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LEAN INFORMATION MANAGEMENT UTILIZING INDUSTRIAL INTERNET

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Abstract: *Just as in consumer business, also business customers are becoming more and more demanding. They demand customized products that are optimized for them providing greater efficiency and productivity. With customized products the main customer sacrifice becomes the delivery time. Efficient and rapid manufacturing require also efficient and rapid information flows - Lean Information Management. In order to increase efficiency, most of the information collection and delivery should be automatized. In this paper, one Industrial Internet innovation seeking to improve and automate inter-organizational information flows using machine data is analyzed according to Lean Information Management principles.*

Key Words: ***Lean information management, Industrial Internet, Manufacture to order, customization***

1. INTRODUCTION

The time of mass production is fading away as customer are requiring products that are more and more individually customized to fit their needs and preferences. According to Pine we need to become "so customer-centric that we will endeavor to get ever closer to fulfilling customer needs *whatever, whenever, wherever, however*, and even *whyever* they need". The most prominent way to achieve this is to identify issues where we are not there yet, and then concentrate to these issues that cause a "*customer sacrifice*, the difference between what a customer truly wants and needs, and what he has to settle for today" (Pine, 2014).

Just as in consumer business, also business customers are becoming more and more demanding. They don't satisfy to any available product anymore but want one that is optimized for their purposes, providing greater efficiency and productivity in their own operations. Instead of buying the cheapest product in a category, also business customers are seeking solutions that provide best value for them, decreasing the importance of product costs.

If the customer value is sought to be maximized (instead of minimizing costs), then also the customer sacrifice need to be minimized. When value from customization exceed increase in costs, the main customer sacrifice is the delivery time it takes to produce an individually customized product. For customized products, there is three major causes for delivery time: a) production queue, i.e. the time an order need to wait until production capacity is available, b) the manufacture-to-order (MTO) process throughput time, and c) shipment and transportation.

In order to remove slack in the production process, the information flow supporting material and production flow need to be as fast and efficient as possible for supporting fast initiation of the production, frictionless production and rapid delivery of finished goods. Since today's production is highly distributed to multi-level supply chains, the information flow also need to cross organizations. All bottlenecks in information flow in the company and with suppliers involved in MTO process need to be removed.

In this paper one Industrial Internet innovation seeking to improve and automate inter-organizational information flows is described and Lean Information Management (Hicks, 2007; Graebsch et al., 2007; Franssila, 2012) principles are used to evaluate its effect to manufacturing. The innovation utilizes data from intelligent machine to automate information gathering process in the shop-floor level. With high level of automation in information processing the need for manual operations from user is diminished freeing-up more time for value-adding tasks. Also, automated collection and transfer of information enables quick reaction to any disruption in production and rearrangement of production. For example, without rules a missing part in assembly line might cause disruption in whole production line, or at least removal of k.o. item from production list, increasing customer delivery time.

The rest of the paper is divided to sections as follows. In Section 2, we briefly describe Lean Information Management concept and its main principles in elimination of waste. Next, in Section 3, we describe the concept of Industrial Internet, a term coined by General Electrics. Next, in Section 4 we describe an Industrial Internet innovation for bridge crane operations, that can be used for automating collection and delivery of process information. Then, in Section 5 we evaluate the innovation according to Lean Information Management principles and how the innovation could improve manufacturing efficiency. Finally, in Section 6, we provide some conclusions and discussion.

2. LEAN INFORMATION MANAGEMENT

In addition to traditional factors of production, the land, labour, and capital, today information is considered as a specifically important production factor. Compared to other factors, information has some unique qualities that make it particularly important; its expansible, compressible, substitutable, transportable, diffusive and shareable (Kendal and Scott, 1990). Also, information often plays a crusial role in the steering and optimization of utilization of other production factors (Franssila, 2012).

Improving the management of information in today's knowledge dependent organization can yield significant operational benefits and subsequently improve organizations' overall efficiency, competitiveness and responsiveness. Such improvements generally involve either expanding the amount of information managed or implementing an additional or new information management system (Hicks, 2007).

Lean Management is a widely applied development approach to improve business performance (Womac and Jones, 1996). It puts special focus on optimizing the usage of resources for the benefit of the customer, including information as a resource. It has proven to yield positive results concerning efficiency and reduction of overall process time (Womack and Jones, 2003).

Because of special qualities of information, many organizations doesn't even try to optimize information processing and flows, but instead introduce new type of information to collect and monitor all the time. Information processing is considered as a cheap substitute for other resources and more information available enables savings in other resources. However, many times this has lead to overreaction when too much of the time of workers is spend on information input and processing instead of adding value to product. This situation calls for Lean information management defined here as elimination of waste in information processes and in concentration to only those information activities that add value to product and substitute other resources instead of consuming them more.

