ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/330348888

The Transformative Effect of the Internet of Things on Business and Society

Article *in* Communications of the Association for Information Systems · January 2019

DOI: 10.17705/1CAIS.04405

CITATIONS
45

READS
5,968

6 authors, including:


Jung P. Shim
Georgia State University(GSU); Mississippi State University(MSU)
157 PUBLICATIONS **5,168** CITATIONS

SEE PROFILE


Michel Avital
Copenhagen Business School
114 PUBLICATIONS **3,392** CITATIONS

SEE PROFILE


Alan R. Dennis
Indiana University Bloomington
306 PUBLICATIONS **24,370** CITATIONS

SEE PROFILE


Matti Rossi
Aalto University
242 PUBLICATIONS **9,705** CITATIONS

SEE PROFILE

All content following this page was uploaded by Jung P. Shim on 06 April 2019.

The user has requested enhancement of the downloaded file.

Communications of the Association for Information Systems

Volume 44 Article 5

1-2019

The Transformative Effect of the Internet of Things on Business and Society

J.P. Shim
Georgia State University, jpshim@gsu.edu

Michel Avital
Copenhagen Business School

Alan R. Dennis
Indiana University

Matti Rossi
Aalto University

Carsten Sørensen
London School of Economics and Political Science

See next page for additional authors

Follow this and additional works at: https://aisel.aisnet.org/cais

Recommended Citation

Shim, J., Avital, M., Dennis, A. R., Rossi, M., Sørensen, C., & French, A. (2019). The Transformative Effect of the Internet of Things on Business and Society. Communications of the Association for Information Systems, 44(1), pp-pp. https://doi.org/10.17705/1CAIS.04405

This material is brought to you by the AIS Journals at AIS Electronic Library (AISeL). It has been accepted for inclusion in Communications of the Association for Information Systems by an authorized administrator of AIS Electronic Library (AISeL). For more information, please contact elibrary@aisnet.org.

The Transformative Effect of the Internet of Things on Business and Society

Authors
J.P. Shim, Michel Avital, Alan R. Dennis, Matti Rossi, Carsten Sørensen, and Aaron French

This panel report is available in Communications of the Association for Information Systems: https://aisel.aisnet.org/cais/vol44/iss1/5

Communications of the Association for Information Systems

Panel Report DOI: 10.17705/1CAIS.04405 ISSN: 1529-3181

The Transformative Effect of the Internet of Things on Business and Society

J. P. Shim
Georgia State University
USA
jpshim@gsu.edu

Michel Avital
Copenhagen Business School
Denmark

Alan R. Dennis
Indiana University
USA

Matti Rossi
Aalto University
Finland

Carsten Sørensen
London School of Economics and Political Science
United Kingdom

Aaron French
University of New Mexico
USA

Abstract:

This paper summarizes the discussion in a panel session on the Internet of things (IoT) at the 2017 International Conference on Information Systems (ICIS) in Seoul, Korea. The panel explored a research agenda on IoT technology and its interaction with business and society. IoT refers to the ever-growing number of numerous physical devices that feature software and location-based technologies that connect together in a network and exchange data with one another. IoT has garnered significant attention in information systems due to its rapidly expanding market and demand from a wide range of stakeholders such as consumers, businesses organizations, and government agencies. The IoT may be the next industrial revolution in which interconnected physical devices will automate skills and tasks. In today's hyper-connected economy, IoT can radically transform businesses and society through increased transparency, optimized production processes, and decreased operating expenses. Overall, the panel identified a six-pronged IS research agenda for IoT that comprises the IoT's impact on business and society, IoT monetization and end-user services, the IoT as a distributed platform, the convergence of the IoT and blockchain, security concerns and solutions, and the IoT and ethics. The paper concludes with a future direction for IoT.

Keywords: Internet of Things, IoT Platforms, IoT Standards, Monetization, End-User Services, Business Transformation, Security, Blockchain Technology, Ethics.

This manuscript underwent editorial review. It was received 04/30/2018 and was with the authors for 2 months for 1 revision. Christoph Peters served as Associate Editor.

1 Introduction

The Internet of things (IoT) refers to things connected to the Internet that can communicate with one another and that one can access through ubiquitous technologies (Atzori, Iera, Morabito, & Nitti, 2012). The IoT has garnered significant attention in information systems (IS) because it affords ubiquitous services with increased connectivity and integration into business and society that offer myriad opportunities. A recent report from McKinsey & Company has projected companies' connectivity expenditures to increase 15 percent annually through 2022 (Baroudy, Kishore, Nair, & Patel, 2018). Further, reports from Gartner, Deloitte, McKinsey, and the Info-Tech Research Group (Raynor & Cotteler, 2015; Info-Tech Research Group, 2015; Zhang, 2016) have emphasized the prevalence of IoT and projected the IoT industry to be a multi-trillion-dollar opportunity with 50 billion devices connected by 2020. In today's hyper-connected economy and environment, IoT has the potential to radically transform businesses and society through increased transparency, increased output and uniformity, and decreased operating costs. Numerous physical devices and objects referred to as "smart" devices (e.g., appliances, trashcans, water meters, vending machines) now feature software and location-based technologies that connect to networks that exchange data with each other ubiquitously. This "instrumented," "interconnected", and "intelligent" connectivity between devices positions IoT as a technology with the potential to make a significant impact on the human enterprise and its organization. The IoT is also one of the technologies setting the path for the fourth industrial revolution in which interconnected physical devices will automate skills and tasks, which will have a direct impact on the way consumers, businesses, and governments interact with the world.

