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Lifecycle Based Distributed Cooperative Service Supply Chain for Complex Product

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1. Introduction

With sharp expanding production capacity and drastically competitive market environment, the surviving precondition for modern enterprise is to promote productivity and competitiveness continuously. As the backbone of enterprise, complex products are always demanded to run with high reliability. However, high integration and intelligence of complex products make the existing industrial service mode not meet new requirements, it is necessary to build a new service mode to optimize the complex products operation.

A favourable industrial service not only makes complex products work in optimal status and high reliability, but also helps to upgrade and innovation of products within all service chain. Both consumer and supplier attach great importance to service support of complex products. The article describes a distributed cooperative service supply chain covered total lifecycle of complex products. Under the service supply chain, services may not only have a higher quality but also reach the customer in a shorter reaction time and at a low price. Consumers, manufacturers and supplierscan get their competition advantage through lifecycle based distributed cooperative service supply chain.

2. The industrial service concerned

2.1 Potential value of industrial service

Under the environment of sharp expanding of production capacity of traditional manufacturing and drastic market competition, product supply is in saturation status since 1990's. It is estimated that supply of 95 percent of products have been saturated or balanceable, the products which demand exceed supply account no more than 5 percent. The product average profit margin decrease continuously. When production capacity expanded to a certain degree, it is very difficult for enterprise to develop only depending on scale economy and scope economy. The hindered production expanding pushes the enterprises to find new expanding ways (ZHENG, 2003). Product service incremental strategy can also realize enterprise development, not through output increase, but innovative service supply that is throughout total product lifecycle.

For manufacturers and suppliers of complex products, the relationship of potential value of industrial service with product lifecycle is shown by Fig.1. Before product sale, the service potential value is negative because resources invested in consultation and planning for consumer. The service starts its increment when products being sold.

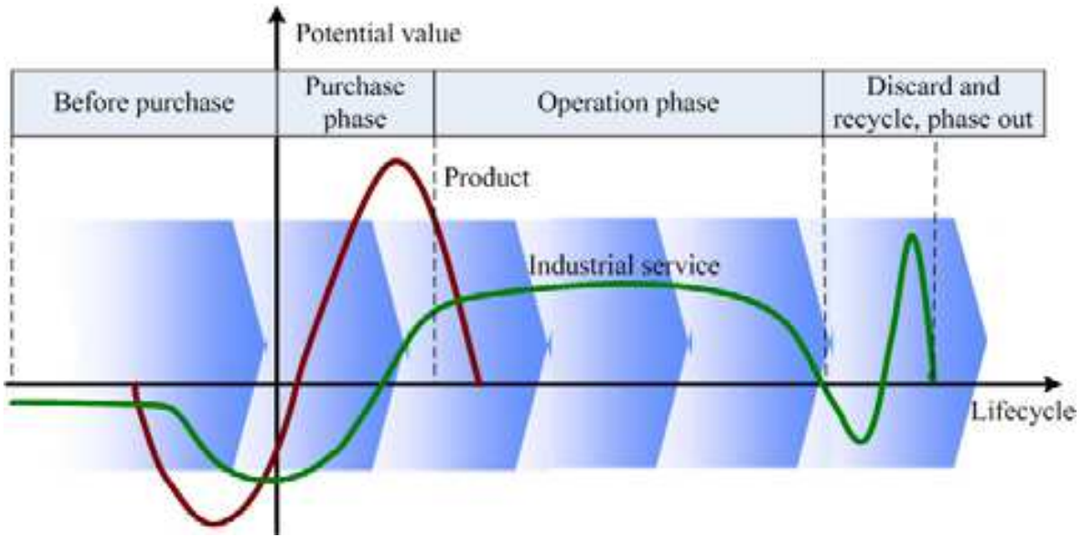

Fig. 1. Relationship of potential value of Industrial service with product lifecycle

2.2 The basis of industrial services

Industrial services concerned here treat the following three terms (McDonald & Payne, 2006; Meier and Kortmann, 2007):

- Intangibility. Services are usually intangible while products are generally concrete. The consequence of a service, however, is always inseparably connected to goods. Different states during needed service delivery are differently materially distinctive.
- Uno-actum-principle. Services are produced and consumed at the same time, hence they cannot be stored.
- Integration of customers. A direct contact between service providers and demanders is fundamental. The active role of customers during the service production leads to specific features with location restraint, because provided service is either carried out or stored in an object which is accessible for customers.

In addition to these characteristics industrial services have diverse definitions with regard to three dimensions: potential, process and result dimension (Meier, 2004). Potential dimension focuses on resources, which are supplied for providing a service. By combination of internal potential factors and corresponding resources, it can be prepared to provide a service according to generated qualification and preparedness. Process dimension regards service process as a connector for potential dimension with external factors, such as customers. Customers play the most important function in process dimension as they can be regarded as the initiator and accompanying elements alongside service procedures. Evidently it makes sense saying that integration of customers involved in service providing processes is necessary. With regard to result dimension, result conditions will be evaluated as an output from customers' view, in order to investigate how the target of the service provision has been reached (Meier et al., 2004).

