2017

African Societal Challenges Transformation through IoT

Salim Al Isma'ili
University of Wollongong, szaai787@uowmail.edu.au

Mengxiang Li
mli@uow.edu.au

Jun Shen
University of Wollongong, jshen@uow.edu.au

Qiang He
Swinburne University of Technology, qhe@swin.edu.au

Abdulaziz Alghazi
University of Wollongong, aa485@uowmail.edu.au

African Societal Challenges Transformation through IoT

Keywords

societal, african, transformation, challenges, iot

Disciplines

Engineering | Science and Technology Studies

Publication Details

Al Isma'ili, S., Li, M., Shen, J., He, Q. & Alghazi, A. (2017). African Societal Challenges Transformation through IoT. 21st Pacific Asia Conference on Information System (PACIS 2017)s (pp. 1-9). AIS Electronic Library.

African Societal Challenges Transformation through IoT

Research-in-Progress

Salim Al-Isma'ili
School of Computing and Information Technology, University of Wollongong, Australia, szaai787@uowmail.edu.au

Mengxiang Li
Department of Finance & Design Sciences, School of Business, Hong Kong Baptist University, Mengxiqang.li85@gmailcom

Jun Shen
School of Computing and Information Technology, University of Wollongong, Australia, jshen@uow.edu.au

Qiang He
School of Software and Electrical Engineering, Faculty of Science, Engineering & Technology, Swinburne University of Technology, qhe@swin.edu.au

Abdulaziz Alghazi
School of Computing and Information Technology, University of Wollongong, Australia, aa485@uowmail.edu.au

Abstract

Very limited trials have been conducted either industrially or academically in trying to uncover the potential of Internet of Things (IoT) in leveraging the societal problems in Africa. Based on the review of the current status of IoT implementation in Africa, we highlighted the potential opportunities to be taken into consideration by different stakeholders to leverage the living standards in the African nations. The study also identified some of the impending challenges that need to be addressed for a successful implementation of IoT solutions. The study proposes a framework that includes the relevant stakeholders, who need to cooperate harmoniously to alleviate the African countries' challenges in areas such as agriculture and healthcare. This paper also proposes a multi-perspective research framework and aims to test it empirically to understand the views of IoT among users and practitioners in Africa.

Keywords: Internet of Things, Africa, Opportunities, Challenges, Transformation

Introduction

Internet of Things (IoT), as one of the disruption technologies, is growing rapidly. The 'things' included in the IoT refer to smartphones, tablets, sensors, and many other new fancy stuff such as wearable electronic devices. More and more machines are connected to each other and to the Internet. This has benefits for enhancing connectivity and obtaining useful and insightful information to make better decisions. In 2015 the number of connected devices was 10 billion. Moreover, in 2016 the number was estimated to be more than 12 billion (GoldmanSachs 2016). In 2020, the connected devices are expected to reach 30 billion (GoldmanSachs 2016). The 5G network is going to be more robust and faster than the current 4G technology. It is going to be a booster for IoT with less latency for about one-fiftieth than the 4G. The IoT scalability is expected to reach 100 times more devices than the population of the earth (GoldmanSachs 2016). Unfortunately, what people perceive about IoT is mainly about transforming business processes and business models. We have heard many IoT providers talking in the media about "change", "change the world", and "transformation", but usually this refers to the business side only, it is more from a business perspective. In other words, there is no clear vision as to what IoT providers wish to do or can do towards easing challenges in regions such as the developing Africa. Also from the humanitarian side, we do not see many thoughts on what this

technology can solve or enhance. We believe this technology can play a significant role in leveraging the living standards of millions of people by helping them in areas such as agriculture to produce high-yield crops with less effort, and also providing them with robust and affordable tools for monitoring and controlling the use of water resources. Similarly, in the healthcare sector, IoT can be utilised to monitor patients' wellbeing.

This study aims to highlight these kinds of opportunities to the IoT providers and institutional authorities to encourage them to better the human kind. IoT has the potential to revolutionise the world in a way similar to what happened during the industrial revolution. This technology can leverage the utilisation and sharing of physical resources, which were under utilisation in the past. IoT is mainly linked to business innovation, the question that requires further investigation is whether this technology can help in solving other problems such as poverty. We find that little has been done either from the technology application side or the academic research side. In this paper, we will posit that IoT has the potential to do more to alleviate the inherited challenges in Africa.

