europese-gezant-aan-nu-b077d28e/

Mpazanje, F., Swechurran, K. & Brown, L. (2013). Rethinking information system projects using actor-network theory: a case of Malawi. *Electronic Journal of Information Systems in Developing Countries*, 1-23. Retrieved from: http://www.ejisdc.org/ojs2/index.php/ejisdc/article/view/1184

Mudenda, C., Johnson, D., Parks, L. & Van Stam, G. (2015). Power instability in rural Zambia, case Macha. Paper. Retrieved from: http://www.cs.ucsb.edu/~davidj/Files/power_zambia.pdf

Mulozi, D.L. (2008). Rural access: Options and challenges for connectivity and energy in Zambia. eBrain Forum of Zambia/IICD. Retrieved from: http://www.bibalex.org/Search4Dev/files/287896/118779.pdf

NOS (16 October 2016). Kunstmatige Intelligentie Kruipt in alle slimme Apparaten. Nieusuur. Retrieved from: http://nos.nl/nieuwsuur/artikel/2137239-kunstmatige-

intelligentie-kruipt-in-alle-slimme-apparaten.html
NYU. (undated) What is datascience? Retrieved from: http://datascience.nyu.edu/what-is-data-science/
Nussbaum, M. (2011). *Creating Capabilities. The Human Development Approach.* The Belknap Press of Harvard University Press. Harvard.
Ogara, E. (2012). PowerPoint Presentation. Presented by Ministry of Medical Services, Head eHealth, Kenya at GSMA & mHealth Summit International Conventional Center, Cape, Town, South Africa 29th May-1 June 2012. Retrieved from: http://warnocksescapades.com/calendar/Policy%20and%20Personal%20Information%20-%20Dr%20Esther%20Ogara%20-%20Kenya.pdf
Oxford Dictionaries. (n.d.). Oxford Dictionaries (online). Retrieved from: http://blog.oxforddictionaries.com/2015/03/cyborgs-cyberspace-csi-cyber/
Parks, L. (2014). Water, energy, access: Internet and mobile phone infrastructure in rural Zambia. In: Parks, L. & Starosielksi, N. (eds) *Signal Traffic: Critical Studies of Media Infrastructures.* Urbana Chamaign: University of Illinois Press.
Partridge, B. (2012). Big data, big impact: New possibilities for m-health. Vital Wave Consulting, 31 May 2012. Retrieved from: http://warnocksescapades.com/calendar/Policy%20&%20Personal%20Information%20-%20Brooke%20Partridge%20-%20Vital%20Wave%20Consulting.pdf
Philips, M. & Markham, A. (10 September 2014). Ebola: A failure of international collective action. *The Lancet.* Retrieved from: http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(14)61606-8/fulltext
Phillips, L. (2014). The political economy of Ebola. *Jacobin*, August 2014. Retrieved from: https://www.jacobinmag.com/2014/08/the-political-economy-of-ebola/
Plaat, A. (2015). Data science and Ebola. Inaugural Lecture on the acceptance of the position of Professor of Data Science at the Universiteit Leiden, 13 April 2015. Retrieved from: http://media.leidenuniv.nl/legacy/oratie-plaat.pdf
Rothberg, M. (2009). Multidirectional Memory. Remembering the Holocaust in the Age of Decolonization. Stanford University Press. Stanford.
Saif, U., Chudary, A.L., Butt, S., Butt, N.F. & Murtaza, G. (2007). Internet for the developing world: Offline Internet access at modem-speed dialup connections. Retrieved from: http://people.csail.mit.edu/umar/publications/ICTD2007-fin.pdf
Schmidt, E. & Cohen, J. (2014). *The new digital age: Reshaping the future of people, nations and business.* London: John Murray.
Sen, A. (1999). *Development as Freedom.* Knopf. New York.
Sen, A. (2009). *A Theory of Justice.* Harvard University Press. Harvard.
SES. (14 November 2014). SES joins the fight against Ebola in Africa. Retrieved from: https://www.ses.com/blog/ses-joins-fight-against-ebola-africa
SES (2015). SES partners fight Ebola Guinea through Deployment Mobile Laboratory B-Life. Retrieved from: https://www.ses.com/press-release/ses-partners-fight-against-ebola-guinea-through-deployment-mobile-laboratory-b-life
Shields, M. (2013). SmartCare. Electronic health record system. Continuity of Care… the long view… In *Erasmus Medical College Symposium*, 2 September 2013, Rotterdam, the Netherlands.
Slater, A. (22 April 2014). The Smart Card insurance revolution in India. GlobalSurance. Retrieved from: https://www.globalsurance.com/news/2014/04/22/the-smart-card-insurance-revolution-in-india/
Smits, K. (2015). Fostering Satellite Connectivity through Public-Private Partnerships - Analysis. IDN 8 June 2015. Retrieved from: http://www.eurasiareview.com/08062015-fostering-satellite-connectivity-through-public-private-partnerships-analysis/
TechTerms (2017) ICT Definition. (January 4, 2010).Retrieved from: https://techterms.com/definition/ict

