Internet based Production Concepts – Implications for Business Management

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Abstract. An important change in the socio-economic environment of industrial firms is the increasing diffusion of Internet technologies in production processes. Applications are on the shop floor, e.g. in networking dislocated assembly lines and in assisting management processes, e.g. in production planning and control. Due to this evolution of direct, IP supported networking (down to the machinery level), an increase of distributed services in production processes is to be expected. This leads to a strong approximation of the traditional production and operation systems and Internet technologies. Therefore, this paper introduces in a first step the recent advances in industrial Internet technologies. In a second step, we will discuss new production concepts and point out their benefits for business processes within industry. However, our main goal is to analyze the arising consequences for Production/Operations Management, as well as for Business Management in general.

Key words: Production Concept, Internet Technologies, Business Management, Production/ Operations Management

Introduction

Through the lack of attention for production, the integration of production processes into the overall business processes is generally disregarded. In production systems, an alignment of new organizational principles with the technical requirements of production systems when designing new production processes permits one to enhance production processes. Information technology is an important instrument to implement this alignment. There are significant amounts of effort being put forth in order to integrate functions, as well as technical systems by using information technologies. These efforts are emphasized by formal and empirical studies that have verified the significant increase in productivity of manufacturing processes by intraorganizational applications of modern information and communication technologies (Barua/Lee 2001, pp. 37).

Technical, but also organizational barriers prevent an overall integration of information systems into the production system. Internet technologies support the evolution and realization of new production systems. The main reason for this is the upcoming convergence of automation and information technology based on a direct Internet–Protocol (IP) supported networking of machines on the shop floor. We introduce Internet based Production Concepts as a solution to the technical problems of integrating the different information systems in manufacturing. Based on this, we show how one can also solve organizational problems. Therefore, this paper introduces in a first step the recent advances in industrial Internet technologies and discusses new production concepts and we point out their benefits for business processes in industry. However, our main goal is to

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analyze the arising consequences for production/operations management, as well as for certain aspects of business management.

Application and Impact of Internet Technologies

Usually Internet technologies are understood in the context of the well-known Internet as the technological basis of a global information and communication network. The term Internet technologies only describes a family of technologies suitable for exchanging structured data about package-oriented transmissions on heterogeneous platforms, in particular protocols, programming languages, hardware, and software. Yet, the internal application of these technologies focuses on Intranets for office information systems. In future, the main industrial application area for Internet technologies is in Field Area Networks (FAN). This leads to an interconnection and networking of automation infrastructure (e.g. machine controls) on the shop floor and information systems (e.g. ERP) that are involved in the production process. Additionally, new Internet technologies such as Web Services and the Semantic Web provide open standards and enhanced techniques for the interconnection of information systems (Bettag 2001). Therefore, new Internet based production systems are possible and necessary because of Enterprise Application Integration (EAI), vertical and horizontal integration are more applicable within the production system. What is important is the openness of Internet technologies. This ensures in the long run, the compatibility with other technologies and the changeability of web-based information systems. Internet technologies are applicable on different systems and devices. This permits the use of different devices as a front-end for the information systems within the production system.

The large amount of available information needs to be structured and organized; otherwise, the complexity would displace the potential of Internet technologies. The directory of resources is a promising concept to link the information stored in various information systems to the organization and therefore make it applicable. In fact, this concept is a management tool to cope with complex organizations broadly supported by information systems. Known implementations of that concept are the active directory of Microsoft or Novell Netware. A rudimentary version is the DNS (Domain Name system) of the Internet, which matches domain names to the IP-addresses worldwide. A more complex standard for that is UDDI (Universal Directory Description Interface), which is actually a part of the heavily discussed Web-Services. Apart from the technical concepts, the idea of the directory approaches is to link the information within a system (e.g. production system) to the various resources within the system. The directory stores the attributes of every acting entity within a system and represents all of the attributes. These entities may be employees, information systems or organizations. The directory enables the entities of the concerned system to find and interact with all of the other entities. The Internet-technology based approach allows a universal directory for the entire system, which was prohibited thus far by technological barriers. The directory also contains the information necessary to set up information transfers and determines which information an entity can provide.

