

## **IoT Integrated Assembly Line - a conceptual model development for car toys assembly line**

I Kurniawan<sup>1</sup>, S Awibowo<sup>1</sup> and A T Pratama<sup>1</sup>

<sup>1</sup> Department of Industrial Engineering, Swiss German University, Alam Sutera, Tangerang, Banten, Indonesia

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**Abstract.** Lean manufacturing is a common methodology widely used by manufacturers around the world. The keys in order to apply lean manufacturing are efficiency and continuous improvement. Efficiency can be achieved towards the utilization of technology between shopfloor and supporting business layers occurs in a system. One of the technologies that can be used is IoT (Internet of Things) and Cloud Manufacturing (CMfg) in specific. This paper contains the concept design of IoT technologies that will be applied in a car toys assembly line. Technology such as RFID, Sensors, and Android-based cloud services will be included in the assembly line system design. RFID and sensors are used to capture a number of components & subassembly parts that occur in the assembly line and the data captured will be forwarded to the ERP Systems. Android-based cloud services are used to monitor and control the systems especially for the shop floor area.

### **Introduction**

Nowadays, all manufacturers around the world are trying to achieve efficiency as high as possible that being driven by global competition and the fast changing of market demand and needs. Efficiency becomes one of the most critical factors in order to reduce resources usage such as labours, materials, and machines which all leading to cost reduction and productivity increases. In parallel, technologies are often developing day by day. By integrating technologies into manufactures, a new paradigm such as Industry 4.0 is born. Technologies integration into manufacturing processes is determined to achieve high productivity and efficiency. Some example of technologies that might be applied to manufacturing processes is Cloud Manufacturing (CMfg) and Internet of Things (IoT).

The purpose of this research is to develop a conceptual model of an IoT (Internet of Things) based assembly line. This research is a development from shop-floor MES-ERP (Manufacturing Execution System - Enterprise Resource Planning) integrated system. Comparison between MES-ERP Integrated System that commonly used in the manufactures especially for assembly line and IoT based assembly line will be discussed. As a result, an expected improvement will be deliberated peculiarly about the impact regarding the implementation of Cloud Manufacturing and the Internet of Things into the assembly line.

Lean Manufacturing & Internet of Things (IoT)

#### *1.1. Lean Manufacturing*

Lean manufacturing is the most commonly used method in order to boost the value-added activity and optimization of an organization [1]. Lean manufacturing is often called the Toyota Production System (TPS) was developed by Toyota Motor Corporation in the 1970s. The purpose of implementing lean manufacturing or TPS is to eliminate waste in the value chain in order to reduce lead time [2]. The critical success for implementing lean manufacturing is continuous improvement by eliminating seven waste and reducing cost so the profit margin might increase [3]. Besides, one of

the pillars for applying lean manufacturing is the involvement of all individuals inside the organization.

The main idea of lean manufacturing is to maximize customer value and to minimize waste, resulting in the increasing of productivity and efficiency due to the elimination of waste and unnecessary things then the value added will be increased [4]. One way to eliminate waste is by decreasing the complexity of products so that the production will be efficient. Then the standardization will be easier to develop and implement [5].

The implementation of lean manufacturing has been used in many sectors of industries. The example of industries that apply lean manufacturing or TPS are electric and electronics, automotive, wood, ceramic, and several more industries [4]. The result of the implementation is proving that lean techniques are compelling and significantly developing enterprises into the next level [2] [3].

### *1.2. Cloud Manufacturing (CMfg)*

For the past few years, cloud manufacturing is developing rapidly and become growing attention [6]. Not only from researches, in industries also heavily exposing cloud manufacturing in order to achieve global competitiveness. Cloud manufacturing becomes one of the pillars to achieve modern manufacturing industries that suitable for high variable demands, volume, and also enhance efficiency and also become an enabler for Industrie 4.0 [7].

The branch of cloud manufacturing itself becomes very wide. Several components being used for supporting cloud manufacturing such as 3D Printing, Robot, Security and Big Data [6]. Thus, cloud manufacturing is a complex system that combines manufacturing operations with service-oriented cloud technologies [8].

