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Variable Production Networks - Successful Operating in an "Alliance of the Best"

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Abstract

Confronted with constant structural changes in society and the manufacturing industry, enterprises have undertaken several innovative activities for optimising their processes. One approach which represents extremely fast adaptation to quickly changing constraints involves building up a "Variable Production Network" (VPN). This is a dynamic co-operation system or network of companies over a specific period. Smaller and medium-sized enterprises particularly benefit from such co-operation, which provides an opportunity for joint development and the introduction of new products and technologies. In addition, many enterprises have realised that such product and resource related links offer the chance to reduce internal complexity, to concentrate on core skills, and to function in an "Alliance of the Best". In order to benefit from the consequent potentials of such co-operation with the same or even reduced costs, the enterprises concerned have to fulfil certain preconditions, namely the capability to adapt to the production network requirements. The development of methods for a networkable production management (NetProM) is the basic goal of an ongoing industrial research project. This paper will present initial results of the project.

Keywords

Variable Production Networks, Production Management Systems, Production Planning and Control (PPC), Controlling and Monitoring, Networkable Production Management (NetProM)

Organizing the Extended Enterprise P. Schönsleben, & A. Büchel (Eds.)

1 INTRODUCTION

Operating in a VPN is one approach which enables companies to survive in modern changing times. This means that the structural and process-related organisational inventions will be used to achieve efficient networking. Different forms of global corporate alliances are being used effectively for doing business in new settings (Starr 1991). Each partner concentrates on its core-competencies and combines this with the advantages of a powerful community.

This new kind of co-operation involves a new form of complexity which is characterised by teamwork over factory borders in a VPN. It demands a new support system which enables planning and control that are suited to networks. Hence, conventional MRP-systems have to develop into Production Management Systems (PMS). These PMSs are prepared for application in VPNs e.g. to support a control or resource-planning for all network participants.

This paper will present the prerequisites and initial project results for the development of new methods.

2 VARIABLE PRODUCTION NETWORKS - IN-PLANT SIMPLIFICATION AND SIMULTANEOUS GROWING COMPLEXITY

Trends and History

During the last few years changes in structural organisation have turned away from the original strong hierarchy to lean management and a further step towards the formation of small, almost independent factory units in the form of profit and/or cost centers. This development is further supported by the parallel introduction of team and group working. Identical trends can be observed with the development of slower, memory-intensive host computers into client-server systems. The decentralised structure is also available in the hardware area, making an efficient technology for an internal interlink. The internal concentration on smaller units overlaps through the different activities which the companies perform in making a start on the optimisation and acceleration of their processes in the area of sequencing. During the initial adaptation of resources the main determinants are the main investigation, followed in a multitude of enterprises by a reconstruction phase, in which there is a segmentation of the existing organisations and processes in accordance with technological or product-related criteria. The product and processes may then be newly developed in a fourth stage (see Figure 1).

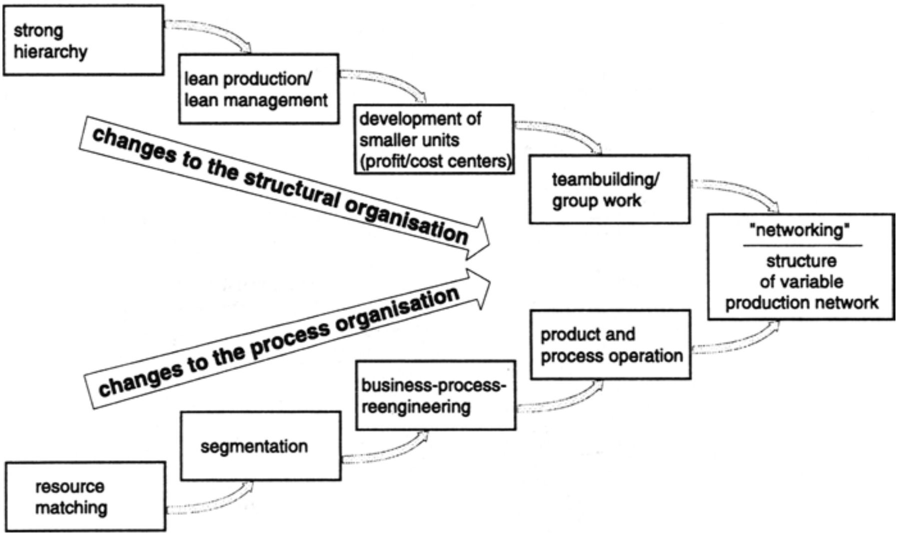

Figure 1 Phases of restructuring.