In this paper, we raise this question: what role the IoT can play in the societal transformation of African countries? The majority of the current IoT initiatives are directed towards the rich countries in the world. We believe that IoT can contribute a great deal towards solving some of the world's complicated problems in poorer countries as well. This study aims to explore the areas where IoT can play a significant role in increasing prosperity and reducing poverty in Africa, through enhancing areas such as agriculture productivity and healthcare performance. This study is trying to identify where IoT can be applicable, and also where it can generate benefits for the disadvantaged world population, and at the same time give sufficient financial benefits to the IoT providers.

Literature Review

IoT Background in Africa

We examined the literature from 2008 till now for searching the terminologies "IoT" and "Africa". Databases such as ScienceDirect, Scopus, Business Source Complete, and Inspec were included. The search generated 255 results. Among them, there were 34 articles in academic journals and one conference paper. Thirty-three of the journals were in English, and two were in French. The French language articles were excluded. The rest were in the categories of news, magazines, and other trade publications. In removing the duplicated articles from the research outcome, 22 articles remained. Among them, only two articles were relevant to the investigation of IoT in Africa. These two articles are inspiring, but further studies are required to enrich our understanding of the paradigm and the potentials of IoT in Africa. This shows how limited the existing research is. One of the two articles that discussed IoT in the African context investigated the integration of RFID and Web 2.0 technologies to enhance inventory management in South African enterprises (Mathaba et al. 2011). The other study touched directly on the implementation of the IoT in small farms to improve the food yield in Africa (Fleming et al. 2016). The authors believe that there is a need for these kinds of studies to be conducted across Africa.

Other than the refereed journal publication, we could not find relevant research studies on the IoT and its impact in easing socioeconomic challenges in Africa from the specialised venues in the benefits of advanced technologies in humanitarian (e.g. IEEE Global Humanitarian Technology Conferences). From the general context of IoT research, wide arrays of previous studies investigated the technical aspects of the IoT (Bęcek 2016; Gondim et al. 2016; Meng et al. 2016; Wright 2017). Other studies investigated the application and the adoption of IoT in practical situations (Dachyar and Risky ; Ding et al. 2016; Wentao and Jun ; Yuqiao and Kanhua 2016) others provided theoretical frameworks (Bo and Yulong 2017). IoT has the potential to create new business models, new technology, and a new role for IT. In this regard, our study aims to explore the potential of IoT in transforming Africa by alleviating its inherited challenges. In our research model, we will present the five potential areas, but in this paper, we discuss only two of them in detail due to the space limitation.

IoT and Agriculture

IoT has been largely implemented in agriculture from the global perspective (Stočes et al. 2016). A study conducted by Ferrández-Pastor et al. (2016, p. 1) demonstrated the usefulness of IoT in the assistance of the development of 'Precision Agriculture". Their study also argued that there are still several IT related issues that hinder the advancement of IoT in agriculture. These include expensive equipment, the complexity of the systems, and the lack of established sensor network standards. It

will be useful to understand whether the same challenges also exist in Africa or there are also other problems. Understanding these challenges is also useful in trying to avoid them and develop better systems that meet the social and economic conditions of Africa. A recent study (Jayaraman et al. 2016) designed an IoT-based platform for enhancing the productivity of farms. The system was deployed in Australia and virtually compatible with any IoT devices. This is a promising system, and it is one of the world's largest systems that provide crop assessments and recommendations. There is a chance that such systems can be deployed in Africa but a thorough understanding of the sociotechnical issues will be useful for developing more customised solutions for the African continent. Some of the potential areas of IoT application in agriculture may also include research agenda like understanding soil composition, needs for water, fertiliser usage optimisation, climate forecast, and increasing the yield of crops. The potential solutions for these problems could be pH sensors, soil moisture sensors, Bluetooth low energy device kits, and automated irrigation systems. There are already some solutions in the market, such as IBM EZ-Farm, which uses IBM Foundation and Bluemax (Kshetri 2016), but people wonder how the same solutions could be escalated to benefit the African nations in large.