### *1.3. Internet of Things (IoT) in Manufacturing*

IoT is a paradigm that develops very fast in the last few years. In manufacturing itself, IoT helps the generation of Industrial Big Data. The new IoT monitoring services transform the machine tools into "cyber-machine tools" and the human operator into a "cyber - operator". By using this concept, generation high volume and variety of data can be obtained [9]. IoT able to connect machines and creating an intelligent network that communicates and control each other autonomously. This technology-driven is able to give efficient and automated manufacturing processes. One technology that commonly used and needs little investment for the actualization of IoT concept is RFID. RFID systems can be used to monitor objects in a real-time situation and can be accessed anywhere and anytime. Other technologies that being the enabler for IoT implementation are sensor and actuators [10].

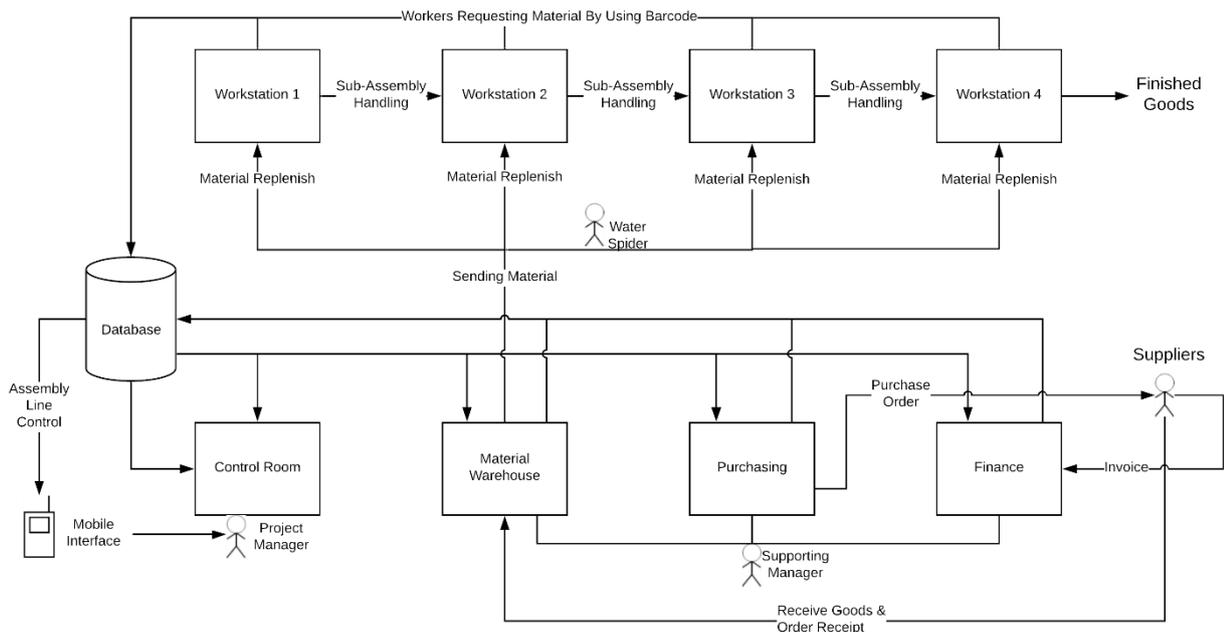
The generation of Industrial Big Data proves to give a quick and accurate situation that occurs in the manufacturing shop floor. The approach also included data processing and visualization. The result is that the factories or plants are more efficient and productive than the conventional factories or plants [11].

### *1.4. Internet of Things (IoT) and Cloud Manufacturing (CMfg) Integration into Lean Manufacturing*

Technologies such as the Internet of Things and Cloud Manufacturing are part of the cyber world. While integrating it with manufacturing activities that often used a physical instrument called Cyber-Physical Production System (CPPS). The key elements of cyber-physical production system are data acquisition and data processing, machine to machine interaction (M2M), and Human Machine Interaction (HMI) [12].

Integration of lean manufacturing with IoT and CMfg start with understanding with lean concept itself. The users around the organization need to have insight that lean is a holistic approach which has the objective to eliminate waste. IoT and CMfg are technologies driven that used to support the objective of lean. By the technologies, all activities and processes able to shorten the lead time and reducing waste while traceability and transparency of information become the primary object why IoT and CMfg able to give a significant effect on the application of Lean Manufacturing and creating a what we called "smart factory" [13].