A trend in many companies towards increased co-operation is shown with this step-wise optimisation and concentration on the basis of core components in the following phases. In the past, co-operation in the areas of research and development has already proved its worth, so that links between procurement, production and supply are being increasingly formed today. The outcome of this, via customer-supplier links (logistic chains), is the formation of stable network arrangements and, in a further development stage, the variable production network. This demonstrates the logistical consequence that the internal decentralisation effort (linked with the concentration on core components) is beeing made across the industry.

Types of Network

The production networks can form themselves from different and company-specific bases. According to existing knowledge there are four basic network types, as represented in Figure 2.

New Roles in Variable Production Networks

A characteristic of VPNs is that they call for completely new tasks, like those of the network organisers (network architects), brokers and network co-ordinators, as depicted in Figure 3 [Dangel et al. 97].

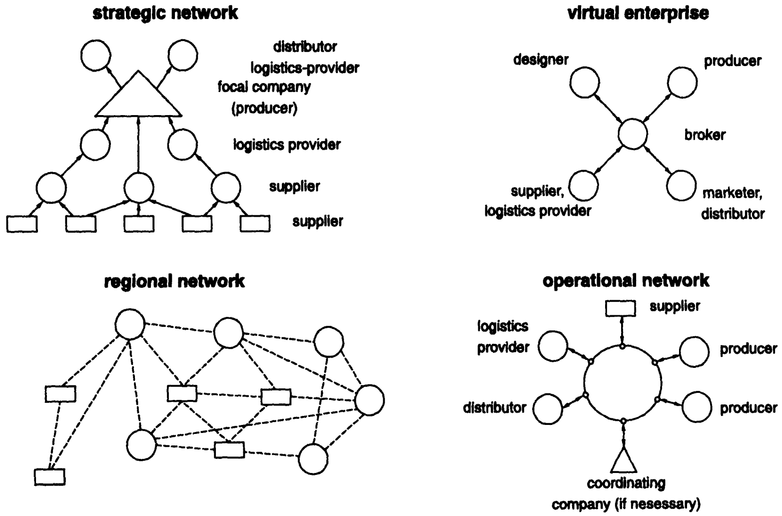

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Figure 2 Overview of network types [in support of Pfohl/Buse].

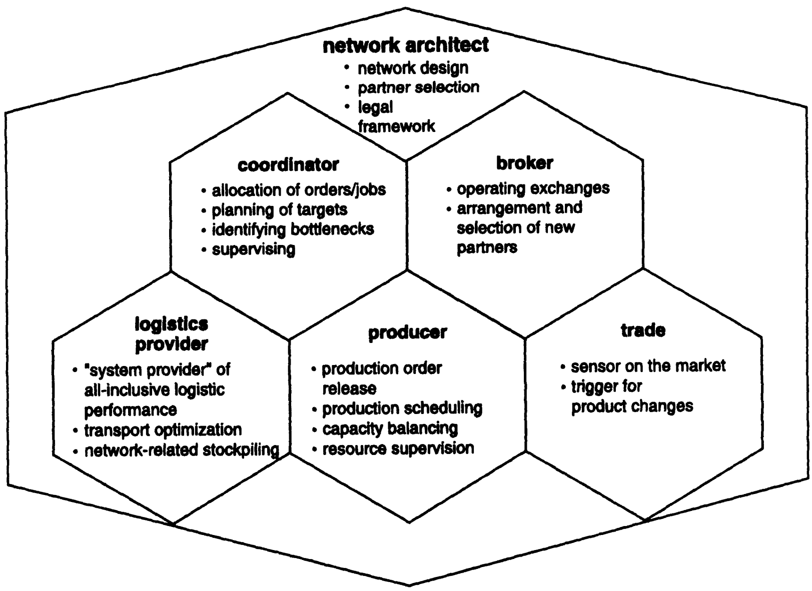

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Figure 3 Roles and tasks in a VPN.

