

Internet of Things: Trends, Opportunities, and Challenges

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Summary

Internet of things (IOT) is a disruptive technological innovation, anticipated for future information technology integration and optimization. The trends of this technology is very wide, covering all major industries and business sectors. However, the perceived adoption and diffusion of the technologies have not yet been achieved. There is still devoid of acknowledgment about IOT and clarification on how different industries can adopt it for their benefits. To understand IOT operations, trends, opportunities, challenges and be able to provide reliable guidelines for potential adaptors of IOT technology, this study focused on the value created by IOT technologies, targeting on the application of IOT technologies in different industries, and explores the opportunities and challenges of IOT adoption in major global industries. The results obtain from the research, provided a holistic overview to understand IOT implementation and utilization in various industries across different regions of the globe.

Key words:

Internet of Things, IoT challenges, IoT Trends, IoT Opportunities, Wearable.

1. Introduction

Information technology has been the spawn of automation and simplification for the past two decades, pertaining pivotal role in the modern business models and implementations. Due to globalization, customers have become aggressively demanding from products and services. Consequently, businesses had to continuously adjust and improve their strategies and processes towards sustainability and customer's focus approach [1]. Efforts to meet the urge and hunger of global dynamic market, has spurred the evolution of new technologies, approaches and techniques; which have been proliferated and pervasively accepted in the global business strategies. This has made modern businesses acknowledge and adopt technologies to improve their business performance and enhanced operations. For instance, the invention of first radio station took 38 years to attract 50 million customers while Facebook with modern business strategy, took only 5 years to attract over 600 million customers around the globe. Nevertheless, technologies have allowed businesses such as WhatsApp to start with less capital and grow exponential with optimized profit [2]. From the past decade, businesses have witnessed rapid evolution and transformation of strategic approaches and plans towards sustainability and growth. These approaches and techniques must be highly aligned with information technology systems to acquire an

optimized profit and tangible business outcome. It is also noted that, not all technologies have the capability and power to alter businesses or social platforms. However, some are projected to have genuine values to improve businesses and digitize social platforms, such technologies are mobile internet, advanced genomics, data analytics and internet of things [3].

Internet of things is among the most discussed technology in our days, intended to connect our physical world with sensors and actuators over the internet into digital platforms, in order to monitor, measure and optimize processes and future forecast [4-6]. It is projected that by 2025, more than 100 billion devices will be connected and contribute over 11\$ trillion in the global market per year while transforming the way people live and work. The impact of IOT is already being experienced in some industries, such as health, automotive, and manufacturing [3, 7, 8]. With the use of wristband wearable device, patient's health information can be monitored and relayed back to the doctor's application for further analysis, treatments, and observation. This has offered an unprecedented approach and technique towards saving lives and effective use of medical treatments to cure patients. Nevertheless, automotive and manufacturing industry has gone beyond and above towards IOT implementation and expectations [2, 7]. Many new technologies emerged, and are being cultivated, as a consequence of IOT. Autonomous vehicle, proactive maintenance systems, and intelligent transport systems are some examples of such systems. These technologies are at the edge of research in some of the global leading car manufacturers and technology moguls, like Toyota, Volvo, Mercedes Benz, BMW and Google, as an effort to guarantee their future existence in the global market [9, 10].

Whilst, most of the global industry are investing heavily in the research, adoption and implementation of IOT, the question still remains "*Will IOT technology bring tangible value to businesses operations and transform the way people work and live?*". This article will investigate the opportunities and challenges presented by the adoption of IOT.

In sections 2, 3 and 4, a short review of IOT concept and its trends, opportunities, and challenges will be discussed, respectively. Section 5 will focus on the Potential Economic Benefits of IOT. Sections 6 review some previous related

works, and finally, in section 7, a conclusion will be outlined and future recommendations will be articulated.

2. Internet of Things

Internet of thing can be defined as sensors and actuators connected through internet into computing systems [4]. From another perspective, IOT can also be defined as a network of connected smart devices which are communicating with each other over the internet using sensors and actuators, without human interaction [5]. According to Irfan Awan et al. [6], IOT is the internet platform connecting smart devices with interfaces and identities, which can communicate among each other through standardized communication protocols. From the above definitions, IOT can be sum up as disruptive utility technology that can be used as a tool to streamline communications between smart devices and human, through sensors and complex IOT integrated systems enabled by data analytics and manipulation. It actually harmonizes the way people connect to the physical world using public service such as cloud computing [11]. Figure 1 elucidate the IOT concept in more demystified approach.

