18.8 Sourcing automation to the crowds – by means of low cost technical solutions

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Abstract

Increasing the level of automation in manufacturing organizations through low costing means should be a very lucrative option for those involved. Increased level of automation would mean higher productivity and could also mean higher quality, thus less lost opportunity cost, higher customer satisfaction, furthermore, less use of engineering materials that make up every tangible product. It is through crowdsourcing where every member of a certain community can contribute with their specific knowledge about a topic, towards innovative new ways of problem solving. The backbone of this specific crowdsourcing methodology is how it is structured by means of value creation module mapping, to a network. Contributions are designed and configured in a sequence of modules, offering the possibilities of comparison on a singular level or even a network level. This approach can be very useful for small and medium enterprises to remain competitive on the volatile global markets.

Keywords:
Crowdsourcing; Innovation; Low Cost Intelligent Automation; Value Creation Networks

1 INTRODUCTION

Modern automated manufacturing systems have driven productivity up and enabled the western world to remain competitive within the global product market. Automated manufacturing systems refer to systems that are capital intensive, where the organization’s money is bound in equipment and systems such as motors, structural infrastructure, conveyors, sensors, actuators, PLCs and controls. On the other side of the spectrum are the manual manufacturing systems that are labour intensive, where money is mostly bound to wages of employees [1]. The automated manufacturing systems have been, by default more expensive than the manual ones, mostly due to the high degree of complexity of the automated manufacturing system. These systems have a much higher number of mechanical components, subassemblies, electrical components and higher degree of signal acquisition such as machine status, various energy and resource consumption. All these sets of subsystems have to be meticulously designed, procured and/or fabricated, assembled, tested, shipped, installed and commissioned before being taken to operational use.

The fabrication of such automated manufacturing systems is carried out by complex supply chains or value creation networks. Typically these networks consist out of various types of actors that are involved in the following steps of material extraction, material processing, manufacturing, retailing, disposal, remanufacturing and recycling, in between is the use phase, carried out by the product’s user. Focusing only on the manufacturing actors, they can be seen as being involved in fabrication, subassembly, assembly and one that normally does the product’s branding and then delivers the automated manufacturing systems to the system’s operating facility. This process is in various steps, steps where manufacturing knowledge is heavily protected.

It is through the internet that information has the possibility to travel fast and to a widespread range of people. It is assumed that these people possess a wide spread of a specific technical knowledge, are motivated, able and willing to share this specific knowledge. Sharing the knowledge in the form of a community could change the view, the manufacturing industry has towards automation. Typically in order to obtain specific knowledge on some task, a member of the community either asks the other members of the community a specific questions on how to solve a specific topic or the member reveals to the community how it solved a specific topic. By this enabling other members of the community to try the solution out, give feedback or provide better means of solutions to that specific topic.

2 VALUE CREATION

Value is relatively complex matter and people differ in terms of how much artefacts and services are worth. Some people go to extremes to get the newest version of smartphones before the general public acquires them, standing in almost endless queues regardless of the weather conditions, while others prefer the less expensive same or similar versions from the competition. Kanji Ueda et al discussed value creation from a sustainable manufacturing point of view and how society could benefit from changing its view towards value. The genealogy of axiology was presented and how the knowledge of value had evolved from philosophical, individual, societal and environmental viewpoints. Their argument was that value is currently of an adaptive nature, that in contrast would be non-sustainable and that another approach towards value would have to be selected. This approach would be in the form of a conjoint value creation also referred to as cocreation, a concept where network externalities play an important role, by providing parts of the value creation [2].
The relevance of sustainability as an integral part of modern manufacturing has been shown at various organizations. They can reduce cost, improve stakeholder relationships, reduce regulatory intervention and risk [3]. The importance of sustainability will continue to grow and the argument will become more and more valid that there is an addition to value creation when carried out in conjoint fashion [4].

2.1 Value creation Module

A way to express how value is created is through a value creation module (VCM). It is expressed by the five factors of it: As product, process, equipment, organization and human. The product specifies what the object is, the equipment specifies by what the object is manufactured, the organization specifies when and where, the process how and finally the human is the one who is carrying the value creation out. The products can be of various types of tangible artefacts that exchange perceived value from an output to an input, until the perceived output value at some point in time is lesser than the input value. At that point in time, when the product is considered not worth selling downwards the value creation or the end of life is reached, some other action has to be taken, such recycling, remanufacturing or different type of usages.

There is a complex interrelation between the five factors, the process requires specific equipment, the equipment relies on specific technology and the technology has to take various external factors into consideration. The equipment is housed in a facility and this facility requires various utilities to operate (e.g. electricity, gas, water, pneumatic air, hydraulics and consumables). Humans operate the equipment, under specific conditions (e.g. working hours per shift, shifts per week, according to remuneration plan, safety plan and hiring policy) but how this all works falls under the organization. The organization also manages the division labour, decides the extent to which processes are vertically or horizontally integrated. Graphical representation of the value creation module is shown on Figure 1 [5].

