RECENT APPLICATIONS OF INTERNET OF THINGS (IOT) IN MANUFACTURING SECTOR – A REVIEW

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Abstract: Internet of Things (IoT) is fundamentally changing the ways factory and manufacturing processes are managed. Leading manufacturers have already developing the ability to interconnect objects such as machineries and materials in establishing smart factory system. Apart from the interconnection advantages, IoT enable them to capture significant market shares by increasing the manufacturing performance through big data analytics. Therefore, it is very important for enterprises to learn and adopt the technology as quick as possible to be competitive. This article reviews the fundamental and applications of IoT in manufacturing engineering field within this decade.

Index Terms: Cyber Physical Systems, Data Analytics, E-Manufacturing, Industrial Revolution 4.0, Internet of Things, Manufacturing System, Smart Factory System.

1. INTRODUCTION

Technology advancement has changed the way manufacturing process being managed. The ability to equip factory and production plant with IoT technology has enable interconnection and interaction with each other to automatically and adaptively carry out design and manufacturing logics as well as the supply-chain logistics. Furthermore, there is a lot of potentials could be achieved when a fully functional IoT-enabled manufacturing environments is developed. Modern manufacturing concept as introduced in Industry 4.0 will be able to possess state-of-the-art Information and Communication Technology (ICT) infrastructure for data acquisition, sharing and storage which will greatly affect the performance of a manufacturing system.

New technologies such as cybersecurity, big data analytics, cloud computing and the Internet of Things (IoT) have been invested by the modern manufacturing industry to improve details clarity, increase production accomplishment, and obtain a condition or circumstance that puts a company in a favourable or superior business position in the new business arena [1]. For an instance, a cyber-physical structure tightly merging manufacturing business in the physical platform with virtual business in cyberspace is one of the new generation of smart manufacturing which rapidly has been enabled as one of the benefits received from the investment which has been made to a great extent, for data-enabled engineering modernization recognizing the utmost potentiality of cyber-physical systems relies upon the advancement of new approaches on the Industrial Internet of Things [2]-[6].

Designing principles to encourage advanced manufacturing is growing progressively as industries happen to be more complicated and the pace of technological growth rises. The method in which manufacturing enterprises perform and manage their firms are being determined by megatrends. Universally, the variety of manufacturing goods and services desired are redefined by uncertain consumer preferences. The conventional standards of industrial management are being questioned and origin of value capture among industries are altering. Moreover, the potentiality to develop new markets which relies entirely on new products and services has been provided by current technologies. One of the crucial themes in innovation principles plans of bigger companies is the digitalization of manufacturing, hence greater attention is being paid to widest range of digital technologies and concepts which inclusive of the internet-of-things, big data, cloud computing, as well as visualization technologies, advanced robotics, 3D printing and artificial intelligence [2], [3]. The global interest in IoT for manufacturing engineering is increasing since 2010. This is obvious especially when we look at the total publications in Scopus database. Recent search shows that there are significant increment in the number of publications over the years. Furthermore, majority of the articles were published in the conference proceedings and journals. These shows that the topics are in the early stage of knowledge development. Total publication in Scopus for Internet of Things for Manufacturing on yearly basis is depicted in Figure 1 and the publication source types are illustrated in Figure 2.
that produces compressed air system that uses a range of IoT sensors to capture critical data related to the performance such as temperature, humidity and compressor vibration during operations that may contribute to system failure and also when the system happen to downtime [12]. Meanwhile, HIROTEC a Japanese-based manufacturer for automation equipment implement the IoT-enable factory that is capable to capture and analyse data from CNC machines located in Detroit, Michigan plant. By implementing the IoT technologies, the company could perform remote visualisation of an automated inspection line for the production of exhaust system, robotic inspection system, measurement devices based on laser technology and camera to perform automated and real-time visualisation. These are then fed into the central system and relevant reports could be generated. KUKA (Keller und Knappich Augsburg) is a currently Chinese-owned manufacturer of an industrial robotic for factory automation has leveraged IoT by connecting smart objects to achieve an automated and interconnected manufacturing system. This can monitor the work in progress in real-time, detect and fix the problem ahead. Rockwell Automation is a leading supplier of industrial automation software. This company has helped the coffee manufacturer to generate a real-time information situation regarding its operational state. The result shown identification the fouling rate between machine producing caffinated versus decaffeinated coffee and predict downtime and decrease the extend of oversupply equipment needed on the production line.

