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Chapter 10
Industrial Internet of Things:
Benefit, Applications, and Challenges

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ABSTRACT

This chapter focused on the importance and influence of industrial internet of things (IIoT) and the way industries operate around the world and the value added for society by the internet-connected technologies. Industry 4.0 and internet of things (IoT)-enabled systems where communication between products, systems, and machinery are used to improve manufacturing efficiency. Human operators' intervention and interaction is significantly reduced by connecting machines and creating intelligent networks along the entire value chain that can communicate and control each other autonomously. The difference between IoT and IIoT is that where consumer IoT often focuses on convenience for individual consumers, industrial IoT is strongly focused on improving the efficiency, safety, and productivity of operations with a focus on return on investment. The possibilities with IIoT is unlimited, for example, smarter and more efficient factories, greener energy generation, self-regulating buildings that optimize energy consumption, smart cities that can adjust traffic patterns to respond to congestion.

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INTRODUCTION

The idea of a world where systems with local processing, sensors and controllers are interconnected with each other and to the larger network and cloud to share data and information is captivating within every single industry. These systems will be connected at a global level with each other and its end users to help entities and users make better-informed decisions based on the data retrieved from these systems. This idea has been given many labels so far, but ubiquitous is the Internet of Things (IoT). The IoT includes everything from smart cities to smart homes, everyday smart appliances, and connected toys to the Industrial Internet of Things (IIoT) with smart agriculture, smart factories, and the smart grid.

The Industrial Internet of Things (IIoT) is often presented as a revolution that is changing the face of the industry in an innovative and rapid manner. However, as it may take a bit of time for global standards to be generalised, the full benefits of IIoT is still a few years away. End users though will still be able to take advantage of the available new IIoT technologies and leverage their existing investment in technologies and people. Introducing IIoT solutions using “Wrap & Re-use’’ approach, rather than a “Rip & Replace” approach will enable greater business control. In addition, this measured approach will drive the evolution towards a smart manufacturing enterprise that is more efficient, safer, and sustainable.

The IIoT vision for the world is one where smart connected machinery and equipment operate as part of a much bigger system that make up the smart manufacturing enterprise. The machinery and equipment, or the “things” will posses’ different levels of intelligent functionality, ranging from sensory functions, control mechanisms, optimisation, and full autonomous operations.

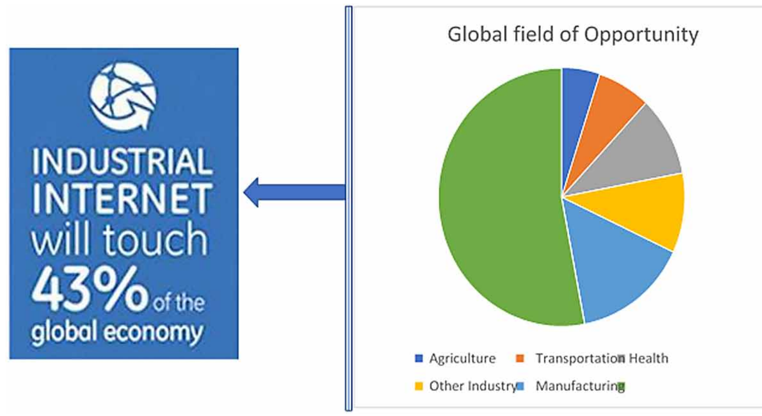
The smart manufacturing plant comprises of smart equipment, machinery, and operations, all of which have high levels of intelligence embedded at the core. The automated and linked systems use various internet and cloud technologies that ensure secure access to devices and information. New and advanced analytics tools allow for Big Data to be processed efficiently to deliver greater business value.

Think of industrial machineries or systems that can sense their own environments and health and make appropriate adjustments. Instead of working until breakdown, the machines schedule their own regular maintenance or adjust control algorithms dynamically to compensate for the troubled part and the communicate this shortcoming to other machines in the system as well as users of these machines. IIoT can solve problems that were previously thought impossible. However, as the saying goes, “if it was any easier, everyone would be doing it”. As IIoT, innovation grows so does the complexity, which makes the IIoT a very large challenge that no company alone can meet. In a recent report on Forbes (), it is estimated that the Industrial Internet of Things could create a total value of up to $11.1 trillion on an annual basis by 2025 and about 70% of this would be captured by business-to-business solutions-leaving the value of the consumer Internet at about $3.5 trillion. In other words, the Industrial Internet will be worth more than twice the consumer Internet will as illustrated in Figure 1 below.

