Chapter 8
The Internet of Things in the Corporate Environment:
Cross-Industry Perspectives and Implementation Issues

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ABSTRACT

The Internet of Things (IoT) is formed by a set of physical objects with embedded sensors, connected using a network so that they can collect and exchange data. Though the concept looks simple, its deployment in industry has enormous potential to bring major business benefits and radical change. This chapter examines IoT technology and how it is being used in the corporate environment. Based on a review of existing literature and case examples, the various definitions and elements of IoT are discussed, followed by an assessment of how IoT is being used and what benefits are being delivered. Some key emergent themes are then examined – security aspects, the significance of 5G networks, and the need for an IoT strategy and project implementation guidelines. The chapter concludes by outlining possible areas for future research and suggests a step-change in the mega-infrastructure connecting IoT devices is imminent.

INTRODUCTION

The term "Internet of Things" (IoT) was reputedly first introduced by Kevin Ashton of the Massachusetts Institute of Technology in a presentation to Procter & Gamble in 1999. However, the concept of connected devices even then was not new, but rather built on the principles of local and wide area networks dating back to the 1970s, overlain with wireless technologies and the Internet. In a manufacturing

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context, it also built upon the supervisory control and data acquisition (SCADA) systems that became commonplace in the 1980s, as part of the shop floor data capture infrastructure that fed the Manufacturing Execution Systems (MES) and Enterprise Resource Planning (ERP) applications at the corporate level. Now, however, applications are much wider in scope. As Vodafone Business (2019) note "by IoT, we mean connecting sensors in things like cars, buildings and machines, enabling them to communicate about their status and environment and to be controlled remotely. It's making possible everything from asset tracking and condition monitoring to preventative maintenance and autonomous cars. The uses of this technology are broad and constantly growing" (p.1). According to Gartner (cited in Zscaler and ThreatLabZ, 2019, p.2), in excess of 20 billion IoT devices were estimated to be in use by 2020, with more than 65 percent of all companies using IoT products of some sort. According to PaloAlto Networks (2021), in excess of 30% of all network-connected endpoints are IoT devices in a typical company today.

Following this introduction, this chapter first discusses a number of different perspectives regarding the IoT concept, and sets out the main components of IoT infrastructure. Then, through an assessment of a number of secondary sources, it identifies the main business areas where IoT technology is being deployed, and assesses the potential benefits of IoT deployment. This is followed by a discussion of a number of emergent themes. Finally, the conclusion summarises key issues, and suggests some possible areas for future research in this field of study.

TECHNOLOGY OVERVIEW

The IoT Concept

There are a number of different but overlapping definitions and understandings of IoT in the extant literature. Wollowski and McDonald (2019) suggest that "at the most basic, IoT is about connecting all sorts of things to the internet. Those things, whether washing machines, cars, our bodies, or our food, produce data, in particular real-time data" (p.119). This is elaborated upon by Zscaler and ThreatLabZ (2019) who affirm that "IoT devices are nonstandard computing devices that connect wirelessly to a network, and have the ability to transmit data. These devices can communicate and interact over the internet, and they can be remotely monitored and controlled" (p.3). Gillis et al. (2020, February) bring in some other related concepts when they suggest that IoT is "a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs), and the ability to transfer data over a network" (para.1). Finally, Qlik (2018) provide an idea of the scale and impact of IoT in their definition: "the Internet of Things is the network of connected devices or 'things' with sensors that collect and transfer data through the internet, from wearable devices, connected vehicles, smart homes and even smarter cities to the Industrial Internet of Things (IIoT) or Industry 4.0. It is estimated that there will be more than 20 connected devices per person on the entire planet by 2020" (p.2).

