TOWARDS HUMANS ISSUES IN CLOUD MANUFACTURING PARADIGM

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ABSTRACT
Cloud manufacturing is a service oriented, customer centric and demand-driven manufacturing model that enable manufacturers to face a dynamics business environment. Due to the products and the corresponding manufacturing processes get more and more complex, operators' daily working life are also getting more difficult. Enhanced human-machine interaction is one of the core tasks for the success of next-generation manufacturing. Most of current research only focuses on the automation and flexibility features of cloud manufacturing, the interactions between human-machine and the value co-creation among operators are missing. Therefore, attentions are needed to the operators, and also their works. One promising approach is future factory concept, with the objective to reduce time and costs of machine control and maintenance. This paper describes the architecture of a system that uses the technologies of augmented reality, internet of things, and wearable technologies to support operators' working and communication in discrete factories.

Keywords: Cloud Manufacturing, Internet of Users, Augmented Reality, Smart glasses

1. INTRODUCTION
Manufacturing is the backbone of the current industrial environment. It plays an indispensable role in global economy. The traditional manufacturing industry was gradually superseded by a global chain of resources and various stakeholders. Therefore, a new dynamic and global business form is needed in the current manufacturing environment. The agility and quick reaction to market changes are essential characteristics, and the high availability and capacity to adequately fulfill customers' requirements is one of the main sustainability criteria. Moreover, centralized operation and management of distributed manufacturing equipment and resources are required (Xu, 2012).
Recently, cloud manufacturing emerges as a new solution to address all the challenges. It is a manufacturing version of cloud computing (Xu, 2012; Putnik, 2012). In this context, manufacturing resources and capabilities are virtualized and considered as services (Li, Zhang and Chai, 2010; Putnik, 2012) and organized in a resource pool (Li, Zhang and Chai, 2010). Virtualization refers to the abstraction of logical resources from their underlying physical resources (Xu, 2012). Cloud manufacturing is oriented towards service provision. Manufacturing services include machines, processing centers, and computing equipment used during the whole manufacturing lifecycle from pre-manufacturing (argumentation, design, production and sale), manufacturing (product usage, management and maintenance), and post-manufacturing (dismantling, scrap, and recycling) (Li, Zhang and Chai, 2010).
Many of existent infrastructures are already cloud-based or changing towards this virtual architecture. To fully and efficiently use those infrastructures, the services should have the ability to dynamically adapt to changes with minimal human intervention (Xu, 2012; Wu et al., 2013). However, it's difficult to avoid human actions in some services. Cloud manufacturing covers the entire manufacturing lifecycle. Therefore, some cloud manufacturing activities are requiring human involvement. Mostly they are after-sales services, which are supporting services of the main products, such as field services, maintenance, diagnosis, user assistance and training, and so on (Putnik, 2012; Camarinha-Matos, Afsarmanesh and Koelmel, 2011).
Xu (2012) considers participators as one of the manufacturing capability, which refer to human resources needed for the job. Besides the human resources, knowledge is also an important factor that represents all the knowledge required to do a specific job. It requires a sophisticated training and advanced knowledge to participate and enable the cloud manufacturing activities.
Integration in cloud manufacturing should be a systemic paradigm to organize humans and machines as a whole system. The integration should be not only at the field level, but also at the management and corporate levels. Wu et al. (2012) analyzed a series of research issues in cloud-based manufacturing paradigm, and cloud-enabled human-computer interaction and human-human collaboration were issues to be considered. They pointed out that more and more computers and other mobile devices get connected to the cloud, it's important to improve the human-computer interaction and user experiences. Mezagar (2011) also pointed out the outstanding importance of the collaboration and cooperation among users in networked enterprises.