The application of Internet technologies within the production system requires either the update of existing infrastructure or the investment of new facilities. In many cases, industrial firms have to protect existing investments, so they have to continue using a technologically obsolete infrastructure. Furthermore, existing information systems are designed to operate in hierarchical and/or centralistic organizations (Scherer 1996, p. 210). These infrastructures are not able to use the coordination benefits of Internet technologies. Nevertheless, to realize the benefits, the application of Internet technologies has to be systematized by a guideline. According to the high interweavement of organization, processes, and the used information technology, such a guideline must not concentrate on the technological aspects, but has to emphasize on the dependencies within the production system. Instead of the term guideline we propose to use Concept for an academic approach that should be applicable in a wide range of industries. Our analysis focuses on production and or-

ganization management, due to the lack of appropriate concepts adopting Internet technologies. Therefore, we suggest using production concepts for the realization of an Internet-based production. Production concepts reflect a comprehensive image of a production system. This means, to design a production concept we need a coherent description of a generalized production system. Based on that description we can develop recommendations, methods, and instruments. The production system consists of two systems, *the management system* and the *operation system*. Additionally, the information system interconnects and interweaves these systems. The operation system deals with the original transformation processes and includes all facilities, machines, logistical equipment, and low-level workers. The management system is responsible for the short run (operational) design, planning, and control of the entire operation system. This differentiation is the basis of the following analysis of the consequences of Internet based production concepts

The considerable advantages of Internet technologies are undisputed for the technological infrastructure of communications and information in production processes. According to Atherton's idea, *Java-based applications* should support planning and control of all production processes. In this scenario Internet technologies integrate the technical CAx-systems with the economical ERP. This means, Java connects different technological environments and acts as a gateway between automation technology and information technology. To make that idea useful for business management, we need an abstract concept, which allows structuring the production system. This concept has to reflect the abilities of the elements of the production system, in order to incorporate the proposed new features generated by Internet-technology use. Therefore, it is useful to speak of actors, when referring to autonomous acting units within the production system. Actors may be humans (planner, workers), technical units with local intelligence (facilities with embedded computational intelligence), and organizational units composed of a number of human and/or technical actors. With this view, we can better analyze the outstanding implications of Internet technologies, especially in coordination and communication. The actors of the production system have a broad set of abilities to set up relationships with other actors. Thus, we can suggest, that every actor may interact with every other actor by using the described directory of resources.

These interactions can range from simple data transfer to complex coordination processes. Additionally, the interaction of actors is not limited to the production system, which means they can communicate with actors outside the production system. This outside communication is one of the main aspects within the *Information-Based Manufacturing, which* describes a highly information-dependent production, which is distributed throughout several enterprises (Shaw 2001, p. 9). Exemplary instruments of Information-Based Manufacturing are optimal information sharing about the supply chain, a high velocity of (re)actions, and an optimal synchronization of production factor appropriation and scheduling between the firm and their partners in the entire supply chain. Therefore, companies have to have agent systems, decentralized planning and operation systems, as well as integrated information and automation technologies in the dislocated production processes for the realization of Information-Based Manufacturing. This intraorganizational view is also accentuated by the concept of the *e-Factory*, which considers the necessary qualities of industrial firms. The author understands the e-Factory as an upright element of an electronic supply chain in E-Business and defines this approach as ”a new, all-encompassing term for all of the electronic control, automation, and intelligent machines that occupy today's factory environment” (Beavers, 2001, p. 14).

Besides the communication and interaction abilities, we have to ask how actors within the production system can arrange the complex tasks that are demanding a high degree of effort in communication and coordination. Especially when we assume high uncertainty, there have to be powerful mechanisms to support those processes. Positive approaches for the application of Internet technologies in manufacturing are observable in context with the keyword '*Web-Integrated Manufacturing*' in engineering research. Web-Integrated Manufacturing describes the general application of Internet technologies in manufacturing, for example, agent based systems, Java, Jini and SOAP (Kühnle et al. 2001, p. 465). Even the international research project ”plant automation

based on distributed systems" uses this approach as a theoretical basis and aims at the development of decentralized, distributed systems of office communication within the machine control on the shop floor. This is supposed to lead to highly flexible, adaptive and simply reconfigurable production systems (Huang/Mak (2001), p. 4). Reconfigurable production systems combine the respective advantages of high-productive and high-flexible systems, because they can be adapted immediately regarding their structure, functionality, capacity, as well as their inherent technology to changing demands.

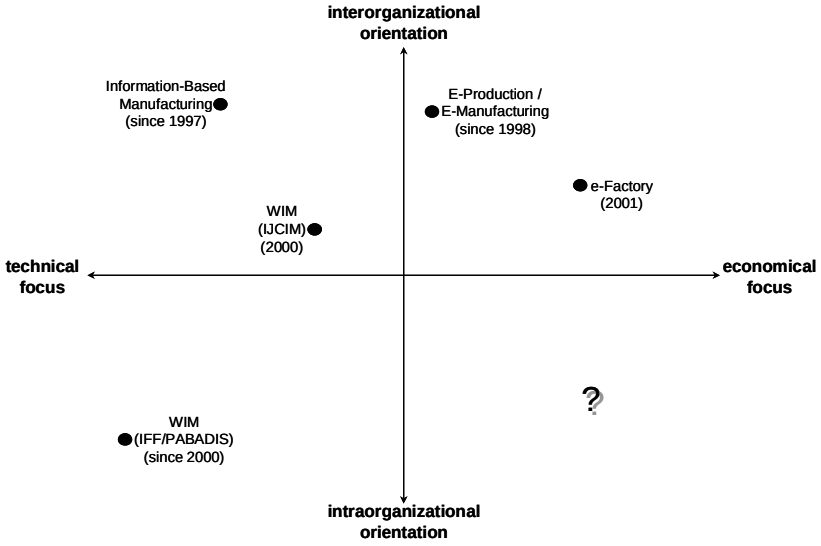

Figure 1: Internet based production Concepts (Blecker 2003, p.19)