However, other authors point out that it is the combination of IoT with other digital technologies that has most potential for radical transformation, notably in the areas of better predictive capabilities and enterprise machine optimization. Custance (2020), for example, notes that "IoT, coupled with cloud, enables efficient sensing and understanding of the environment, machines, assets, and people, providing a broad range of applications which can help businesses and their staff" (p.3). In similar vein, Carew (2020, July 31) has assessed the potential of Artificial Intelligence (AI) working with IoT. He points out that "the relatively recent combination of AI and IoT into the artificial intelligence of things (AIoT) has added a level of actionable insight to the traditional IoT" (para. 1), and concludes that "combining AI and IoT also allows organizations to collect data from millions of IoT devices in a more organized and efficient manner. AI-based algorithms sort out and eliminate useless data for your organization and save time and costs" (para. 14). This is reinforced by Gloss (2020, December 31) who notes "with the massive amount of IoT-generated data, organizations must turn to machine learning algorithms for real-time data processing. Use cases, such as patient monitoring, autonomous vehicles or predictive maintenance depend on instantaneous actions to keep people safe" (para. 12).

The role of advanced analytics in the processing of IoT generated data is highlighted by other authors. For example, Johnson (2020, April 23), writing in the context of improved supply chain efficiencies, notes "IoT isn't just about sensors; it also includes analytics. With a properly outfitted IoT network, manufacturers should be able to quickly determine that a supply chain is overwhelmed and locate alternate supply chains and component sources" (para. 10). Koegler (2018, April 2), takes this a step further by emphasising the potential of IoT to impact upon all main business processes which underpin corporate Enterprise Resource Planning (ERP) systems. Koegler asserts that "the inefficiencies of manual analysis and processing, that kept managers from taking quick and decisive action, are being eliminated by the nearly seamless connection between IoT and ERP in the supply chain" (para. 3).

In summary, however the IoT concept is defined or conceptualised, it is generally viewed as more or less all-pervading across IT systems and their underlying architectures. This has enormous implications for its impact on business operations and management in future years.

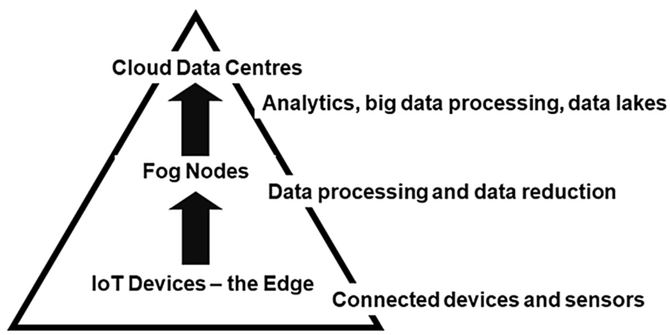
The Main Technology Components of IoT

Various authors view the main physical/technology components of IoT somewhat differently, which is not surprising given its all-pervasive potential across systems and computer networks. In a broad context, IoT devices can be seen as part of a cloud ecosystem for data collection and storage comprising three tiers (Figure 1). At the upper tier is data storage in the cloud, a repository for a remarkable amount of transactional, archival and big data, and used for disaster recovery and backup purposes, as well as real-time operational data. This, to date, has generally be seen as the application layer, where IoT data is analyzed and used, exploiting analytical tools, AI, and Machine Learning (ML) modelling. In the middle tier is fog computing, essentially an architecture of nodes that are linked to the lower level IoT devices, undertake computation and reduction of data, and then move this data from the lower tier devices up to the upper tier via the internet. Fog nodes can be located anywhere between the data source and the cloud. Finally, at the lower tier (commonly called "the edge"), are the IoT devices and sensors connected to the internet, and requiring vast amounts of storage capacity. As noted by Horison Information Strategies (n.d.), "the cloud, fog, edge and the IoT (the cloud ecosystem) are altering the way data is being generated, processed, and stored from anywhere on the globe. The cloud is becoming the new core data center" (p. 1).

Qlik (2018) also views IoT in terms of an ecosystem, which mainly concerns the lower tier of the overarching cloud ecosystem depicted in Figure 1. Qlik (2018) note that it "can be broken down into four distinct layers: devices, connectivity, operations and analytics". Devices are seen as IoT sensors. Connectivity refers to how devices are connected and managed, and how data from sensors is collected. Operations concerns the centralized logic which is executed on the collected data, enabling action. Finally, analytics provide new insight, and new logic. "This can be fed back into the ecosystem at the operational, connectivity or even the devices layer" (p.2). Similarly, Gillis et al. (2020, February) consider that "an IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments" (para.4).

