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A Survey on Internet of Things-enabled Real-time Machine Management System in New Zealand

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Abstract

Certain types of machine processing create the most value for the factory, comparing with other part of manufacturing process. This means machines are key components creating major profit for factories. In order to collect the real –time data from machines economically, Internet of Things (IoT) enabled real-time machine management platform is introduced. The real-time machine management platform is designed to base on radio frequency identification (RFID) technology. This platform can capture real-time data of raw material, manufacturing machine and workers. In order to make our platform more in line with the characteristics of New Zealand local manufacturing and has more potential commercial value and research value, a survey with a purpose of knowing the status was designed. The results of this survey show some problems of New Zealand local manufacturing enterprises, which are significant for guiding the industry for making full use of cutting-edge technologies to design the machine management platform in the near future.

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Keywords:Internet of Things; Real-time; Machine Management System; Survey.

1. Introduction

As an emerging technology, Internet of things (IoT) can offer promising solutions to transform the operation of many existing manufacturing system into a smart level. Sensory, communication, networking, and information processing technologies provide the foundations for IoT. RFID (Radio Frequency Identification) is one of the most important in these foundational technologies [1]. There is a growing interest in using IoT technologies in various industries. A wide range of industries IoT applications have been developed in recent years. Currently, manufacturing enterprises got uneven distribution of resources leads to inefficiencies problem in manufacturing execution due to the late, inaccurate, and unreliable information from traditional paper-based data collection system [2].

Therefore, an IoT enabled machine management platform that combines New Zealand's local manufacturing circumstances is universally needed and has practical commercial value. This platform is based on RFID technologies in order to achieve real-time tracking, detection and management of raw material, processing machines and workers. The real-time and historical data of manufacturing things are processed by this platform in order to show to shop floor manager in an intuitive and efficient way. The data has effect on manager to make a right decision of shop floor.

Industrial IoT (IIoT) is part of a larger concept known as the Internet of Things (IoT). The IIoT will revolutionize manufacturing by enabling the acquisition and accessibility of far greater amounts of data, at far greater speeds, and far more efficiently than before [3]. IIoT can significantly improve connectivity, efficiency, scalability, time savings, and cost savings for industrial organizations.

In order to know the circumstances of New Zealand's local manufacturing, a survey was designed to get some information from real industry people. Some data from this survey show the status of New Zealand's local manufacturing industry and the problems they are facing. These status and problems have effect on the future design of IoT enabled machine management platform.

This paper is organized as follows. Section 2 gives a literature of related topics. Section 3 presents the analysis of

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survey result and the status of New Zealand's local manufacturing industry and the problems they are facing. Section 4 talks about the discussions which conclude this paper.

2. Literature review

This section reviews related research which is categorized into several dimensions: Relevant technology of IoT, Architecture of Internet of things, Machine to Machine communication, real-time data from manufacturing system, and IoT-enabled manufacturing.

2.1. Relevant Technology of IoT

IoT is an emerging technology based on sensory, communication, networking, and information processing technologies. Radio frequency identification (RFID) is an indispensable foundational technology for IoT. RFID system is composed by a RFID reader and RFID tag. It can transmit the identification information at short range wirelessly. RFID offers an opportunity to allow people identify, track, and monitor objects automatically [4]. Due to its tracing, tracking physical objects abilities, RFID is widely used in industries such as logistics, manufacturing system, and supply chain management and healthcare service monitoring. In addition, RFID system also can capture precise real-time information from the involved devices which support manufacturing enterprise to reduce labor cost, simplify business process, increase the accuracy of inventory information and improve business efficiency. Up to now, the RFID system has been successfully used by numerous manufactures in many industries [4, 5].

Nowadays, the concept of Internet of things (IoT) comes into the spotlight and draws plenty of attentions from a variety of industries for its extensive practical outlook and revolutionary change that it could bring to the traditional industry. Among those areas that will benefit from IoT, manufacturing is a sizable part that would share approximately one-third of the future market by 2025 according to Al-Fuqaha.

To effectively upgrade and transform the traditional manufacturing industry to a more intelligent advanced manufacturing, several models were developed by some scholars, such as cloud computing and Internet of Things-based cloud manufacturing service system, shop floor trajectory visualization model and interaction model between smart factory and customers. Also, various commercial products and solutions that apply IoT from a small scale to a large scale are up out the market, such as Watson IoT solution from IBM and Beckhoff IoT bus coupler based on Twin CAT system. They all showed the bright future of applying IoT technology to traditional manufacturing.