## Design Architecture



**Figure 1. Design Architecture of IoT based Assembly Line**

### 1.5. Design Architecture of IoT based Assembly Line

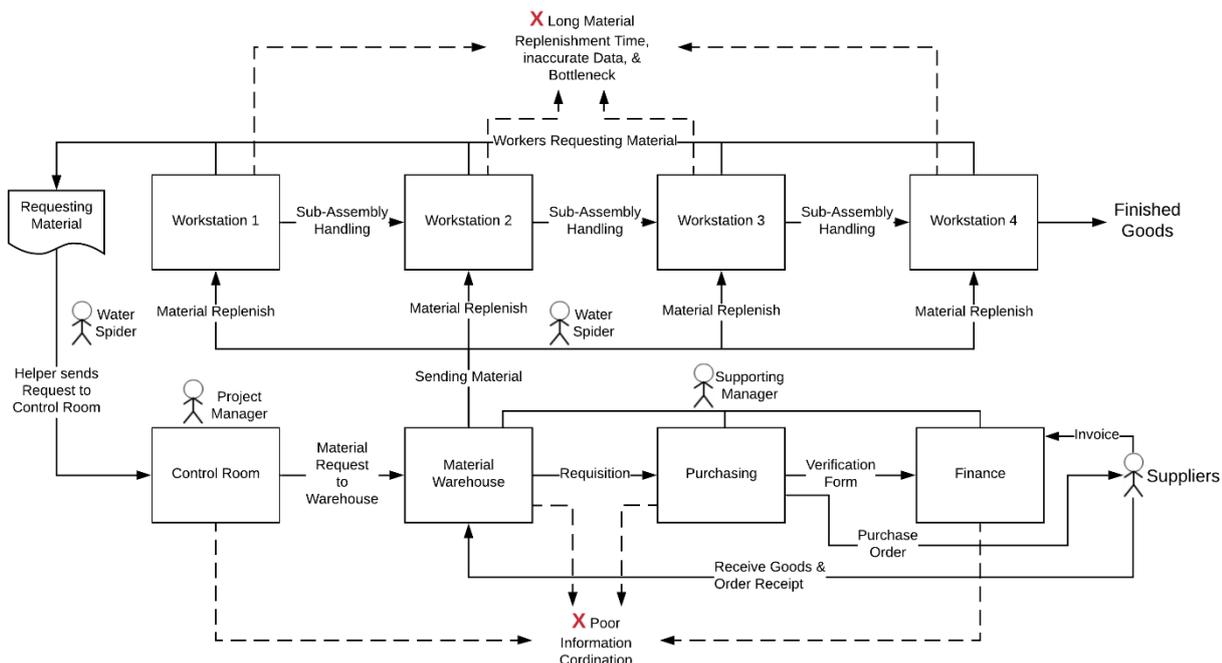
Figure 1 is the developed new system architecture where several new technologies will be implemented.

- E-Kanban: E-Kanban or Electronic Kanban will be developed by using barcode and scanner. Barcode will be used for labeling the material components. Each type of material components will be attached with a barcode. When the material needs to be replenished, the worker in the workstation will scan the barcode by using a scanner. The scanner sends the data in this term is the material requested. The data will be stored in the database and automatically connected with warehouse material. The warehouse material will receive the material requested and prepare the materials to be sent off to the shop-floor area.
- Sensors: In order to have precise data of sub-assembly or finished products, the assembly line will be equipped with sensors. The sensors will determine the number of items that have been produced. The data will be record and store in the database so that the control room would be able to monitor the working progress accurately and in real time situation
- Android System Cloud Based
- The android-system cloud-based is used to monitor the shop-floor. The android system will retrieve the data from the database about the shop-floor condition in the form of android application on the mobile device. The data that can be retrieved are:

- a. Machine or workstations status
- b. Number of production from each workstation
- c. The material in workstations status (Indicating of workstation needs material replenishment)

These are used to smoothen or fasten if there is a problem that needs immediate response that can be monitor from every device connected with the system as long as there is an internet connection.