IoT and Healthcare

Body sensing networks (BSNs) are one of the areas that have been proposed for the efficient use of the IoT in healthcare, with the particular use of inexpensive ambient sensors that can be installed in a patient's home to monitor their behaviour and well-being (Lo et al. 2005). Low-energy wireless connectivity can advance IoT initiatives, which can be developed even in remote areas in Africa due to the inexpensive cost that is traditionally associated with installation. However, the challenge here could be in the availability of the bandwidth to make these solutions viable. Wearable sensors have been widely used in the healthcare industry. There is an opportunity for such devices, sometimes in combination with ambient sensors and BSN, to easily track and monitor the health of the people even in remote areas. It will cut several direct and indirect costs, such as patient's mobility to the hospital to get treatment. These technologies can provide the patient with instant and accurate access to health monitoring services even in remote areas. In the next phase of the fieldwork plan in Africa, we intend to explore more potential areas where IoT can have a positive impact.

IoT Challenges

The two main obstacles to IoT are security and privacy (Ivaşcu et al. 2016). The extent of these issues can be very critical when we imagine the hacking to the power grid stations and petroleum refineries. Privacy and security are particularly critical in wearable healthcare devices, and IoT needs to be highly protected against privacy breaches and malicious attacks that might cause harm to the users (Lo et al. 2005). African government and project owners need to understand what the challenges are evolving from the IoT and how they should design their infrastructure to tackle these challenges. 92% of IoT users have worries about security (KPMG-SouthAfrica 2016). Cybercrime globally is costing about US $ 445 million each year. This number can be much higher due to the connectivity of a huge volume of devices in IoT (KPMG-SouthAfrica 2016). Gartner stated that IoT is one of the trending technologies in recent years and organisations need to have a clear IoT platform strategy for their adoption. Biggs et al. (2015) raised the concern of standardisation due to the expected increase in offerings and competition among IoT vendors.

The availability of sufficient and economical infrastructure and Internet bandwidth for implementing IoT solutions is essential (Zander et al. 2015), and governments in Africa should be able to provide this infrastructure to support the creation of IoT solutions. RFID is one of the enabling technologies for IoT and (Bardaki et al. 2012) argued in their study the needs for enhancement of RFID to achieve successful IoT deployment. This indicates that it is important to provide not only successful IoT technologies but also to improve other collaborative technologies that support the IoT project deployment. Another problem is that many wearable devices have been designed for consumers and this, in some sectors such as health care, makes it difficult for such devices to get clinical approval by the regulators. The developers purposely avoid seeking clinical approval due to the length and expense of such process (Lo et al. 2005). Understanding and identifying the challenges specific to African countries will be important in our next field work. They will be the drivers towards overcoming them to provide efficient IoT technological solutions.

IoT Stakeholders

The IoT initiatives in Africa might require the involvement of various stakeholders. These include:

Policymakers: IoT relies on the availability of an efficient network infrastructure. Mobile networks and the availability of frequencies are essential. A government's responsibility is to ensure the availability of communication and the connection infrastructure to ensure the successful implementation of IoT projects. Also, collaboration between countries is essential for making the IoT viable to the whole Africa. IoT has been extensively developed in countries such as the United States and China, and it has been applied to specific areas that might, in some cases, not be relevant in Africa. Africa can identify its unique requirements for the applications of IoT. Africa has the opportunity not only to adopt IoT but also to lead in the adoption of this technology, especially in the development of applications and special sensors.

IoT Services Providers: IoT providers have an essential role in the societal transformation through the demonstration of the practicality and the benefit of their solutions. Understanding and appreciation of the potentials of the IoT could be the first step towards decision and policy makers consideration. IoT providers should be able to solve the prevailing privacy and security issues. IoT providers in Africa will always have concerns about the supportive policies and regulations in these countries for promoting the awareness and implementing the innovation of agriculture, healthcare, and education systems. Open data and data accessibility policies are still not clear for many African countries. IoT cannot be successful if there is no permission to access the produced data in the defined three sectors. Data ownership is one of the challenges for acceptance of the IoT by the users (Darrow 2016).

Local Communities: it is particularly important to involve the local communities and the end users of the IoT project in order to understand their needs, expectations, and what is the best way of delivering and implementing IoT projects.

Theoretical Foundations and Research Model

The research model is based on the integration of two theories, namely: Social Shaping of Technology (SST) and Actor Network Theory (ANT). SST is associated with the explanation of technologies and the processes surrounding innovation. The theory covers a wide array of factors including political, social, organisational, and cultural issues. The theory explains the impact of these factors on the technological and social change (Williams and Edge 1996). ANT describes the actors that have a common interest in a heterogeneous environment. The focal concern of this theory is in explaining the relationships that exist between materials (things) and concepts. It involves both human and non-human elements in a network of relationships (Law and Callon 1988). SST will provide the research with important theoretical perspective as the study aims to investigate the potential transformation that IoT could have in societies. ANT is important for the potential qualitative data analysis (Deering et al. 2012), and it is also appropriate because it highlights both the technical and the social aspects of the study context (see Figure 1). The SST was not only used in information systems studies but also in various technological artefacts such as refrigerators and light bulb. ANT is a social science theory. It is a constructive rather than explanatory approach. From the context of the two theory, we understand that they are useful in studying the IoT challenges and opportunities in a social environment.