Connecting value creation modules enables for the representation of value creation chains or value creation networks where more than two value creation modules are connected together. As automated manufacturing systems are heavily dependent on processes and equipment, only those two will be depicted:

- Processes: They specify how products are manufactured. The processes come in a sequence, traditionally the output of one process becomes the input of the next process until finished parts, subassemblies or desired finished products are readily available. Manufacturing processes are classified in the main operations of transformation, transportation, storing and inspection. Many process types can be carried out in a different type of manner, such as cutting process that can be carried out by means of a hacksaw, a band saw, a lathe or even a CNC machine.
- Equipment: In order to carry out the different types of processes, specific types of equipment are required. The equipment is based on different types of technology and/or functionality and even different brands.

2.2 Value creation chains

Manufacturing systems can be seen having five different levels depending on the perspective of the organization. These levels are device/unit process, line/cell/multi-machine system, facility, multi-factory system and enterprise/global supply chain. The three first levels of interest to this paper are depicted as following [6]:

- Device/unit process: Single machines, equipment, devices or machine tools that perform desired functions. Including support tools such as jigs, fixtures, moulds, clamps and measurements tools, furthermore, instrumentation such as gauges, sensors, actuators and control units. This level can also be considered as a single value creation module.
- Line/cell/multi-machine system: Series of device/unit processes that performs an intended function of producing parts, components or subassemblies, though not the intended output of the factory. This system can be viewed as a value creation chain.
- Facility: The desired output of the factory is carried out within a facility. It can be parts, components, subassemblies or finished products. A facility is a good example of a value creation chain.

Representing value creation chains on the above mentioned levels, where the focus on the processes as a primary connection point offers the possibility to create a modelled representation of the process. Figure 2 represents the value creation chain, the value creation module from Figure 1 is there shown in miniature version of it to show the process flow from the first process to the last.

![Figure 1: A value creation module [5]](image1)

![Figure 2: Model of a value creation chain](image2)
3 MANUFACTURING SYSTEMS

The term manufacturing system refers to a system that transforms necessary inputs, such as raw material, parts, components, subassembly, assemblies and energy, into desired equal finished outputs. These desired outputs are then in significant amounts sold onwards and what is referred to as downstream, towards the buyers of these outputs.

3.1 Automation

The term automated comes from automation and is defined according to the Merriam-Webster on-line dictionary as: “Automation has the possibility to increase precision and accuracy compared to what can be achieved through manual workers” [7]. Automated in that context refers to equipment, a process, or system that operates by automation. Full automation should then replace all human labour for the specific operation the automation covers and semi-automation is a process where some level of automation exists. Automation has the possibility to increases precision and accuracy. Compared to what can be achieved through a manual workers.

A conventional view is that as there is a trade-off between automation and flexibility, i.e. as automation rises the flexibility decreases. Lotter and Wiendahl presented in 2009, a model where three levels of automation (manual assembly, hybrid assembly and automated assembly) are presented as areas and located in between the spectrums of flexibility, quantity, quality and variant diversity as presented on Figure 3 [8]. Even though the tasks refer to different assembly procedures, these different spectrums are applicable to the processes that fall under the scope of this paper and main focus will be on hybrid assembly to automated assembly setups, where quality and quantity is important.

![Figure 3: Utilization areas for manual, hybrid and automated assembly concepts [8]](image)

Manual tasks are best suited to low quantity where high variant diversity can be expected. This requires a high degree of flexibility from the operational and organizational structure but lower quality of the end product can be expected. Automated tasks are best suited to high quantity where low variant diversity exists. The highest degree of quality can be expected but due to the system’s restrictions it has a low degree of flexibility. Hybrid tasks (semi-automated tasks) fall in between manual and automated tasks, with medium quality, flexibility, quantity and variant diversity.

3.2 Complexity of Systems

The spectrum for automated manufacturing systems covers simple configurations to complex system configurations. Complexity is influenced by the quantity of information, the diversity of information and the information content. Generally speaking, processes complexity increases with the lack of clear requirements and the unreliability of tools. As processes and tools become more reliable the complexity of the process systems reduces [9].

Monument is a terminology for objects of such proportion that they are unmovable and which will stand the test of time. Generally monuments referred to type of structures that are either created to commemorate an important historical person or an event of important or horrific historical proportion for a group of people. In the manufacturing industry it is used in a negative manner for a wrongful selection of machinery, with considerable amount of costs attached to it. Traditionally they are equipment such as heat-treatment ovens, paint sprays equipment and large automated machining centres [10].