### Use Case: Car Toys Assembly Line



**Figure 2. Design Architecture of MES-ERP Integrated System.**

The case study taken for this research is the car toys assembly line. Figure 2 is showing the design architecture, and a problem occurs in the current situation in the assembly line [14]. The assembly line implemented MES-ERP integrated system, and several things are installed in the assembly line as follows:

- Utilization of workstations by using Raspberry Pi with touchscreen and Modbus as the connection with the server.
- Conventional Kanban Card is used to notify the helpers whenever the materials are reaching the minimum level. The card will be attached and bring by helpers (water spider) to materials warehouse. Material warehouse will give the materials request based on the Kanban card. Project Manager in the control room is equipped with Andon screen to see the real-time progress situation in the shop-floor area.
- Customized ERP system in order to support business level inside the system. The ERP System consists of a warehouse module, purchasing module, and finance module. The purpose of ERP implementation is to smooth the flow of information inside the systems. Not only for fast information flow, but an ERP system is also relied on information accuracy and decrease miscommunication or misleading information.
- An integrated server uses in the integration of MES-ERP in shop-floor area. The server contains data gathered from the shop-floor area, ERP System, and Control Room.

Even though there are many things already implemented inside the systems, but there are several problems still occur in Figure 2 as follows:

- Long Material Replenishment that was causing shortage of material in the workstations
- Queue of helpers (water spiders) in the materials warehouse (this become the reason the material replenishment time become very long)
- Inaccurate of production number from each workstation.

### *1.6. Car Toys production with IoT Based Assembly Line*

IoT based assembly line is the way to eliminate problem occurs in MES-ERP Integrated system, and the new system can reduce many wastes in the system. The wastes that identified mostly are waiting and motion. In fact, inaccuracy of information and coordination also a big problem in terms of data acquisition.

IoT based assembly line does not change the whole system. On the other hand, it is a development from the existing system as part of continuous improvement occurs in the assembly line. The new system enhances the MES-ERP integrated system. The conventional Kanban is replaced by E-Kanban to improve data acquisition and to reduce waste of motion. The helpers do not need to send the Kanban card to the warehouse, but the operators in the workstation only need to scan the barcode for requesting materials, and so the warehouse received the material request and asked the helper for sending out the requested materials. Sensors in the assembly line will record the number of productions from each workstation; in that way, the data of processing time and the number of throughputs will be retrieved for diagnostic and analysis for improvement. These are parts of data acquisition and big data.

The last implemented technology in the new system is Android System Cloud Based. It is part of cloud manufacturing where it has become a base component for modern manufacturing. The purpose is to obtain big data and real-time control. The real-time control able to see the number of production, machine or workstation status, and material status in the workstation, and so, if there is a problem that needs an immediate response, the assembly line status is connected with an android system that can be accessed by Android smartphone.

Table 1 is showing the summary and expected impact of new technologies implementation.

**Table 1.** New Technology and Expected Impact

New Technology	Expected Impact
E-Kanban	Data acquisition accuracy, faster material replenishment, motion reduction, elimination of waiting time
Assembly Line Sensors	Data acquisition, improvement of data accuracy
Android System Cloud Based	Real-Time Control, Data acquisition

## Conclusion

One way for an organization to stay competitive is by continuous improvement. Notably, production and manufacturing are now entering Industry 4.0 era which IoT, big data, and cloud manufacturing are becoming essential components. The purpose is always the same, increasing efficiency and enhance the productivity of the production system itself. Industry 4.0 itself is a technology-driven approach, and this research is showing the impact of technologies implementation into a conventional assembly line.

A new IoT integrated assembly line can obtain the enhancement of information flow, data acquisition, and big data. E-Kanban, Sensors, and Android system cloud-based are the new technologies that will be implemented into the assembly line. The new technologies are part of continuous improvement in order to develop an efficient assembly line. In addition, data acquisition for big data is also obtained by the new system. Data acquisition and big data can be used for assembly line diagnostic for future development. Real-time control becomes an advantage of the system for immediate response. To sum up, most of the technologies are used for improving information flow and data acquisition.

The limitation of the research is that the developed model is limited to 4 workstations and have the least variety of product, and only three new technologies implemented. Since there are many kinds of Industry 4.0 technologies, but this research only conducts E-Kanban, sensors, and cloud-based system. The implementation of the new system into the bigger size of the assembly line and variation of products can be considered as future research. The analysis of big data by the data acquisition from the assembly line also being an opportunity to explore. There is a chance to implement new technologies that might give benefit to the assembly line and enhance the efficiency and productivity of the system.

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