Figure 1 points out that the combination of economic focus and intraorganizational orientation is thus far missing. There are Approaches that are focusing on the interim relationships, such as e-Factory or Information based Manufacturing. Other ones are exclusively concentrating on technical detail on using Internet technologies in the production system. The E-Manufacturing and E-Production concept indicated in Figure 1 exclusively deal with interorganizational tasks and focus on supply concepts such as auctions for efficient supply management. (Wildemann 2002, p. 22) Therefore, we would like to concentrate our investigation on the empty fields, which means to set up an intraorganizational and economically focused production concept. This requires the set up of a new production concept addressing the application of the shown technical potentials in a production system. Therefore, we define a new production concept called Web-based Manufacturing:

> "Web-based Manufacturing is an Internet technology based production concept, that is an in theory well-founded guiding-idea, based on empirical knowledge where appropriate, on the organization, planning, control and evolution of production systems. It aims at easily reconfigurable, high flexible production systems based on the comprehensive application of Internet technologies on the shop floor. The main goal is to achieve market- and resource oriented competitive advantages supported by the application of Internet technology based technological and/or conceptual procedures and processes in a decentralized coordinated, according to informational criteria organized and ad-hoc structures forming the production environment." (Blecker 2003, p. 23)

In this paper, we would like to concentrate on two corresponding aspects. The diffusion of Internet technologies causes the production system to alter, affecting the capabilities of it. This may cause other systems and functions of the company to adjust their relationship with the production system. This investigation focuses on coordination and communication problems, which the Produc-

tion/Operations management must deal with. Strategic decisions apart from technological directions (to use Internet technologies) are outside the scope of this context. In contrast, there are very strong implications of the changes in the production system for gaining competitive advantages, for the management of operations itself and for business management within the industrial company.

Implications of Internet based Production Concepts

Consequences for Production/Operations Management

The main tasks of Production/Operations management to operate an existing production system are the (operational) design of the resources and processes on the one hand and to plan, operate and control them on the other hand. (Corsten 1998) Production/Operations management has to deal with the following tasks for the configuration of potentials and processes in a production system:

- Allocation and capacity management of potential factors
- the draft of the internal organization of the manufacturing system as well as,
- the planning of the layout

The main objective of these tasks is to efficiently configure the operation system. To examine the implications we have to analyze the changes within actors and the abilities when designing the materials flow and information system.

In production, the configuration and preparation of facilities strongly determine the organization of possible output and the necessary processes. Changes in the capabilities of the facility influence the management of operations by lessening or enlarging the range of possible processes and therefore the output of the production system (Naylor 2002). The integration of computational power leads to a higher set of possible activities. Based on the local computing power they are able to detect its state and store several data. The facility, which is now (due to autonomy) an actor within the manufacturing system can order by itself the necessary material or inform the maintenance crew (that can be outside the plant) of possible faults. This actor can provide the entire set of necessary information to every actor within the production system (and outside). Therefore, production management has to change some restrictions when planning the operational layout of the operation system and drafting the internal organization.

We interpret the materials flow as a physical connection of two actors. The exchanged objects between the actors can be completely described by the possibilities of Internet technologies. This shows a direct integration of the materials flow system into the information system. Therefore changes in the materials flow system are attainable faster and at a lower cost. Through that, it is also possible to form a highly flexible materials flow. The high information availability and the real time state of the production system allow high-flexible supplying-relationships, which are not bound to an inflexible, redesigned materials flow. Production/operations management can use these possibilities to vary the layouts to better conform to the production program. Even larger changes in the production quantity or quality are manageable, if the actors are able to produce the parts. Also in the operation system the mobility of actors is manageable. Excepting physical barriers with large facilities, a change within the layout can be accomplished very fast and the materials and information flow are immediately changeable.

We have identified four major changes of actors in the design of potentials and processes:

- communication outside the production system
- enlargement of actors capabilities
- mobility and connectivity of actors and factors
- adaptability of information and materials flow system

This leads to the conclusion, that there is a larger set of possible operation system structures based on the assumption that strategic directives, as well as the limitations of the production system itself (such as the plant) remains the same.