The IoT has resulted in numerous new technologies referred to as "smart" technologies. The current principal growth areas for IoT products have been in consumer goods, which range from connected cars to voice-activated assistants in smartphones, wearable devices, and appliances with sensors. IoT consumer products have affected consumers' daily lives through service automation, allowing, for example, to open locks (e.g., with a remote control), to shop and pay for goods (e.g., using a smartphone to shop online with an electric wallet), and to track fleet trucks on the highway and in freight yards. The use of sensors on animals, such as sharks, allows researchers to study their migration and activities (Ritz & Knaack, 2017). Many IoT applications have the potential to increase efficiency, improve quality of life, and enable better management. The IoT can also allow governments to create and integrate intelligent technical solutions that smart cities require, such as smart transportation systems, smart parking, smart buildings, and smart bridges.

While IoT offers many bright benefits, it also has a dark side. Some have also expressed concerns about the negative consequences that IoT may have on the nature of work and data security. The introduction of IoT and automated systems has already fueled industry cost savings as the manufacturing industry has replaced many employees with wirelessly controlled robots. This trend will likely eliminate thousands of more manufacturing jobs in the future. The debate about whether manufacturing firms should outsource their jobs or not (and, thus, lead to onshore employee losses) will no longer represent a primary concern as manufacturing turns from human resources to IoT-enabled production.

In this paper, we provide IS scholars with an IoT-related research agenda. Various obstacles remain in the IoT arena, such as connection efficiency, platform and standards, security, data analytics, monetization of end-user services, the convergence of the IoT and Blockchain, privacy, and compliance. The panel addressed the following questions to the audience:

- What connectivity issues does the IoT experience?
- How efficient are IoT devices from a technical perspective?
- What is the status of IoT platforms and standards?
- What role does cybersecurity play in the IoT and why is IoT security so important?
- What are characteristics, challenges, and trends of IoT data analytics?
- What are the challenges in sensor-based service management?
- What strategies are most appropriate for IoT data monetization?
- What role does the convergence of IoT and blockchain technology play?
- What benefits, privacy concerns, compliances, and ethical issues can we expect with the IoT?

With IoT influencing the way consumers, businesses, and governments interact with the world, we need to explore numerous related opportunities and challenges in IoT from multifaceted perspectives to holistically view the phenomenon.

This paper summarizes a panel session on the IoT at the 2017 International Conference on Information Systems (ICIS). The panel explored a research agenda of IoT that the opportunities and challenges of technology in the context of its interaction with business and society drive. Against the backdrop of IS research, this paper comprises four sections. In Section 2, we provide background information on the IoT in the business context. In Section 3, we present a six-pronged IS research agenda for IoT that comprises the IoT's impact on business and society, IoT monetization and end-user services, the IoT as a distributed platform, the convergence of the IoT and blockchain, security concerns and solutions, and the IoT and ethics. Finally, in Section 4, we conclude by discussing future directions for IoT.

2 Internet of Things in the Business Context

One can apply the IoT to and adopt it in various industries, such as utilities, transportation and logistics, consumer electronics, public sectors/smart cities, smart buildings, and industrial automation. Figure 1 demonstrates numerous use cases in various industries (Shim et al., 2017a; Kamilaris & Pitsillides, 2016). One can fundamentally dichotomize the IoT into two types: consumer IoT and industrial IoT. Consumer IoT encompasses common devices for everyday use that revolve around end-user consumption, such as smartphones, tablets, refrigerators, televisions, and household appliances. Industrial IoT involves the transformation of industries, such as power companies using the IoT to control electrical grids and transportation agencies controlling traffic signs. Connectivity has become a significant component of everyday life from the home to the office. Figure 2 illustrates numerous connected enterprises, such as open architected common platforms; edge-enabled devices, data, and analytics; global-scale data and analytic services; and common applications and service workflow. Furthermore, these enterprises comprise connected buildings, vehicles, workers, homes, plants, aircraft, and supply chains. These examples represent a fraction of connected devices since IoT also covers remote monitoring devices used in remote locations. A dramatic increase in machine-to-machine (M2M) installations characterize the IoT's diffusion.

Figure 1. IoT in Various Industries and Use Cases (Shim, Dam, Coursey, & Barney, 2017b)

Businesses across all industries can use the IoT to improve productivity, reduce operating expenses, and assist with new product development. One can identify how IoT can affect businesses and consumers in concrete examples, such as in Coca-Cola's using the IoT to improve its business by gathering real-time data on products that it needs to restock in its vending machines. Coca-Cola can also pull data on which products sell well to improve their product line (Coates, 2016).