Other sources suggest the main technology components of IoT can be classified into four main groupings: sensors, networks, standards and intelligent analysis, taking a slightly different approach to that of Qlik (2018) and Gillis et al. (2020, February). In this classification of IoT technologies, a *sensor* is seen as a device that is capable of producing a digital, electrical or optical output for a particular state or an event. The data so generated by a sensor will be electronically transformed by another device into information, which will be used while taking decisions. As an example, gas sensing technology is being used in this way for industrial safety and environmental monitoring (Seongbin et al., 2020; Wei Xu, 2020). A *network* may consist of many elements (e.g., routers, bridges, etc.) and is used for transmitting the signal collected by a sensor to the different components of the network. Wi-Fi is one of the technologies used for connecting the network components.

Figure 1. IoT and the cloud ecosystem



Standards are needed for a range of activities, including data handling, data processing, and storage of the data collected through sensors. A common theme with IoT networks is the heterogeneity of protocols, data formats, software and hardware platforms. Literature has shown that Service Oriented Architecture (SOA) has the ability to deal with the problem of heterogeneity. Costa et al. (2020), for example, have explored the adoption of OMG standards in the development of SOA-based IoT systems. They concluded that it is essential to construct a model of the system, and run the simulation, to ensure that the model meets organizational requirements prior to its implementation. The *intelligent analysis* of data from IoT devices has been made easier by computer vision, natural language processing, and speech recognition. Technologies that support the use of analytics in IoT include AI and open-source data analysis software.

Having examined the relevant terminology and technical elements of IoT, this chapter addresses the following research questions:

RQ1: In what business areas are IoT projects being implemented and what are the perceived benefits?
RQ2: What key implementation issues are arising from recent experience?

MODE OF ENQUIRY

The above research questions have been addressed through an extensive literature and technology review, followed by internet searches to find up to date case studies of IoT technology deployment. The initial review of academic and business publications helped establish basic definitions and meanings, and also revealed the various perspectives on the IoT concept. The internet searches were conducted using Google in the period January to May 2021. The generated information formed the empirical basis for this chapter. From this material, which is in the public domain on the World Wide Web, a number of short quotations are taken from blogs and other web sources and are included here. The authors took the view that they did not need to seek permission to use these quotations, which are clearly referenced in the chapter. Saunders et al. (2018) emphasised the importance of the authority and the reputation of such sources, and the authors felt that both these conditions were met in the material cited and quoted in the chapter.

The case examples, although from secondary sources, provide a deeper understanding of the research context, and enable the formulation of answers to the research questions (Yin, 2013). The research approach is interpretivist, based on secondary qualitative data. The focus of enquiry is on the industrial sector, whilst other areas of society and business where IoT is impacting (e.g. the home, the medical sector, and agriculture) have been excluded from this review. This is a conceptual review of existing sources, which aims to synthesize areas of conceptual knowledge that can contribute to a better understanding of issues, ideas, models and debates (Petticrew & Roberts, 2008). The conduct of the review generally followed the five-step procedure set out by Khan et al. (2003): (1) framing research questions for the review, (2) identifying relevant work, (3) assessing the quality of studies, (4) summarizing, and (5) interpreting the findings. In interpreting the findings, the authors identified the key themes and narratives by an informed reading and re-reading of the relevant material.

FINDINGS

Use Cases: Where Is IoT Being Implemented?