However, in previous studies related to cloud manufacturing, the human resources and the knowledge management are rarely discussed. Major problems remain with respect to the interface between the enterprise corporate level and the manufacturing shop floor level (Panetto and Molina, 2008). Integration of humans with software and hardware is one of the fundamental requirements to satisfy the new development in the industry (Panetto and Molina, 2008). Based on previous study, we discovered some weaknesses of the current research in cloud manufacturing:

- Insufficient methods to support the field services.
- Lack of collaboration among operators.
- Lack of communication between the field services and the back office.
- Inefficiently knowledge management in field

Our research question is how to connect "humans" through updated networking technology in a contextually aware manner. Based on our recently discovering, a new solution is needed to facilitate a closed loop in the cloud manufacturing. We will employ different state-of-the-art technologies to support the collaborative manufacturing training, maintenance and management among different participants and departments. While other research more focuses on Internet of Things, our standpoint is the human factor in cloud manufacturing, namely Internet of Users. We discuss the solution within a practical case study. The company is a laser machine builder, and they sell machines to customer companies. They also provides centralized helpdesk and remote assistance, training, etc.. Our solution can increase the value of cloud manufacturing, avoid waste and increase sustainability, and in the meanwhile it can help to reduce risk and prevent human error on the shop floor. We will perform a pilot study to evaluate the use of wearable technologies (smart glasses) in improving the communication channel.

2. STATE-OF-THE-ART REVIEW

2.1. Cloud Manufacturing

Cloud manufacturing is a new multidisciplinary domain that encompasses state-of-the-art technologies such as networked manufacturing, manufacturing grid, virtual manufacturing, agile manufacturing, Internet of Things, and cloud computing (Xu, 2012; Li, Zhang and Chai, 2010). It is a value creation manufacturing process across globally networked operations. It involves global supply chain management, product service connection and management of distributed manufacturing units (Mezgar, 2011).

Under the umbrella of cloud manufacturing, manufacturing resources and capabilities can be intelligently sensed and connected to the wider internet, and automatically managed and controlled using Internet of Things (IoT) technologies (e.g. Radio-frequency identification (RFID), wired and wireless sensor network, embedded system) (Tao et al., 2011a). These resources and capabilities can be fully shared and circulated based on users' demand. There are three category users, namely providers (who own and provides the manufacturing resources and capabilities involved in the whole lifecycle of manufacturing process), operators (who operate the cloud manufacturing as a mediator, mostly deal with sales and business management) and consumers (who subscribe these resources and capabilities according to their needs and pay for they used) (Tao et al., 2011a). In some other research, the users are also defined as consumers, producers and managers (Wu et al., 2013). Dissecting and analyze deeply, the managers can be divided into cloud broker (who manages the use, performance, and delivery of cloud services, and negotiates relationships between cloud providers and cloud consumers) and cloud carrier (who provides connectivity and transport of cloud services from cloud providers to cloud consumers) (Wu et al., 2012).

In the introduction to cloud manufacturing, Xu (2012) uses two important concepts to describe cloud manufacturing: "integration of distributed resources" and "distribution of integrated resources". Providers publish their resources into this cloud manufacturing platform, and then the distributed resources are encapsulated into cloud services and managed in a centralized way. Consumers can use the cloud services according to their requirements. They can request services ranging from product design, manufacturing, testing, management and all other stages of the product lifecycle (Xu, 2012).

Although the concept of cloud manufacturing is mirroring from the definition of cloud computing, most of the resources in cloud manufacturing need to be operated manually by a human (Hu et al., 2012). This is unlike the virtual resources in cloud computing. In addition to the performance of manufacturing equipment, the human activities also have a great impact on the quality of the product. It's very difficult to maintain high-performance operation because the system consists of a group of devices, such as robots, numerical control machines, sensors, and so on (Park and Jeong, 2013). To improve the quality of manufacturing processes, products, the focus can move to improve people's performance. So the human activity must be considered as an important factor (Hu et al., 2012; Chituc and Restivo, 2009). Ford et al. (2012) suggest that enhanced human-machine interfaces and collaboration software are drivers of distributed manufacturing.

The scopes of human resources in cloud manufacturing formation vary depending on different definitions. Put it in a simple way, human resources are the personnel who engaged in the manufacturing process, i.e., designers, operators, managers, technicians, project teams, customer service, etc (Wang and Xu, 2013). Lv (2012) defines human resources including technology person and management person needed in the product developing process. They are the most precious resources in the activities of manufacturing business, plenty of knowledge and experience storage in the brains of these persons, is the inheritance and crystal of human knowledge and mental (Lv, 2012). Jiang et al. (2013) describe human resources in two parts: the personnel in the traditional manufacturing and the personnel in cloud computing development. Human resources include product design and development personnel in the traditional manufacturing, product management and maintenance personnel, product planning and marketing personnel and the personnel of cloud computing development and maintenance and so on.

