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An Overview of the Rising Challenges in Implementing Industry 4.0

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Abstract—Industry 4.0 is the fourth industrial revolution that was first introduced in Germany which then becomes a trend of future manufacturing industries. The Industry 4.0 also referred as the umbrella concept for new industrial paradigm which consists of a number of future industry characteristics, were related to cyber-physical systems (CPS), internet of things (IoT), internet of services (IoS), robotics, big data, cloud manufacturing and augmented reality. By adopting these technologies as the key development in more intelligent manufacturing processes including devices, machines, modules, and products, the process of information exchange, action and control will stimulate each other, subsequently to an intelligent manufacturing environment. However, in order to fully utilize the advantages of industry 4.0, there are some challenges that need to be overcome. This paper reviews the challenges in implementing Industry 4.0. The literatures found in this paper mainly from Google Scholar, Science Direct and Emerald. In short, the challenges can be imparted into seven major categories. There are data management and Integration, knowledge-driven, process, security, capital, workforce, and education.

Keywords: Industry 4.0, cyber-physical systems, internet of things, internet of services, manufacturing industry

1. Introduction

The Industry 4.0 enables manufacturing sector to digitized the built-in sensing devices in all manufacturing components, products and equipment virtually. The digital analysis and process of the related data, in pervasive system with the fusion of function and physical objects is believed have the ability to transform every industrial sector in the world, which evolving faster and greater impact to the society than any of the other previous industrial revolutions; 1.0, 2.0 and 3.0 [1]. Hence, the Industry 4.0 is a contemporary issue that concerns today's industrial production as a whole and is meant to revolutionize. In 2011, Germany introduced Industry 4.0 in the Hannover Fair event, this symbolizes a brand new era of industrial revolution. When the idea first came, lot of efforts were put on by the European manufacturing researchers and companies. They interest in this project or concept is due to the fact of under Industry 4.0, production will become more efficient and less cost required. The concept is achievable by incorporating the information exchange and the control in product manufacturing and machines to acts simultaneously and interoperable [2]. However, there are numerous challenges occur that need to be determined systematically to make sure a smooth transition along the implementation of the concept. Hence through this review, some little attention and to the challenges are considered closely in implementing the concept of Industry 4.0. Nevertheless, this review paper will aid the confused politicians, researchers, consultancies and practitioners to understand better of the concept of Industry 4.0, since they are often made inconsistent statements on the implications of the Industry 4.0 [3].

2. Challenges in Implementing Industry 4.0

2.1 Data Management & Integration

Data management and integration refers to the best ways to make full use of the data that being gathered. Data that bring contribution to the eruption in data-driven world for production environment is collected and generated from different machines sensors, data partners and infrastructure, process, product, quality, plant and logistics. However, the ways of data processing, storing and management of data for each organization start to face various future demands and challenges [3]. The ability to provide computing services with high speed and reliable machines possesses huge potential and cannot be underestimated. The advantages of high utilization and large scale of

data management with minimum budget allow developers an edge compares with own computing power generated by the companies themselves [4].

Firstly, big companies often faced problem related to insufficient of standard approach to manage the data due to the unnecessary data kept in different departments with various types of data renewal, minor enrichments and extensions. Hence, management for the diverse landscape of data drives a system to some degree of redundant profile in related to hardware, software, licenses and skills. The cost is always over the top of budget, thus becomes unnecessary overhead in a situation of competitive production. According to Khan & Turowski [5] action made on redundant data leads to wrong decision.

Secondly, companies have responsibility to secure the data transmission and protect the data to ensure all nodes through the network are secured from the manufacturing equipment to the terminal of data controller. One of the challenges for Industry 4.0 is transformation of data in various smart devices to keep all data neither before nor after transformation [6]. Therefore it is crucial to ensure successful exchange of data within companies and their departments for the availability of data for another process. External partners shared their data with others companies to improvise the process i.e. material logistics data able keep the stock level as less as possible. Companies have to share the state of manufacturing progress at their production line with others intelligently if for further process is required. The prospected products and equipment were need an improvement of manufacture shall be shared digitally within companies or stakeholders in similar interest so that the data is improvised and the production cost is under control [3].