Emerging research efforts have investigated the innovation dynamics of digital platforms that implement multisided markets, which facilitate distributed innovation complements (de Reuver, Sørensen, Basole, 2017; Constantinides, Henfridsson, & Parker, 2018). This work pertains highly to understanding the innovation dynamics of the IoT. Platform research points to the essential need to first consider the interrelationships between digital services, platforms, and infrastructures. For example, in the smartphone ecosystem, individuals and companies create apps in a highly distributed innovation arrangement to deliver value to smartphone users (Eaton, Elaluf-Calderwood, Sørensen, & Yoo, 2015). The main app store platforms capture this value and take a platform tax. The service (apps and media content) is subsequently distributed on the open Internet. One can see the IoT as further developing generative digital infrastructures (Sørensen, 2016). This generative infrastructure functions as a delivery mechanism for IoT services, which deliver value to someone. Digital platforms that leverage a platform tax on contributions likely capture this value (Kazan, Tan, Lim, Sørensen, & Damsgaard, 2018).

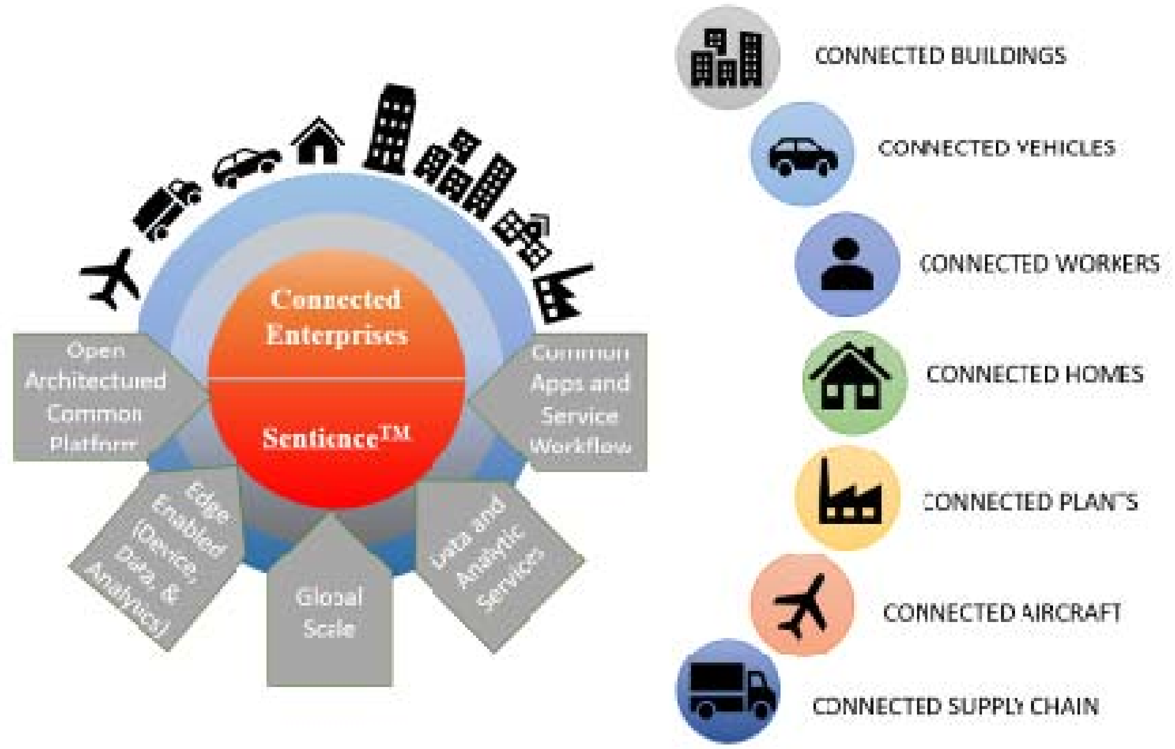

Figure 2. Industrial IoT: Connected Enterprises (Patel, 2018)

Much work has focused on developing devices, communication standards, and a range of suggested use cases for the IoT. Companies, such as General Electric, Siemens, Samsung, Huawei, Nokia, ARM, and many others have focused on establishing IoT middleware and platforms. While the diversity of IoT platforms expands, they remain mostly isolated and uncooperative. Few widely established middleware and digital platforms exist beyond the current platforms, such as Apple, Google, and Amazon, which seek to expand their reach by broadening their device ecology beyond smartphones and tablets. The diversity of IoT use cases makes it unlikely that these few companies alone will successfully capture the IoT market, set the middleware standards, and control the global IoT market through a duopoly or triopoly. The complexity of the possible use cases with new types of devices and the existing in-depth knowledge of these use cases across a diversity of companies make a scenario in which the current digital platform companies dominate the IoT highly unlikely. Whereas smartphone generativity has mostly pertained to software, the IoT more concerns hardware generativity and hardware-software integration.