2.2. Human beings Activities

Wu et al. (2013) emphasis on their research that a high level of automation will be required to ensure the efficiency and effectiveness of machines and manufacturing process on the shop floor with minimal effort, but it does not imply the absence of human beings.

Dual Resource Constraints (DRCs) are known as when capacity constraints stem from both machines and human operators (Xu, Xu and Xie, 2011). Hu et al. (2012) created a classification of the cloud manufacturing services by the degree of human involvement. The first type of services can run automatically without human resources (such as computing resources). The second type of services involves human pure manual activity that has nothing to do with proficiency (such as driver's driving skills has few effects on the quality of logistics services resource) while the third type of services is ranked based on the skill level of a worker (for instance lathe operator's operation skills can seriously affect the quality of workpiece).

Based on the intensive research review (Xu, Xu and Xie, 2011), they summarized several issues should be addressed when considering both humans and machines factors in a system: job release, job dispatching, worker flexibility, worker assignment, and worker transfer costs. In cloud manufacturing concept, these humans-related activities are not neglected. This finding implies the importance and priority to face these challenges in cloud manufacturing context.

Human operators, as a manufacturing resource, include both knowledge and skill, the capability of learning and acquiring new skills, and also related performance of operation (Luo et al., 2013; Xu, Xu and Xie, 2011). The knowledge refers to all kinds of knowledge possessed by the resources elements and experiences accumulated in manufacturing process (Luo et al., 2013). It is build up and accumulated based on the repeated interactions with machines, which is a learning process. More precisely, human knowledge includes experiences in performing a particular manufacturing task and manufacturing method, i.e., engineering knowledge, product models, standards, evaluation procedures and results, customer feedback, etc. (Luo et al., 2013; Wang and Xu, 2013). Knowledge management (KM) is the core and most essential part of cloud manufacturing reference models (Zhang and Jin, 2012; Zhang et al., 2014; Meier et al., 2010; Luo et al., 2013; Tao et al., 2011; Wu et al., 2012). Effective and efficient knowledge sharing and collaboration among operators are the keys to implement successfully KM and improve the operator's activities. Thus it's crucial to facilitate a well-designed information communication among all operators.

2.3. Technologies Supporting Human Beings

When use Information Communication Technologies (ICTs) to support business activities, there always some problems to be considered. The term ICT includes and focuses on not only technological improvement, but also improvement of aspects such as organization, human interaction, psychology, and man-and-machine interaction (Karim and Söderholm, 2009).

2.3.1. Internet of Things

Internet of Things (IoT) is one of the most critical technologies in cloud manufacturing. Based on IoT and virtualization, the distributed manufacturing resources are identified and connected to the cloud manufacturing and the resource sharing platform via network (Zhang et al., 2014; Wang and Xu, 2013; Huang et al., 2013), and then providing the service dispersedly with these centralized resources (Wei et al., 2013 2). It provides a promising strategy for large-scale distributed manufacturing system cooperation and integration (Liu, Li and Wang, 2011) by real-time monitoring (Liu et al., 2011). IoT makes computing truly ubiquitous, in which the internet extends into the real world and provides a standardized way for the cyber-space to understand the conditions, events and material movements in the real world (Liu et al., 2011; Michel, 2014). IoT is an essential enabler of cloud manufacturing.

With IoT, various data required (e.g., the information of sound, light, heat, electricity, mechanics, chemistry, biology, and location) can be acquired in real time by taking advantage of sensor networks (Tao et al., 2014; Chen, Chen and Hsu, 2014). It has been used in various applications; especially, it has been fundamentally changing the practical production and logistic operation with the aim of intelligent manufacturing (Tao et al., 2014; Chen, Chen and Hsu, 2014).