Next, the level of investment in big data for the company act as important role for the IT infrastructure in their company. However, not all of organization is cooperating big data. Their project implementation is depending on the type of organization. They mostly not depending on just a big data project to fulfill their requirement, but a complex stacking structure of data is always involved [7]. Due to the complex and big stacked-data to manage, without a right concept, a project becomes incompetence and unable to analyze the data in just ~~a~~ single big data project [8]. For example, fault detection and error log data of machines and processes. So it's a huge challenge for Industry 4.0 to presenting the data in different formats for different users [9].

2.2 Knowledge-Driven

The continuously growing amount of manufacturing data provides a detailed rendition of the smart factory. However, manufacturing data cannot be applied directly due to its structure encapsulated by a complex variable metric, high dimensionality, and high noise. The domain provides a preliminary ontology to data semantic for future data application. By utilizing the big data of intelligent manufacturing, the pro-active maintenance of equipment could be sustained. Besides, the realization of optimize design for manufacturing product could be predicted through data mining. Hence, the optimization of production line can be accomplished in the establishment of a smart factory [10]. Traditional industry can be transformed into an intelligent industry with the implementation of knowledge-driven manufacturing. In order to achieve a knowledge-based intelligent manufacturing, the manufacture entity must have the abilities of smart data compiling, data integration, and extraction of the nature's manufacturing resource. The integration of data resources such as product data, supply chains, and logistic data into service platform is crucial for the smart factory in order to provide product services such as quality analysis and sales forecasting. Generally, knowledge discovery helps manufacturing entity made a scientific decision for planning and scheduling the manufacturing product [11].

At first, regarding intelligent requirements of equipment, it is important that the underlying manufacturing resource is under monitored and being control for dynamic scheduling, information integration and reconfiguration of production line in smart factory. For each stage of the production line, there is necessary to improve the technology level of the underlying manufacturing equipment. Through manual configurable parameters and self-reconfigurable robots in manufacturing line, new methods are provided to make full use of function expansion to increase productivity.

Besides, the coordination and information interaction among the multi-module manufacturing units can be explored in the context of hybrid production. In addition, the efficiency of the workshop can be increased by optimizing combination of programs. The manufacturing equipment should achieve the intelligence level which provide compatible data interface, able to collect production information, and support generic communication protocol [11]. Moreover, in the smart factory, all manufacturing

equipment able to intuit with the circumstance and cooperate among each other. Smart factory is well-known for its flexible manufacturing. However, there are still many setbacks such as strong proprietary of production line, dynamic scheduling, and constraints of tight coupled system [10].

On the other hand, emerging knowledge of training and skill development of Industry 4.0 in Malaysia may have the head start to enhance modern manufacturing technologies especially in sector of automotive, electronics and construction industries. Thus, the lack of knowledge from all aspects of training and skill need to be fulfil by the manufacturing firms to implement Industry 4.0 smoothly. The workers in production are retiring and taking production knowledge and experience with hem. Other issue is to decrease the turnover rate and retain the new hiring within organization. On-the-job instruction can be expressed through the use of augmented reality such as observing the way of an experienced workers performing specific task. With such method, the training programs will work effectively for specific job-related skills. As many employees will be working on a greater variety of tasks, training in a wider set of skills will often require and be provided in demand. It is essential to cultivate the positive perspective among employees, encourage them to adapt new processes and facing new challenges. In case of industry 4.0 scenarios where changes are prominent factor, the challenge becomes diversified and complex [5].

2.3 Process

Process Integration within and across boundaries of enterprises also acts as the challenges to implement Industry 4.0. Series of processes involved in a life-cycle of product, start from design until production, provides services and receives feedback from customers. These processes can be separated along enterprise boundaries or distributed within an enterprise. Various of involved standards, methods, interfaces, unique characteristics, and technologies in every enterprise have had makes the integration process more challenging. These processes of integration along with the production system will enable decisions making and optimize the process in real time. So that the logistic system is manageable to optimize and the cases of out of stock or production overload which caused loss in revenue can be reduced and eventually prevented [12].

Higher product variability to shorten the life cycle of product require high flexibility production structure that easily reconfigured for new demand of products. Traditional automation is unable to achieve this flexibility. Cyber-Physical Systems (CPS) is the important aspect to solve the current planning and production processes that is rigid [13].