IoT applications are already found in most areas of business, but some business processes are showing clearer potential for benefits delivery than others. Johnson (2019a) reported on research undertaken by Nemertes Research Group in over 400 companies from different business sectors. The study of use cases identified nine main process areas where IoT projects were deployed, including asset tracking and management (30.5% of use cases), system health monitoring (15.5%), facilities or environmental monitoring (13.3%), capacity planning and management (11.5%), and customer engagement (11.1%). Vodafone Business (2019), on the other hand, researched the IoT adoption rate in different industry sectors. They found that transport and logistics companies had the highest adoption rate at 42%, and also achieved the biggest year-on-year increase (15%). They reported that these companies were using IoT for a number of different purposes, including tracking consumption (e.g. the use of fuel), and tracking the location of vehicles and cargo, which can help to identify smarter travel and shipping routes, avoid congestion and reduce fuel use. IoT is also "paving the way for adopters to offer entirely new product and services - like working with insurers to offer dynamic pricing of cargo insurance" (p.11).

Other leading business sectors in the adoption of IoT were insurance and financials, healthcare, the automotive sector, energy and utilities companies, manufacturing and industrials, and retail. For energy and utilities companies, many projects that aim to reduce waste and environmental impact rely on IoT technologies. For example, for “smart meters and smart grid systems, 67% are using IoT to measure consumption” and “IoT is also being used to monitor remote infrastructure — 75% are using it to monitor the physical security of assets and improve customer service by optimising the job planning and routing of service staff” (Vodafone Business, p.13). Mendes et al. (2020) have discussed how IoT enabled meters will be used for the efficient management of power distribution in future.

In the retail sector, 80% of respondents saw IoT projects as mission-critical. “Much of the new in-store technology transforming the industry either revolves around IoT, or includes it in some form” (Vodafone Business, 2019, p.14). Bigelow (2021, April 14) has also pointed out how IoT is used extensively in physical retail store environments. He notes “IoT devices can tag every product, enabling automated inventory control, loss prevention and supply chain management - placing orders based on sales and inventory levels” (para. 21). In the automotive sector, IoT devices are part of a paradigm shift that is transforming the industry. Smart cars are fitted with IoT devices to improve the driving experience, notably as regards safety, comfort, and early detection of car faults (Chugh at al., 2020). In a smart car, different functionality is utilized optimally, so that the impact on the environment will be negligible. Smart parking is another area where IoT devices are being deployed (Luque-Vega et al., 2019).

In the manufacturing and industrials sector, Vodafone Business (2019) reported that “IoT is also bringing the concept of digital twins to life.” Digital twins - detailed virtual replicas of physical systems - can help solve key issues such as “identifying a correlation between equipment failure and sudden temperature changes”, and can also help “predict the effects of proposed changes and enable new revenue streams through servitisation” (p.14). Koegler (2018, April 2), again in the context of supply chain management, notes “IoT technologies are increasingly used as supply chain visibility tools, especially in the realm of logistics. Combining basic computing capabilities with multiple sensors and continuously available communication operations offers a near-real-time view of orders, their locations and their condition from origin to destination” (para. 4). Another dimension to IoT in manufacturing is predictive maintenance and predictive failure. Carew (2020, July 31) observes “factories need numerous technical devices that require IoT in order to function properly, but the addition of predictive analytics technology means that companies can avert - or at least plan for - outages, system failures or maintenance shutdowns - something that becomes pivotal for system maintenance” (para.11). Carew concludes that “in industrial high-pressure situations, algorithms can assess when a pump is likely to fail and alert workers beforehand, giving the factory time to get ahead of a failure and apply maintenance to prevent a shutdown” (para. 13).

Waste management is another industry that has benefited from the deployment of IoT technologies, and this has been researched by a number of authors. Qiu et al. (2020) investigated how IoT devices can be used to support the recycling of limited resources and thereby reduce waste, whilst Idwan et al. (2020) have studied the efficient management of waste-carrying trucks using IoT devices. Kozina et al. (2020) proposed new techniques for managing pollutants and harmful chemicals from trucks carrying waste products and Liegeard and Manning (2020) proposed schemes for managing the e-waste generated from IoT devices. It is nevertheless clear from the literature that still more effective methods are required for the efficient and eco-friendly management of e-waste (Das et al., 2019; Fan et al., 2019; Voca & Ribic, 2020).