Tao et al. (2014) highlight three different applications of IoT in manufacturing from three perspectives, respectively in the workshop, in the enterprise and among enterprises. The general application in the workshop is using the data identified and acquired from IoT enabled manufacturing layers to achieve the automatic control. IoT technologies catalyze influential innovations in the business model and industries such as manufacturing (Maguire and Chan, 2014). However, Michel (2014) pointed out that the IoT is still not mature especially on plant floors. The challenges for broader adoption include security concerns for plant-floor networks and a fuzzy understanding of how the IoT translates into practical use.

2.3.2. Internet of Users

Under the support of rapid development of RFID, sensor technologies and also modern wireless communication, IoT promote the stable interconnection of anything in the manufacturing field (Li, Zhang and Chai, 2010). However, most of current research (Xu, 2012; Zhang et al., 2014) focuses on the connection between products, physical devices or enterprise systems. The “things” refers to machines, automation controllers and other physical devices being connected to the internet (Michel, 2014). Since human resource is also one of the significant manufacturing resources and capabilities, it’s critical to consider a human as a “thing”. Michel (2014) provides an example to describe the importance of considering interconnections with people, processes and data in this IoT concept.

Tao et al. (2014) mention that current rapid development of embedded systems and technologies provide enabling technologies for realizing the intelligent embedding of physical terminal manufacturing equipment and the interconnection of M2M (including man-to-man, man-to-machine, and machine-to-machine) in manufacturing.

The idea of Internet of Users (IoU) as a deeper level of IoT application in cloud manufacturing was proposed (Tao et al., 2014). The users (including service provider, consumer, and operator) of cloud manufacturing are primarily internet users, while IoT is one of the enabling technologies to realize the connection and communication among these users, and to form the IoU.

Many smart devices these days can be used for different applications. Wearable technology as one of the favor is inextricably linked with the consumer Internet of Things as a new category of connected devices evolves. A wearable device is giving easy access to a range of services able to connect via a range of technologies including GPS, wireless, Bluetooth, and also via direct connection to a range of fixed infrastructure terminals. Wearable technologies can provide user augmented view of the world and real-time data, beyond this, they can also form an integral part of the “Internet of Things”. The idea is to enable sensor-equipped "things" to communicate with one another in meaningful, actionable ways.

Thierer (2014) emphasis that wearable technologies are networked devices to collect data, track activities, and customize experiences to users’ needs and desires. It can be considered as a subset of IoT. Wearable technologies are supported by augmented reality (AR), which refers to the ability to superimpose virtual, registered information over a user’s view of the real world such as a real object or a space, so people can get information from the augmented data about the real object or space (Paul and Park, 2013; Furht, 2011).

Wearable AR employs a head-mounted display (HMD), a wearable computer, and a set of sensors to determine the position and orientation of the user’s head. As users move their heads, the HMD updates their virtual world view accordingly. Thomas and Sandor (2009) discuss about the benefits of wearable AR, and one of the benefits is that users can receive information while performing other simple tasks. Also, a wearable AR can give users navigation guidance to a particular location in real time.

There is an enormous opportunity for wearable computing in manufacturing, especially smart glass solutions such as Google glass. Plex promotes its cloud ERP as a comprehensive solution for manufacturing, in which the “IN-YOUR-EYE ERP” is integrated with Google glass and offer people working without using their hands. The user will be able to interact with the real-time, transactional materials, manufacturing and financial information captured by ERP (Gould, 2014).

Thomas and Sandor (2009) also demonstrate a scenario in the manufacturing industry that wearable AR can help assembly line worker to improve their industrial working processes.

BMW Company announced the usage of Augmented Reality like a visual guideline in real time for its workers. The application consists of glasses with headphones, thanks to this mechanic sees and hears the exact instructions about how to repair a car, while at the same time he can ask for the information which tool is right for next step of assembly or repair (Kubac et al., 2013). Similar tutorials are easily transferable to other sectors of human activity. They can serve as a training and educational applications for students in schools, in preparing manuals purchased goods (e.g. furniture), or the rapid training of employees for any device. However, most of the applications and implementations of AR are still in theory and only very few of them are presented as practical demonstration.