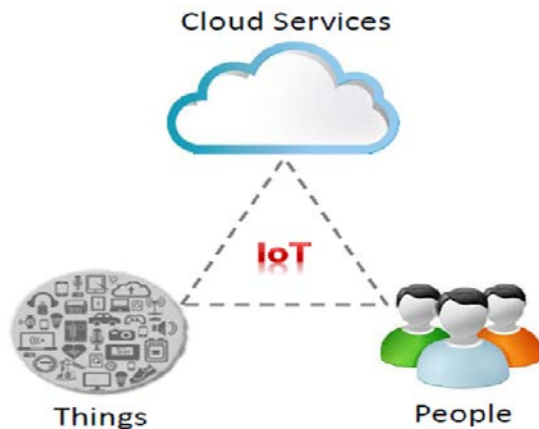


Fig. 1 IOT Concept [11].

The competence to monitor, measure and manage things from the physical world will not only spur, but also spawn new opportunities in many fields through data-driven decision making, optimizing performance in systems and processes, save time and enhance the quality of life. By monitoring machines in manufacturing industries or vehicles on the road using sensors that provide real time information, can help companies to acquire more out of their physical assets and optimize business process. Nonetheless, machine management systems in the manufacturing industry dominated a great deal of efficiency

and effective manufacturing. These systems can be enhanced with the use of IOT technology to effectively monitor, measure and optimize production [4]. However, IOT must persevere over stream of impediments to reach its desired potential benefits, which will require massive dedication and commitment in time and investments. Governments, organizations, and institutions must support the technology through awareness programs in academics and media, while financing local research and development programs. There are still many concerns on the security, privacy, interoperability, power consumption, and modular standards for communication between devices to devices and devices over the internet. These challenges highly contribute minimum adoption rate and hinder the attainability of the extreme benefits of IOT. There are quite number of R&D currently taking place in the field of IOT. Aiming to further explore and exploit opportunities and possibilities so as to foster overall IOT adoption around the globe [12].

3. IOT Trends

Many researchers and scientists are very optimistic toward the potential of IOT in many fields, ranging from manufacturing, health and medication, transportation, arts, agriculture, etc. However, considering on the existing platforms and application services level in terms of global market penetration is still a paradox. The general identified reason is the lack of standardization between smart devices, leading to segmented commitment towards addressing IOT solutions. To curb the rise impediment on the current modular deficiencies, several standard development organizations such as ETSI (European Telecommunication Standard Institute) and ITU (International Telecommunication Union) have spurred technical committee working on with modular standard on communication protocols between smart devices and final user applications, which so called machine to machine (M2M) model [13]. This initiative will enhance on the adoption efforts currently taking place, such as in buildings using sensors as energy saver mechanism in the lighting system, home automation through networked smart devices, automotive industry adopting devices aiming to improve passenger's safety and transportation experience, and last but not least is in health industries, implementation of monetizing devices which will improve health care and medication. All these efforts and determination are due to the anticipated global economic impact that IOT promises to contribute in near future of less than ten years from now. IOT will not only influence on the way we work and do business, but it will also have an impact on the social-economic platforms. It will not be seen as an individual system, but rather as utility system, which will be used for myriad of purposes, while some applications will be

customized and digitized daily life activities, such as global delivery services, where drone will be used for deliveries while controlled and monitored over the internet. Cities will have no traffic light and insurer will charge their customers according to their driving pattern. Sensors in buildings will not only be used as a means to save power, but also to improve quality of living through enhanced security, proactive maintenance and interactive safety applications [14]. IOT will incorporate myriad opportunities and possibilities over the next few years to come. However, to acquire its pick potential benefits, rigorous effort must be directed in solving communication standards, interoperability between IOT systems and security.

4. Challenges Prone to IOT Adoption

As one of the emerging technologies with myriad possibilities and future prosper anticipations, IOT has been growing exponential over the past few years. The nascent acceptance of IOT has resulted into positive impacts and expectations towards future global digitalization [8]. However, according to Malaysian Minister of Science, Technology and Innovation; YB Datuk Seri Panglima Madius Tangau, "IOT is such amazing and fantastic technology, where its maximum potential benefits can only be experienced through collaboration", this signifies that collaboration is pivotal to heighten IOT values [15]. Nonetheless, European Union envisaged that there is an urgent need to address IOT challenges and liabilities, and proactively propose future solutions that will spur adoption processes around the globe [12]. Security, interoperability, and issues concerning development in emerging economies are the main impediments towards maximum adoption scale of IOT [8, 16].