2.4 Security

Internet of things (IoT) will increase the present vulnerability and risk to the system. Systems need to be organize in higher security with more connections, nodes and burden of connectivity. Industry 4.0 will urge for safer cyber security. The facing problem may not only harm individually but also will their reputation and caused loss of producers. The rapid growing number of heterogeneous information in Industry 4.0 and the trend of moving the information to cloud system raise the awareness of security risk. The ability of remote control of the physical devices increases the risk of industrial data in comparison to the normal data system. The growing trend of utilizing IT in manufacturing system is making our life easier. However, this might also be a 'time bomb' from security perspective [5].

Every digital devices, no matter smart phones or industrial machines need to keep updating on a regular basis. This cause mainly to avoid threats or to reconfigure the system changes to keep the data safe. However, the used processing capabilities at production level for some of IIoT devices are very limited. This is not recommended due to its enquiring new methods or tools and measurements to make sure the devices are safe. Security holes can be easily exploit through the logical controllers of the factory when the production facility is being targeted [14].

Transition into Industry 4.0 is not easy and has all sort of impacts on production system, especially in security. The issues for most of manufacturing companies are, they not paying too much effort on implementing a better security system while adopting the Industry 4.0's paradigm. The interconnected organizational systems lead to the critical financial impacts that easily increase the exposure to lot of security void. Software vulnerabilities in the system components give chance to malicious hackers to disrupt the whole production chain. This potentially possesses physical destruct on for a long time to the production system [15]. In conclusion, privacy and data authentication are the major challenges for Industry 4.0 [16].

2.5 Capital

The new industry will be characterized by a developments of a variety new technologies such as robotics, artificial intelligence, nanotechnology and biotechnology. Large capital investments needed for innovation through the high level of technology and process of systems. Allocation of capital, budgeting and financial strategies are needed. This allocation is impotent to support the transformation towards Industry 4.0. Tax planning encompassed much different considerations, for instance it is very important

measurement to support innovative investments and skills empowerment. This type of transformation will needs large investment in new technology that never been used before. Therefore, such transformation does not come cheap, which alienates businesses with smaller scale and in long term may weaken their business competitiveness in the market [5]. This requires adopting high capital management approach for transformation towards Industry 4.0.

2.6 Workforce

One of the biggest challenges for implementation Industry 4.0 is related to the people which is the human workforce. Even though current jobs and positions in manufacturing industry are slowly replaced by automation but humans will still be the organizers of this revolution of industrial. However, most of the workers are facing the problems of which lack of related knowledge for the industry, then limits the workforce efficiency of manufacturing. The establishment of new Cyber-Physical System in the Industry 4.0 based approaches of work organization had increase the intrinsic motivation and fostering creativity that enable employments advancing to embrace Industry 4.0 [17].

In Malaysia, production is still mainly dependent on foreign labor. To embrace this new technology, a complete change of mindset is needed. This not only can increase productivity and efficiency but also can make use of digital platforms to expand the markets. Even though now is still considered as an early phase of Industry 4.0, it is no doubt that workers are encourage to acquire more variety set of skills. A huge sector of workers will be eliminated but in the meantime this may increase employment rates for technical and skilled workers. This sector of workers whose work is repetitive will face a challenge in keeping their job and more importantly keeping up with the industry [18]. Companies are well-advised to address employees' anxieties and concerns about dependency on system of technical assistance, data transparency and safety of workplace and human-machine interaction systems to enhance their trust.

2.7 Education

A successful higher education and its organization will beneficial to the implementation of Industry 4.0. In the bright side, Industry 4.0 provides mechanical engineers a chance to showcase their creativity and abilities by implementing the value added improvement plans to the field of mechanical engineering. There is no doubt a needs from the industry to search for professional personnel that is ready to face the coming challenges. University play the major role to nurture the future professional personnel for the industrial sector.

Therefore, it is very important for the students to acquire the necessary knowledge and ability to carry out the given task in the future. This only can be achieved by mutual understanding between universities with the professional firms out there, on what is the requirements they are looking for the future workforce in the industry [12]. Lack of education policy and insufficient mobility in some companies will disable the use of talents pool [19].

Other than that, the organizations of higher education are essential along the development of the automation industry. They should invest more in in-depth research teams for the areas of information technology, digital, new materials and biotechnology. This sudden changing pace of transformation into Industry 4.0 will require educational institutions to revisit on how fast they can adapt, flexibility providence, and bring up innovative to the future economy and technology trend. The higher education organizations promote research in applied research, technology research, teaching aids and information technology application in teaching and training management.