As such, the emerging number of standards and IoT platforms, which may or may not provide interoperability and smooth user experience, represents the IoT's immediate challenge for innovation. Any future in-depth and open collaboration between platforms seems unlikely. For IoT platform contenders, a smartphone platform may look like an enticing inspiration to fence off the open Internet and claim a platform tax on service. However, given the demand-driven markets of technology with network externalities and the various use cases for IoT, the end user experience will likely remain fragmented and poor unless the IoT industry establishes significantly more open standards and interoperable services and data. A lack of collaboration and interoperability between IoT platforms can both result in reduced user experience and lack of advanced features.

3 IS Research Agenda for IoT

The discussion among the panelists revealed six key topics of interest to IS scholars: the IoT's impact on business and society, IoT monetization and end-user services, the IoT as a distributed platform, the convergence of the IoT and blockchain, security concerns and solutions, and the IoT and ethics.

3.1 IoT Impact on Business and Society

The short-term and immediate impacts of innovations often receive the most attention, especially in popular media. However, society will most likely realize the IoT's most significant impacts over decades rather than years. Instead of human labor-intensive manual inventory updates that cost time and money, the IoT allows real-time updates based on the physical movement of things to inform businesses about when to replenish inventory, which not only saves time but also operating expenses. Ever-growing streams of data that smart objects, smart machines, and smart buildings produce have become part and parcel of the human enterprise. Sensors can send real-time updates on conditions such as humidity, light, temperature, motion, and sounds. Many sectors can use these sensors, such as in healthcare, where wearable sensors can report on the health and conditions of patients through remote monitoring (Chatterjee et al., 2018).

With the rapid growth of the IoT industry, the demand for IoT-enabled development has continually increased, though the supply of programmers has remained stagnant over the past decade (Roscher-Nielsen, Ratliff, Rudy, & Petroules, 2017). Thus, many companies face challenges in acquiring the necessary skills to create IoT-enabled devices to meet the demand. To create such devices, companies need people with high-level technical skills in current programming languages and who understand the business environment and infrastructure that these devices will operate in. Software developers are always in high demand, but IoT's growth will increase that demand, which may give the IS field the opportunity to grow enrollment at universities to meet the demand for graduates. To capture the attention of the industry and hire IS graduates, we will need to make some changes—especially for IS departments to compete with the technical institutes that provide specific skills that companies seek. Surprisingly, many universities still teach programming using Cobol, Visual Basic, or HTML. While these programs can help students learn programming logic, they lack the desirable qualities that many companies look for when hiring new employees.

The IoT can also transform society in many different ways. For one, it represents an instrumental factor in creating smart cities, which could usher in a new era of city dwelling. For example, the IoT could monitor a city's infrastructure and send a signal if any part of a building became overloaded with vibrations (e.g., from an earthquake). IoT can also manage traffic during traffic jams, peak hour traffic, or accidents. Streetlights equipped with IoT sensors can automatically adjust brightness according to how much light the clouds block.

3.2 IoT Monetization and End User Services

Many industry analysts see the IoT as a way to streamline supply chain management with more efficient output and to provide sensor-based service management in the B2B and B2C contexts. However, new customer services based on a radical rethinking of IoT possibilities offer far more interesting opportunities to provide customer value and monetizing services. For example, companies can follow how each company in a supply chain processes food to avoid foodborne disease outbreaks. Companies can also provide customers with detailed information about where the food comes from and how stakeholders in the supply chain have treated it.

As for monetizing the IoT, for each IoT-based service, several different parties need to cooperate. The participants in the supply chain need to support the technology and standards that the service involves. Since devices or tags offer the most comprehensive data when they used throughout the supply chain and since only the customer-facing or supply chain-coordinating parties can monetize their benefits, the business models must ensure all involved parties receive benefits and, thus, cooperate (Leminen, Westerlund, Rajahonka, & Siuruainen, 2012; Keskin & Kennedy, 2015).

From device manufacturers to software developers, complexities stem from the need to minimize cost, size, and power consumption while maximizing processing and storage capacity. Cost does not represent an issue with high-value items, but it does for cheap mass-produced goods and perishables. B2B businesses have largely seen the IoT as a cost-cutting and better-tracking opportunity. Indeed, some businesses already provide services by business models based on leasing and continuously monitoring and providing preventative maintenance, such as Rolls Royce, which leases engines to airlines (Thomas, 2016). In this case, the data that sensors in the engines provide allow Rolls Royce to employ a new service-based business model.