To realize the outstanding potentials generated in the design of potentials and processes, management has to adopt the new abilities of actors for the operation of the production system. The main management task for efficient operations is the coordination of actors to produce the desired output with the aid of production planning and control. The basic tasks of production planning and control are:

- Master production scheduling (based upon aggregate sales planning)
- Materials and capacity requirements planning
- Shop floor scheduling and the control of manufacturing processes

In a common approach, these tasks are performed sequentially, with steering information top down and feedback bottom up based on the common used MRPII concept. It is often argued that this approach is quite inelastic, especially under uncertainty. The distinction of different steps in planning and control is theoretically important, but in organizations, most people engage in both planning and control (Naylor 2002, p. 451). Based on the high influence of Internet technologies, we have now to discuss the implications for production planning and control.

Production planning and control suffers from inflexible and inelastic mechanisms (Reiss 1998). Therefore, we have to precisely look for forms of planning and control, which enhance flexibility. To extend the flexibility of the production planning and control, decentralized planning and control mechanisms are often suggested. Without a decentralized production planning and operation the ”autonomy of the decentralized units exists only on the paper“ (Reiss 1998). In fact, production planning and control is a mechanism to coordinate the different actors within the production system to reach the maximum effectiveness of manufacturing. Therefore, we have to implement decentralized coordination within the production system.

First, a strong information and communication system that transports the data needed for the planning and operation to the planning actor(s) is necessary. The quality of these data depends, however, significantly on the preparation within the operation system. (Reiss 1998) The actors in the operation system should be enabled to process the corresponding information locally for the production planning and control. The decentralized information processing capacity of all actors described in the Web based Manufacturing allows higher information quality, as well as quantity. Since the quality of the total result of a planning process significantly depends on the quality of the flow of information, we expect a positive influence on the planning quality by the elements of Web based Manufacturing.

Operations management does not gave to realize the entire production of planning and control, but can concentrate on the fine-tuning and the solving of occasional problems, because the actors do the certain planning and control processes autonomously. The integration of decentralized actors into the planning process requires the set up of workflows. The integration of workflow management system and production planning and control-system reduces organizational barriers between the administrative layer and manufacturing. The commitment of workflow management therefore leads to a more efficient realization of the production plan and operation. Users obtain additional support in the case of repetitive workflows that require the production planning and control-sys-

tems. So for example, data acquisition can be computer-assisted organized over several actors (Scholz-Reiter 1998). Through that an indirect communication is set between the possibility for management and the operation system, without having to create a system.

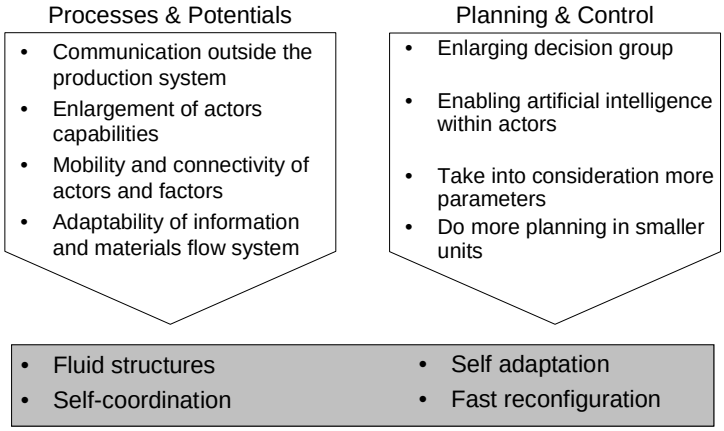

Figure 2: Consequences in operations management

Based on the enhancement of the information system, it is possible to reorganize production planning and control all along the actors of the production system. The production planning and control is divided up in this case for example into small groups, which carry out autonomously a part of the planning and operating tasks. Only a small number of parameters are reported to the planning actors in the management system. By distributing planning responsibilities along the actors, we have to prohibit that the actors spend too much time on the planning activities. The responsibilities should be defined according to the experience and knowledge of the actors. If that is not possible, we recommend leaving the responsibilities centralized or – if possible – use different sorts of artificial intelligence. For example, an intelligent system could suggest two ore more different solutions to a problem, and the actor decides – maybe on implicit knowledge – which one to decide upon. Through Internet technologies the necessary information, as well as decentralized computation, power is available. This means, operations management can use the computation power when necessary.

Compromising, the design of the planning processes is a complex task, but with the help of Internet technologies, we can identify the following implications:

- Enlarging a decision group
- Enabling artificial intelligence
- Take into consideration more parameters
- More planning in smaller units

This means, that industrial firms can apply the already known concepts of the decentralized production planning and control, as well as partially autonomous manufacturing technologies more effectively. A further advantage of Internet technology in the production system is that they reduce the up to now rigid and often inflexible infrastructures and the resulting high configuration intensity. Operations management can implement flexible and easily reconfigurable production systems.