Right sized tools are tools that are neither too little or to large. An example for right sized tool is a toothbrush. It fits perfectly between the palm and fingers and is capable of performing the task of brushing all the teeth, including the jaws. In the manufacturing industry it is mainly used for simple and low cost machinery that is capable of performing processing tasks in a compatible manner compared to more expensive machinery. This machinery sometimes requires modification to it.

3.3 Low Cost Intelligent Automation

The origin of Low cost intelligent automation (LCIA) comes from Hitoshi Takeda, a term that was coined in the 1990s. LCIA is primarily applied in assembly, mechanical processing and in-plant transport. LCIA describes a process where pre-existing machinery is equipped with simple mechanical appliances that augment the function of the pre-existing machinery such as by ejecting parts from the machinery after work has been carried out on it and/or transporting the part from it. An example is an automatic release mechanism coupled by means of lever mechanism or sensors to a stand drill. When the drill reaches a predefined position, the drilling is subtracted, the stand drill shuts down and the work piece is ejected from the fixture holding it in place through the process. LCIA is superior to full automation because production facilities may be rearranged and newly combined according to different value streams in a much easier way, this makes ensure that the machinery will not become a monument [11].

4 OPEN INNOVATION AND CROWDSOURCING

There is an immense amount of information that is either being sought after and exchanged on the internet, where more than 2 billion e-mails are sent, more than 2 million queries are made on Google, more than 2 thousand FourSquare users perform check-ins visits every minute and AgentAnything receives around a one unique visits every two minutes. The AgentAnything website, offers the citizens of New York and New Jersey the possibility to have almost any task carried out for them. The tasks or the missions as they are referred to have to be defined and an agent, someone, has to be willing to do the task. Tapping into only a small
proportion of this huge knowledge exchange would be very lucrative for organizations.

Open innovation occurs when companies open their boundaries to the outside in order to seek different, improved or new ideas to problems they have. This process is depicted in a graphical representation on Figure 4, originally drafted by Professor Henry Chesbrough but for the sake of this paper it is adapted. Open innovation is generally highly dependent on the customers [12]. Open design is a form of open innovation, and come in various forms such as open manufacturing, open prototyping, open idea generation, open community projects, open downloadable design and open design tools [13]. There are three core practices for integrating customers to open innovation: Lead-user method, internet toolkit and idea competitions. The lead-user method is an invitational (receive an exclusive invitation to participate), directed (given no instructions) or suggestive (given no instructions) approach where few experts or lead users are invited to carry out the innovation. The internet toolkit as the name implies is when the users are obtained through internet portals. This process can be directed or suggestive to and mostly participative, i.e. everyone can participate. The last form is idea competitions where there is a specific topic, requiring a solution. The idea competitions are often used early in the innovation process, participative and carried out in a directed or suggesting form [14],[15]. Difference to the other two the idea competition offers direct incentives for the best results and depending on the types of motives and incentives. The motives are learning, direct compensation, self-marketing and social motives. It is through motives that open design can be manipulated and the activation of participates triggered. A proper design of the components for activation and participation support is required [14].

What open innovation might means for small and medium enterprises (SMEs) is an access to competences that they normally do not possess and are not capable of maintaining. The necessary expertise can be sought after when required, even in specific intervals suiting their available investments [18]. Important for the SMEs, is to specify the requirement for each task they have for the crowds. Newly acquired competences also pave the way for dialogs with larger enterprises or new markets [14]. Policymakers within the OECD also agree with the importance of collaboration with external partners and open innovation, as it is one of the highlighted seven main policy areas for SMEs [19].

4.1 Crowdsourcing Examples

There are currently various examples where open design works, examples are 3D printers, robots, laser cutters, machine tools, CNC machines, electronics and many more. To name specific projects then the RepRap (http://reprap.org) project, that has the goal to print printed circuit boards by means of additive manufacturing. The RepRap project has been going on for several years now and during this time immense improvements have been done by the community behind the project. Another well worth mentioning project is the Global Village Construction Set (GVCS, http://opensourceecology.org/gvcs.php). It is a network of farmers, engineers and enthusiasts. It is an open design for manufacturing initiative where the contributors have designed over 50 machines and built several of them, such as bulldozer, soil pulverisers and presses. Even though the GVCS is an open design platform it already shows how modern technology can be built with a proportion of the cost of buying similar machinery from an original equipment manufacturer. A very well-known crowdsourcing scheme is the one of the European Commission that carries out crowdsourcing of open calls through its research programme framework. For each call there has to be made a proposal. The calls have requisitions in terms of composition of parties (i.e. industry, universities and research institutes), number of parties and quality of how well the proposal fits the call. Unique for this type of crowdsourcing is that successful proposals are funding during duration of the project. The reason is the amount of capital and time bound to the project, since few would have the financial capacity to work on a project for months and only receive payment once the project would be completed [20].