IoT Project Benefits

There are a number of mainly technical benefits of IoT deployment. For example, communication between connected electronic devices is enhanced, and data packets can be more easily transferred over connected networks. Here, however, we are concerned more with the business benefits that IoT projects are delivering. Vodafone Business (2019) reported that, from their survey of 1,430 qualified respondents involved in IoT strategy development, the number of companies using IoT had risen to over a third. In his foreword to the report, Stefano Gastaut, Chief Executive Officer, Vodafone IoT, asserted that "companies are seeing the benefits of IoT and choosing to do more with it. Almost every adopter says their projects are delivering results, and over half say that the benefits are significant." Such benefits, he noted, included cost reductions, improved safety, and "increased responsiveness to entirely new revenue streams." Some of these benefits are seen as industry-specific, and some are applicable across a range of industry sectors.

The *monitoring and improvement of overall business processes* is highlighted by Gillis et al. (2020, February) as a key benefit, and this is supported by Johnson (2019b) who notes "the biggest ROI kicks in, not from tracking assets or measuring the environment, but from optimizing processes in light of that information" (p.5). Machine learning and artificial intelligence technology are being used in many industries (Dave et al., 2020; Mehta et al., 2019; Patel et al., 2020) for tracking the quality of the manufactured product, and thereby product consistency and timely delivery to the end-customer. Product manufacturing lines produce huge amounts of data, and IoT technologies facilitate data analysis to support significant process improvements.

An *improvement in customer service* is also cited as a potential benefit of IoT deployment. For example, health care industries are using IoT technologies for designing wearable, integrated, and effective medical monitoring and analysis devices, which has provided significant benefits for the patients, the end-customer. New small and multifunctional medical devices are also facilitating more efficient delivery of medication through smart drug delivery systems (Hua et al., 2020). In the drinks industry, Custance (2020) reported how Britvic successfully used IoT technology in a customer trial of new products. The author notes "the data from the reporting infrastructure…. and the overall learning Britvic gained from the trial, is now shaping future product development" (p.19).

Improved efficiencies - savings in time, money, and resources - is another potential benefit. Oil and natural gas companies, for example, are increasingly using IoT technology, embedded in, or linked to, drones and autonomous vehicles, for inspecting the gas lines in hostile areas, as well as using autonomous mining equipment for oil exploration (Singh et al., 2018). Product inspection in many traditional manufacturing companies was hitherto done by manual methods combined with statistical sampling. This was mainly due to the lack of appropriate technology, and sampling inspection was often carried out after manufacturing the product. Thus, if a defective product were made, it would become scrap, which constitutes a type of waste. In addition, sampling inspection is not fool proof, and defective products can still reach the customer, affecting the company's reputation. With the availability of IoT technologies, used, for example, in a machine vision-based inspection system, an inspection of the product is made possible during the manufacturing of the product itself (Patel & Kiran, 2019a, 2019b; Patel et al., 2019; Vakharia et al., 2017). This can help ensure a defect-free production process, a consistent quality of the end product, and enhancement of the company's reputation.

Employee productivity can be enhanced in a range of situations in multiple industries. With the advent of IoT, the incidence of workplace-related accidents will decrease. For example, in aerospace companies, heavy objects were moved manually by using hand trolleys from one work station to another. This is a high risk process, with the possibility of serious accidents. With the development and deployment of advanced material handling systems, using IoT technology, such risks are minimised. Similarly, in many automobile manufacturing companies, spray painting is now making use of industrial robots that utilise IoT technology. Hitherto, this was done by operators, who could suffer from respiratory-related problems and complications, due to the harmful chemicals contained in some paints. With the availability of IoT technologies, workspace environmental factors, such as temperature and humidity, can be monitored and controlled in real-time by using sensors, to provide a healthier working environment. Similarly, in machine tool manufacturing industries, operators have, until recently, had to do a range of mundane tasks, such as loading the workpiece into a machine tool or unloading the finished component after machining. These tasks can now be done using industrial robots, that utilise IoT devices, allowing the operator to focus on core functions such as the writing of part programming - a sequence of instructions for working on a part – using computer numerical control (CNC) software. This involvement in more productive and creative activities also enhances job satisfaction (Kiran, 2021a). Similarly, Pivac et al. (2019) point out how smart wearable sensors that use IoT devices can provide thermal comfort to the workers, significantly enhancing the operator's productivity in the workplace.