In contrast, consumer businesses have leveraged the IoT in various ways, such as to create self-stocking and self-notifying refrigerators that automatically order more food products when stocks become low and allow food delivery via cameras and a smart lock, features that automatically save water, and sensors that readjust air quality. These types of automatic services increase convenience and show the potential of quantified information when providing services. A fridge magnet that allows users to reorder products and businesses to market them represents an integrated working example that demonstrates the possibilities of the IoT in consumer businesses (ThinFilm, 2018). The magnet enables the user to reorder products and pay for them through their smartphone app. We can see this type of mobile marketing app as a harbinger of data-driven IoT apps in which one can obtain information about products and even enhance the service experience through data available from the supply chain. Keskin and Kennedy (2016) note that an intelligent assistant, such as Amazon Echo or Google Home, can tie hardware sales (fridges), perishables (Amazon Fresh and groceries), and underlying service infrastructure and effectively create monopoly services through convenient ordering.

3.3 IoT as Distributed Platforms

One fundamental theoretical difference between IoT and most of the other new technologies is the materiality of IoT devices and their physical-spatial properties, which is quite different from other IT technological innovations and applications that are merely one more software package in the computer, laptop, or mobile device. Once installed, an IoT device (e.g., a vending machine) owns the physical space it occupies (at least until one replaces it). That physical space may be on a wall, a counter, a building, or a city street. As such, these spaces do not allow much room for a second IoT device. Once a physical product “owns” a location, it tends to stay there for a long time, which means the initial entry opens the door for follow-on innovation that may take on a very different form. For example, consider the smart trashcan. Once one deploys such a trashcan on a city street, it owns the space. Only the smart product will operate in that space. The trashcan can then become an electronic advertising display, emergency alert system, a Wi-Fi hotspot, a sensor array, a beacon, and so on. Any other vendor that tries to offer IoT solutions has to compete with the fact that an IoT device already exists in that space. Thus, IoT devices represent inherently potential platforms whether their vendors conceive of them in this way or not.

3.4 IoT and Blockchain Convergence

The IoT has the potential to transform business and society, but myriad technical, regulatory, and social obstacles hinder its diffusion. Blockchain technology can help to mitigate some of these roadblocks. Specifically, one can use blockchain technology to provide a solution to data security issues, identity management, and data monetization. The IoT builds on the vision that everything can be connected to everything to everything else to exchange data. Nodes can be anything that produces or consumes data: people, smart devices, services, objects, triggers, and sensors of all sorts. Connecting things assumes that we can trust the data’s veracity, but this assumption is questionable. The identity of the source and sink of the data can be spoofed and the data can be fake. As such, data security and reliability significantly hinder the IoT’s development and diffusion. Blockchain technology can authenticate the identity of the nodes in a network. It can also verify that only by authorized nodes can access data and, thereby, maintain data privacy and access control.

Building on its ability to create a distributed and tamper-proof digital record system, blockchain can turn IoT data traces from a security hazard into a reliable source of valuable data. Leveraging blockchain technology, IoT devices can send data to a private blockchain-based tamper-resistant database and, thereby, allow only authorized stakeholders to access and contribute IoT data without the need for central control and management (Shim et al., 2017a). Consequently, by providing the transparency across different stakeholders and across borders, the IoT implemented in combination with blockchain technologies can help to reduce misrepresentation and fraud in the entire supply chain (Huh, Cho, & Kim, 2017). The IoT on blockchain can provide more than just visibility: it can benefit not only logistics and supply chain management but also payment and value exchange management, organization and public administration, and an advanced collaborative economy on a global scale.

Blockchain can enable micropayments that can be used to monetize the data in IoT networks. For example, cars can send traffic information to other cars, to navigation services, and to traffic control centers. These kinds of data can be traded (or auctioned) in big data marketplaces that can facilitate analytics, marketing, and research as value-added services. Blockchain can enable a cost-effective way to pay data producers. However, the current common blockchain platforms involve high overhead and delays that conflict with high-bandwidth dynamic IoT networks. Using blockchain in the IoT would require forging lightweight blockchain architecture that mitigates the high overhead and delays while maintaining its ironclad security and privacy benefits (Dorri, Kanhere, Jurdak, & Gauravaram, 2017).

The IoT and blockchain convergence remains nascent and offers myriad research opportunities for IS scholars. System design challenges pervade throughout the entire milieu of IoT integration, and adding blockchain may mitigate some issues but also create some new technical challenges, especially given the immature and fast-evolving state of the technology. Furthermore, beyond the apparent technological challenges, IoT and blockchain convergence poses organizational challenges from both the business and public administration viewpoints. Last but not least, the sociometric properties of IoT and blockchain will likely have an effect on how we perceive and treat these IoT devices and how we behave and conduct everyday life when IoT devices pervade our natural habitat.

3.5 Security Solutions and Concerns

Drones have emerged in social, environmental, and economic applications such as energy conservation, environmental control, and traffic optimization and now see use in improving security through monitoring infrastructure, in preventing accidents, and in containing disasters. For example, General Electric has started using drones to inspect railroads and power lines. The drone flies along the tracks ahead of the train to spot any problems on the track (e.g., downed trees, stalled vehicles, broken tracks) so that if there is a problem, the engineers can stop the train in time. This also means that utility and railroad companies do not need to send human workers in helicopters or trucks to conduct manual inspections.