Telegraph. (8 October 2014). Liberia attacks British Airways for suspending flights to Ebola hit country. *The Telegraph.* Retrieved from: http://www.telegraph.co.uk/news/worldnews/ebola/11148672/Liberia-attacks-British-Airways-for-suspending-flights-to-Ebola-hit-country.html

TICAD VI Nairobi Declaration. (2016). Advancing Africa's sustainable development agenda. TICAD partnership for prosperity. Retrieved from: http://www.mofa.go.jp/af/af1/page3e_000543.html

United Nations. (2014). Remittances and diaspora resources in the context of the preparatory process for the Third International Conference on Financing for Development. Side event, co-organised by Bangladesh and Switzerland, 13 November 2014, United Nations Headquarters, New York. Retrieved from: http://www.un.org/esa/ffd/wp-content/uploads/2015/01/se-summary-remittances-13112014.pdf

UNDESA. (29 July 2015). World population projected to reach 9.7 billion by 2050. New York: United Nations Department of Economic and Social Affairs. Retrieved from: http://www.un.org/en/development/desa/news/population/2015-report.html

UNFPA. (2016). *The state of world population 2016.* United Nations Population Fund. Retrieved from: http://www.unfpa.org/sites/default/files/pub-pdf/The_State_of_World_Population_2016_-_English.pdf

United Nations Security Council. (2014). *With spread of Ebola outpacing response, Security Council Adopts Resolution 2177 (2014) urging immediate action, end to isolation of affected states.* Retrieved from: https://www.un.org/press/en/2014/sc11566.doc.htm

Unwin, T. (2014). On Cyber and the Dangers of Elision. Personal blog. (15 January 2014) Retrieved from: https://unwin.wordpress.com/tag/cybersecurity/

Unwin, T. (29 August 2016). "Reclaiming ICT4D" - in the beginning. Retrieved from: https://unwin.wordpress.com/2016/08/29/reclaiming-ict4d-in-the-beginning/

Van Bussel, (2009). Internet en Darwin hebben veel met elkaar te maken. 4 September 2009. Retrieved from: http://www.vbds.nl/2009/11/02/internet-en-darwin-hebben-veel-met-elkaar-te-maken/

Van den Herik, H.J. & De Laat, C.A. (2016). The Future of Ethical Decisions made by Computers. In: *The Art of Ethics in the Information Society.* (Lisa Janssens ed.), Amsterdam University Press. (pp. 49-54)

Van den Herik, H.J. (2016). Intuition is programmable. Valedictory Address, Tilburg University.

Van den Herik, L. & Van Reisen, M. (2017) Human Rights Inquiry and the Empowerment of Diaspora. (forthcoming)

Van Oortmerssen, G. (2009). *Darwin en het Internet.* Tilburg University.

Van Reisen, M. (2009). *Window of opportunity. Development cooperation in the European Union after the fall of the Berlin Wall.* New Jersey: Africa World Press.

Van Reisen, M., Estefanos, M. & Rijken, C. (2012) *Human Trafficking in the Sinai Desert: Refugees between Life and Death.* Wolf Publ. Oisterwijk.

Van Reisen, M., Estefanos, M. & Rijken, C. (2014) *The Human Trafficking Cycle. Sinay and Beyond.* Wolf Publ. Oisterwijk.

Van Reisen, M. & Rijken, C. (2015). *Sinai trafficking: Origin and definition of a new form of human trafficking*, Vol 3, No 1 (2015). Retrieved from: http://www.cogitatiopress.com/socialinclusion/article/view/180

Van Reisen, M. (2016a). Protection of heritage in the information age: The changing nature of international diplomacy. Public Lecture at Great Zimbabwe University, 31 August 2016, Masvingo.

Van Reisen, M. (2016b). The data revolution and innovation of knowledge - African leadership for an open science cloud. Keynote address, EAI, AfriCOMM. 8th EAI International Conference on e-Infrastructure and e-Services for Developing Countries, 6-7 December 2016.

Van Reisen, M. & Gerrima, Z. (2016). The order of things: Changing identities in Eritrea through ICTs. In: Mawere, M. (ed.) *Violence, Politics and Conflict Management in*

Africa: Envisioning Transformation, Peace and Unity in the Twenty-first Century. Bamenda: Langaa, pp. 367-400.