Overall, the technologies and problems mentioned above highlight the possibilities and needs for development of a comprehensive solution to support the human and machines connected in term of cloud manufacturing.

3. METHODOLOGY AND CORE CONCEPTS

The cloud manufacturing system is defined as a centralized management of distributed factories with their distributed manufacturing resource, such as machines, tools, materials, people and information, to produce a value-added physical product based on specific customer’s requirement. Its ultimate goal is covering the entire manufacturing lifecycle. Various studies have been carried out to understand the manufacturing resources virtualization and sharing process. Human resources are also important elements to fully realize the cloud manufacturing formation. In this research, we focus on the human resources and human activities in the real factories and propose an integrated solution to manage the interconnection and collaboration among humans with different roles, and our solution can support the effective human participation in term of cloud manufacturing.

In order to implement such architecture, a communication channel needs to be established where factory information are available in real-time to support the humans (users) on the shop floor. Figure 1 presents the reference model of the humans and machines both connected and embedded in the cloud manufacturing with specific information flows.

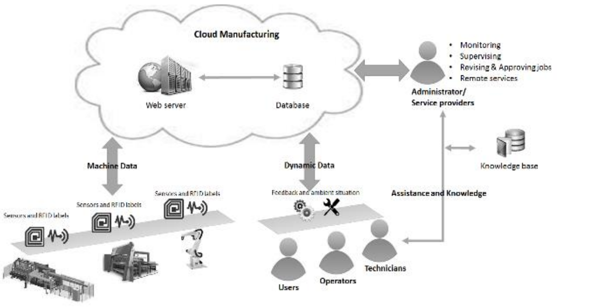

Figure 1: Reference Model for Humans and Machines in the cloud manufacturing.

There are two core components to enable this communication channel: "Internet of Machines (IoM)" and "Internet of Users (IoU)"

- IoM: All manufacturing resources, i.e. machines, pieces of equipment, robotics, and devices are connected with the internet. Their manufacturing capabilities are perceived by an adoption of the connecting sensors, embedded systems and RFIDs, and all related data are collected to achieve the automatic control and monitor. The adoption of IT promises the cloud manufacturing system having a real-time understanding of conditions, events and material movements in the physical world. This IoT does not only enable the manufacturing resources virtualization but also support the intelligent operation.
- IoU: The users on the shop floor including operators that control and manipulate the machines daily-based and technicians who can perform supervision, maintenance and repairing services. IoU is to the term to describe the connection and communication among the users. Besides the users working on the shop floor, administrators and remote assistants are also part of this IoU. Administrators' main tasks are monitoring the shop floor in real time and making adaptation when risk or error happens. Remote assistants mainly work in the help center and respond to the urgent events and hotlines.

Because the data can be captured from multiple sources in the distributed local factories, a data aggregator is needed to integrate the data. It provides important functions, such as domain service, location service, server load balancing, and more.

Knowledge-based is also a critical component. It is a document library that retrieves knowledge from users' activities. It includes how to control the machines, how to operate the equipment, how to use the devices, and so on.

The aim of this research paper is to provide a new concept of cloud manufacturing and technically provide industrial operators with a better approach in their working life and making the right decisions optimally.

4. PROJECT APPROACH

This section presents a case study of a real factory. It is a global company A which provide sheet metal processing machinery. Its customers are the sheet metal fabrication factories. They order customized metal sheet fabrication lines combining punching or laser cutter machines with automated bending and sorting capabilities from our case company A.

Based on the observation and analysis of the machine operator's actions and factory's activities on the shop floor, several processes were found to be suitable for improvement, such as the operator's machine control capabilities, maintenance and repair operations, and also the factory helpdesk processes. The main requirements from the case company are: to use a better remote desktop to control the machines, video sharing to monitor the factory production lines and data access thru cloud services. These requirements were discussed with the company personnel teams who are responsible for the machine operating, maintenance, and helpdesk services. Respectively, three primary stakeholders were identified: machine operator, maintenance personnel and helpdesk unit.