LITERATURE REVIEW

According to Khan, et al. (2020), “the adoption of emerging technological trends and applications of the Internet of Things (IoT) in the industrial systems is leading towards the development of Industrial IoT (IIoT). IIoT serves as a new vision of IoT in the industrial sector by automating smart objects for sensing, collecting, processing, and communicating the real-time events in industrial systems. The major objective of IIoT is to achieve high operational efficiency, increased productivity, and better management

Figure 1. Global Field of Opportunity for IIoT.



of industrial assets and processes through product customization, intelligent monitoring applications for production floor shops and machine health, and predictive and preventive maintenance of industrial equipment. In this paper, we present a new and clear definition of IIoT, which can help the readers to understand the concept of IIoT. We have described the state-of-the-art research effort s in IIoT. Finally, we have highlighted the enabling technologies for IIoT, and recent challenges faced by IIoT." (Khan, et al., 2020).

Industry 4.0 and its main enabling information and communication technologies are completely changing both services and production worlds (Aceto, Persico & Pescape, 2020). "This is especially true for the health domain, where the Internet of Things, Cloud and Fog Computing, and Big Data technologies are revolutionizing eHealth and its whole ecosystem, moving it towards Healthcare 4.0. The authors by selectively analysing the literature systematically surveyed how the adoption of Industry 4.0 technologies (and their integration) applied to the health domain in changing the way to provide traditional services and products. In their paper, Aceto, Persico & Pescape, 2020 provide (i) a description of the main technologies and paradigms in relation to Healthcare 4.0 and discuss (ii) their main application scenarios; and then provide an analysis of (iii) carried benefits and (iv) novel cross-disciplinary challenges; finally, extract (v) the lessons learned". (Aceto, Persico & Pescape, 2020).

As claimed by Jaidka, Sharma & Singh (2020) "The emerging Internet of Things (IoT) provides a wide range of platform to different technologies by connecting different devices and are automated by using sensors. It builds a platform and is responsible for functioning of various smart devices over a range. After installing IoT in devices they can communicate with each other without involving human and computer interaction, it is also being widely used in all the fields, as no human intervention is required in any IoT based applications. In a paper we present a survey of how IoT is transformed into IIoT (Industrial Internet of Things), what is Industry 4.0, what are key differences between IoT and IIoT, various application of IoT in different sectors, powerful features and advance characteristics of IoT. Since the demand of IoT systems is increasing in various fields day by day and ease of life after using smart devices but then also it possesses certain limitations too. The later part of paper focuses on security threats and issues addressed by IoT based systems along with ways to overcome the limitations possessed in the system". (Jaidka, Sharma & Singh, 2020)

In their paper titled "Challenges and Recommended Technologies for the Industrial Internet of Things: A Comprehensive Review", Younan, et al. 2020 states that the "physical world integration with cyber world opens the opportunity of creating smart environments; this new paradigm is called the Internet of Things (IoT). Communication between humans and objects has been extended into those between objects and objects. Industrial IoT (IIoT) takes benefits of IoT communications in business applications focusing in interoperability between machines (i.e., IIoT is a subset from the IoT). Number of daily life things and objects connected to the Internet has been in increasing fashion, which makes the IoT be the dynamic network of networks. Challenges such as heterogeneity, dynamicity, velocity, and volume of data, make IoT services produce inconsistent, inaccurate, incomplete, and incorrect results, which are critical for many applications especially in IIoT (e.g., health-care, smart transportation, wearable, finance, industry, etc.).

Discovering, searching, and sharing data and resources reveal 40% of IoT benefits to cover almost industrial applications. Enabling real-time data analysis, knowledge extraction, and search techniques based on Information Communication Technologies (ICT), such as data fusion, machine learning, big data, cloud computing, blockchain, etc., can reduce and control IoT and leverage its value. Their research presents a comprehensive review to study state-of-the-art challenges and recommended technologies for enabling data analysis and search in the future IoT presenting a framework for ICT integration in IoT layers. Their paper surveys current IoT search engines (IoTSEs) and presents two case studies to reflect promising enhancements on intelligence and smartness of IoT applications due to ICT integration". (Younan, et al. 2020)