3. Why provide industrial services cooperatively?

In the background of globalization and increasingly drastic competition, only the enterprise with strong kernel competitive power can survive and develop. For users, their motivation

to purchase complex products is not to buy something usable, but to utilize the advantages brought by high-tech equipment to enhance competition dominance of their main products. It means that, for manufacturers and suppliers, the development of high-tech equipment is only one of preconditions to succeed in market competition. To win a dominant market position, high-tech equipment itself should associate with necessary technical services to form a 'binding body' of product and service assembled by product, service, information, concern and other factors. Through these technical services, manufacturers can share technical evolvement with users and upgrade equipment technically, and users can keep their equipment in good status and good reliability, promoting the kernel competition powers of both parties.

Normally, there will come forth some problems in running process of complex products. For users, complex products always, with high technology contents and complicated structures, include many integrated technologies and important parts of different manufacturers, it is too complicated to diagnose, maintain and repair. Even though getting training courses, it is difficult for users to judge and solve all problems in products running, this is to say users can't face market competition independently without the service support from manufacturers and suppliers of products; they need the manufacturers and suppliers to keep the running status of products optimal and increase their productivity and competitiveness. For the manufacturer and supplier, a series of questions will follow,

- With increase of parts supplier number, quality tracing, claim and settlement contain many procedures and take long time;
- The users distribute all over the world, the service personnel can't acquire needed locale information in time, resulting in high service cost and service delay;
- The technical field is too wide, mastering all correlative technologies is beyond ability of a technical person or single corporation of manufacturers and suppliers. Therefore, the traditional industrial service supply mode can't already meet the demands of consumers and enterprises, to study and establish a new distributed service supply chain is imperative under the situation.

To realize globalized distributed industrial services, cooperative relationship and network should be established. Since it is impossible that the service personnel of manufacturers or suppliers, no matter how large their scale is, reach every needed place in a short time. The enterprises, therefore, must discard old competition idea and build 'two-win' cooperative service supply, through the cooperation with sales partners, technical service suppliers and other manufacturers, supplying timely services supported by corresponding communication and information technology.

The evolution from traditional service mode to cooperative service mode is shown in Fig.2.

In traditional industrial service mode, consumers buy products and receive technical services from suppliers. However, the solution of most of problems already needs the supports of parts suppliers and machine tools manufacturers. For complex machine tools, its assembled parts are supplied by many manufacturers; many factors such as the communication and harmonization between corporations, the harmonization in corporation interior, the difference of excuted standards and document formats and so on can become barriers to service supply. Under this circumstance, the needed services are supplied in lower efficiency, as time passes, resulting in consumers' complaint and distrust, the potential users lost. For users, equipments, that can not run in their optimal capacity or which problems can not be solved in time, will mean low productivity and competitiveness.