However, IoT devices can also create security problems because many users do not download and install security patches for their smart thermostat, doorbell, or baby monitor. The “Mirai” botnet, which was based on IoT devices, took the Internet by storm in late 2016 (Krebs, 2016). Likewise, the distributed denial of service (DDoS) attack on Dyn (a major DNS provider) that shut down large portions of the Internet in the United States on 21 October, 2016, largely came from IoT devices. So, consumers who do not download security patches potentially put the whole Internet at risk of additional disruptions.

3.6 IoT and Ethics

A code of ethical research, which one needs when dealing with enhanced smart systems, devices, and organizations, represents another aspect of the IoT that IS research needs to consider. Numerous researchers have dealt with ethical issues in information systems, such as Mason (1986) in his classic paper. Specifically, Mason elaborates on privacy, accuracy, property, and accessibility, which numerous researchers have used as the basis for their studies on IT ethics over the past three decades. Furthermore, ethical standards and conduct in IoT can reduce unethical behavior. Since IoT is an emerging technology, we believe that researchers should conduct ethical research on it—particularly in areas of healthcare, manufacturing, transportation, utilities, consumer electronics, and autonomous and connected cars (Waddell, 2017).

As Berman and Cerf (2017) have pointed out, we should pay careful consideration to the social and ethical conventions that are embedded in emerging ubiquitous digital infrastructures such as the IoT. On the one hand, the integrated ecosystem can focus on increasing efficiency of operations, empowering consumers, or providing opportunities by meeting a wide range of needs. On the other hand, the IoT infrastructure should be tuned to mitigate unintended consequences, such as privacy issues and inappropriate behavior (Berman & Cerf, 2017). As organizations further delve into understanding how to design and build these systems, they will need to consider governance in particular. Indeed, innovators, companies, governments, and individuals will have a shared responsibility to create and use a framework that assigns responsibility and accountability based on what promotes the public good.

4 Conclusion

A Cisco study found that about 60 percent of IoT project initiatives stall at the proof-of-concept stage and that only 26 percent of companies have had an IoT project initiative that they considered a success

(ITP.net, 2017). The Cisco study established that the most successful organizations engage with the IoT partner ecosystem at every stage. The study further showed that the top benefits of IoT included improved customer satisfaction, operational efficiencies, improved product/service quality, and improved profitability. Thus, organizations will benefit most from a holistic approach to IoT that takes in consideration the IoT devices, platforms, and standards, while paying attention to the socio-economic ecosystem that concerns with security, privacy compliance, data monetization, and technological convergence.

We need to consider how our lives will change when most devices become smart devices (Brynjolfsson & McAfee, 2016). Businesses and governments have already begun to take note and incorporate the value that the IoT presents into their business models. The IoT can drive new standards of quality in mundane products and services. It can also change daily job functions and the structure of the job market. The demand for IoT has increased significantly over the past several years, while the number of programmers has remained constant, which will create a high demand for programmers in the future. The number of programming jobs may increase but not at a rate that would replace the millions of jobs lost given programming's specialized nature.

To meet the needs of the industry and society, the IS field will need to rethink the programming courses it offers and its strategy in meeting this need. At a minimum, all Web-based programming classes should include HTML5, CSS3, and JavaScript as the core programming languages. These three languages are becoming the foundation of all Web-based applications and can respond to any environment from mobile devices to desktops. Using these languages, students can learn the programming fundamentals needed for success while also learning specific tools in high demand in the industry. Universities that have more resources can add additional programming courses using specific languages commonly used for IoT development, such as Java, Python, C, PHP, or Swift. Many universities already offer some of these languages, so they may need to simply refocus their programming goals to meet industry's needs. For higher-level programming needs, universities can consider courses that involve Linux, Ubuntu, Raspberry Pi, and specialized programming languages such as Unity or Qt Quick. While some universities have already started moving in these directions, they still need to make significant progress overall.

Leveraging blockchain technology, organizations can develop IoT networks to provide the infrastructure of a brave new digital future. In addition to the infrastructure, organizations need to consider interoperability when developing IoT networks. For instance, most IoT vendors have an incentive to capture as much as the IoT market possible along with their IoT ecosystems. Thus, they do not primarily care about interoperability. We hope that small and medium-sized companies step into the IoT market with innovative approaches that consider interoperability in particular. For example, they could use data to create new types of experience goods that attract little extra cost if the same IoT devices or smart tags are already used to manage the supply chain and product information. The plethora of data and wealth of information have the potential to significantly transform and perhaps disrupt various areas that concern society, government, and businesses.

When connected to, for example, individual products and the production process or story, these types of services can provide new business models and enhanced revenue (e.g., people could pay more for a proven locally sourced perishable) and provide food safety when the IoT device or tag can track the temperature of s perishable across the supply chain.