3 VARIABLE PRODUCTION NETWORKS - AN EXAMPLE -

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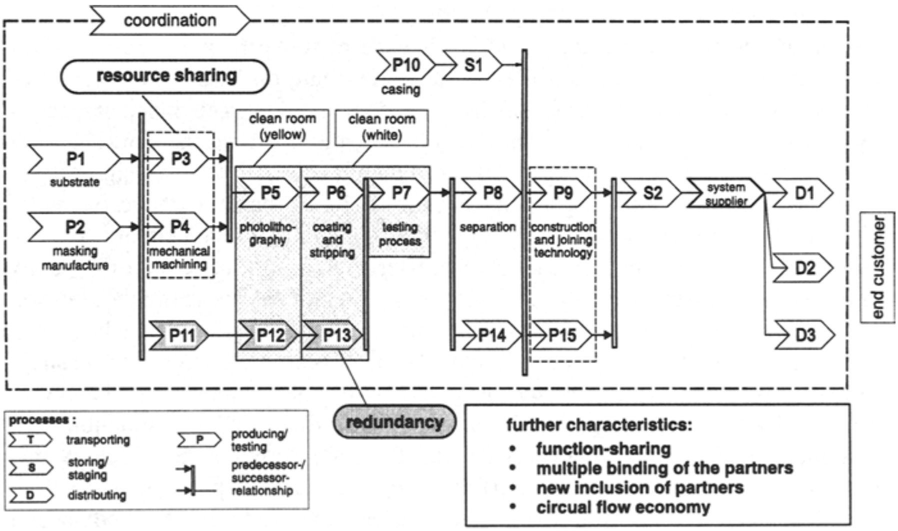

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Figure 4 Variable Production Network for the production of micro-electronic components.

Figure 4 shows as an example the networking of a number of companies to supply micro-electronic components. A generally valid process chain is used for the model which, as represented, leads to a networked process chain [Kuhn 95]. Besides this it shows that a production network can fully describe the three forms of process chain elements: Producing/Testing [P], Transporting [T] and Storage/Supply [S]. In this example companies P1 and P2 supply the raw material for the production of micro-electronic components, in this case a wafer. This is followed by a mechanical operation (companies P3 and P4) in which the production photolithography, loading and removal connect up from differing spatial classes. Parallel to this is the identical process chain of companies P12 and P13 which are in the position to carry out the same production already described in a common, cost-intensive testing process. As a rule single-use wafers are isolated through the companies P8 and P14. The production-area structure and connection-technology integrate all the necessary components in a single casing. The stores, S2, hold all the finished wafers for further work (e.g. for production of an acceleration sensor). The actual production process is at this point in time finished and the end product can be given to the trader (distributor) [Dangel et al. 97].

Potentials and Risks of a Variable Production Network

A characteristic of a VPN is the conscious planning of redundancy. This means that more than one process or partner produces the same product or service. In Figure 4, for example, the processes P5 and P12 are, as described, redundant. This status is distinguished by the identical inputs or outputs of one or more processes. Redundancy increases the flexibility of the network and the assurance of supply for the customer.

Experiences have shown that an independence between the participants on this must be maintained to work in different networks (multidiscipline connections of partners). For individual partners this has the advantage that their independence is only reduced by one network. On the other hand the total network has the consequential characteristic of a possible conflict of goals in capacity assignment or prioritising of tasks appearing in the network. This is because the capacity of multidiscipline partners is not exclusively in the availability of the network.