Such improvements in processes and efficiencies derived from IoT implementation may ultimately lead to a transitioning to an adapted or *new business model.* As Bigelow (2021, April 14) concludes "IoT isn't just changing the way businesses operate. It's enabling a variety of new business models that let organizations derive revenue from IoT projects and products" (para. 42). The author notes a number of business model types where IoT may act as the catalyst for such change. These include the commercialisation of data generated by IoT devices, the establishment of new IoT platforms providing AI services, and pay-per-use products where IoT data facilitates location, use and rental payment of, for example, motorbike or bicycle rentals.

Improved decision-making, notably when IoT technologies are used in conjunction with analytics, is another potential benefit. Western Reserve University laboratory, for example, used multiple accelerometers to collect vibration data of a bearing motor and used IoT to predict the fault in the motor. They also claimed that the accuracy of their prediction was 90% (Huang et al., 2019). In the automotive industry, manufacturing companies often face problems related to the supply of raw materials – quantity, quality, and timing. Radio Frequency Identification Devices (RFIDs) - a form of IoT device – can ascertain the status of raw materials supply in real-time. This helps both the manufacturer and supplier improve procurement decision-making and inventory management. IoT technologies combined with analytics are helping manufacturing companies in knowing what are value-added activities, and what are non-value-added activities. By eliminating or minimising non-value-added activities, there is scope for waste reduction and hence profit maximization (Kiran, 2021b). Many of the benefits discussed above have the knock-on effect of increased revenue and profit generation. Indeed, Palo Alto Networks (2021) concluded that "while some of the most striking benefits of IoT revolve around business process efficiency, productivity, and cost reduction, an increasing number of enterprises are also recognizing IoT as an extraordinary source of intelligence into how their products are really changing the lives of their employees and customers" and that "insights derived from IoT-generated data are proving to be invaluable to business decision makers" (p.3). This is reinforced by Bigelow (2021, April 14), who concludes "the real power and benefit of IoT is the long-term insights that it can provide to business leaders", by "evaluating and correlating a huge quantity of seemingly unrelated data to answer business questions and make accurate predictions about future circumstances" (para. 23).

DISCUSSION

The previous sections have provided an overview of the various definitions of IoT, its main technical components, where IoT is being deployed in industry, and what the main potential benefits are. From this review, several further issues have emerged that are worthy of discussion.

Firstly, *security* is a key concern. A recently published industry report (Zscaler & ThreatLabZ, 2019) notes that "IoT devices have become commonplace in enterprises from all industries and nearly every corner of the globe", but that "there has been almost no security built into the IoT hardware devices that have flooded the market in recent years, and there's typically no way to easily patch these devices. While many businesses have thought security for IoT devices unnecessary, because nothing is stored on the devices, this isn't the case" (p.12*)*. There are a number of security related challenges in IoT implementation: privacy issues, handling unstructured data, standards for data markets, and data provenance - secure data provenance can effectively enhance data trustworthiness, which is critical to many decision-making processes. PaloAlto Networks (2021) observed that "enterprise security teams are already tasked with protecting IT endpoints connected to the enterprise network. Under the new normal—with the exciting new concept of IoT at the helm—they also have to contend with challenges arising from the increasing prevalence of IoT devices connected to an enterprise's central network yet generally unmanaged" (p.4). Dongxian et al. (2021) have studied network security and have used machine learning techniques, such as neural networks and support vector machines, for enhancing security of wireless networks. In similar vein, Gloss (2020, March 11) sees AI as a key part of the security solution in IoT. She notes "the proliferation of IoT devices that organizations use complicates cybersecurity", but "through automation, AI can flag threats, investigate them further and prioritize risks" (para. 8).