3 CYBER PHYSICAL SYSTEM AS THE REFERENCE ARCHITECTURE IN IOT

Based on cloud computing, there are several categories which are cyber-physical system, design and process. In each category, it is divided into two. For the cyber-physical system, it is divided into architectural and infrastructural principles and wireless sensor networks. Meanwhile, for the design and process, it is specialized into cloud based process planning, cloud manufacturing ERP and process monitoring. Cyber physical system refers to the integration of computing technologies that interact with the physical world in a closed loop. Based on the research by Xu et al. [13], they mentioned that the applied of modern technologies of information communication such as computation and control communication can fix the guidance and control the capability of physical system like manufacturing equipment. Meanwhile, in IIoT system, typical cyber physical system are categorized into two components which are cyber system and physical system. The control and communication infrastructures that were implemented in the operation, interconnection and intelligence of industrial system are included in the cyber system. Therefore, the manufacturing and automation system that applied in the industrial devices to attempt in an automation tasks are included in physical systems. In order to fix the realistic threats and feasible security solutions for given design patterns, common design patterns in IIoT applications will be used [14]. Furthermore, the cloud manufacturing services could also benefit the process planning execution. This is feasible as process level and component level are described based on the manufacturing tasks and manufacturing services. As the process planning will be conducted using the cloud infrastructure, the system adopts CM and service oriented computing are proposed in order to access towards knowledge based and effective process

2 INDUSTRIAL IOT FOR MANUFACTURING SECTOR

The booming of the high advance technology give impact to the manufacturing industry during German strategy initiative to lead market and provider of advanced manufacturing solution that called Industry 4.0. Additionally, researchers also highlighted that Industrial Internet of Thing is one of the critical pillar of Industrie 4.0 [7], [8]. Meanwhile, Hamzeh et al. [10] investigated the implementation of the Internet of Thing (IoT) for the small-medium sized enterprises (SME’s) for local New Zealand manufacturing. The result shown that Industry 4.0 with IoT could be the key to transform and enhance Small-Medium Sized Enterprises in the future by referencing to the model that can be used for local enterprises to give the benefit from Industrie 4.0 concept. In order to understand the difference between Industrial Revolution 3.0 and 4.0, Schweichhart [10] has illustrated the differences as in Figure 3. In a monumental progress, German Electrical and Electronic Manufacturers’ Association (ZVEI) has introduced Reference Architecture Model Industrie 4.0 (RAMI 4.0) to support the Industry 4.0 initiatives [11]. The proposal gained worldwide acceptance and successfully influenced leading manufacturers to develop their own reference models to execute their own Industry 4.0 efforts. Figure 4 shows a three-dimensional map with the most important aspects of Industrie 4.0. In another related progress, manufacturers have been using the benefit of IoT applications to upgrade their manufacturing processes and supply-chain business models. Kaesser Kompressoren is a German manufacturing company
planning and simulation services by starting from the monitoring services [15]-[17]. The reference architecture is shown in Figure 5.

![Figure 5: Reference Architecture of the Cloud-Based Cyber-Physical System [17]](image)

4. IOT SERVICE PATTERNS FOR CPS
Previous research stated that the links between the hardware gadgets, vehicles, structures and connection of network and others implanted with hardware, programming, sensors, intelligent decision support and system network are critical in developing an efficient IoT-based manufacturing systems [18]-[20]. There are three main service patterns in the IoT which are [20]:

- Information publish facility is driven by physical world
- Sensing-controlling resource is driven by occasions in the physical world, while.
- IoT search service is driven by the client directly.
Insightful (smart) elements. The CPMS used web technologies for depiction and are open for revelation. Cyber-physical based manufacturing system (CPMS) had plot as the acknowledgment of smart administration in manufacturing physical space. For example, production procedure smart planning, factor of design generation, optimizing the layout of shop-floor, production scheduling and management of inventory [23]-[27]. These are some of the application that being implement in IoT manufacturing by using the cyber-physical systems. Meanwhile, Microservice IoT-Big Data design supported the conveyed production of multidisciplinary reenactment models, overseeing in a streamlined path surges of information originating from the shop-floor for genuine advanced synchronization, guaranteeing security and secrecy of reasonable information [28]. Automation, high integration, flexibility, sustainability and intelligence are the most important components which distinct smart manufacturing from traditional manufacturing which has been driven by the driving forces which inclusive of Internet of Things (IoT), smart sensors, big data etc. [29]. Production optimization, capacity scheduling and integrated circuit manufacturing are part of the application provided in smart manufacturing which have brought such an extreme impact to assorted industry sectors. Enhancement of product quality and minimization of danger can be led by applying modern computer processing technique for instance deep learning and make practical and effective use of big data to identify, design, and monitor processes involved in production [30]. Improved customization as well as method of fabrication has also been significantly affected by the advancement of additive manufacturing [31]. These modernizations had academia, government as well as industry to shift their focus on the growing areas of the application utilization. The countries which have recognized the cruciality of smart manufacturing have invested massively in this sector. In warehouses as well as shop floor, IoT employed will encourage manufacturing implementation structure, organization of warehouse systems, control of warehouse systems, and management of conveyance systems [27], [32]. In order to choose wisely among options of operational and production decisions, information from other plants along the production chain as well as from the suppliers involved are very crucial. Those needed information can be gained by merging details produced from different machines on the plant floor which could provide manufacturing firms with real-time intelligence. The process mentioned involves sensors which smart manufacturing is depending on to produce the details needed [29]. Sensors can also aid one of the applications of IoT by supervising machinery in real time to uphold a concept of from a part of mend and change to forecast and avoid. Table 1 summarizes the contrast of manufacturing in smart and traditional way in general manner. Powerful analytics projected from studying real-time data composed from a plant could be a very powerful tool to plan an automatically computerized workflows of an optimal production system via the elements of IoT. This includes the utilization of the ability to communicate through codes between machines and goods produced the output from the conversation will then be interpreted to highlight production requirements and crucial upcoming steps need to be conducted.