Resource distribution is a central characteristic for the removal of capacity bottlenecks or the reducing of capital-intensive investment, as mentioned above. Each process has so-called resource pools assigned, inside which the transformation processes produced and the necessary resources are brought together. Resource distribution means that two or more companies share rare resources with varying rights of disposal, depending on the situation and requirement. In Figure 4 companies P3 and P4 share common resources, in this case production facilities and areas (fixed location) such as personnel, material, work tools and organisation tools (independent of location). A fundamental distinction is made between long-term and planned resource-sharing as well as spontaneous resource-sharing to remove acute bottlenecks. With long-term resource-sharing, the resource capacity for the total requirement of the partners can be laid out and ordered once. The spontaneous resource-sharing serves as a matter of priority as a quick reaction to remove bottlenecks which exist short term.

The sharing of functions can include every process of the participating partners. This involves a distinction between an analysis of functions, that is, a concentration on the main components of the partners, and a bundling together of functions for common use, as when, for example, a purchasing network takes advantage of a "piece count" effect (economies of scale effect). Function sharing for the use of an "analysis of functions" is translated through a detailed illustration of the process to function fulfilling.

In order to integrate new knowledge and processes quickly into the network, new partners can be taken on. The performance that these partners bring to the group can extend from the supply of simple raw materials to the complex performance in service. A new intake of partners brings in advantages in the willingness of the partner, but this must follow a meassured assessment of the process route of the potential partners, with a long term link to give the best guarantee. The taking on of new partners leads to the restructuring of the existing network and consequently finds expression in the newly configured process chain.

Alongside the chance of enormous speed and flexibility, further possibilities of increased reuse and recycling (R&R) exist for scrap and components in the network. The goal of R&R is to create a closed loop, reducing disposal costs and diminishing waste-disposal problems. Partners may be able to increase the goals of R&R together [Wiend et al. 96a].

To summarise what has been determined: VPNs are variable, elastic and offer a multitude of opportunities. The opportunities must however be taken and the risks, in particular the higher flexibility, diminished.

Consequences for Information and Communication Technology
Considered in the first instance it can be established that VPNs in practise cannot be sufficiently developed in planning, control or monitoring for example, with the potential offered by today's available information and communication technology [Spur 96]. This is especially valid for SMC networks. The new complexity in VPNs makes, for example, selective information from the partners possible. To avoid an uncontrollable data flow the information that is necessary for the control or development of the special processes for the partner must be chosen automatically. This information should be sufficient to the extent and detail of a specification of the actual logistic achieving of objectives from key data up to the information about the status of individual orders [Wiend et al 96]. To make the outlay possible, particular methods and instruments are needed at this moment in time [Linsi 95, Semic 94, Schob 96].

The information of partners in a VPN could, as described above, be prepared methodically so that feedback in planning and control for regulation purposes is possible. Such methods, in particular the regulation of variable objectives (the so-called adaptive regulation of a network) are not possible at this moment in time.

4 REQUIREMENTS OF THE NEW METHODS FOR PLANNING AND CONTROL

Methods of planning and control suitable for networks are necessary as mentioned above [Inger et al 95, Kernl 95]. With them the special structural characteristics of the network, such as function and resource-sharing as well as redundancy of the processes, must be controlled and used. These methods are still not in familiar systems, or only contained as a start [Dombr 95].

In order to make production management networkable in accordance with the mentioned requirements, conventional but already existing network-task furthered PPC-systems should supplement the stressed communication-relevant components in Figure 5.