As IoT devices become cheaper and their complementary software services mature, we can expect a proliferation of new applications and business models based on the data that they generate. As more appliances, machines, and devices connect to the Internet, the risk that more information will become exposed will increase. At the same time, we need to understand and regulate these risks because many can invade end users' private spaces and unauthorized intruders or hackers can access confidential information, which may have grave consequences. The IoT, as with every other technology, has its advantages and disadvantages. While we should keep advancing as a society toward this digitalized future, we should do so in a responsible manner. In conclusion, we believe that future research should explore opportunities and challenges in the IoT from multifaceted perspectives in order to more holistically understand it.

Acknowledgments

We gratefully acknowledge the panel audience at “Internet of Things (IoT): Opportunities and Challenges to Business, Society, and IS Research” panel at the 2017 International Conference on Information Systems for their helpful comments. We also acknowledge Professor Olivia Sheng who served as a panelist.

References

Atzori, L., Iera, A., Morabito, G., & Nitti, M. (2012). The social Internet of things (SIoT)—when social networks meet the Internet of things: Concept, architecture and networking characterization. *Computer Networks*, *56*(16), 3594-3608.

Baroudy, K., Kishore, S., Nair, S., & Patel, M. (2018). Unlocking value from IoT connectivity: Six considerations for choosing a provider. *McKinsey&Company.* Retrieved from www.mckinsey.com/industries/high-tech/our-insights/unlocking-value-from-iot-connectivity-six-considerations--for-choosing-a-provider

Berman, F., & Cerf, V. (2017). Social and ethical behavior in the Internet of things. *Communications of the ACM, 60*(2), 6-7.

Brynjolfsson, E., & McAfee, A. (2016). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. New York, NY: W.W. Norton & Company.

Chatterjee, S., Byun, J., Dutta, K., Pedersen, R., Pottathil, A., & Xie, H. (2018). Designing an Internet-of-things (IoT) and sensor-based in-home monitoring system for assisting diabetes patients: Iterative learning from two case studies. *European Journal of Information Systems*, *27*(6), 670-685.

Coates, J. (2016). Why retail giant Coca-Cola is using IoT connected vending machines. *Internet of Business.* Retrieved from https://internetofbusiness.com/supply-chain-iot-coca-cola/

Constantinides, P., Henfridsson, O., & Parker, G. G. (2018). Special issue introduction: Platforms and infrastructures in the digital age. *Information Systems Research, 29*(2), 381-400.

de Reuver, M., Sørensen, C., & Basole, R. (2017). The digital platform: A research agenda. *Journal of Information Technology*, *33*(2), 124-135.

Dorri, A., Kanhere, S. S., Jurdak, R., & Gauravaram, P. (2017). Blockchain for IoT security and privacy: The case study of a smart home. *In Proceedings of the IEEE International Conference on Pervasive Computing and Communications* (pp. 618-623).

Eaton, B. D., Elaluf-Calderwood, S., Sørensen, C., & Yoo, Y. (2015). Distributed tuning of boundary resources: The case of Apple's iOS service system*. MIS Quarterly, 39*(1), 217-243.

Huh, S., Cho, S., & Kim, S. (2017). Managing IoT devices using blockchain platform. *In Proceedings of the 19th International Conference on Advanced Communication Technology* (464-467).

Info-Tech Research Group. (2015). *Seize the potential of the Internet of things today*. Retrieved from https://www.infotech.com/research/ss/seize-the-potential-of-the-internet-of-things-today

ITP.net. (2017). *Cisco: 60% of IoT projects staff at PoC stage*. Retrieved from www.itp.net/612937-cisco-60-of-iot-projects-stall-at-poc-stage.

Kamilaris, A. & Pitsillides, A. (2016). Mobile phone computing and the Internet of things: A survey. *IEEE Internet of Things Journal*, *3*(6), 885-898.

Kazan, E., Tan, C.-W., Lim, E. T. K., Sørensen, C., & Damsgaard, J. (2018). Disentangling digital platform competition: The case of UK mobile payment platforms. *Journal of Management Information Systems*, *35*(1), 180-219.

Keskin, T., & Kennedy, D. (2015). *Strategies in smart service systems enabled multi-sided markets: Business models for the Internet of things* in *Proceedings of the 48th Hawaii international conference on System Sciences* (pp. 1443-1452).

Krebs, B. (2016). New Mirai worm knocks 900k Germans offline. *Krebs on Security.* Retrieved from https://krebsonsecurity.com/2016/11/new-mirai-worm-knocks-900k-germans-offline/

Leminen, S., Westerlund, M., Rajahonka, M., & Siuruainen, R. (2012). Towards IOT ecosystems and business models. In *Proceedings of the International Conference on Next Generation Wired/Wireless Networking* (LNCS vol. 7469, pp. 15-26).

Mason, R. (1986). Four ethical issues of the information age. *MIS Quarterly*, *10*(1), 5-12.

Patel, J. (2018). *Critically Connected*. Presented at MAC IoT Atlanta Leadership Council Meeting, Atlanta, GA.

Raynor, M., & Cotteleer, M. (2015). The more things change: Value creation, value capture, and the Internet of things. *Deloitte Review*, *17*, 51-65.