With the aid of a communication network, it is possible to permanently create new networks so that transaction nets are formed between the actors in the operation system. This leads to the conclusion that there are now ”fluid“ structures or even intraorganizational spherical networks, (Miles/Snow 1995), with the attributes shown in figure 2. To use this within the production system, we propose a continuous change process that means the changeover form one stable configuration to another. These changes are driven from the either production system itself, which means

they are initiated by operations or management system. The changes are made in a very short sequence whereby actors are coordinating the necessary tasks to apply the changes autonomously. The different configurations have different output levels, which means that a new configuration is able to produce goods that in another configuration were not possible. This requires that the actors can change certain attributes and conditions of themselves, which is made possible by the distributed computational capabilities and the decentralized organization of the operations described above. Thus, we can say that the actors in the production system are able to provide a wider range of production possibilities because of the use of Internet technologies.

Implications for Business Management

Organizational Integration

The fundamental changes in the production system affect different interdependencies of the production system with other sub-systems within the enterprise. Talking about integration, we have to differentiate organizational integration and the integration of computer systems. Organizational integration means a better communication between different departments, the coupling of processes, and the distribution of responsibilities along the business process, but not along department frontiers. Information system integration in turn often means a very tight interlocking of application systems. This has several disadvantages; because if there are changes in one system, in the worst case, all integrated systems also have to be changed. Until Internet technologies arose, there were no real alternatives, which provided open, flexible, and changeable interfaces. Internet-technology-based integration is a coupling of the information system, meaning that these systems interact with others, without any limitations. Thus, we have now an infrastructure that allows the support of different organizational integration forms, namely horizontal, lateral, and vertical.

In a horizontal view, we have to analyze the integration with supply and distribution. On the supply side, there is always the dilemma between low inventory costs and a high availability of materials and goods. Therefore, in mass production there had been made a large amount of effort to introduce Just-in-Time mechanisms. (Wildemann 1992, p. 4) However, when we think of stochastic demand of materials and occasional demand for semi-finished products, the dilemma remains the same, because JIT is not applicable due to uncertainties. To optimize the supply in the case of statistical demand, forecasting methods, likewise simulation, are suggested (Feldmann 1999, p 3). The better the information base e.g. for simulation is, the better the forecasts are. The use of the suggested Internet-technology-based approach allows one to access in real time the actual state of the operation system. This means that the supply system can instantly react to changes in the demand of materials and adapt the supply forecasts. Furthermore, with intranet-tools a direct communication with the actors in the operating system allows one to adapt the supply process to the actual production processes through a direct coordination with the concerned actors.

On the market side, the information of new orders is directly available within the production system. It is now possible to check if an order that may not be within the standard production program, or may be produced before it is taken into the production plan. This allows a fast reaction to customers. This is a direct consequence of the new possibilities in configuration of potentials and processes. Moreover, the production planning and control can integrate the new products into the production plan after the new production processes are set up. Thus, management has not to spend a lot of time in implementing the necessary processes within the production system and the coupling with the processes outside. Self-coordination within the production system allows setting up these processes without management. Management is much more responsible for assuring the supply of goods and materials, the coordination and the logistics inside are mostly done autonomously.

Internet technologies also engage a vertical integration of information systems. This integration reaches from planning up to the technical operation of the machines. Through that a specific systems for the interaction of operation and management systems such as ERP are not necessary (Blecker/Graf 2003, p. 38). The integration of hierarchical layers based on the use of Internet technologies helps to avoid communication barriers between those layers by eliminating information-asymmetries. The widely used ERP-systems like SAP/R3 are not flexible enough to allow frequent changes within the structure of hierarchies. Management can now assume that a change in the organizational structure is not hindered by inflexible information system. This means, that management has a wider margin in redesigning organization.

Ability for interorganizational cooperation

The implications for the internal organization of an industrial company are widespread. These changes also affect the ability of the production system, to handle interfirm cooperation. Today it is often necessary to focus on specific abilities and to cooperate with other companies to stay competitive and to use skills optimally.

As a result, the production management has also to handle multiple relationships with other production systems. There are different concepts of cooperating. If the cooperation is performed mainly along the value chain, then we speak of supply chain management. Especially for smaller or medium sized companies cooperation with competitors in networks are suggested (Mildenberger 1998). The cooperation forms force the firms to open in order to conform their information and materials flow to other companies. Internal capabilities of the production system deriving from the application of Web based Manufacturing help to fulfill some important prerequisites of production networks. Characteristic prerequisites for networks are, for instance, a high degree of mutual trust, reciprocal relations, a certain knowledge about the network and its participants, and a common network-specific identity. By using the concepts of Web based Manufacturing, the knowledge of networks can be much better provided, because the network participants can be integrated into the information systems as if they would be within the company. Resources of network partners are linked with the help of the directory of resources. Therefore, the resources can be handled much as internal ones are when setting up specific processes. A comprehensive and unrestricted flow of information among companies enlarges mutual trust and reciprocal relations within the network. This is more applicable based on the Internet-enhanced abilities of human actors. They can directly communicate with other actors in the remote operation system based on a direct networking. This allows for the implementation of virtual teams even in the operation system.