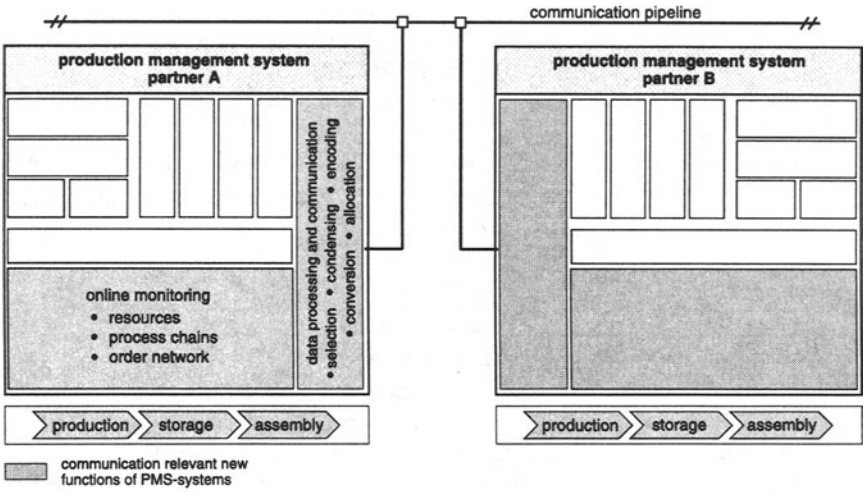

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Figure 5 Structure of a networkable Production Management System (PMS).

In order to guarantee an adequate information level, monitoring modules have to be developed. Those modules are able to read back at each time "online" the relevant information concerning resources, process chains and order nets. Efficient cooperation in a VPN requires a data adaption of the information designated for the transmission to the net-partner. This involves the data selection or data encoding of secret information. To avoid the network-partner becoming flooded with data, detailed information has to be selected and condensed in a manner acceptable to the partner. This means e.g. the transmission of the actual product-lead time instead of the determination of the operation lead times for each workstation. The example in Figure 5 shows the data transmission via a communication pipeline between the PMS of partner A and B. If partner A communicates with partner B, the incoming data has to be converted so that partner B is able to read the information. In addition the data has to be allocated to the corresponding ppc-task.

The background produced for these are worked out in the following section and represented as objectives of a research-project in order to make the planning and control in a VPN partnership possible. A complete and all-embracing software system should be consciously looked at in the development. It should be possible in a VPN to operate much more through modules which already work off the existing software system, supplementing the PPC-system and making it able to network. This not only has the advantage that small and medium sized enterprises can introduce this software model with relatively low expenditure and good value for money, but also that the flexibility of the system with the changeability of a VPN is maintained. In this way, belonging to a network is no longer software-dependent.

5 GOALS AND FIRST RESULTS OF FUTURE RESEARCH

The basic goal of an ongoing project is the development of methods for a networkable production management, that is to make it possible for companies with different prerequisites to control the complexity of a VPN and to make the new changes with regard to speed, flexibility and cost savings useful for them.

The developed modules will offer answers to the specific problems of the partners. Additionally, the modules are implemented so that economical adaptation is possible in other companies.

The first step is to introduce a networkwide monitoring system. Next, modules have to developed to extend the existing PPC points of difficulty into Production Management Systems (PMS). This involves, for example, methods for a defined quantity, schedules and resources planning in a function and resources distribution between partners in the small series and jobbing production or methods for a rapid and objective orientated task distribution in redundant processes.

Project members are, besides the Institute of Production Systems (Hannover, Germany), a software company and three manufacturing companies. Each of them is partner in its own network. Additionally, some chosen suppliers of the manufacturing companies are also integrated in the project team. A better synchronisation along the whole value-added chain between the network-partners will achieve a more efficient production process. The main goal is the improvement of the logistical performance-values delivery time and punctuality of delivery.

Concept of a Monitoring for Networks

The first project step enclosed steady-state-analysis as e.g. business process registrations, product-structure analysis and bottleneck-oriented logistic analysis. On this basis common requirements on a networkwide monitoring system have been derived. The requirements are orientated on defined network-intersections between the producers and suppliers. In consideration of heterogeneous production circumstances involving the existing data and software systems a concept of a *Monitoring for Networks (MoNet)* has been developed. Figure 6 shows that the use of an online-connection is possible as well as a standardized off-line data-transmission [Helms et al. 97].