Secondly, the *advent of 5G networks* will provide a further, significant, stimulus to companies to embark on IoT projects, and enhance potential benefits. Erasmus (2020, April 6) underlines the connectivity between IoT, 5G and other digital technologies. He observes that "today's technology trends are all about faster speeds, more connectivity, greater security and higher efficiency. This is especially true as it relates to the major impact that IoT technology is making in almost every vertical. Specifically, IoT is being weaved into other popular connective innovations, such as 5G, Wi-Fi, AI, data analytics and blockchain" (para.1). Companies will be able to use 5G private networks to deploy IoT in remote locations to transmit data without significant investment in network infrastructure. Horison Information Strategies (n.d.) also suggest that the faster speeds of 5G wireless transmission will give a further push to edge computing and the use of IoT sensors, and cite the example of the global video surveillance storage market, which "is expected to grow from $7.5 billion in 2020 to $10.2 billion by 2025 while generating much of its data at the edge" (p.3).

Thirdly, and building upon the previous point, *edge computing* has emerged as a new concept linked to the surge in the use of IoT devices. The thinking underpinning this is that in the three-tier model depicted in Figure 1, the computation and storage of data will take place near to the IoT devices which are gathering the data, rather than moving the raw data to the fog tier for reduction and processing via the internet, which physically may be very distant. This has significant benefits in some circumstances. Horison Information Strategies (n.d.), for example, cite a number of such cases: "autonomous cars use edge computing to make the time-critical decision about stopping a self-driving car in real time", and "a remote weather station will use sensors to measure temperature, wind speed, humidity and barometric pressure transmitting data that may be used immediately for safer flight navigation" (p.3). They note that a typical autonomous vehicle (which can be viewed as an "edge device") can generate 40 TB of data within 8 hours, presenting major challenges for bandwidth capacity and data storage.

Fourthly, there are clearly implications for the *development of an IoT strategy* as part of an overall IT or digital transformation strategy. Vodafone Business (2019) conclude "there's a general consensus that IoT shouldn't be considered in isolation. To realise the full benefits, organisations need to integrate it with other key technologies. 89% of the most sophisticated companies think of IoT alongside analytics, AI and cloud, not as a standalone technology" (p.17). They note, however, that although legacy systems and infrastructure are obstacles to an effective IoT strategy, the situation is improving due to the increased availability of off-the-shelf solutions, and the provision of new functionality in major software products (such as ERP and CRM systems) that facilitate the integration of IoT devices. In addition, "many telecommunications providers are offering dedicated IoT platforms, making it easier for companies to develop, test and manage IoT projects" (p.17). Nevertheless, as noted above, the absence of industry wide standards is likely to continue to hamper IoT integration for some time.

This complex technical and business environment underscores the need for implementation guidelines to support organisations and practitioners embarking on IoT projects, and this is evidenced in the growth in such material available on the internet in the recent past. At project level, Nemertes identifies a four-step guide: 1. Identify the business processes and define success metrics. 2. Embed sensors to capture information. 3. Conduct analysis to uncover trends. 4. Optimize performance (Johnson, 2019b, p.4). Clearly, from a technical viewpoint, a wide range of factors needs to be considered in determining an IoT architecture – security, privacy, data backup, disaster recovery, device identity etc. Organizations may have to acquire dedicated IoT teams to implement and maintain such projects, although another approach to IoT and system integration is to use the cloud. Some Platform-as-a-Service (PaaS) providers now offer IoT services, facilitating the integration of IoT and cloud-based systems through the use of application program interfaces (APIs). Shacklett (2021, April 7) notes that "by hosting IoT and system apps in the cloud, organizations also ease the amount of bandwidth needed on in-house networks to support IoT traffic" (para. 16). Moore (2021, May 10) points out that public cloud platforms are now often used for IoT deployments, noting in particular "the cloud offers organizations a scalable resource for IoT data analytics. Public clouds such as AWS, Google Cloud Platform and Microsoft Azure provide IoT services" (para. 17).