Ritz, J., & Knaack, Z. (2017). Internet of things. *Technology and Engineering Teacher*, *76*(6), 28-33.

Roscher-Nielsen, N. C., Ratliff, E., Rudy, G., & Petroules, J. (2017). Internet of things and security (panel discussion). *Qt*. Retrieved from https://www1.qt.io/event/iotsecurity/

Shim, J. P., Avital, M., Dennis, A., Sheng, O., Rossi, M., Sorensen, C., & French, A. (2017a). Internet of things: Opportunities and challenges to business, society, and IS research in *Proceedings of the International Conference on Information Systems*.

Shim, J. P., Dam, R., Coursey, C., & Barney, D. (2017b). *IoT and the opportunities for mobile operators.* Panel discussion at the Wireless Telecommunication Symposium, Chicago, IL.

Sørensen, C. (2016). The curse of the smart machine? Digitalisation and the children of the mainframe. *Scandinavian Journal of Information Systems*, *28*(2), 57-68.

ThinFilm. (2018). *Campari America taps Thinfilm's NFC mobile marketing solution to drive ecommerce.* Retrieved from http://thinfilmnfc.com/2018/01/08/campari-america-taps-thinfilms-nfc-mobile-marketing-solution-drive-ecommerce/

Thomas, I. (2016). Enabling the outcome economy in the IoT. *GlobalSign*. Retrieved from https://www.globalsign.com/en/blog/enabling-the-outcome-economy-in-the-iot/

Waddell, K. (2017) The Internet of things needs a code of ethics. *The Atlantic.* Retrieved from www.theatlantic.com/technology/archive/2017/05/internet-of-things-ethics/524802.

Zhang, K. (2016). A passive multi-channel synchronization solution for IoT. In *Proceedings of the 8th Annual S3 Workshop* (pp. 42-44).

About the Authors

J. P. Shim is CIS faculty and KABC Director at Georgia State. He is Professor Emeritus and was Professor/Notable Scholar/John Grisham Professor at Mississippi State (MSU). He received grants on telecom/RFID/e-business from NSF, Microsoft, Small Business Administration, and Mississippi IHL. He has published books and 100+ articles. He taught at U of Wisconsin, New York University, Chinese U of HK, and MSU. He has served as WTS/IEEE Program/chair, IoT Track/Panel/chair, and AMCIS Program Co-chair.

Michel Avital is Professor of Digitalization at Copenhagen Business School. Digital innovation entrepreneurship is the leitmotif of Michel's work that focuses on technology and organization with an emphasis on its social and organizational aspects. He has published over 100 papers on topics such as blockchain technology, sharing economy, big data, open data, open design, generative design, creativity, innovation, green IT and sustainable value. He serves as an editorial board member of seven leading IS journals and he is an advocate of openness, cross-boundaries exchange, and collaboration. Further information: http://avital.net

Alan R. Dennis is Professor of Information Systems and holds the John T. Chambers Chair of Internet Systems in the Kelley School of Business at Indiana University. He was named a Fellow of the AIS in 2012. His research focuses on three main themes: team collaboration; digital nudging; and IS security. He is Editor-in-Chief of *AIS Transactions on Replication Research* and AIS President Elect.

Matti Rossi is a Professor of Information Systems at Aalto University School of Business. He was the winner of the 2013 Millennium Distinction Award of Technology Academy of Finland for open source and data research. His research papers have appeared in journals such as *MIS Quarterly*, *Journal of Association for Information Systems*, *Information and Management* and *Information Systems*. He is a past Editor-in-Chief of *Communications of the Association for Information Systems* and the President of AIS.

Carsten Sørensen is Reader (Associate Professor) in Digital Innovation within Department of Management at The London School of Economics and Political Science (carstensorensen.com). Carsten has since the 1980s researched digital innovation, such as; enterprise mobility, and digital infrastructures and platform innovation dynamics. He has published widely within, for example, *MIS Quarterly*, *Information Systems Research*, *Journal of Information Technology*, and *Information Systems Journal* and has 25 years' industry consulting experience for IMF, Microsoft, Google, PA Consulting, Orange, Vodafone, Intel, to name just a few.

Aaron M. French is Assistant Professor of MIS at University of New Mexico. He received his PhD from Mississippi State University. His research has been published in the *Journal of Information Technology*, *Information and Management*, *Behaviour & Information Technology*, *Journal of Computer Information Systems*, and *Communications of the Association for Information Systems*. His research interests include Internet of things, bring your own device, social networking, big data and analytics, and cross-cultural studies.

Copyright © 2019 by the Association for Information Systems. Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and full citation on the first page. Copyright for components of this work owned by others than the Association for Information Systems must be honored. Abstracting with credit is permitted. To copy otherwise, to republish, to post on servers, or to redistribute to lists requires prior specific permission and/or fee. Request permission to publish from: AIS Administrative Office, P.O. Box 2712 Atlanta, GA, 30301-2712 Attn: Reprints or via e-mail from publications@aisnet.org.

View publication stats