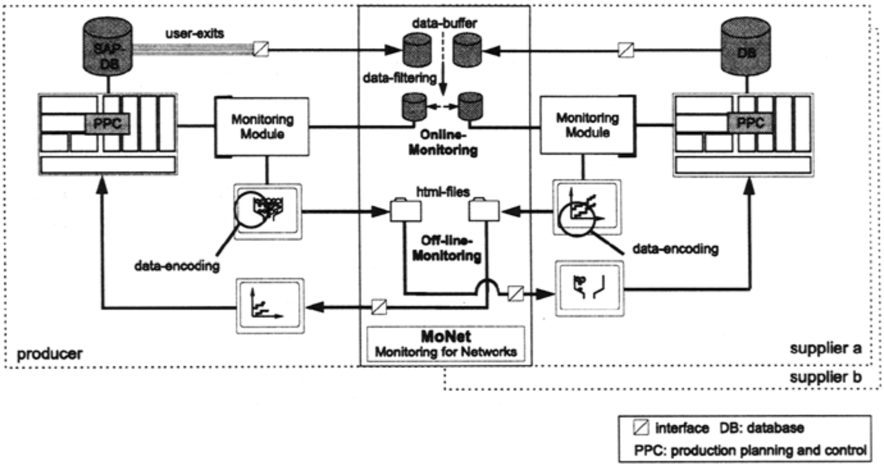

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Figure 6 Monitoring for Networks (MoNet).

The developed monitoring methods, which as explained above can be used either on- or off-line, are structured in a modular toolset. This offers the possibility to generate the corresponding method for each specific monitoring application. The development of methods suitable for networks has not been finished yet. An example of an application of a monitoring method is depicted in Figure 7. The funnel in the middle of Figure 7 represents the manufacturing process of a producer. The funnel opening represents the actual capacity of the producer. The funnel is filled up with orders (the size of the circles shows the different work contents of the orders). The actual fulfilment in the given example is equal to the actual work-in-progress level. In this case the actual work-in-progress level is much too high. Consequently, capacity bottlenecks will occur. To avoid these evident bottlenecks the placing of chosen orders to the suppliers is one possibility. The monitoring system allows the producer to look at the supplier's production situation. The supplier's level of work-in-progress indicates whether a short-term placement of orders will be meaningful.

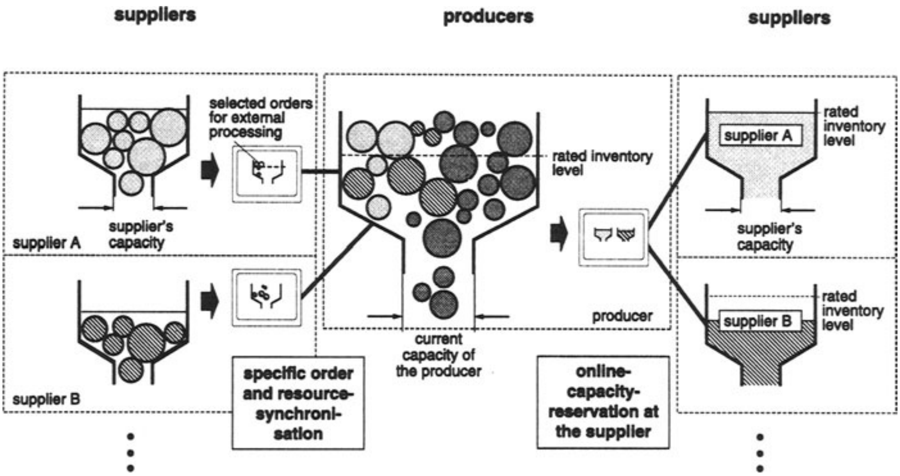

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Figure 7 Lines of sight for capacity-sychronisation in networks.

The second line of sight enables the supplier to detect specific bottlenecks at the producer's production or to synchronise its own production e.g. with the assembly-process of the producer. But only those orders which are chosen in advance by the producer are visible to the supplier. Hence, a monitoring system has to support both lines of sight.

6 SUMMARY AND PREVIEW

From relevant investigations of today's established PPC-systems it can be seen that the success of their introduction is substantially dependant on the actual situation of the system it is built in and on the basis of relevant, consistent configuration of the parameters. The objective, besides this, must be to bring the planned and actual values to the surface and thereby to estimate the requirements for the planning and the control of the process. As well as this, there must be the agreement and integration of overriding objectives of the production network in the evaluation and configuration process of PPC parameters. In this the necessary modules for classifying the data to the respective planning and control functions should be worked out.