Information publish service make use of wide-ranging of detectors to recognize the conditions of objects in the apparent world. The data will transmit into cyberspace and publish for the clients. Sensing-controlling service or Cyber-Physical System (CPS) is smart system that consists of computational and physical elements. The elements are continuously assimilated and interact closely to recognize the transformation states of the real-world. The computers and network that are embedded by the service will track and run processes with feedback loops that impact the computations and vice-versa. IoT is a process that search object physically. The user needs to ask question about the location or state of physical object by sending them to the cyberspace. Then, by exchanging information between the cyberspace and physical world, the system will give the location and state of physical object in the real world [21]. Based on the three patterns, the Industrial IoT incorporate the Cyber-Physical System. Concept of Industrial Automation and Control Systems (IACS) is achieved and frequently called as Operational Technology (OT), that utilization in differing enterprises including assembling, transportation and utilities, and furthermore alluded as cyber-physical systems (CPS). The transformation of Industry 4.0 is portrayed by its reliance on the utilization of CPS that capable correspondence with each other and making self-governing, decentralized choices, with the reason to improve industrial effectiveness, profitability, safety, and clarity [18]. Additionally, Thrampoulidis et al. [22] supported the argument by stated that CPS is one of the key constituents in Industry 4.0. Through the evolution of Industry 4.0, cyber-physical microservices (CPMSs) have been created which physical units of the manufacturing plant are convert to

Fig. 6.: IoT service patterns illustrations (Ma and Liu, 2018)
On top of that, the same approach can be applied to project predictive maintenance to enhance machine’s health. This countermeasure could bring to lessen machinery time of which an activity is stopped and resulting higher production as we know the amount of useful life left prediction and automate condition-based maintenance strategies which is beneficial to plan out the future. The manufacturing sector usually consumes for 33% of the worldwide energy. The energy saving is gained due to dynamics and regulation of closed-loop energy algorithm which wisely balance assets to the small-energy state while conserving the throughput level. All this happens when continuous measurement of energy consumption is corresponded with manufacturing blueprint and condition of goods. Small manufacturers, in particular, should not be anticipated to go through with it in this situation and may need to gain from both intelligent partnerships with vendors and directorate initiative which support the implementation of new and other advanced manufacturing policies and technologies. Nowadays, manufacturing firms are frequently improving their performance especially in certain important aspects such as costs, efficiency of production process, time to market as well as product price to stay competing in the business arena. In order to survive, manufacturing firms should always keep in par with customer needs by utilizing new technological paradigm such as IoT which will help company to stay up to date with the global market situation [33]. By making wise decisions, information can always be shared autonomously with entities whom prioritize cooperative communication. By monitoring resources in real time for the manufacturing sector, unprecedented opportunities will occur enabling higher safety and performance.

5. CONCLUSION
Applications of IoT have benefited in increasing the production number and fulfilling the customer demand via product customization which resulting in increasing the customer satisfaction, sustain the social aspect, stable the revenue streams and elevate the number of customer loyalty. Industrial IoT also enable the real-time supervision even tough from farther distance. Also, Industrial IoT can be seen as one of the solutions to cater the huge number of product demands. Able to interoperate and interconnect between distinct systems is another strength of Industrial IoT which can yield in more innovative work and ease to use those different systems. This can reduce the cost in investing in new-standardized system.

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REFERENCES

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**Table 1**

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<th>IoT Enabled Manufacturing</th>
<th>Traditional Manufacturing</th>
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<tbody>
<tr>
<td>• Global resources</td>
<td>• Constricted assorted resources and preordered resources</td>
</tr>
<tr>
<td>• Flexible and adaptive routing</td>
<td>• Fixed routing</td>
</tr>
<tr>
<td>• Immediate interconnection</td>
<td>• Minimum interconnection</td>
</tr>
<tr>
<td>• Solitary organization</td>
<td>• Self sufficient control</td>
</tr>
<tr>
<td>• Big data ability</td>
<td>• Remote information</td>
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**REFERENCES**

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