IoT aims to connect different things over the networks. Therefore, the wireless sensor network (WSNs) is another indispensable foundational technology [6]. WSNs is mainly used to connect sensors to sense and monitor the performance of machine in manufacturing system. Moreover other relevant technologies such as barcodes, smart phones, social networks, and cloud computing are being used to build a more efficient, more accurate and more intelligent network to improve IoT [7, 8] As more and more interconnection technologies and IoT related technologies has been improved and implemented, IoT has larger impact on manufacturing system and enterprise system field.

The RFID-based technologies still get much room for improvement. So far RFID only can transfer information in short range, to achieve the goal of remote transferring information, RFID can combine with WSNs technologies to track and trace things in real-time [9]. In future, more efficient IoT applications which fit the industrial environments can be generated by integrating the wireless intelligent sensor and RFID technology [1].

2.2. Architecture of Internet of things (IoT)

A large number of devices involved are made by different manufacturers in IoT. Hence there are many interaction problems with communication between things and information exchange. An architecture can perfectly fit the heterogeneity and complexity of IoT is urgently needed. The design of an architecture need to consider extensibility, scalability, modularity, and interoperability among heterogeneous devices [1, 4]. Quite a few ideas have been proposed to create multi-layer Service-oriented architecture (SOA) for IoT based on the selected technology, business needs, and technical requirements [5-7]. For example, a five layers architecture include: sensing, accessing, networking, middleware and application layers.[8, 9] A four layers architecture for IoT include: Sensing layer, Networking layer, Service layer and Interface layer.

The decentralized and heterogeneous nature of IoT requires that the architecture provides IoT efficient event-driven capability. Thus, SOA is considered a good approach to achieve interoperability between heterogeneous devices in a multitude of way [1].

2.3. Machine-to-Machine (M2M)

M2M communication is often used for remote monitoring, tracking and tracing [10, 11]. M2M communication has a great contribution in some respects such as manufacturing system, warehouse management, remote control, robotics, traffic control, logistic services, supply chain management, fleet management and telemedicine [12]. It forms the basis for a concept known as the Internet of Things (IoT). Key components of an M2M system include sensors, RFID, WSNs, a Wi-Fi or cellular communications link and autonomic computing software programmed to help a networked device interpret data and make decisions. The Internet and improved standards for wireless technology have expanded the role of telemetry from pure science, engineering and manufacturing to everyday use in products like home heating units, electric meters and Internet-connected appliances. Products built with M2M communication capabilities are often marketed to end users as being "smart." Currently, M2M does not have a standardized connected device platform and many M2M systems are built to be task- or device-specific. It is expected that as M2M becomes more pervasive, vendors will need to

agree upon standards for device-to-device communications [13]. M2M refers to technologies that allow both wireless and wired systems to communicate with other devices of the same ability. Similar with WSNs, M2M system possesses distinctive characteristics such as support of a huge amount of nodes, seamless domain inter-operability, autonomous operation, and self-organization [14].

2.4. Real-time data from manufacturing system

Due to the highly stochastic of manufacturing enterprise, some uncertain disturbances such as delays on customer order, logistics errors and high level of work-in-process (WIP) inventories leads to a huge cost [15-18] .Therefore a reasonable decision-making is very important to improve efficiency of manufacturing shop-floor [19-20]. To support decision-making such as logistics planning and scheduling, enormous data need to be collected. In order to collect large amounts of data more quickly and timely, an intelligent manufacturing environment which able to sense and interact between operators, machine and raw material is needed. As a widely used technology in supporting the logistics management on manufacturing system Radio frequency identification (RFID) is a quite reliable technology to build a smart manufacturing environment [21]. Due to RFID devices are deployed systematically on the shop-floor to track and trace manufacturing objects and monitoring the performance of machine, enormous real-time data from shop-floor are collected timely [20]. Such data are so complex, abstract, and variable so it is difficult to make full use even the data carry great useful information and knowledge. Therefore a modal is used for reconstructing raw data to achieve visualization of useful data to help manager make decision is urgently needed. An innovative RFID-Cuboid model which follow the production logic and time stamps to help manager interpreted data is mentioned [22]. Based on the current technologies, the approach firstly should combine Internet of Things (IoT) and Cloud Manufacturing to transform the traditional industry environment to intelligent environment [15]. Secondly, an intelligent model which can interpret data by following the production logic and time stamps should be used under the intelligent manufacturing environment [22-25].