A study by Leminen, et al., (2020) analyses "Industrial Internet of Things (IIoT) business models in the machine-to-machine (M2M) context. Thereby, it develops a conceptual framework to categorize different types of business model innovation for companies operating in the M2M business space. Business model innovations tend to cross multiple industries and drive ecosystems in which smart objects facilitate business models and service applications that are incrementally or radically novel in terms of their modularity or architecture. Our framework identifies four distinct types of IIoT business models: (I) Company-specific business models, (II) Systemic business models, (III) Value designs, and (IV) Systemic value designs. Moreover, it sheds light on different abstraction levels of business model building blocks and exposes the characteristics and differences in the value potential between the four business models. Finally, we advance the idea of 'value design' referring to business models of multiple actors coupled together, ultimately resulting in complex networks and ecosystems of diverse things, processes, and companies". (Leminen, et al., 2020)

According to Kim & Tran-Dang, 2019, "recently, the technological advancement in embedded systems and wireless communication has enabled interconnection of massive electronic devices to support innovative services and promises better flexibility and efficiency. Such paradigm is referred to as the Internet of Things (IoT) that promises ubiquitous connection to the Internet, turning common objects into connected devices. An emerging class of IoT-enabled industrial production systems is called the Industrial Internet of Things (IIoT) that, when adopted successfully, provides huge efficacy and economic benefits to industrial system installation, maintainability, reliability, scalability, and interoperability. Their paper introduced the concept of IIoT from technological and practical application aspects". (Kim & Tran-Dang, 2019).

Digital technologies have changed the way supply chain operations are structured (Radanliev, et al. 2019). In their article, (Radanliev, et al. 2019), "develop design principles to show determining factors for an Internet-of-Things approach within Supply Chain Management. From the design principles, the article derives a new model and a transformational roadmap for the Industrial Internet of Things in Industry 4.0 supply chains of Small and Medium Enterprises (SMEs). Their focus is on SMEs. Their literature review included 173 academic and industry papers and compared the academic literature with the established supply chain models. Taxonomic review was used to synthesise existing academic and practical research. Subsequently, case study research was applied to design a transformational roadmap. That was followed by the grounded theory methodology, to compound and generalise the findings into a theoretical model. Their research design resulted in a new process of compounding knowledge from existing supply chain models and adapting the cumulative findings to the concept of supply chains in Industry 4.0. The findings from their study present a new model for Small and Medium Sized companies to transform their operations in the Industrial Internet of Things and Industry 4.0". (Radanliev, et al. 2019)

Balaji, Nathani, & Santakumar, 2019, posits that "Internet of things (IoT) is a very unique platform which is getting very popular day by day. The very reason for this to happen is the advancement in technology and its ability to get linked to everything. This feature of getting linked has in itself provided multiple opportunities and a vast scope of development. The fact that technology in various fields has evolved through the years, is the reason why we observe a rapid change in the shape, size and capacity of various instruments, components and the products used in daily life. And this benefit of simplified technology when accompanied by a platform like IoT eases the work as well as benefits both the manufacturer and the end user. The Internet of Things gives us an opportunity to construct effective administrations, applications for manufacturing, lifesaving solutions, proper cultivation and more. This paper proposes an extensive overview of the IoT technology and its varied applications in life saving, smart cities, agricultural, industrial etc. by reviewing the recent research works and its related technologies. It also accounts the comparison of IoT with M2M, points out some disadvantages of IoT. Furthermore, a detailed exploration of the existing protocols and security issues that would enable such applications is elaborated. Potential future research directions, open areas and challenges faced in the IoT framework are also summarized". (Balaji, Nathani, & Santakumar, 2019).

Rehman, et al., 2019 looks at "big data production in industrial Internet of Things (IIoT) and claim that it is evident due to the massive deployment of sensors and Internet of Things (IoT) devices. According to them, big data processing is challenging due to limited computational, networking and storage resources at IoT device-end. Big data analytics (BDA) is expected to provide operational- and customer-level intelligence in IIoT systems. Although numerous studies on IIoT and BDA exist, only a few studies have explored the convergence of the two paradigms. In their study, they investigate the recent BDA technologies, algorithms and techniques that can lead to the development of intelligent IIoT systems. They devise a taxonomy by classifying and categorising the literature on the basis of important parameters (e.g. data sources, analytics tools, analytics techniques, requirements, industrial analytics applications and analytics types). They present the frameworks and case studies of the various enterprises that have benefited from BDA. They also enumerate the considerable opportunities introduced by BDA in IIoT". (Rehman, et al., 2019).