Due to the demand of customers for faster order fulfillment on the one hand and the necessity of reducing logistics cost, many companies are trying to implement the supply chain management-approach. Organizations invariably require considerable resources to implement highly integrated supply chain systems. Most of the software packages for creating e-supply chain systems are quite expensive and require several powerful information systems. Cost reduction can be reached through the ability for autonomous linking of processes, thus management has not to set up many prerequisites for the interconnection with the other companies in the supply chain. Especially when a company participates in different supply chains, this ability makes a higher number of supply-chain connections possible at low costs (Beavers 2001).

Efficient and fast order fulfillment is supported by the mentioned horizontal integration of supply and distribution. Through the application of those concepts, the production system is prepared to participate in a supply chain without comprehensive efforts of business management.

Managerial Consequences

The application of Web based Manufacturing affects the coordination within the production, as was shown above. The employees are now able to act more autonomously based on the enlarged information base and the additional coordination mechanisms. This leads to a better diffusion of knowledge within the manufacturing system. A self-organization of actors is now possible. To make that operational, managers have to change some of their typical behavior. They have to provide the actors the possibility to make decisions on their own. This requires a definition of competencies beforehand. Due to the fast changing processes within the operation system, this is a continuous process. Indeed, management in Web based Manufacturing has much more information about the actors. This is possible because of the real-time access to information of the actors, allowing much better problem solving and forecasting. Managers can navigate through the data of the particular actors in the production processes. However, the real-time access must not be used for an extension of control. In this case, actors would recognize the information system as a guiding and assistance instrument, but not as a perfect inspection mechanism. This would lead to defensive behavior and would leave employees unmotivated. The challenge for leadership is to use the highly integrated information systems that connect and integrate all actors within a specific system.

Management can use these portals in a top-down and/or a bottom up approach, depending on the origin of a coordination process. Top down means that management delivers information to the actors.

The differences to conventional communication are:

- cross media abilities
- 1:n communication
- possibility of an immediate reaction of actors

This allows the management to implement new process and guidelines within the manufacturing system. A further advantage is the possibility of direct feedback. An instrument for applying the abilities of Web based Manufacturing is in manufacturing portals. Portals transport the information and duties of management to the actors. The actor obtains the most important information summarized based on the information of his/her profile on his/her personalized browser. The above-mentioned directory of resources matches the information to the actor. The use of manufacturing portals for leadership purposes is only valuable if the design, as well as the usage from management side adjust to the different needs and abilities of the employees in the production system. To do this, we have to combine the features of manufacturing support within the manufacturing portal with information collecting. The presentations of information, as well as an easy data input are the key success factors for the use of dialog-oriented Internet technologies. This means that management obtains a direct link to every employee in the production system. This enhances the quality of leadership, which was not possible prior.

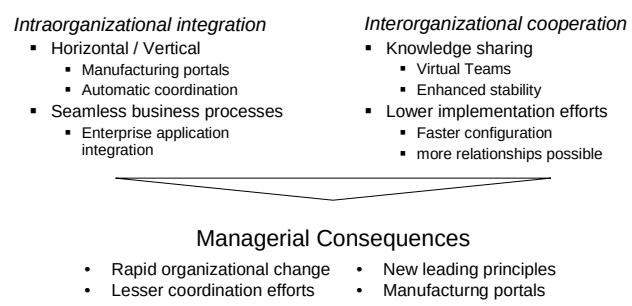

Figure 3: Managerial Consequences of Web based Manufacturing

The very easy access to the overall information system allows the integration of several concepts within the production system. The implementation of new accounting mechanisms is a very challenging objective in many industrial companies. It is often argued that common accounting systems as the marginal costing is not suitable, if indirect costs present the larger part of total cost. The propagated solution to this problem, activity based costing, is difficult to implement due to the complexity when defining the relevant activities. Web based Manufacturing helps to reduce the complexity by attaching the actors approach. Combined with the directory of resources, the information system stores a representation of the activities of every actor. Thus, cost management can use this information to calculate the real prices of the activities and therefore implement activity based costing. Figure 3 summarizes the implications of Internet based production concepts on business management

Sustainable Competitive Advantages through Internet based Production Concepts

To show strategic implications of this, we have to look at the market based view, as well as the resource based view. From a market-based view, success factors are an important concept for strategic management. Critical success factors are defined as factors that enable companies to gain a competitive edge over their competitors. Thus, critical success factors largely determine a company's long-term prosperity and growth. The kind of factors that are critical for strategic success have not been clearly defined as of yet. This is mainly due to conceptual deficiencies of research in this area. Still, there is a large degree of consent regarding costs, quality, flexibility, time, product variety, and service of being critical success factors. Exploiting these critical success factors creates strategic advantages for the respective company for a certain period. Thus, a company needs to have at least in one of these critical success factors a competitive advantage in order to survive in today's competition. Web based Manufacturing supports companies to exploit several success factors by the preposition of several success potentials. Therefore, we examine some success factors and the effects of Web based Manufacturing on them (Diller/Luecking 1993).