4.1 Security

Security is a perennial concern when discussing about information technology and its implementation. Nonetheless, IOT has emerged with new security challenges that needs to be closely considered and neutralized to experience significance adoption rate and heighten public trust. End users' concerns are mostly in the privacy of their data and devices, especially when considered that these millions of connected devices will be able to communicate with each other and with human, not only that, but also pervasively exposure of daily used home, work and personal devices into this huge network of interconnected smart devices. This raise myriad concerns on the data ownership, privacy and regulatory policy [16]. Regulatory boards together with system developers must work together ensuring devices are reliable and operate in

secured network with rigorous respect to user's privacy, this will spur and foster the adoption process amid taking IOT one step closer to its full potential benefits.

4.2 Interoperability

Over 40% of IOT benefits are anticipated to be as of direct result of interoperability and immense data analytics capabilities [17]. Once devices are efficient and cost effective and integrated, flexible with articulated legal policy and global modular standards, significance value will be created through data monetization, measurement, and optimization. Currently the global market seems to be dominated with proprietary products operating in silo-manner towards their company's policies and regulations and not towards modular standard of communication between smart devices [12]. However, to forestall the scale and magnitude of adoption rate in near future, IOT regulation bodies, organizations and institutions must work together to come up with an advanced and flexible platform for software engineers to develop IOT applications, modular standard must incorporate several sub standards for IOT devices and networking, which can foster interoperability and flexibility, while extending value in services and products towards customers and end users.

4.3 Development Issues and Emerging Economies

IOT promises a great invention in solving major issues in developing and emerging economies, such as industrialization, weather forecast and anticipation, proactive measure and maintenance, water safety and distribution, economic forecast, construction and effective use of power, and many more. Ensuring gracefully adoption of IOT in the region, the following issues much be closely monitored and improved, such as infrastructure design and implementation, market readiness, investments encouragement, legal and privacy policy, technical skills, resources and public awareness. These issues must be significantly addressed as a pre-emptive measure towards adaptation and implementation of IOT project in the area. Government, institutions, and organizations must concurrently work together in promoting and supporting IOT initiatives and solutions [8]. Many researchers, scholars and scientists, envisaged that IOT will have great impact to our future economic growth which will affect not only the developed nations but also reflect significant blow of benefits towards emerging and developing economies [2, 3, 8, 13].

Figure 2 depicts Potential IOT Economic Impact by 2025 [3].