Industrial production plays an important role for achieving a green economy and the sustainable development goals (Beier, Niehoff, & Xue, (2018). Therefore, the nascent transformation of industrial production due to digitalization into a so-called Industrial Internet of Things (IIoT) is of great interest from a sustainable development point of view. This paper discusses how the environmental dimension of a sustainable development can potentially benefit from the IIoT—focusing especially on three topics: resource efficiency, sustainable energy and transparency. It presents a state-of-the-art literature analysis of IIoT-enabled approaches addressing the three environmental topics. This analysis is compared with the findings of a survey among Chinese industrial companies, investigating the sustainability-related expectations of participants coming along with the implementation of IIoT solutions. China has been chosen as a case study because it brings together a strong industrial sector, ambitious plans regarding industrial digitalization and a high relevance and need for more sustainability. The survey was conducted with the means of a questionnaire which was distributed via email and used for direct on-site interviews. It focused on large and medium sized companies mainly from Liaoning Province and had a sample size of 109 participants. (Beier, Niehoff, & Xue, (2018).

Major challenges identified by Xu & Li, 2014 in their paper were security and privacy whereas traceability, visibility and controllability were identified as the benefits of Industrial IoT. Also mentioned was the idea that success of IoT is influenced by calibration of standards which would improve interoperability, reliability, compatibility, and global connectivity.

The future research direction mentioned by Breivod & Sandstorn, 2015 in their paper is interoperability and compatibility. Basically, by what means will the long-lived systems and new services which are based on fast-paced technologies integrate with each other. The paper discusses general IoT challenges, automation domain specific constraints, and industrial IoT challengers then lastly managing those Industrial Internet of Things challenges.

Gurtov & Korzun (2016), outlines in their paper some of IIoT challenges as integration with 5G wireless networks, Software Defined Machines, ownership and smart processing of digital sensor data. It explains how these challenges affect IIoT and it outlines some proposals for tackling these issues. The outlined proposals are secure communication architecture for the Industrial Internet based on Smart Spaces and Virtual Private LAN Services.

Hartmann & Halecker (2015), describe IIoT as the industrial application of IoT. They state that IIoT is technologically focused, however the cyber-physical systems have not been defined clearly. Based on the critical review of evolutionary cycles regarding IIoT, (Hartmann & Halecker, 2015) suggest a perspective on the changing rules in IIoT and define strategic challenges and imperatives for IIoT innovation management.

The next big industrial revolution that we are looking at is Industry 4.0. IoT is set to play a very big part in this. Some of the benefits of IoT adoption in energy management process discussed by the authors in their paper includes: Finding and reducing energy waste sources, Improving energy-aware production scheduling, Reduction in energy bill, Efficient maintenance, and its management. They also discussed a few challenges in implementing IIoT solutions within their systems. The paper did well in presenting on how IIoT can be utilized to solve many environmental issues currently faced in the industry. We looked at how these concepts and solutions can be applied in industries locally and signal out constraints or benefits we may encounter here. (Pacis, Subdio & Bugtai, 2017)

Niranjan, et al. 2017 discusses the use of Industrial Internet of Things to connect industrial machines with sensors and controllers over the internet and collecting data that can be used by authorized users in the useful manner. It further investigates how IoT based industry automations will enable the control and monitoring of in-house production systems from anywhere in the world. The paper makes a brief comparison of automation in the industry through time. The journal however falls short in including some evident data from factories in the real world to further support the ideologies discussed in the paper.

Kettuen & Salmela, 2017 study focused on determining the state and trend of digital transformation in manufacturing industry in Finland. It also focuses its studies on the impact on a business's competitive edge the use of Internet of Things can give and if digital transformation is becoming a necessity. A research was conducted with numerous companies where data was generally collected through semistructured interviews. Some challenges of introducing IIoT specifically within manufacturing industry were also discussed in this journal.

Canizares & Valero, 2018 in their paper focused on a company in the metal-mechanical sector. It aimed to show the improvements that could be obtained from the applications of Internet of Thing in this company. It reported findings on how some improvements on the company's processes made these processes more efficient and at the same time reducing costs. It also defined KPIs and the application of existing technologies such as RFID and Wi-Fi are utilized to aid in the rollout of IoT technology within the company. The research quantified some of its results in term of process efficiency which is a key to smart factory automation.

Industry 4.0. It investigates the security challenges and inherent risks that result from the Internet of Things and Industry 4.0 within the context of digital transformation. With the widespread use of devices and data, it discusses the lack of standards, and ubiquitous adoption without due understanding of the need to consider the shift in implications. The use of IoT will enable companies to take advantage of the rich data streams that can be collected and analysed from myriad inexpensive sensors and devices. (Bligh-Wall, 2017)

Abdelhafidh & Fourati, 2017 in their paper, briefly discuss the development of various IoT applications in different industries with the rise of Industry 4.0 such as IoT in healthcare Industry, Smart Agriculture, IoT in manufacturing and Industry Security. Most of the paper, however, focused on the use of IoT for a Fluid Distribution Monitoring System, which includes Water Distribution networks and Oil & Gas Distribution networks. IoT becomes a source of big quantity of data obtained from heterogeneous and dynamic connected objects. In our research we explore and build upon on the idea of using IoT based systems to monitor real time information in the industry and how we can incorporate the use of cloud storage to collect and store real-time and historical data.