Although some other major critical success factors have been discovered, costs are still of major importance to strategic management. *Costs* are lowered by reducing coordination costs that in manufacturing include the reduction of set-up and idle times.

Quality as a success factor is also affected. Quality is defined as the degree of customer satisfaction provided by a product or service. Quality consists of two major sources: conceptual quality and production quality. Conceptual quality describes to what extent a customer needs are taken into consideration in the conceptual and designing phase of a product or service. Web based Manufacturing supports this by direct communication with customers, e.g. through a configurator. Production quality is defined as the transfer of conceptual quality into product quality. The enhancements in coordination also cause the process quality to rise meaning that actors avoid defects by keeping in mind the entire production processes.

Flexibility is an important characteristic of companies enabling them to quickly adapt to changes in their environment. *Flexibility* is strongly enhanced because of the various options to change parameters in the production using Web based Manufacturing. What is noteworthy is the enhanced organizational flexibility and the flexibility of actors.

Product variety forces the production, apart from the technical requirements, to engage in more so in different production processes. This causes operations to handle a higher amount of information in production planning and control. The information load for actors can be lowered with artificial intelligence (e.g. agent systems), decentralized coordination and computation capabilities of Web based Manufacturing.

In today's competition, *time* becomes increasingly important. This shift in importance is mainly due to the contradictory development of the two major components of time companies of every industry have to deal with: time to market and time on the market. While the time until products are ready for being brought to the market has significantly increased over the past decades, their average time of presence on the market has shortened dramatically. This development requires companies to view and actively manage time as a critical success factor. Due to the seamless integration of the production system and the connections to other systems, production can react much faster on customer needs. Therefore, *time* as a success factor is also supported.

The realization of a competitive advantage with only one critical success factor is not enough to assure profits. Thus, companies have to realize several success factors simultaneously. The market-based view suggests the implementation of hybrid strategies such as mass customization or outpacing strategies. However, these strategies concentrate on the overcoming of porter's cost/differentiation distinction. There are several other critical success factors that are supported by Web based Manufacturing. Thus, companies have to clearly verify whether they will try to implement one of the suggested strategies or if they will try to realize a completive advantage by realizing and defending a set of success factors. This means that they have to formulate a specific strategy based on the success factors that are realizable through the implementation of Web based Manufacturing. Thus, market based competitive advantage is generated by a specific combination of success factors accelerated by Web based Manufacturing.

There is evidence among many authors that a unilateral view on competitive advantage neglects the internal perspective. Competitive advantage is created not only by realizing success factors, but also by internal capabilities and processes. The so-called Resource Based View attaches more importance to that. Capabilities, competencies and resources are resources in the sense of the resource-based view if they are not transferable, resisting wear, inimitable and not substitutable. These criteria may be valid for organizational, tangible, intangible, and financial resources. (Wernerfeld 1984).

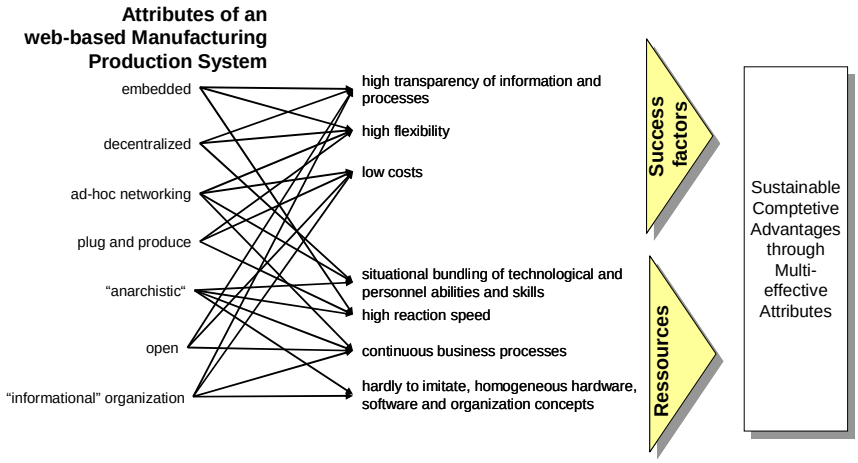

Figure 4: Sustainable Competitive Advantages through Web-Based Manufacturing

When applying Web based Manufacturing, especially intangible, tangible, and organizational resources influence competitive advantages. The technologies suggested by Web based Manufacturing could therefore never be a strategic resource, because they are mostly based on open standards. Indeed, the application of the potentials of Internet technologies by using the suggestions of Web based Manufacturing may be a strategic resource. The integration of computational power into most facilities alters those facilities. The embedded computers help to conform the machines better into the operation system and integrate it with human actors and the information system.