To eliminate waste and to concentrate on value-adding activities, Hicks (2007) develops five key principles of Lean information management. They are:

- **Value.** The information and attached functionality must provide value for the information consumer. The information consumer can be the end customer but is more likely internal user of the information system. The information can be managed due to regulatory requirements, for effective management or operations of the organization or to support core competencies and processes in delivering their products or services.
- **Value stream.** In a context of information management, value stream can be considered to represent the series of processes and activities that ultimately results in the presentation of the information to the information consumer. For the purpose of reducing waste, it is important that the sequence of information processes are well integrated and where possible activities are automated.
- **Flow.** The "flow" principle of lean suggest that the value creation steps should be made to flow. In a context of information management, this means that at least the most valuable information flows and is available for information consumer in real time as soon as it is generated or acquired.
- **Pull.** The "pull" principle of lean states that manufacturers should only design and provide what the customer wants and only when the customer wants it. Information and additional functionality should only be implemented if and when it is demanded by the information consumer.
- **Continuous improvement.** The fifth principle involves regular reviews of the information management system, all associated infrastructure and processes. This is necessary as legislation, used information systems, business processes, processes that support delivery of products and services change with time.

These five principles are used to evaluate accordance of Industrial Internet innovation to Lean information management and to identify further development opportunities.

3. INDUSTRIAL INTERNET

The concept of Industrial Internet was first coined by General Electrics with their seminal report in 2012 (Evans and Annunziata, 2012). The term represents the deeper meshing of the digital world with the world of machines. The advanced computing and analytics, decreased cost of sensors and new methods of connectivity has brought us to situation where it is not only possible to profoundly transform the global industry but also many aspects of our daily life and how we do our jobs.

According to Evans and Annunziata (2012), together these developments bring together three elements, which embody the essence of the Industrial Internet:

1. Intelligent machines: New ways of connecting machines and fleets of machines with advanced sensors, controls and software applications.
2. Advanced analytics: Harnessing new methods for advanced analytics of machine and context data to better understand how machines operate and interact in larger systems.
3. People at work: connecting people at any time and place to support their activities and objectives.

The intelligent machines can be used to automate many of the previously manual information collection and input activities, freeing machine operators' time from information input activities to value adding work. Machine data collected from tens or hundreds of sensors can be collected and analyzed to meaningful form in order to improve the machine usage or the whole surrounding system. Analytics can be used to filter and identify meaningful information from tons of data, and to offer it in understandable and visual form immediately for the information user. The Industrial Internet will turn

the machines to serve human workers, instead of human workers to serve machine operations.

4. SUGGESTED SOLUTION

Next, we suggest a Industrial Internet innovation to optimize information flows in a MTO supply chain. MTO supply chain is here understood as a supply chain where Original Equipment Manufacturer (OEM) receives the customer order and at least one of its direct supplier participate in MTO process by providing a customized sub-assembly for OEM. Crucial for success of the supply chain is to minimize the throughput time in order to minimize the total delivery time to the customer. For this purpose it is extremely important to ensure frictionless production and to catch all abnormalities sharply.

Production planning and scheduling in MTO supply chain require synchronization of multiple organizations and supplies from MTO supplier need to be right on time for assembly of OEM, and even Just-In-Sequence management method is often applied. If the supplier fails to deliver the subassembly in time, it might have severe consequences in the assembly line of the OEM, causing extra costs in workarounds of production. Because of that, early warnings and information is extremely valuable for minimizing the disrupting effect of delivery failures and for swift rescheduling. This calls for systematic process of collecting and sharing status information of suppliers production to OEM, to catch anomalies and prepare for disturbances.

However, creating a systematic process for collecting and sharing status information manually consumes other resources (time of the workers) without any benefit to the end product most of the time. As Hicks noted, the concept of waste is generally well understood and visible in the areas of manufacturing, but less clear and visible in the context of information management. For example, Graebsch et al. (2007) found that in two student product development projects only 12% of information transfers added value of the end product. It is expected, that most of the status information collection and sharing doesn't produce value but only consumes other resources and this kind of activity should either be automated or obliterated. We prefer the first one, since rarely, when the status information is not ok, the value of that information jumps to the sky. It is extremely important to catch this kind of abnormal information as soons as possible for being able to take corrective actions minimizing damage when something starts to go wrong.