2.5. IoT-enabled Manufacturing

Cloud Computing and Internet of Things-Based Cloud Manufacturing Service System (CCIoT-CMfg) is the manufacturing system concept using IoT and Cloud Computing (CC) to provide the ability of the full sharing, free circulation, on-demand use, and optimal allocation of manufacturing resource and capabilities (MR&C). It can be applied to achieve the "4Cs" (Connection, Communication, Computing, and Control) of Mr&cs. In the CCIoT-CMfg paper, several contributions are listed here: a) the overview of the application of this system is proposed within the workshop, within the enterprise, and among enterprises. b) Technologies like IoT and CC are addressed to the bottlenecks in industry c) The relationship of CMfg, IoT and CC is discussed. d) The technology systems for realizing CCIoT-CMfg are pointed out. e) The advantages and challenges of implementing are studied [16].

Zhong proposed a shop floor trajectory visualization model [21]. In this paper, RFID is used as a key technology to integrate IoT and Cloud manufacturing. RFID-Cuboid model is developed to visualize abstract raw data focusing on the production logic and time stamps. An industry example is presented to show feasibility and practicality. Furthermore, some insights are gained. Firstly, the mined average logistics time will help make Material Requirement Planning (MRP) and production decisions. Secondly, performance data of various operator contributes to the optimization of logistic decisions. Thirdly, Buffers occurred on the logistic activities can be studied by checking work in progress (WIP) inventory level [17, 18].

Benefit from extractable real-time data by applying autonomously technologies such as IoT, problems in the production line are easier to find and take strategic adoption and gain experience. Furthermore, due to high speed and ubiquitous interconnection, a more flexible and high freedom communication between customer and product producer. Thus, a more significant and frequent influence on product designing will be made by the customer to achieve mass customization to develop a better solution.

3. Survey on IoT-enabled Real-time Machine Management System in New Zealand

3.1. Selected Questions

The first step to build a suitable machine management platform is to understand what does the New Zealand users want. Consequently, a questionnaire was made and spread to the 16 different New Zealand manufacturing companies in New Zealand 2017 manufacturing and design conference to get the idea of what are their expectations for the system. We interviewed the people from maintenance department, some of people from R&D department. And some of the people are the managers of the shop-floor.) The results from typical 4 questions are selected for discussion in this section with some further analysis.

- *Question 1*

This question is aiming to figure out the demand for an asset management system and the popular systems that have been using among the factories and also could be the competitors in the future.

From the survey of different level factories, it is found that over 60% of the surveyed companies have an asset management system. This reveals that over half of the New Zealand companies do need a computer system to help them to manage their asset and are relatively familiar with an asset management system. Therefore, the current using asset management should be investigated for either taking the useful features or avoiding infeasible functions based on the customers' requirement.

CIMCO CNC software and solution, which is used by one of our surveyed company, called We Can, was invested and surprisingly found its incredible functionality, including editing NC program, shop floor network, machine data

collection, CNC document manager, etc. Among those aspects, the machine data collection software draws the most of our attentions as it has the real-time machine monitoring function. Indeed, it has the real-time data collecting, the powerful machine performance analysing ability and the maintenance optimization function, however, after experiencing the interface, the complicated and over functional user interface seems like a momentous reason pushes the small and medium sized factory owners away. Because the redundant functions cost money to buy and also take time to learn to use. It seems necessary to condense the variety of functions that some of them are not frequently used so that the interface could be simpler and more intuitive and the learning period for new users could be cut shorter.

- *Question 2*

The purpose of this question is to find out the attitude of the potential customers to a new technology.

It is found that 75% of the surveyed companies were holding an open attitude and clearly stated that they would like to try the IoT-enabled machine management platform. This is obviously a good news and encourages the development of this platform. Over half of the remaining companies are holding a wait and see attitude rather than a complete no. In conclusion, New Zealand is happy to embrace new technology, which means it is a favourable environment for new developed technologies.

- *Question 3*

A peek of what a shop floor manager normally considers is reveal in this question, from where it is observed that machine's working temperature attracted the most interest of the shop floor managers. Because temperature is a basic indicator of the machine's working condition. Especially when the temperature exceeds normal working temperature, the manager can clearly find out the abnormality before severe damage happens. To collect temperature data, implementing temperature sensors could be a feasible way.