CONCLUSION

In conclusion, and in answer to the two RQs noted above, experience to date suggests IoT devices and projects are being implemented in all main business process areas. However, those business areas where there is a successful track record of utilizing data collection devices are, not surprisingly, leading the exploitation of IoT data capture and processing. These include, in particular, manufacturing and logistics, and, in a wider context, energy monitoring and medical applications. The benefits derive from the analysis of the vast amounts of data that IoT devices can provide, potentially producing enhanced efficiencies and productivity, better customer service, more effective decision-making and business process improvement. This may ultimately lead to a change in the basic business model of the organisation, in some instances. The implementation issues are diverse and multi-faceted, and impact at various management levels from strategy development to project management and technology integration.

This review clearly has its limitations, in that it is based exclusively on secondary material drawn from other sources, and does not include, for example, primary interview feedback from those involved in IoT projects. Nevertheless, the authors believe that it provides a useful overview for practitioners embarking on IoT projects, and can act as a basis for future research in several related areas. It is estimated that by 2025, there will be 80 billion connected things globally (IDC, 2014). This will bring some key challenges for IT practitioners as digital change sweeps through industry and society at large. With the increase in connected devices and the sharing of data between them, the security risks grow almost exponentially. With large companies dealing with potentially millions of connected IoT devices, the problems involved in the management of such large quantities of data are significant. These problems are exacerbated by the absence of common, internationally recognised standards to regulate IoT devices and their connection. As with many previous step-changes in technology evolution (networks, operating systems, the personal computer, the internet), standards tend to lag behind the early implementers.

These challenges, significant though they are, are put in perspective when one considers the other implications of the growth in the deployment of IoT and other digital technologies, notably AI, in future years. Sherwood (2018, March 20) sees this future technology landscape as “an industry-wide ecosystem in which data from connected devices can be shared and monetized by everyone” (para. 4). Rather like the invention of the centralised telephone switchboard, which replaced manual switchboards in telephone exchanges around the world in the late 19th century, this represents a threshold change in the mega-infrastructure supporting these new technologies. AI, however, will play the role of the switchboard operators, providing connectivity through unified platforms that may be industry specific or span industry sectors. Manufacturing companies have been striving to achieve supply chain excellence for several decades, and the advent of IoT and related technologies can further speed this process. The implementation of IoT projects will allow organizations to enhance integration across the supply chain, with consequent improvements in efficiency, flexibility, and customer service. The key to this will be the convergence and consolidation of IoT platforms, which will be able to seamlessly exchange data between people, networks, devices and applications.

Although these developments will be driven in the main by the large technology companies, there is nevertheless scope for academic research in a number of related fields. From a “top-down” perspective, there is clearly no universally agreed methodology for integrating IoT into wider digital transformation and IT strategies. This provides scope for research into how the leading-edge user companies are attempting this. Are these companies treating IoT just as they would any other technology, and incorporating it into their existing IT strategies? Or do they view it as a “game-changer”, requiring a complete re-think of how technology is deployed? And how do perspectives vary between industry sectors? From a more tactical “bottom-up” viewpoint, and given the lack of standards in operation today, research into the role of IoT gateways and other necessary middleware to facilitate integration and day-to-day operations would be of value. Security strategy, policies, tools and use cases is another area where further research is needed, as security risks emanating from non-standardised IoT implementations become more evident. Much remains to be done to fully deliver the benefits of IoT technology. It is hoped this brief review will be of value to those practitioners and researchers working in this rapidly evolving field.

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KEY TERMS AND DEFINITIONS

Application Programming Interface (API): A software product that allows two applications to talk to each other. Traditionally used to link on premise business applications, now of new significance in the cloud environment.

Edge Computing: Computation and data processing close to the point of capture of that data by IoT devices.

Fog Computing: The architecture of nodes that lie between the IoT devices and the cloud-based storage environment. These nodes can format and reduce data volumes before passing that data onto the cloud for onward processing and storage.

Internet of Things (IoT): The IoT is formed by a set of physical objects with embedded sensors, connected using a network so that they can collect and exchange data.

Machine Learning: A technology used to make a computer-controlled device, to observe, understand and learn a given situation and make future predictions like a human brain.

Platform as a Service (PaaS): A cloud environment in which users can both develop and deploy systems and applications.