The solution provided in this research is that: Company A manages all the production lines in the form of cloud manufacturing, and its customers are cloud services consumers while company A is hosting this cloud manufacturing platform as a cloud services provider. Company A provides cloud services such as monitoring, supervising, revising & approving jobs, remote services. Figure 2 is a cloud manufacturing architecture that represents all the required functionalities and services integrating for:

- Real-time data capture service: for real-time data acquisition from the machines/pieces of equipment/devices/robotics through the embedded intelligent sensors. All data is maintained in the cloud-based repository.
- Process monitoring service: The helpdesk unit can monitor the production process in real-time. The users can access all the relevant actual and historical data based on their roles and the data is available to different users in different views. It provides data analysis and management suggestions on multiple screens communicational interface for creating a virtual presence environment.
- Field work assistance service: The users are mainly machine operators and maintenance

personnel. They can receive data through mixed-reality technologies to enhance their capabilities and skills. This collaborative and value co-creation environment is an extension of the knowledge management.

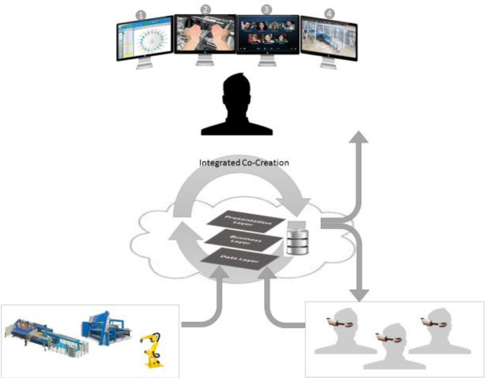

Figure 2: Overall System Architecture for Implementation

The 'cloud' infrastructure is for integration of representation, mixed-reality representation, real-time management model, and communication for collaborative management. It consists three layers: the data, business and presentation layer.

The presentation layer supports all interfaces, views, presentations and communications for users. The traditional single screen desktop environment needs to expand to large screens for control, monitoring and communication features. Therefore, this presentation layer provides two different kinds of display for back office and for the field working.

The business layer defines applications and functionalities such as Collaboration among users, Sharing Telemetry from machines to users, Real-time information from the shop floor to back office, etc.

The data layer represents cloud-based data repository and data management, also including knowledge bases. The technologies used to implement this data layer are querying, selection, and refinement.

4.1. Augmented Reality and Smart Glasses

In fact, at the back office of the helpdesk, a browser-based dashboard into production status is displayed on several oversized flat screens (see Figure 2). This specific solution includes four environments: 1) Production management feeding from ERP/MES 2) Operator's live view from smart glasses 3) Conference call for collaborative environment 4) Real-time video streaming from local production line.

The capabilities for video calling and augmented reality applications of Smart Glasses were appreciated as highly useful for both operators and maintain personnel. The smart glasses include sensors, accelerometers, cameras, microphones, and other capabilities that can be used to collect and transmit various types of user information. The real-time connection between them and helpdesk allows for significant time saving and improved field services. When data captured by smart glasses is fed into cloud-based data repository in the data layer, the presentation layer will push the refined and analyzed information out to the browser-based dashboard and show on helpdesk unit's screen. By using smart glasses, the real-time insight and instance feedback can be provided to helpdesk unit, this will enable remote assistances and services. Figure 3 shows smart glasses can support services for different stakeholders, namely machine operator, maintenance personnel and helpdesk unit.

Figure 3: Services can be supported by smart glasses

4.2. Use Case of Smart Glasses

This purpose of this pilot study was to measure the usefulness of smart glasses at the application level and to set the stage for future works to fulfill the setup of cloud manufacturing. In this paper, only the onsite maintenance scenario is described from the communication channels, roles and relevant tasks at the factory floor. This use case presents how company A provides field maintenance services to their customer factories.

When a customer, identifies the need for a maintenance service, he can difficultly describe the current fault or issue. The company A needs more information about the status of machine/equipment/device and potential error codes to give the customer a hint for a potential solution. If it is a trivial case, the maintenance personnel are required to solve the problem.

The activities performed by the maintenance personnel are depicted using an UML use case diagram. We observed prolong time for fixing faulty machines. Wearable devices can provide considerable improvement in this scenario above. We focused on implementing new functionalities as showing telemetry on the smart glasses customized menu for calibration and settings. Remote connection with helpdesk personnel, display machine usage history etc. Figure 4 presents these features. It shows the use case map for maintenance and remote assistance.