An initial concept of a monitoring system in networks has been presented as one result of an ongoing project. The development of methods and modules as described will extend the commonly used PPC-systems to Production Management Systems suitable for networks.

7 REFERENCES

[Dangel et al. 97] Dangelmaier, W. et al.: Vision-Logistik - Logistik wandelbare Produktionsnetze, Hrsg.: Dangelmaier, W.; HNI-Verlagsreihe, Band 31, Paderborn 1997.

[Dombr 95] Dombrowski, U.: Einführung eines standardisierten Multisite-PPS-Systems in Client-Server-Architektur, Tagungsband zum 17. AWF PPS-Kongreß „Moderne PPS und Vitale Fabrik", 08.-10. November 1995 in Böblingen.

[Helms et al. 97] Helms, K.; Höbig, M.; Saretz, B.: Netzwerkfähiges Monitoring als Voraussetzung einer kooperativen Auftragsabwicklung – Anforderungen und Konzepte, Beitrag zur Fachveranstaltung: Dem Tend voraus: Wandelbare Produktionsnetze, Dortmund, 25.11.97.

[Inger et al. 95] Inger, R., Braithwaite, A., Christopher, M.: Creating a manufacturing enviroment that is in harmony with the market - the "how" of supply chain management. Production Planning & Control. Vol. 6, No. 3, p. 246–257.

[Kernl 95] Kernler, H.: Durchlaufzeitverkürzung im PPS-Verbund. ZwF 90 (1995) 3, p. 95-97.

[Kuhn 95] Kuhn, A.: Prozeßketten in der Logistik: Entwicklungstrends und Umsetzungsstrategien, in Zusammenarbeit mit: Baron, Chr.; Bernemann, St.; Kaeseler, J.; Manthey, Chr.; Wenzel, S.; Winz, G., Dortmund 1995.

[Linsi 95] Linsin, M.: Fit für die Zukunft – Wohin geht der Trend bei PPS? AV 32 (1995) 2.

[Schob 96] Schober, F.: Interdependenzen von Unternehmensstrategien und Informations- und Kommunikationsstrategien, ZfB 66. Jg. (1996), H. 1, p. 29–48.

[Semic 94] Semich, W.: Information replaces Inventory at the virtuell Corporation. Datamation, 7, 1994, p. 37–42.

[Spur 96] Spur, G.: Informations- und Kommunikationstechnik in der Produktion, ZWF 91 (1996), p. 62-63.

[Starr 91] Starr, M. K.: Global Corporate Alliances and the Competitive Edge, Quorum Books, New York, 1991.

[Wiend et al. 96] Wiendahl, H.-P.; Fastabend, H.; Helms, K.; Jäger, M.: Zukünftige PPS-Systeme müssen Logistik-Netzwerke beherrschen. Industrie Management – Special „PPS Management" 1996, p. 6-10.

[Wiend et al. 96a] Wiendahl, H.-P.; Fastabend, H.; Helms, K.: Produktionsmanagement in wandelbaren Produktionsnetzen – Merkmale, Anforderungen und Instrumente, Conference-Paper: Dezentrale Produktionsstrukturen am 17. und 18. September 1996, Hannover.

8 BIOGRAPHY

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Born Febuary 11, 1938 in Wickede/Ruhr, Germany he graduated from the University of Aachen with a Diploma in Engineering. 1967-1970 he was a research assistant at the Laboratory for Machine Tools and Workshop Management, (Prof. Opitz) before gaining his doctorate summa cum laude in Engineering. 1972-1974 he was head of "Planning and Quality" at a big industrial firm and stayed there as head of the Technical Department, Paper Machine Branch until 1979, when he was appointed as full-time professor and director of the Institute of Production Systems (IFA), University of Hannover. He is a referee for various research associations and has been a full member of CIRP since 1989. In 1997 he became President of the German Scientific Society of Production Engineering (WPG).

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