Vibration Frequency is another type of information commonly required. For a machine maintenance perspective, vibration monitoring gives a great advantage enabling transitioned from a calendar-based maintenance to a condition-based maintenance, which can lower the maintenance cost by cutting off the useless repairing fee on faultless machines. Because vibration analysis allows checking the machine's condition, while, without stopping the running machine or even dissembling the machine.[19] There are already mature vibration sensors up on the market that could collect the vibration data of the machine real timely.

Spindle speed of a machine tool is also a basic and necessary index that some of the shop managers would like to know. However, it is not as needed as the previously mentioned two indexes. There are also some other types of information, such as material property and tool coordination trajectory, that a few companies would require. This information could be additional options for customization instead of appearing directly in the user menu.

- *Question 4*

This question helps to get the idea of how users would like the data to be presented and in fact, it helps us avoid some unfeasible design concept. At the beginning, there was an idea from me, which is making the data all presented by the same type of chart to make the interface looks neater and simpler. Whereas, from the result of the questionnaire, it is the opposite way that up to 75% of the users would actually prefer a multi type of chart data presentation rather than a single type chart presentation. It is not applicable by simplifying the diagrams to a single type. Because the presentation type need to suit the information that is presenting. To conclude, a combination diagram design would be more suitable to the platform. This platform can capture real-time data of raw material, manufacturing machine and workers.

3.2. Key Findings and observations

Most of the companies completed this survey is small scale only Fisher & Paykel health care is a medium scale company. Among those NZ companies, different types of machines are used in one company. The maintenance period varies a lot with the machine type, which span from one day to half year, some of them have longer than half year. But based our investigation, most of machines' maintenance period are one month or over one month. Such maintenance the machine needs to be shut down for thorough inspection. And the most common way is manual inspection. This kind of maintenance waste a lot of manpower and time, and the machine cannot produce for a long time. However, the operating performance and whether the maintenance is needed are decided by the relative indicators, such as temperature, spindle speed, vibration frequency, etc. Once the relative indicator becomes out of the reasonable range, it indicate that the working machine requires maintenance or some change of components. Using these indicators to monitor the real-time operating performance can save more time, and costs, and also reduce the possibility of accident and the unnecessary cost. Therefore, the system that can do the real-time data collection and machine management has met the market requirement of New Zealand manufacturing industry.

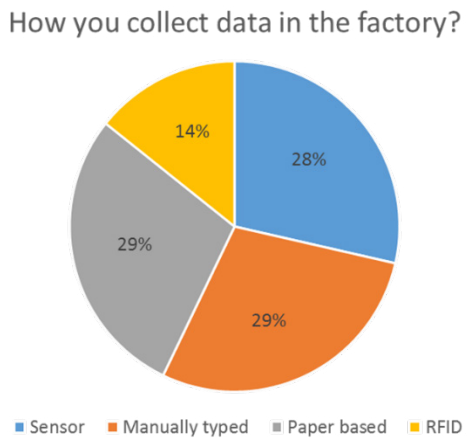

Figure 1. Survey Results 1

The result in Figure 1 shows that the most type of collecting data in New Zealand is paper based and manually typed. There

are many disadvantages in this way of data collection and storage:

- Cannot capture data timely which not only lead manager to make wrong decision cannot improve the efficiency of shop floor but also result in no timely maintenance of machine.
- Collected data is easy to occur error or mistake due to the manually collect.
- The data is easy to occur losing or man-made tampering due to the paper based storage.

Sensor is used to collect some fundamental data like temperature, vibration frequency, etc. However it cannot collect the data which is used to evaluate the efficiency of worker or machine. The manager cannot track the raw material and worker.

RFID is not widely used, only Fisher & Paykel Ltd. a big scale company apply it slightly. But they do not know what kind of data is useful and how to use it to help to make decision. Therefore, in order to make full use of the captured and collected data, data model of this platform is responsible for processing, classifying and standardizing various heterogeneous data into a formatted scheme. Thus, the formatted schemes could be further used for advanced decision-making such as production planning and scheduling or real-time machine status monitoring.

Our next concern is whether real-time data have effect on the decision of the shop floor manager. The results show that real-time data attach all companies attention, because in the current manufacturing industry always want to know who did what, when, where, and why that are termed as '5w' questions. However some traditional approaches like phone calls, e-mails, manually record and on-site visits cannot record data precisely and timely. Thus, a real-time data capturing platform is needed by current New Zealand manufacturing industry.