Our research model considers the inclusion of various stakeholders (i.e. IoT providers, policy makers, and users), who have the potential to be involved in the IoT initiatives, which can have influences in transforming third world societies. As specified in Figure 1, the ANT approach is found to be a useful theoretical tool for analysing the complexity of the network of relationships, the communication network, and the technological entities role (Cresswell et al. 2010). Understating the relationships between different actors in a network helps in examining the social influences (Datta 2011). The SST will help us in analysing the 'sociotechnical transformation' (Russell and Williams 2002, p. 45). The integration of the two theories is ascertained to be appropriate for guiding this study.

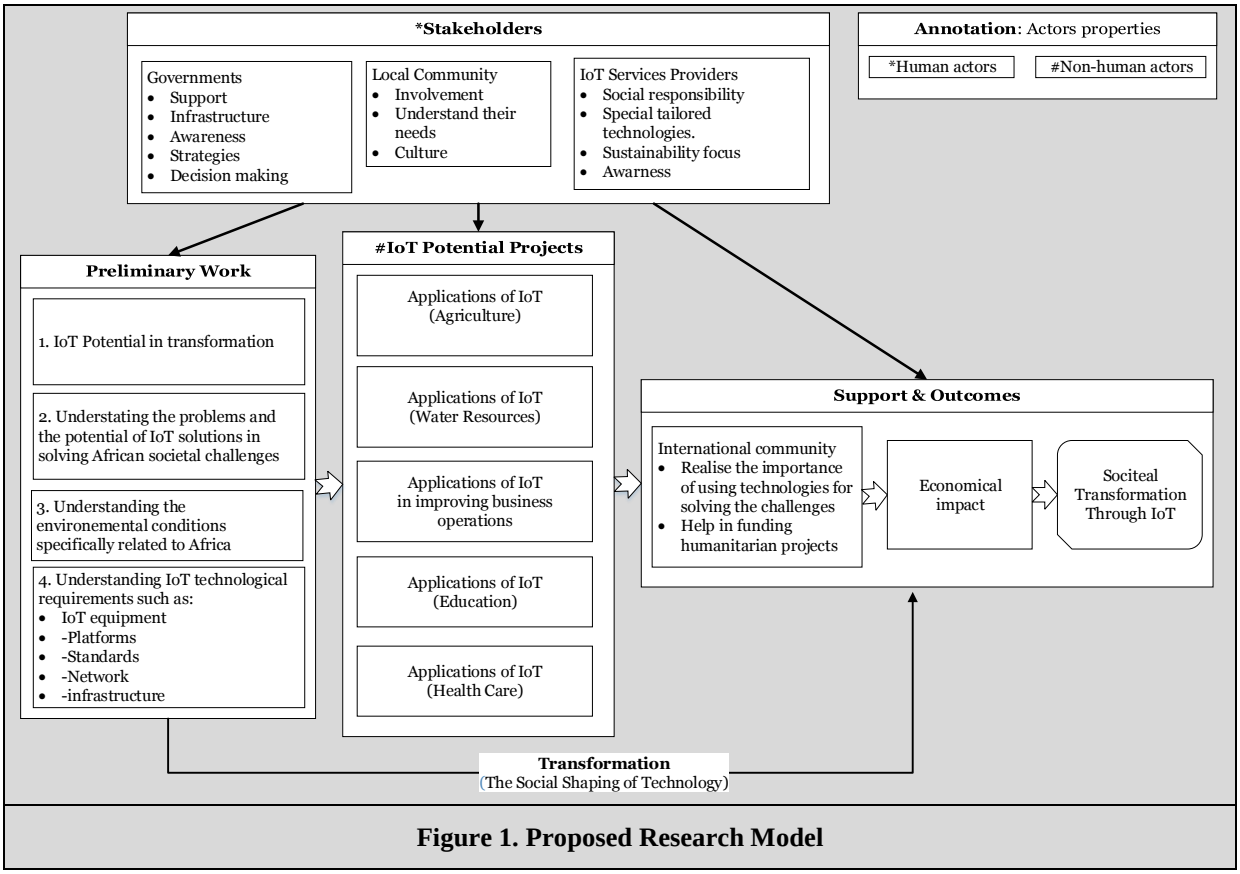

Figure 1. Proposed Research Model

Methodology

As discussed above, this study has proposed SST and ANT as possible theoretical foundations for exploring the potentially positive impacts that IoT could have for the alleviation of societal challenges in Africa. The field study will be based in Tanzania where we have available resources and social background to initiate the research. We plan to conduct case studies, observations, and analysis of documents and materials. The field study will also include semi-structured interviews with various people including individuals in communities, decision-makers in the local municipalities, government policymakers and experts in the area of IoT application. Measurement items will be sourced from the literature as applicable. The research will follow an exploratory approach due to the current limited understanding of this topic as evident in the literature. For data analysis, we are planning to use Nvivo v.10 and Tableau Analytics v.10.

Discussion

The paper also proposes a research model and pursues suggestions from the research community. Future field studies are required to evaluate the impact of the implementation of IoT technologies in different societies in Africa. This paper acts as an agent for change by highlighting some of the areas where IoT can make significant contributions to the standing challenges in areas such as agriculture and healthcare. We hope the message of this paper can reach the IoT providers and articulate their business strategies in transforming not only 'things' to services but also people from miserable situations to more favourable situations. In realising the potential of IoT in solving African challenges, governments need to take the initiatives in establishing the infrastructure of this technology. Governments need to think about investing in fibre optics backbone infrastructure for Wi-Fi technology and other supportive infrastructures. African country leaders need to have a clear plan to benefit their communities