The organizations of higher education must improve the quality of scientific research in professional education and institutions to proactively address the potential impacts from Industry 4.0 on educational development and delivery [20]. In the Table 1 below, it conclude the previous research on studies related the challenges faced by the Industry 4.0 from 2010 to 2018 in several countries. The framework as depicted on Figure 1 below shows the seven challenges for manufacturing in Industry 4.0.

Table 1. Previous researcher study of the challenges of Industry 4.0

Authors	Data Management & Integration	Education	Knowledge-Driven	Process	Security	Workforce	Capital
Zetter, (2011)					X		
Scheer, (2012)		X	X				
Zhang et al., (2013)				X			
Max et al., (2014)		X					
Khan & Turowski, (2016)	X		X		X		X
Agrawal, (2016)	X						
Wang et al., (2016)			X				
Stock & Seliger, 2016						X	
Barreto et al., (2017)	X				X		
Selamat, (2017)	X						
Chen et al., (2017)			X				
Khan et al.,(2017)		X	X		X		
Marcos et al., (2017)		X		X			
Van & Kim, (2017)		X					
Li& Lian, (2018)	X				X		
Wolf et al.,(2017)		X				X	
Muller, (2018)	X			X		X	

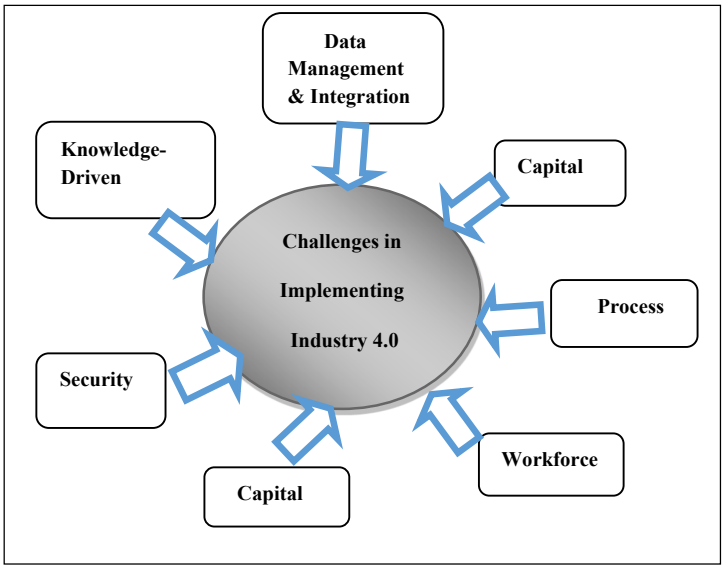

Figure 1. Conceptual Framework of challenges in implementing Industry 4.

3. Discussion

Industry 4.0 defined as advance technologies where supported by the internet technologies such as embedded systems. It served as a role to integrate and combine the intelligent machines, human sectors, physical objects, manufacturing lines and processes across organizational stages to build a new types of technical data, systematic and high agility value chain [21]. Germany launched the strategic initiative mooted in 2011 under its High-Tech Strategy 2020 which purpose to switch from centralized to decentralized networks under which connected devices and equipment communicate with each other and respond to gain information at revolutionizing the manufacturing industry [11]. The Public Private Partnership (PPP) for Factories of the Future (FoF) deploy and initiate related topics of Industry 4.0 at European level. In the United State, they promote Industry 4.0 by Industrial Internet Consortium (ICC) [22].

This new industrial revolution can cope by the basic idea that has been widely implemented in many other countries. Internationally, many governments have come to realize the trend and take action specifically to the impact of Industry 4.0 could bring in the future. It can be noticed from the government plans all around the world as stated below;

3.1 United State

In 2011, to make sure United State (US) well prepared for the next generation of manufacturing, president of US at that time is Barack Obama started a series of national-level actions, discussions and recommendations, titled as 'Advanced Manufacturing Partnership (AMP)'. The undertaken initiative of AMP is to make more companies in ready mode to invest heavily on advanced technology and businesses. In 2017, the global programmable logic controller market was estimated at USD 8.491 billion and is expected to achieve USD 10.595 billion by 2023, registering a CAGR of 3.7% during 2018-2023 (the forecast period).