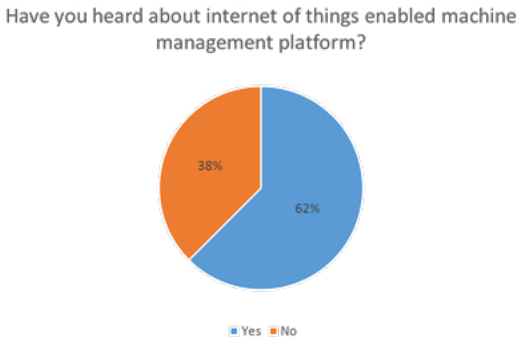

Figure 2. Survey Results 2

The investigation on whether the local manufacturing company in New Zealand has a sufficient understanding of the IoT platform was conducted. The results show that about 60% of New Zealand's local manufacturing industry is well aware of the IoT enabled machine management platform and is interested in trying and applying this platform. However there are nearly 40% of the manufacturing enterprises do not know the platform, and there is no intention to replace the platform in the future, the traditional management system is still the main choice of these enterprises. This show that IoT enabled machine management platform need to be spread so that more manufacturing enterprises to understand it. More importantly, let these enterprises relies that the benefit received is much greater than the investment for using this platform. Therefore we should consider that the most of companies in New Zealand are smaller scale, they cannot afford very high cost. We need to try to reduce the cost of this platform as much as possible in order to design a system which is acceptable for small company.

There is a cycle that been followed to design the IoT-enabled machine management system. It includes research, investigation, graphical design, detailed code design, and demo interface making and testing. Currently, the research and investigation are completed by reviewing published papers and surveying target users.

Through the study, not only the academic progress that has been done is get familiar but also the research gap is identified. The concept of IoT is firstly figured out including its definition, architecture and application fields. Secondly, some typical IoT-enabled manufacturing models are revealed and showed there is a blind spot of using IoT, which is machine management area. Thirdly, some IoT-enabled real-time data collecting systems are revealed to give some inspiration on how to implement real-time data collecting system on machine management area. From the literature review, the research gap is identified more clearly, which is to develop a real-time data collecting and presenting system used for machine managing.

There are some insights gained after taking the survey and analysing the result.

- The platform should only contain necessary functions so that it could be affordable and easy to start, which is more suitable for small and medium sized companies.
- New Zealand companies have the demand to machine management systems and also are mainly open-minded to them.
- From the survey, temperature and vibration frequency are two main indicators about machine working condition. Both of them could be monitored by external sensors.
- The presentation of the data should be in multiple ways and it could change to the form that suits the data best. In such a way, the user might have a better understanding of the condition of the machine.

In order to make the platform suit the local users in a next level, these insights from them will guide us through the design of the content and the layout of the platform. Further code design and demo interface constructing and testing will be developed in the next semester.

4. Discussions

Several contributions from this paper are significant. Firstly, after the survey, several observations could be obtained:

- Due to the standards and architecture of IoT are still not perfect and there is lack of relevant technologies of M2M, the current manufacturing system cannot be perfectly optimized.
- Under the situation of IoT attract a huge interest from large amount of research group, along with the improvement of M2M relevant technologies, a scientific and reasonable architecture will be designed to show the useful real-time data.

- The improvement of real-time data visibility and traceability can have positive effect on the manager of manufacturing intuitively. A platform which combine IoT, M2M and real-time data capturing improvement in future, a smart, efficient manufacturing system is promising.

Secondly, after the analysis of survey result, several observations obtained:

- The platform should have function that by using real-time relative indicator data to achieve real-time monitoring of working machine. So that the platform can detect whether the machine need maintenance timely.
- Currently, most of New Zealand manufacturing enterprise still uses traditional data collection and machine management system. Traditional system cannot record data precisely and timely. Thus, a real-time data capturing platform is needed by current New Zealand manufacturing industry.
- A few enterprise uses some emerging technology like RFID to collect data but they do not know how to process data in order to find out useful data. Therefore, the platform should have function that can process data so that show useful data to shop floor manager.
- Most companies in New Zealand are smaller scale, they cannot afford very high cost, and therefore we need to consider the cost of platform. The aim is to design a system which is acceptable for small company.

In general, an IoT enabled machine management platform in line with the characteristics of New Zealand local manufacturing has substantial commercial value and research value.

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