RESEARCH METHODOLOGY

To gather information on the studied topic, the research was conducted in two parts. The first part focused on research based on published materials such as journal articles, website data and books. This research helped in understanding the concept of Internet of Things and how it is being integrated in the industrial world (Industrial Internet of Things).

The second part of the research focused on exploring the Technology Acceptance Model (TAM) and its use to identify the drawbacks of integrating Industrial Internet of Things concepts to the Fijian manufacturing industries. This research was conducted through surveys which were designed after consulting the variables studied in the Technology Acceptance Model. Two surveys were designed, and they were focused on collaboration from two sets of contributors. The first sample had a size of fifty participants, and these were comprised of managers from the information technology and operations departments of manufacturing industries in Fiji. The second survey was intended towards a more general user base consisting of information technology officers and other potential users of the integrated technology. This sample focused on a group of hundred participants.

We have looked at five applications of Industrial Internet of Things (IIoT). Starting from industrial automation to predictive maintenance, smart logistics management, enhanced product quality and lastly smart inventory management. To begin with; **industrial automation**, the usage of coordinated systems like computers or mechanical devices and information expertise systems for management of diverse processes and equipment's in a manufacturing industry to substitute personnel's. Succeeding further from mechanization to the opportunities of industrial development. These systems can be categorized into three basic categories been fixed automation, programmable automation and flexible automation. "Industrial automation spans over many different types of control systems, e.g., motion control, protection systems, and digital control. Furthermore, industrial automation can be found in many different domains that execute different processes" (Breivold & Sandström, 2015).

- **Predictive Maintenance** is an approach which ensures cost savings for routine or time-based preventive maintenance due to smart metered connections. Procedures are aimed to aid in concluding the state of in-service equipment in order to forecast in what period maintenance ought to be executed. With the innovations in big data analytics and cloud computing predictive maintenance is continuing to grow. "Predictive maintenance relies heavily on data, and IoT provides the best methodology for analysing data and connecting all users" (Bayoumi & McCaslin, 2016).
- **Smart Logistics Management** is made up of smart products from smart services, basically having the precise product at the accurate time at a true place of need and want in the prefect condition. They are invisible, calm and therefore transparent in management and it releases personals from controlling of logistics. "Smart means that planning and scheduling, ICT infrastructure, people and governmental policymaking need to be efficiently aligned." (Kawa, 2012).
- **Smart Logistics** is the coordinated relationship of these four fundamental areas. ICT infrastructure provides right resources at the exact time for more fast and detailed information which permits enhanced planning and scheduling. As we are moving into augmented intelligence, people and machines work together for the benefit of all. People are provided training before they commerce working with these smart yet complex machinery at first. Lastly, policies which are important as they govern everything in the business.
- **Enhanced product quality** is critical for both the customer satisfaction and the business growth. Factors to consider for enhanced product quality is design, production, inspection and traceability. Adjustments are done in product design to close gaps identified and quality inspection while in production with latest technologies. Unknown causes of defects that delay inspection are identified and enhancement in traceability to increase quality and speed. "Zhang et al. designed an intelligent monitoring system to monitor temperature/humidity inside refrigerator trucks by using RFID tags, sensors, and wireless communication technology" (Xu, He, & Li, 2014).
- **Smart inventory management** links all aspects of inventory management flawlessly, from raw materials to finished goods. Such management provided visible effect using frameworks and interconnected intelligent technology systems in real time. There is real time inventory updates, alerts of issues and updates of latest process the inventory is in and also materials utilized to get output. Radio frequency identification tags, barcodes and intelligent sensors are used to identify, trace and track all required objections and devices. Reduction of expiry products and improvement in workflow. "As more and more physical objects are equipped with bar codes, RFID tags or sensors, transportation and logistics companies can conduct real- time monitoring of the move of physical objects from an origin to a destination across the entire supply chain including manufacturing, shipping, distribution, and so on" (Xu, He, & Li, 2014).