This creates a unique infrastructure, which may be a strategic tangible resource. Furthermore, Web based Manufacturing influences organization. The ability to use the ideas of Web based Manufacturing is because of the improved organizational effectiveness, a strategic resource.

Therefore, in a resource-based view, Web based Manufacturing creates competitive advantages by generating unique organizational, tangible, and intangible resources.

Competitive advantages are only valid for a specific time. This period may vary from industry to industry. To obtain sustainable, competitive advantages should be resistant against uncertainties and erratic fluctuations in market circumstances. This requires completive advantages to alter new requirements instantly. The claim for sustainability is actually an ambiguity. Competitive advantages last by definition over a long period. Industry cycles and innovations limit the durability of competitive advantages. We showed for the market based view, as well as for the resource based view, that Web based Manufacturing significantly enhances the competitiveness of companies regarding their production. The enhancements derive especially from the new organizational abilities regarding coordination and information availability. Thus, success factors such as strategic resources derive from the enhanced abilities to change and to communicate. These abilities are also necessary to design new products and processes. Therefore, companies implementing Web based Manufacturing realize new products better and faster.

Competitive advantage may be generated through Web based Manufacturing from a resource based, as well as from a market based view. Especially strategic resources are hard to copy by competitors. Therefore, by the application of Web based Manufacturing sustainability of competitive advantage occurs.

Perquisites for the Realization of Internet based Production Concepts

We have shown some implications of the overall use of an Internet-based production concept. We assumed the employees, organization, and technology to change. In fact, management has to take care that the strong requisites can be handled. Therefore, we have now to examine some prerequisites that management has to arrange. First, the discussed decentralization is to be realized effectively. Additionally, the actors approach requires a modularization of the organization. Management has to hand over competencies to other actors. There are several problems to consider. First of all, the actors must be able to cope with the additional (leading-)tasks they have to fufill. Therefore, human actors have to be trained well, to handle the responsibility and the coordination tasks that have to be performed autonomously. What is important is the embedding of artificial actors into the organization. The consideration of organizational actors is an additional issue. The problem of different modularization concepts is a lack of explicit interfaces between the different organizational units. Organizational actors allow the considering of e.g. a work cell as a unit. Based on this, it is possible to define clearly the in and outputs of such an organizational actor. This is necessary to allow an efficient interaction with artificial actors.

In human resource management, the implementation of the decentralized organization structures requires the employees to change some of their behavior. They have to be more cooperative, which requires having better communication abilities. Indirect communication over different Internet-based communication technologies requires employees to have a good knowledge in handling information technologies. They also should have a basic understanding of how the omnipresent network operates; otherwise, they would understand it as a black box. This would lead to a passive, not an active use of the information network. Therefore, human resource management has to train employees to meet the requirements. The trainings should also reduce the resistance of employees. The suggested mechanisms make the work environment more transparent. This is often a critical task, which may cause resistance.

Technological barriers are also critical. Internet based production concepts require adequate machinery that has embedded computation power. In addition, there has to be the necessary networking infrastructure. Additionally, barriers result from the existing infrastructure. In many cases, industrial firms have to protect their existing investments, so they have to continue in using a technologically obsolete infrastructure. Furthermore, in some cases, the application of specialized, non IP-based machinery is necessary and/or the cost of a complete migration to Internet based field area networks a prohibitive high.

Technology management has to ensure the implementation of Internet technologies within the production system. This means, that an overall technology strategy has to be created, that ensures that all investments are made with respect to the Internet abilities of desired technologies. Facilities, as well as information systems have to be strategically equipped with Internet technologies. This also means that existing information systems may be extended to meet the new requirements. The information system strategy is an important for the successful implementation of Web based Manufacturing. The alignment of an information system strategy and business strategy was often argued as a critical factor for business success. Actual studies have found that it is important that the IS-Strategy is aligned with the business strategy, which means that the information system strategy reflects and supports the business strategy.

Conclusion

In sum, Web based Manufacturing offers in comparison to the current production concepts many advantages. They apply new technologies widely in order to generate options in production, which were up to now unavailable and in order to realize competitive advantages. However, the application of Internet Technologies leads to modifications in the production system inducing modifications in operations management. A situation emerges in which planning and control functions are transferred into the operation subsystem, and communication demands between the higher management and the operations increase.

The intraorganizational application of Internet technologies will be the generic networking infrastructure for production processes in future. Especially Web-based Manufacturing opens up to now unavailable options to enterprises and creates sustainable competitive advantages. We presented the changes within the production system and the deriving changes for production management. These changes effect business management. Nevertheless, there are strong signals that for industrial companies through an application of Internet-based production concepts, sustainable competitive advantages arise.

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