Examples of crowdsourcing activities that are closer to the use case considered in this case are based on a structure similar as the VCM’s structure: Who, what why and how. Wikipedia has an undefined group (the who), deals with public goods or wiki-articles (the what), intrinsic incentives
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Equipment to replace is vital, therefore, the value creation understanding on the manufacturing systems and which breaking down systems to smaller sizes. Having clear systems should be avoided in the beginning, focusing on automation but are dependent on human labour. Complex specifically on hybrid systems that have some degree of competitive setup [21]. Innocentive for public goods, for multiple incentives based on a portal’s users, for undefined groups dealing with private goods for payment as well as with the Innocentive problem in a competitive manner.

SME-related activities on crowdsourcing platforms are numerous, most of them new start-ups. One such platform is ideaken (http://www.ideaken.com/) that offers a closed platform between a problem seeker (a company) and a network of problem solvers (group of individuals). A problem solver receives remuneration, once the company is satisfied with the solution.

4.2 Crowdsourcing LCIA

Crowdsourcing of any problem poses various challenges. There has to be a clear understanding on whose attention to attract, its qualification, if there should be any ties to specific types of organizations, furthermore, what should be the incentives and how to measure how well the task has been carried out.

The challenge of LCIA is how to deal with complexity that means should the call be limited to a single machine or a setup of machines. What is the success criterion of the call, i.e. should the main objective be to reduce costs, compared to similar on-the-market solutions or provide cost reduction through a shift from labour intensive operations towards more capital intensive operations. The proposal of this paper is to utilize the sustainable manufacturing platform to set up or seek out value creation modules for crowdsourcing purposes, specifically on hybrid systems that have some degree of automation but are dependent on human labour. Complex systems should be avoided in the beginning, focusing on breaking down systems to smaller sizes. Having clear understanding on the manufacturing systems and which equipment to replace is vital, therefore, the value creation module mapping behind the sustainable manufacturing platform comes in handy. It enables the comparison of solutions and backs up the decision making process. Other dimension that the platform offers is a comparison of solutions that contain advantages in terms of environmental value, pragmatic or psychological on top of the economic value addition already being considered internally within the system.

4.3 Sustainable Manufacturing Platform

The applicable sustainability surroundings for LCIA crowdsourcing tasks are local production, inclusion of developing countries and consumer’s involvement in product’s design and improvement. It supports economic growth and development through locally available resources, created through solutions made available through open innovation [22]. Through locally available resources, shorter material loops are made available and through greater reutilization and recycling efforts a net environmental improvements can be gained [23]. This combination provides the means to produce products of higher quality compared to before, improving human wellbeing at reduced consumption rate for non-renewable material sources.

As the previous examples show there is a need to specify the calls properly and address them to specific target groups. Heyer et al in 2013 proposed the utilization of the sustainable manufacturing platform (SMP) in order to collect knowledge, store the knowledge in the repository, thus making it usable for the members of the platform. Figure 5 shows a framework of the knowledge pool for sustainable manufacturing. The SMP could be used in various fields and different places of the world, e.g. in the less developed parts of the world in order to improve living conditions of people [23]. The target group for the LCIA would be undefined groups of people with special industrial and automation knowledge, willing to share their knowledge with others. The incentives for the contributions would be in the form of evaluation score (i.e. feeling of competence) and the prospect of improving the lives of others in a collaborative manner. The system enables feedback to the users, so that the users gain more knowledge by sharing ideas and experience of use. What remains is to establish the breakdown of the manufacturing system’s elements to be improved with LCIA. The SMP system’s requirements enable the setup of different types of information details ranging from unit level to a facility level.

4.4 Limitations

Besides the organization’s fear of losing knowledge or letting their competitors know too much of their core competences there are several limitations to this proposed methodology.

![Figure 5: Framework – Sustainable Manufacturing Platform (SMP) [23]](image-url)
what is expected as a result. As previously stated LCIA has a limited span of application fields. The open design movement that could be attractive for SMEs seems to be in the development phase, not fully ripe and several questions remain unanswered, such as regarding property rights and security of data.

5 CONCLUSION

Automation has great potential in replacing human operators in tasks that are physically difficult or even beyond human capacities, in tasks that are monotonous, and in dangerous environments (e.g. bomb threats, fire, underwater). From an industrial point of view the objectives is nevertheless, to reduce labour costs and improve quality. Automation comes at a cost and simultaneously binds capital, where system integration is important. In order to increase the change of crowdsourcing activities they have to be assigned for the right people under the right boundary conditions [21]. Essential is to select the correct incentive-support components in order to stimulate activation and participation [14]. This paper presented how low cost automation opportunities for SMEs can be inserted on the SMP, a call made in order to start analysing the problem. LCIA contains great opportunities but in order to realize them the VCM have to be modelled sufficiently and the specific processes requirement published in the form of an open call.

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7 REFERENCES