For the purpose of demonstrating applicability of Industrial Internet for Lean information management with a concrete case, we narrow the focus area in this paper to supply chains producing large or heavy items that are transferred in factories with a industrial crane. Industrial cranes, also called as bridge cranes, are used in factories to move heavy items to buffer stock, to and between workstations and finally transferring finished goods or subassemblies for shipment. They are mostly used manually with wired or wireless controllers, according to instant production phase and material need. Some of the modern cranes include functionality of storing position information of few or dozens of locations in the factory and using semi-automatic target drive functionality to move the crane to specific pre-hand defined locations.

To support crane operations with a modern control system and to manage buffer stocks in the factory, an Industrial Internet innovation was developed in a laboratory environment. It is a tablet based control and tracking system for industrial cranes. It focuses on four areas; automatic warehouse management, assisted crane steering, work process reporting and user experience.The system connects with the crane and read machine data from the crane and uses this information to automatically track work processes in the factory.

Our solution, named "CraneTab", stores information about each item brought to a warehouse. Once an item is in the system, it is tracked until it's shipped. When moving items between different areas in the warehouse, the system selects storage deposits and pickup locations automatically based on predefined warehouse logic. Crane can be programmed to follow predetermined routes and drive via safe areas. It improves both the work safety as well as the work process systematisation. CraneTab's crane steering capability is designed to be an assistive feature so that transition between automatic and manual crane operation gets completely seamless, providing important flexibility. Therefore, all item movements are tracked automatically with manual, semi-automated or fully automated crane steering. Our innovation design process focused on simplicity of use, thus the main goal was to provide user with only the most relevant information that is necessary for completing the task at hand. Another important goal was to achieve considerable improvement in learnability. That would enable more efficient use of temporary, new or external labour.

Stock status and work process information can be shared with other systems and organizations through a real-time remote status view. This feature would help to predict material needs, plan material flows better, use floor space more efficiently, reduce the number of lost items and improve cost-efficiency. It also allows real-time status monitoring and early catch of deviation from scheduled production plan. The CraneTab can be used both by supplier and OEM to automate collection and sharing of production status information requiring no increase in use of other production factors.

5. EVALUATION

The suggested innovation is evaluated according to five principles of Lean information management to evaluate its accordance to the principles and to identify further development opportunities.

- Value. As long as the production process proceeds as planned and scheduled, status information offers at most reassurance for managers in charge. It doesn't add value to the end product or to the use of other resources. Because of this invaluability, it is not reasonable to consume other resources to collect and share this information, suggesting obliteration of status information process. However, as soon as something abnormal happens, the swift notification and delivery of status information

becomes crucial for re-scheduling and recovery from disturbance. Thus, automated process of collecting and sharing status information provides value, since it doesn't consume other resources but bring forward information when its valuable. Thus, innovation conforms with the value principle.

- Value stream. As described above, most of the information collecting and transfer activities are automated and with system integration ensures that information is delivered for the information user. Thus, innovation conforms with the value stream principle.
- Flow. The innovation is based on automatic identification of process data and delivery of status information all the time. It operates in real time and deliver information forward in flow manner. Thus, innovation conforms with flow principle.
- Pull. The innovation offers different views to stock and status information in a pull manner, but basic functionality is based on constant delivery of the status information in a push manner. On the other hand, information user can pull more detailed information whenever needed. Thus, innovation only partially conforms with pull principle.
- Continuous improvement. Innovation writes a log all the time, offering users a possibility to evaluate and assess production processes with accurate data gathered in normal everyday situation (instead of specific measurement days causing variation in process) and all the time. This provides production managers opportunity have real data of extant process and to identify bottlenecks and other improvement areas in the process. In addition, change and continuous improvement is supported as systems is very easy to re-configure to match new or improved operations. Thus, innovation conforms with the continuous improvement principle.

According to evaluation the suggested innovation conforms well with different principles of Lean information management.

6. DISCUSSION AND CONCLUSIONS

Information is becoming more and more important production factor as natural resources are becoming scarce and green values pushes to find new production techniques, new materials and new product structures requiring less resources. Information, on the other hand, is not a scarce resource and its utilization to substitute use of other resources is thus highly recommendable.

In this paper, we described an Industrial Internet innovation increasing the value of the machine and how it can support the production process by automating previously manual information input tasks. According to evaluation against Lean information management principles, it was shown that Industrial Internet innovations truly have a potential to bring profound transformation to global industry, and not just improve predictive maintenance of machines.

For our knowledge, this paper is the first research paper on Industrial Internet, and at least the first paper analyzing Industrial Internet innovation from information management perspective, and Lean information management theory particularly. Limitations of the paper include the research method, a theoretical-analytical research method analyzing one innovation against evaluation criteria. This field of research is only now emerging (both Industrial Internet and Lean information management) and a lot of more research, especially empirical studies, are required.

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