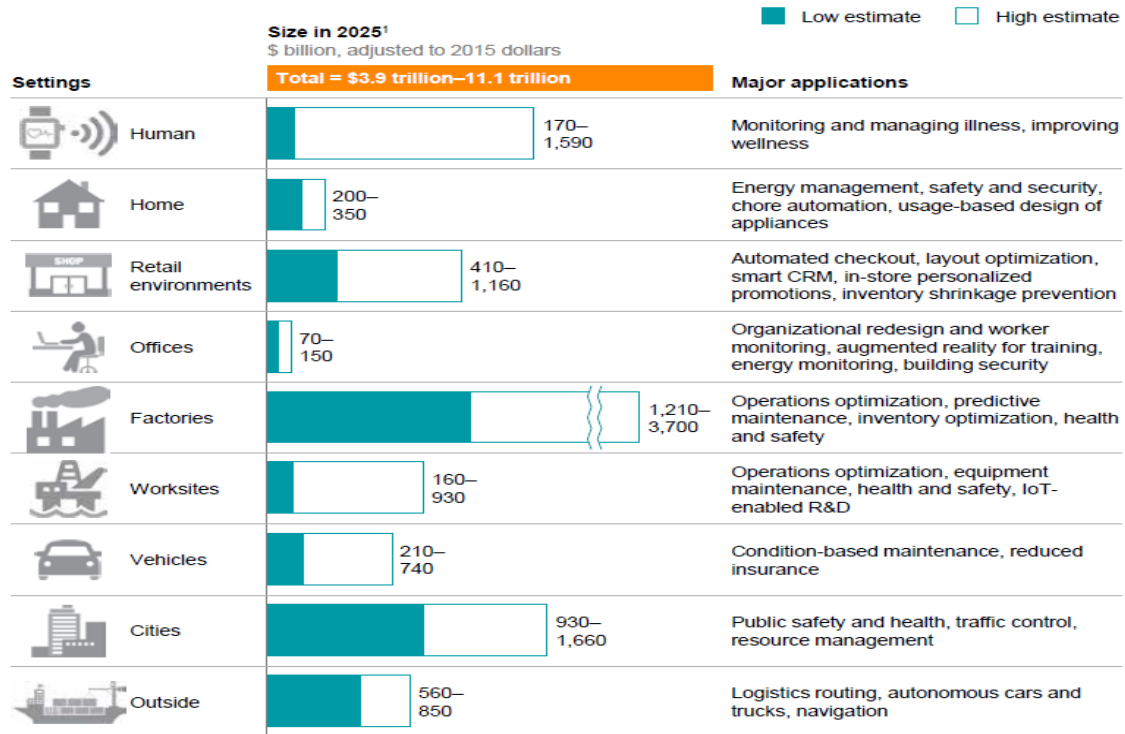


Fig. 2 Potential IOT Economic Impact by 2025 [7]

5. Potential Economic Benefits

Based on the several research conducted, indicated that IOT will have an immense impact on the global economic platform for the next ten years [2, 4, 5, 12]. The transformation and optimization of the global economic will solely depends on the adoption scale of IOT devices, affordability, liability, and durability of smart devices and technology acceptance scale for consumers as well as workers. There are myriad possibilities and potential spreading from industrialization to home automation and from business monetization to optimization. According to McKinsey, factories will experience the most economical potential benefit in the next ten years, of about \$3.7 trillion per year by 2025, followed by smart cities, which will affect as much as \$1.7 trillion.

5.1 Wearable and Health Care

IOT wearable smart devices has already being used in health care and security. According to the research conducted by Ericsson [18] in Brazil, China, Korea, United Kingdom and United State of America, projected that the number of people owning wearable has almost doubled from 2015 to 2016, and increased by 16%, from 14% to 30% by this year. While other users estimate that in future, wearable will replace smart phone as a primary tool for interaction and communications due to its perpetual

advancement. The other issue raised by Ericsson research is the flexible adoptability of those devices, which make it difficult for a user to spend a day without wearing it once you are used to it [18]. However, there is still a major concern in users' data privacy and existing social, economic, and legal norms. Governments should work akin together with the private sector in health care and security to ensure effective data sharing between institutions, and emphasis on collaboration in order to achieve great values from IOT. Governments and institutions should not only support IOT through financial packages, but also must take necessary measure to ensure user privacy and security through efficient regulatory policy and legal framework [19].

5.2 Home Automation and Smart Cities

IOT offers wide range of applications to enhance home automation towards smart cities. With the use of sensor and actuators embedded in smart homes, allow security through door and windows sensors, power optimization through sensors implanted in electric devices, proactive maintenance, and device optimization through integrated IOT devices. Moreover, IOT devices will improve and monetize smart cities through integrated citywide smart devices, such as city surveillance and security through integrated camera systems, improve traffic and transportation through smart traffic system, pipeline leakage detection by sensing the pipeline operations and

distribution. All these and many more are expected to change the way we live, work and play [7]. Nevertheless, there is still tangible concern in a sense of power consumption, due to over 100 billion connected devices, which will be connected by 2025. The power consumption for IOT devices must be enhanced and reduced to its minimum level, developers must come up with effective solutions to eradicate these issues. Texas Instruments currently are working on a mechanism to produce power from IOT devices that can be generated from wind motion, vibration, and solar power. It is very productive and effective approach to address this issue before IOT pervasively spread throughout the globe. Developers and semiconductor manufacturers must come up with suitable designs for smart devices with minimum power consumption as possible. Concurrently, they should also address modular standard of communication between smart devices which will be flexible, safe and secured in order to gain consumer trust and ease of use, which will result into heighten adoption scale [11].

5.3 Smart Manufacturing

Manufacturing generates more data than any other sector in the global economic, the sad thing is that most of these data are lost or used to its curtailed potential. This could be due to lack of technology and support systems capable to perform such task. However, IOT systems when combined with data analytics can contribute handsomely towards task automation, proactive maintenance of the machines systems, effective monitoring, quality assurance and flexible production towards customers focus approach. Sensors attached to factory machines will be collecting data throughout production line, with effective use of data analytics technology, these data will be monitored, measure and optimized for better business and production processes [17]. Companies like Toyota are already shifting from traditional manufacturing to more digitize one. According to Toyota's Senior Vice President, Mr Jeff Moore (North America and America), in order to meet market demand in America, the company is starting to migrate into digital production, where sensors and actuators will be implanted in both new and old machines so as to monitor and provide real-time data from production line. This data will be used to eliminate defection, enhance production, and save cost. One of those system that are already being adopted by Toyota is Toyota Operation Availability System (TOAD), this system has saved over 40,000 working hours in one specific plant and \$6 million in operational cost savings [20].