from these accessible technologies. The issues of device and system compatibility require the delivery of open source software and hardware. Additional supportive network infrastructure and technologies for IoT are essential for boosting the implementation of proper solutions towards the alleviation of the inherited problems in Africa. The lack of support from governments might have a negative effect on the ability of these emergent technologies to provide

solutions to problems such as the lack of education, health care, agriculture development, and proper management of water resources.

Conclusion

This paper contributes to alerting the research community of the significance of IoT-enabled transformation in Africa. The discussed challenges require a collaborative effort from various stakeholders to convert the potentials that these promising technologies have upon practical solutions. We believe that enhancing the performance of sectors such as education, healthcare, and agriculture through the use of IoT technologies would help in leveraging the prosperity of the African countries.

References

Bardaki, C., Kourouthanassis, P., and Pramatari, K. 2012. "Deploying Rfid-Enabled Services in the Retail Supply Chain: Lessons Learned toward the Internet of Things," *Information Systems Management* (29:3), pp. 233-245.

Bęcek, K. 2016. "Real-Time Mapping: Contemporary Challenges and the Internet of Things as the Way Forward," *Geodesy & Cartography (2080-6736)* (65:2), pp. 129-137.

Biggs, P., Garrity, J., LaSalle, C., and Polomska, A. 2015. "Harnessing the Internet of Things for Global Development," International Telecommunication Union, Geneva, Switzerland

Bo, L., and Yulong, L. 2017. "Internet of Things Drives Supply Chain Innovation: A Research Framework," *International Journal of Organizational Innovation* (9:3), pp. 71-92.

Cresswell, K. M., Worth, A., and Sheikh, A. 2010. "Actor-Network Theory and Its Role in Understanding the Implementation of Information Technology Developments in Healthcare," *BMC Med Inform Decis Mak* (10:1), p. 67.

Dachyar, M., and Risky, S. A. "Improving Operational System Performance of Internet of Things (Iot) in Indonesia Telecommunication Company," Place of Publication: Jakarta, Indonesia. Country of Publication: UK.: IOP Publishing, p. 012014.

Darrow, B. 2016. "Internet of Things: The Question of Who Owns the Data Is About to Get a Lot Trickier." 15 January 2016, from http://fortune.com/2016/04/06/who-owns-the-data/

Datta, P. 2011. "A Preliminary Study of Ecommerce Adoption in Developing Countries," *Information Systems Journal* (21:1), pp. 3-32.

Deering, P., Tatnall, A., and Burgess, S. 2012. "Adoption of Ict in Rural Medical General Practices in Australia: An Actor-Network Study," *Social Influences on Information and Communication Technology Innovations*), p. 40.