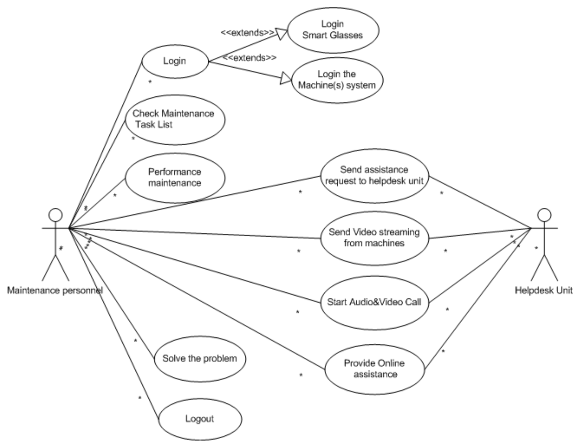

Figure 4: Use case for maintenance personnel hands free concept

In this solution we explore the possibilities for use of state-of-the-art technologies to map value streams and increase value, to avoid waste and increase sustainability, and to reduce risk and prevent a human error on the shop floor. The collaboration environment will be aided by the smart glasses and functionalities such as instant communication and file sharing. More research can be further investigated for the technology to be widely implemented and adopted on the shop floor in reality. Figure 5 provides a vision of using smart glasses to identify machines and display machine datasheet on the right corner of the screen.

Figure 5: Vision of Smart Glasses

5. CONCLUSION

Cloud manufacturing is to encompass the whole product manufacturing lifecycle: from market analysis to design and production, testing, training, usage, and maintenance; and finally dismantlement (Li, Lin and Chai, 2010). Cloud manufacturing business model can help SMEs to innovate their process, product and production side, but the support for the purchasing step, maintenance and training sides always be neglected. Moreover, in order to implement the cloud manufacturing successfully, it's very critical to share a huge amount of data and unstructured manufacturing related information across upstream design and downstream manufacturing in the cloud manufacturing environment (Wu et al., 2013). However, it lacks of a framework for seamless information sharing mechanisms to facilitate communication and collaboration in distributed and collaborative settings.

Our goal is to connect people into this cloud manufacturing as Internet of Things, and design a communication channel between the shop floor and the back-office. This communication channel ensures while workers serve on-site the administrators or remote helpdesk can collaborate and provide remote assistance or services.

Smart glasses represent a new approach for business communication. There are several applications available, such as navigation guidance, however, not so many innovations in the manufacturing industry. This solution can be easily applied to SMEs for monitoring and assist their field service purposes, because they are flexible, portable and cost limited. Workers can wear the smart glasses to receive specific guidance and instruction when they are performing on-site tasks, such as repair, maintenance and training. Having this wearable system enables hands-free viewing of in situ information that is location based and registered to physical objects and also workers can still receive information while performing other simple tasks (Thomas and Sandor, 2009). The advanced technologies in personal wearable devices combined with cloud manufacturing concepts provide an opportunity to co-create value and streamline human-machine interactions. This will help manufacturers create customized information and assess the workers' performance.

Although this smart glasses solution totally changes the manufacturing and it can bring even more possibilities for manufacturing, it's a controversial solution. First of all, the smart glasses continually raise various concerns regarding to privacy and safety from many international government regulations. The privacy refers to both critical information and operation records. Secondly, using the small display over the eye-field will cause potential health risks (headache) (Kubac et al., 2013). Thirdly, due to the supporting of information visualization, it might cause an issue of information overload (Ford et al., 2012). It's very important to filter the information and make sure the information are effective and efficient (Kubac et al., 2013). Another big barrier hinder this smart glasses usage in factories is the disputes over the access to adequate wireless spectrum to facilitate ubiquitous networking capabilities (Thierer, 2014).

Besides, the manufacturing systems should be designed considering the socio-economic context and other factors, such as product cost, level of required flexibility, desired product quality, therefore, it's important to balance the automation and human activities (Chituc and Restivo, 2009).

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