6. Related Works

For the past few years, there has been extensive IOT R&D initiatives in many scopes, including development platforms, home automation, connectivity, and

communication between IOT devices and more. For instance, Onion Omega Company developed a microchip called Omega 2. Due to difficulties and challenges faced by the developers while developing IOT applications, most of the platforms and development boards available are complex and not easy to use especially with IOT app development. Omega 2 chip is a flexible development board, providing a conducive environment for developers to develop and easily integrate devices with sensors and actuators. The chip is equipped with full Linux operating system, which can support Wi-Fi connection, apps control manoeuvre, support many coding languages with simple drag and drop programming, and finally it cost only US 5\$. This chip will foster IOT app development and innovation, due to its incredible easy to use platform and a very affordable price. It is anticipated to enhance and spur developers to be more creative and innovative and scale up adoption rate of IOT technology [21].

Furthermore, google has recently introduced a device called google home, which helps consumer integrating with their home smart devices and the world through natural language. The device recognize voice via voice recognition sensors attached to, it is then performing a requested task and reply back to the user. The integration begins with home appliance to internet applications, provide control, monitoring and alert the user of any possible threat or security issues. This innovation will enhance and marginalize IOT devices while creating high adaptation rate of IOT in home automation. Once, the technology is effective and efficient in terms of functionality, security and privacy, will foster consumer participation in the technology and heighten adoption rate [22].

There is also approach adopted to enhance integration between IPV6 with Intelligent Transport System (ITS). IOT is expected to connect billions of devices with different standards and architecture, this project is perceived to facilitate the communication between cars, traffic management systems and other IOT applications over the internet. As an effort to acquire interoperability between different proprietary products and services, this will also empower app developer to aggressively innovate new integrated apps, which might scale up adoption rate [23]. Another IOT innovation is the CARV, it is a digital ski coach that has already helped many professional skiers and transform their skiing experience. This is a wearable device that can be placed in the ski boots and earphone in the ears and come up with mobile app to support its functionality. Having motion and pressure sensors, this device is able to monitor, measure and analyse user's motions. By doing so, it can consult the user on real-time base, and suggest better ways to improve and enhance the ski experience. According to Filip Flisar current ski world champion "Carv brings new perspective to skiing. The pressure sensors allow you to see exactly what's going on and along with the mobile app it's a great combination- it really works" [24].

As an incentive towards full scale IOT adoption, Amazon is expecting to launch its new series of convenient shops throughout United States. These shops will be set up with sensors and actuators, and supported with complex IOT systems. The sensors will sense user's information on the products as he/she picks it up. The data will be conveyed back to the system where it will be manipulated and checkout the user's selected products online without any interaction of human assistant such as cashiers. In other word, customers will be able to go into the shops, take what they want and leave, without having to queue up to cashiers for payment. Everything is done through the mobile app from the customer's mobile phone [25].

Lenovo introduced IOT platform services, which offer IOT services options regarding to user's specification. Using this platform, Lenovo can integrate user's preference devices over same platform, regardless if it is old or new, and provide accessibility to the platform according to the user's needs and requirements. This application can be used in home automation, industry and manufacturing and many other fields depending on the requirements [26]. Using Lenovo platform, facilitate companies and other organization towards adoption of IOT technologies coinciding with their business processes and solutions, as a result more valued created and heighten business growth.

7. Conclusion

IOT is a new technology with extended hype due to anticipated global economic impact in few years to come. IOT will be used to enhance and change the way we live and work. These factual perceptions can only be reality, if IOT is pervasively adopted throughout the globe, not only that, but also there must be high level of collaboration between institutions in developing effective and modular communication standards between smart devices, manufacturers must engage in smart devices production with affordable prices and high security functionalities. These factors will facilitate maximum adoption of IOT, and allow consumers and institutions to acquire optimal value from IOT technology.

Governments and international organizations must come together in promoting awareness of the technology both in academic institutions and social platforms, this will enhance and foster adoption in a massive scale.

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