3.2 Germany

In 2012, an action plan known as 'High-Tech Strategy 2020' had been passed by the German government. This project grants billions of Euros each year to develop the latest technologies in manufacturing industry [22]. In 2018, Volkswagen presents 48V progressive hybrid, VTG turbocharger and Miller combustion process, and mild hybrid diesel systems for their new model of vehicle.

3.3 France

In 2013, French government launched 'La Nouvelle France Industrielle'. This program prioritized 34 sector-based ways in France's industrial policy. (Conseil national de l'industrie 2013) French start-up 2B1st Consulting and has been introduced at Hannover Messe as a collaborative digital tool, which designed to help companies in triggering solutions for the implementation of industry 4.0[23].

3.4 United Kingdom

In 2013, a long term action plan for manufacturing industry in United Kingdom (UK) called the 'Future of Manufacturing' was implemented. This program refocused and rebalanced the policy to support the resilience of UK manufacturing until 2050 [24]. In 2018, Rolls-Royce is partnering with the Alan Turing Institute to explore how Artificial Intelligence (AI) and analytics can be applied at scale to supply chains and predictive maintenance.

3.5 European Commission

In 'Factories of the Future (FoF)' for 2014, European Commission adopt a new contractual Public-Private Partnership (PPP). A total of almost 80 billion Euros of funding for consecutive 7 years in the period of 2014 to 2020 will be provided for the program Horizon 2020 (European Factories of the Future Research Association, 2016). In 2018, the European Commission has announced a new series of measures to put artificial intelligence (AI) at the service of citizens and boost Europe's competitiveness in the field with a budget of €20 billion by the end of 2020.

3.6 South Korea

'Innovation in Manufacturing 3.0', a plan launched by the South Koreans in 2014 that emphasized four ways and tasks for a new improvement of Korean manufacturing [25]. The new autonomous car developed by Hyundai's Genesis sedan is capable of tracking moving objects, avoiding collision risk, driving on narrow roads and recognizing traffic lights and speed limit signs.

3.7 China

In 2015, China government launched two action simultaneously, 'Internet Plus' and 'Made in China 2025' strategy. Ten major aspects in the sector of manufacture are prioritized to boost the industrialization in China [26]. In 2018, Chinese government officials said that they would eliminates the roles of need in car manufacturers such as General Motors to collaborate with the local company to open factories in China. China decided to stop the foreign ownership demands on electric transportation makers in 2018 to open up more technology's pipelines bring into China.

3.8 Singapore

In 2016, Singapore government has launched its RIE 2020 Plan (Research, Innovation and Enterprise) with budget of $19 billion. The advanced manufacturing and engineering domain had identified eight key of vertical industries [27] Singapore is developing its own machines that can help to make slight tweaks for fully automate hydroponic farms and maximize its crop yield.

3.9 Malaysia

In Malaysia, government was aggressively take actions by undertaking various efforts to leads a hand for ~~to~~ industry's players in embracing the concept of Industry 4.0 through the implementation of automation and smart manufacturing. In the Budget 2017, the government had been highlighting several new incentive packages to accelerate the growth and adoption of manufacturing and Industry 4.0 in Malaysia. For instance, Supermax Corporation Bhd which was a glove industry is currently under the automation of Industry 4.0 in manufacturing, and the government's continuing support through incentive programmers will help spurs the growth of their industry. Next, technical advisor are making prediction regarding the trend of industry 4.0 as one that possesses the ability to transform each industry in all nations because of the rapid growing nature of digital revolution which is the fundamental base of Industry 4.0. Former Malaysian's prime minister Datuk Seri Najib Razak has had initiated the government's plan to implement the TVET. This is to assist the development of Industry 4.0 in the future by increasing

the workforce to fulfill demands. In this program, government allocated RM50 million to improve caliber and the competitiveness of the workforce to helps economic development of the nation. This budget is allocated from 30% of the Human Resources Development Funds (HRDFs), were collected to aid TVET plan.

4 Conclusion

As mentioned above, there are a lots of challenges in implementation of Industry 4.0 for industrial sector, specifically in manufacturing. To overcome all those challenges, it needs dedication and collaboration from government and private sectors. Government may do more on the education for next coming wave of workforce and implement more programs and funds to assist the development of Industry 4.0. On the other hand, employers need to engage more on the development of Industry 4.0 to kick-start the growth of the industry in private sectors. If more and more companies starting to implement Industry 4.0, it would be easier for companies to overcome the challenges of Industry 4.0, since their involvement will be benchmarking to each other.

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