Ding, L., Chen, Y., and Li, J. 2016. "Monitoring Dangerous Goods in Container Yard Using the Internet of Things," *Scientific Programming*), pp. 1-12.

Ferrández-Pastor, F. J., García-Chamizo, J. M., Nieto-Hidalgo, M., Mora-Pascual, J., and Mora-Martínez, J. 2016. "Developing Ubiquitous Sensor Network Platform Using Internet of Things: Application in Precision Agriculture," *Sensors (14248220)* (16:7), pp. 1-20.

Fleming, K., Waweru, P., Wambua, M., Ondula, E., and Samuel, L. 2016. "Toward Quantified Small-Scale Farms in Africa," *IEEE Internet Computing* (20:3), pp. 63-67.

GoldmanSachs. 2016. "The 5g Revolution: The Internet of Things Meets Everything." 01 February 2017, from http://www.goldmansachs.com/our-thinking/pages/iot-meets-everything.html

Gondim, J. J. C., de Oliveira Albuquerque, R., Nascimento, A. C. A., Villalba, L. J. G., and Tai-Hoon, K. 2016. "A Methodological Approach for Assessing Amplified Reflection Distributed Denial of Service on the Internet of Things," *Sensors (14248220)* (16:11), pp. 1-31.

Ivaşcu, T., Frîncu, M., and Negru, V. 2016. "Considerations Towards Security and Privacy in Internet of Things Based Ehealth Applications," *Intelligent Systems and Informatics (SISY), 2016 IEEE 14th International Symposium on*: IEEE, pp. 275-280.

Jayaraman, P. P., Yavari, A., Georgakopoulos, D., Morshed, A., and Zaslavsky, A. 2016. "Internet of Things Platform for Smart Farming: Experiences and Lessons Learnt," *Sensors (14248220)* (16:11), pp. 1-17.

KPMG-SouthAfrica. 2016. "The Internet of Things: Threat and Opportunity in One."

Kshetri, N. 2016. "The Economics of the Internet of Things in the Global South," *Third World Quarterly*), pp. 1-29.

Law, J., and Callon, M. 1988. "Engineering and Sociology in a Military Aircraft Project: A Network Analysis of Technological Change," *Social Problems* (35:3), pp. 284-297.

Lo, B. P., Thiemjarus, S., King, R., and Yang, G.-Z. 2005. "Body Sensor Network–a Wireless Sensor Platform for Pervasive Healthcare Monitoring," *Proc. 3rd Int. Conf. Pervasive Computing*), pp. 77–80.

Mathaba, S., Dlodlo, N., Smith, A., and Adigun, M. 2011. "The Use of Rfid and Web 2.0 Technologies to Improve Inventory Management in South African Enterprises," *Electronic Journal of Information Systems Evaluation* (14:2), pp. 228-241.

Meng, Y., Qingkui, C., and Xiong, N. N. 2016. "An Effective Massive Sensor Network Data Access Scheme Based on Topology Control for the Internet of Things," *Sensors (14248220)* (16:11), pp. 1-25.

Russell, S., and Williams, R. 2002. "Social Shaping of Technology: Frameworks, Findings and Implications for Policy with Glossary of Social Shaping Concepts," *Shaping technology, guiding policy: Concepts, spaces and tools*), pp. 37-132.

Stočes, M., Vaněk, J., Masner, J., and Pavlík, J. 2016. "Internet of Things (Iot) in Agriculture - Selected Aspects," *Agris On-Line Papers in Economics & Informatics* (8:1), pp. 83-88.

Wentao, Z., and Jun, D. "The Application of Internet of Things Technologies on the Status Management of the Equipment under the Coal Mine," Place of Publication: Jiaozuo, China. Country of Publication: Switzerland.: Trans Tech Publications Ltd., pp. 921-925.

Williams, R., and Edge, D. 1996. "The Social Shaping of Technology," *Research policy* (25:6), pp. 865-899.

Wright, A. 2017. "Mapping the Internet of Things," *Communications of the ACM* (60:1), pp. 16-18.

Yuqiao, Y., and Kanhua, Y. 2016. "Construction of Distance Education Classroom in Architecture Specialty Based on Internet of Things Technology," *International Journal of Emerging Technologies in Learning* (11:5), pp. 56-61.

Zander, S., Trang, S. T.-N., Mandrella, M., Marrone, M., and Kolbe, L. M. 2015. "Integrating Industry Characteristics in Inter-Organizational Is Adoption Models: A Mixed Method Approach," *PACIS*, p. 206.