Benefits and Challenges of IIoT

- **Facility management** is the interconnectivity of nearly all the systems in communication to each other and with personnel via interface whilst keeping hardware's connected. These physical systems are progressively able to competent to control and connect themselves automatically within an information network. **"**This is far more than just installing a robot or processing a fully automated conveyor belt. These physical systems will be able to behave as autonomous systems in a changing environment" (Hartmann & Halecker, 2015) Sensors can also be used to monitor alarm vibrations, temperature changes and other dynamics that can be future reasons for less operational conditions.
- **Real-Time data** is mobile information when compared to cloud-based or decentralized. A large data center placed someplace in the world is a cloud and accessed on need basis. Whereas real data is communicated same time as the operations are happening for these manufacturing industries where data is crucial for the success. Integration with IIoT enables companies to collect data from assets and make informed decisions in real time.

The biggest industry concern is safety and is very much minimized when IIoT is adopted by industries. Potential issues are identified prior therefore reducing risks taken by individuals and actual hazards can be avoided. Enhanced industrial safety is enabled through efficient procedures and remote real time troubleshooting leading to less dangerous travel for personnel. Lastly, environmental footprint, enabled by smart meters that monitor consumption of industry resources such as fuels, time, water, electricity, etc. Resource utilization will be identified through the meters and changes will be made according. From increased efficiency to lessened safety risk and reduced travel, IIoT adoption can significantly reduce the environmental impact. Using less energy, avoiding oil spills and other accidents, and emitting less carbon are significant enough to pay attention to IIoT. IIoT also allows for clearer monitoring of energy and resource usage.

The biggest challenge of IIoT devices are security vulnerabilities as private information can be communicated with the automatically shared information. "Protecting privacy in the IoT environment becomes more serious than the traditional ICT environment because the number of attack vectors on IoT entities is apparently much larger" (Xu, He, & Li, 2014) Adoption of IIoT can lead to more security vulnerabilities and challenges in the absence of a properly secure and encrypted network. IIOT permits tracking, monitoring and connectivity of industrial data. "Reasonable efforts in technology, law, and regulation are needed to prevent unauthorized access to or disclosure of the privacy data" (Xu, He, & Li, 2014) "Therefore, the software architecture of an IoT solution needs to protect the interconnected devices from intrusions and interference from new attack vectors (i.e., coming from the communication channels) from entering the system so as to ensure secure operations" (Breivold & Sandström, 2015).

Second challenge is the absence of IIoT standards. For the success of manufacturing industries, it requires standardization in terms of capability, interoperability and reliability. "In order to provide high-quality services to end users, IoT's technical standards need to be designed to define the specification for information exchange, processing, and communications between things", (Xu, He, & Li, 2014). All in all, IIoT technology and innovations will spread widely from standardization.

An essential challenge for the industry is the cost of implementing IIoT which cannot be underestimated. Return of investment is not very promising in terms of cost if a detailed proposal is not prepared. Advantages of integration with the current or move to the new infrastructure should be listed with all the information possible. A lot of possible future issues and challenges can be avoided if such a step is taken in the present.

Last challenge identified is skills set, just having the approval with funding from higher management is not enough. We have to keep in mind who's going to make it happen and take the project till end, to design, develop, implement, fine tune and maintain the new structure. This is where skill set challenge comes in. To have the correct skill ready for the correct merge from current structure to the new one with IIoT. "Analyzing or mining massive amounts of data generated from both IoT applications and existing IT systems to derive valuable information requires strong big data analytics skills, which could be challenging for many end users (Xu, He, & Li, 2014).

PROPOSED TECHNOLOGY ACCEPTANCE MODEL (TAM)

The technology acceptance model was used to study the integration and use of industrial internet of things in the Fijian context. A total of eight factors contributing to the technology acceptance model were employed to understand and outline the results of the tests. The variables used for this study were perceived risk, cost, self-efficacy, compatibility, perceived usefulness, perceived ease-of-use, behavioural intentions, and actual use.

Perceived risk is the risk factor of integrating IIoT concepts into the business operations. The stakeholders may be wary whether these integrations would work since there are not many successful examples locally. The employees may also misinterpret the integration of such technology to affect their jobs. This can be thought of as having a negative impact on the implementation and usage of IIoT in local industries.

Cost is one of the major factors of hindrance when it comes to technology integration. The cost of equipment, setup, training and integration into the business is always posed as a challenge. Though these costs are generally one-off, they are worth a significant monetary value and stakeholders may feel that if the IIoT project does not fulfil its promised functionalities, then the capital investment will be lost. This is seen as another negative impact to the IIoT integration.