Van Reisen, M., Fulgencio, H.T., Van Stam, G., Ong'ayo, A.O. & Van Dijk, J. (2016). mMoney Remittances: Contributing to the quality of rural health care. Conference Paper, AfriCOMM.

Van Reisen, M., & Mawere, M. (eds). (2017). *Human trafficking in the digital era: The ongoing tragedy in the trade of refugees from Eritrea.* RPCIG, Bamenda: Langaa.

Van Reisen, M., Kidane, S. & Reim, L. (2017). The trauma of survivors of Sinai trafficking. In: Van Reisen, M. & Mawere, M. (eds) *Human Trafficking in the Digital Era: The Ongoing Tragedy in the Trade of Refugees from Eritrea.* RPCIG, Bamenda: Langaa.

Van Reisen, M., Gerrima, Z., Ghilazghy, E., Kidane, S., Rijken, C. & Van Stam, G.J. (2017, forthcoming). Tracing the emergence of ICT-enabled human trafficking for ransom. In: Rijken, C. (ed.) *Handbook for Human Trafficking.* Routledge: London.

Van Reisen, M. & Dechesne, F. (2017). mMoney, Mobility and Healthcare: Towards a Meta-Theory of System Diversity. *TILT Conference 17-19 May 2017.* Tilburg University. Forthcoming.

Van Reisen, M., Kibiki, G., Mons, A., Mons, B. & Schultes, E. (2017) A FAIR Data architecture for data protection of m-Health and e-Health solutions in East Africa. *TILT Conference 17-19 May 2017.* Tilburg University. Forthcoming.

Van Stam, G., Johnson, D.L., Pejovic, V., Mudenda, C., Sinzala, A. & Van Greinen, D. (2012). Constraints for information and communication technologies implementation in rural Zambia. In: Jonas, K., Rai., I.A. & Tchuente, M. (eds) *Fourth International IEEE EAI Conference on e-Infrastructure and e-Services for Developing Countries* (AFRICOMM 2012), Yanoundé, Cameroon, Springer.

Van Stam, G. (2017). Keynote Victoria Falls. Unpublished draft, 11 February 2017 (in possession of author)

Vital Wave. (2016). *Digitizing payments in Uganda.* Case Study. Retrieved from: http://vitalwave.com/wp-content/uploads/2016/12/Digitizing-Payments-in-Uganda-Case-Study-2016-2.pdf

Weijland, P. (2017). Personal communication to author. Unpublished.

Wilkinson, M., Dumonitier, M. & Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Nature.* Retrieved from: http://www.nature.com/articles/sdata201618

The White House. (16 October 2014). *Executive Order-Ordering the selected reserve and certain individual ready reserve members of the armed forces to active duty.* The White House.

World Bank. (2016a). *Migration and remittance factbook.* World Bank.

World Bank. (2016b). *World Development Report 2016: Digital Dividends.* World Bank.

Wu, X., Fellow, IEEE, Xingquan Zhu, Senior Member, IEEE, Wu, G.-Q. & Ding, W. Senior Member, IEEE. (2014). Data Mining with Big Data. *IEEE Transaction on Knowledge and Data Engineering,* Vol. 26, No. 1, January 2014. Retrieved from: http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6547630

Yesilkagit, K. (2016). Public administration with a focus on international governance. Inaugural Address, Leiden University.

Zheleva, M., Paul. A., Johnson, D.L. & Belding, E. (2013) Kwiizya: local cellular network services in remote areas. In *MobiSys13*, Taipei, Taiwan. Retrieved from: http://cs.ucsb.edu/~davidj/Files/kwiizya.pdf

Notes

1 https://en.wikipedia.org/wiki/SmartCare. Wikipedia is used as a site of communication on the Zambian SmartCare Card.

2 Development for ICT.

3 De term fractal werd geïntroduceerd in 1975 door Benoît Mandelbrot en is afgeleid van het Latijnse fractus (gebroken).

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International cooperation is fundamentally changing in the digital era. In crises situations, such as the Ebola crisis in Liberia, data science helps innovate international cooperation. However, short-lived time-bound investments in digital connectivity, employed to address such crises lack a perspective on long-term sustainable cooperation. In many places, contextualized e-Health and e-finance are being developed to strengthen connected health care.

In order to reflect on how international cooperation can exploit such opportunities in the digital era, new theorization is required; such a theory may explain how societies develop different paths-ways as they progress, conducive to the specific context parameters that impact on what is possible and desirable. This is proposed as a theory of system diversity.

International cooperation should then seek to connect specific local realities, to contribute to progress drawing on global data science. The data protocol Findable, Accessible, Interoperable and Reuseable (FAIR) forms a basis for such cooperation. Local engineering, local ownership of data, and local leadership over the data are critical for delivering progress in the digital era.

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