Self-efficacy relates to the efficiency of the proposed technology system. This variable determines how efficient the technology is in terms of its use and cost effectiveness. Self- efficacy is seen as a positive impact towards the integration of IIoT.

Compatibility determines if the proposed technology will be easily adapted in the organisation given its current infrastructure and workforce. If the proposed technology can fit into the operations seamlessly without changing much of the equipment already used and if it is easy to use with little to no training required by the current workforce, then it poses itself as an advantage.

Perceived usefulness is considered as a cognitive construct (Park, 2009). As defined by Davis in his paper, perceived usefulness is "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989). In IIoT, the perceived usefulness would be the how the employees would see the innovations as support to their daily functions. Would it make their work easier and efficient? From the stakeholder's perspective, they would see the perceived usefulness as how integrating the IIoT technologies would benefit the organisation by increasing productivity, work efficiency and provide data for futuristic growth.

Perceived ease-of-use "is an assessment of the mental effort involved in the use of the system" (Park, 2009). It concerns the perception of a user's interaction with a proposed system. The introduction of IIoT technologies to local industries will be largely impacted by employees' perception on the ease-of-use of the system. If they feel it is too difficult to operate, they will have rejection towards the implementation. The stakeholder's perspective also matters. If they feel the technology is not fit for operation by their current workforce, then they may hesitate to integrate such technologies into the organization's operations.

Behavioural intentions as defined by the consumer health informatics research resource is "a person's perceived likelihood or subjective probability that he or she will engage in a given behaviour" (Consumer Health Informatics Research Resource - Behavioural Intention, n.d.). The behavioural intentions of the stakeholders and the employees towards IIoT integration defines how they perceive IIoT to be beneficial and do they need to adapt such to a change for the organisation to prosper?

Actual use simply means the actual integration of the IIoT technologies into the business. It attempts to question whether the actual system will be implemented or if this is just a perception that the systems will be beneficial towards the organizations overall performance. Figure 2 describes the proposed model

Figure 2. Technology Acceptance Model for IIoT in the Fijian Context

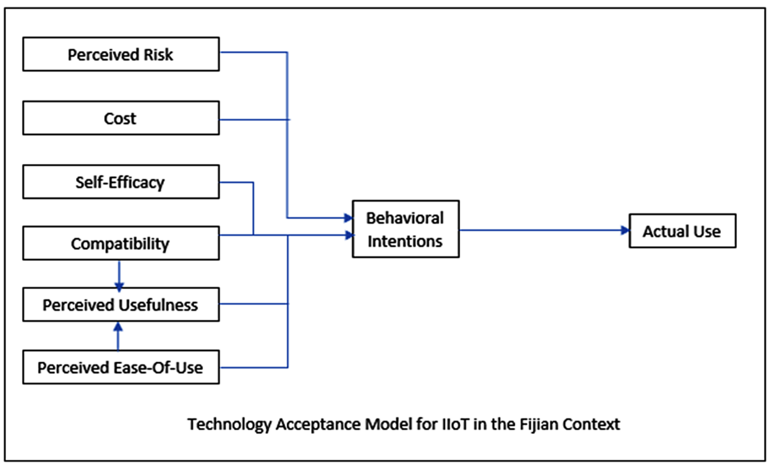


diagram for technology acceptance of Fijian industries.

HYPOTHESIS BASED ON THE TECHNOLOGY ACCEPTANCE MODEL

There were four hypothesis statements which were drawn from the technology acceptance model. These are outlined as follows:

H1. The actual use of IIoT is affected by the behavioural intention to use
H2. Perceived Risk and Cost of IIoT projects negatively affect Behavioural Intentions of decision makers

H3. The Perceived Use of IIoT is affected by Compatibility and Perceived Ease-Of-Use
H4. The Perceived Ease-Of-Use of IIoT, its Self-Efficacy, Compatibility and Perceived Usefulness

Table 1. Research Questions developed from the Technology Acceptance Model

Construct	Definition
Actual use (AU)	Are there any current or future IIoT projects outlined for your organisation?
Behavioural intention to use (BI)	Are the decision makers willing to accept IIoT integration into the organizational operations?
Behavioural intention to use (BI)	How likely is it that the decision makers will integrate IIoT into the organizational operations?
Cost (C)	Is the cost associated with IIoT project implementation a hinderance to the organisation?
Cost (C)	In your opinion, do you think the benefits of IIoT will outweigh its implementation costs?
Perceived risk (PR)	How likely is it that the IIoT project implementation will be successful?
Perceived usefulness (PU)	Do you see the implementation of these technologies as a benefit to the organisation?
Perceived ease-of- use (PEOU)	Are the current employees ready to accept the implementation of such technologies?
Self-Efficacy (SE)	How efficient do you think the IIoT technologies are when compared with legacy systems?
Compatibility (CO)	With the current infrastructure available, how likely is it able to support the implementation of IIoT projects?

directly affect the Behavioural Intentions of Stakeholders and employees

Table 1 depicts the research questions developed from the Technology Acceptance Model.

Enabling IIoT: Opportunities and Challenges

IIoT revolution has been made possible by the advancements in hardware, network connectivity, data analytics and storage and cloud infrastructure. Powerful and affordable hardware is empowering smart sensors, wireless networks, and gateways. Ability to carry large volumes of data over networks for processing had made possible greater analytics. These analytics for a range of data sets in real-time as well as offline has given rise to new business models and more efficient workflows. Getting all these components to work together in harmony is what makes the whole greater than the sum of parts.

The overall IIoT adoption started gradually and seems to be accelerating now. Just like all other revolutions, the 4th industrial revolution is also not without its own resistance and challenges. There are several factors that slowed its expected adoption rate, ranging from technical to human aspects. Some of the most significant are:

Factors Affecting Adoption of IoT

As depicted in Figure 3 below:

- **Security and Safety Concerns**: For the entire end-to-end deployment and at each stage and interfaces in between, including physical security of the deployment, data security and safeguards

- **Integration Difficulties**: Legacy hardware, lack of inter-operability, mix of multitude of technolo-

Figure 3. Factors Affecting Adoption of Internet of Things

gies and protocols, lack of IT infrastructure on the shop floor
- **Infrastructure Requirements:** Reliable and consistent network connectivity, storage space and analytical processing power required to handle very large data volumes
- **Business Related Challenges**: Complexity of deployments, Initial investment, not very attractive

- **Return on Investment**: unless full potential is realized using analytics, system down-time and testing for deployments
- **Human/Social issues**: Lack of trained resources with technology and domain skills, worker concerns about job security, reluctance for change, retraining
- **Ecosystem issues**: Too many platforms and vendors to choose from, lack of interoperability and accepted standards

Apart from these, all industrial deployments must adhere to the established standards related to confidentiality, availability, integrity, and safety as well as typical enterprise IT security practices.

RESEARCH FINDINGS

From the responses collected in the surveys out of the fifty organizations that responded, 80% mentioned there is some form of IIoT engagement being carried out by their respective organizations. Out of these, 90% responded saying their organizations is interested in further integrating IIoT technologies into the production line and other aspects of the business.

The responses from both the surveyed groups outlined the major issues in implementing IIoT into Fijian industries as employee empowerment. 80% of the respondents believe that the current set of employees in the organisation are not well informed about the benefits and operations of IIoT technologies and/or they will not be able to work with the new technology without any form of training. 70% stated that there is a lack of collaboration between the stakeholders and the information technology department to discuss the implementations. 90% respondents claimed the organisation is not ready to bear the costs of integrating IIoT technologies, as the stakeholders are unclear of its actual functional benefits and its returns on investment.

The responses from the general employees group also portrayed similar results where 87.5% responded that the benefits of IIoT implementation outweighs its challenges. This group also thought of the cost of implementation as a major drawback with 87.5% responding to this as a challenge. 58% of these employees thought there is a need to provide training to the current skill set of the organization in order to successfully implement IIoT technologies.

CONCLUSION

From this research, it was found that IIoT is an important aspect, which needs to be adapted by the local industries in order for them to maximize efficiency and profits. This would in turn help the consumers as the prices of items may decrease as well as providing a maintained supply. From the research, it was quite evident that the major drawback for IIoT in local industries is due to the lack of pioneering organizations in these technological advancements. Through further research based on international adaptation and benefits of localization of IIoT concepts, this gap can be bridged.

The technology acceptance model portrayed positive results towards the hypothesis statements. It provides a platform for conclusion that states there are mixed reactions from employees and stakeholders towards the actual use of IIoT. There are positive impacts on the behavioural intentions towards IIoT through the perceived ease of use of the system, its usefulness to the current organizational operations, its compatibility with the current systems and people and the proposed efficiency. There are, however, negative impacts as well such as the cost of the project implementation and the perceived risks of the IIoT integration, which lead to a negative mindset towards the actual integration of these technological systems. These challenges may be overcome by outlining the benefits of IIoT and overall acceptance on the global scale. A further proposal on the benefits per cost analysis will help improve on the behavioural intentions.

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