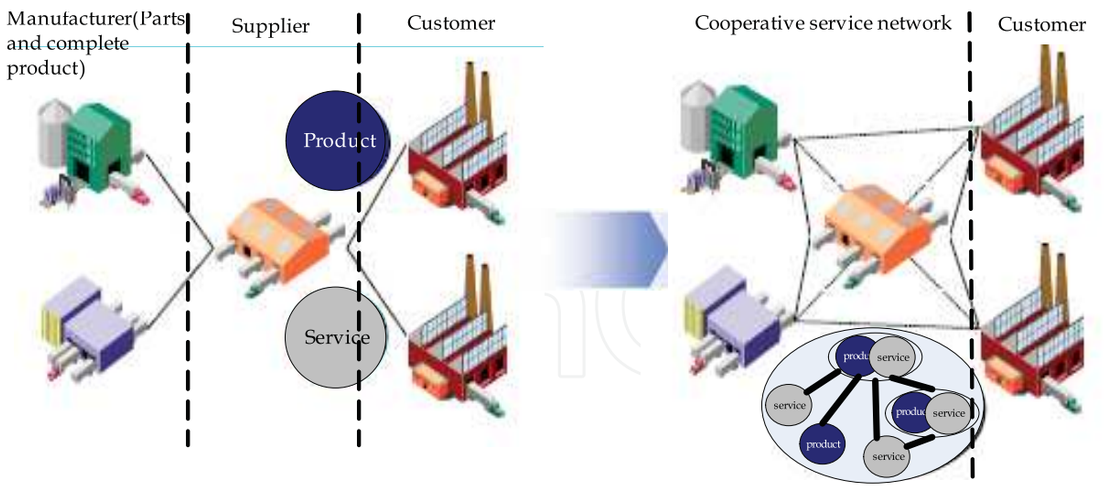

Fig. 2. Evolution from traditional service mode to cooperative service mode

A new service idea gives the answer to above existing problems. According to this idea, industrial service is supplied not by single supplier or manufacturer, but by a group, named cooperative service network, which is formed by parts manufacturers, complete machine tools manufacturers and suppliers through a certain harmonizing and switch-on mechanism. With this service mode, customers receive industrial services through cooperative service network in total product lifecycle from product choice and production line planning to equipments replacement, discard or recycle. The 'product' purchased by customer is not a product in traditional meaning, but a 'new product' formed by product itself band with cooperative service; the service begins from the beginning of the customer contacts with supplier.

With cooperative service, the customers receive the guarantee that machine tools run reliably, stably and efficiently, and through service network, the manufacturers and suppliers can obtain more available running information from customers, helping to grasp future market requirements and promoting improvement and innovation. In the course of collaboration with partners, members of service network can take complementary advantages to enhance their kernel competition power and expand their market share, realizing two-win development by market share, profit share, risk share and advantage mutual utilization.

4. Organization form and business model of distributed cooperative service network

Three important factors concerning distributed service system are given (Fig. 3) as follows,

- Form of Service Provider. It describes how, with the defined criterion, the local service provider can establish its term of business systematically.
- Type of Resource Distribution. It describes the structure of a service net, which consists of locations where availability of potential resources is given. It has various influence on dependency such as "number of machines" and "type of machines", "locations of customers", and "environment, frequency and continuousness of customer´s demanding of services", which are necessary to define distribution structure of services either centralized or decentralized.
- Operational organization of distribution system. It decides which company in the supply chain and which kinds of resources integrated in providing processes are suitable and available.

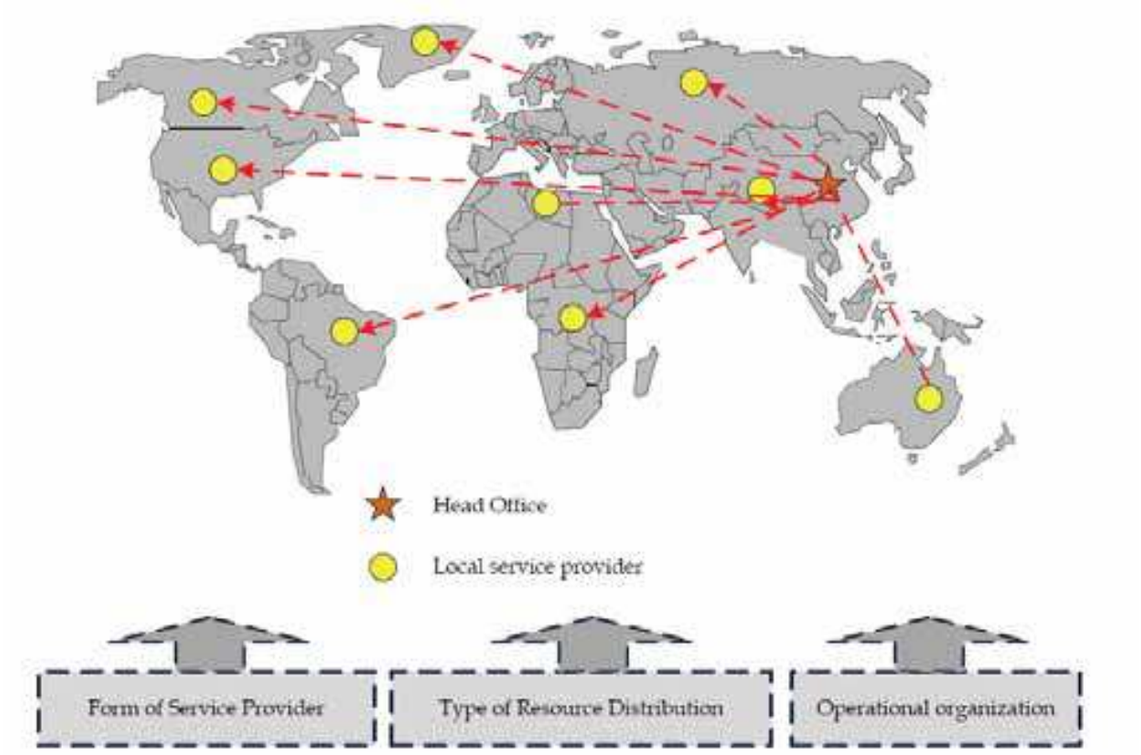

Fig. 3. Factors of service distributed system

4.1 Form of the service provider

In order to provide suitable services to customers in time, the company must establish a suitable allocation and form to support the providing service.

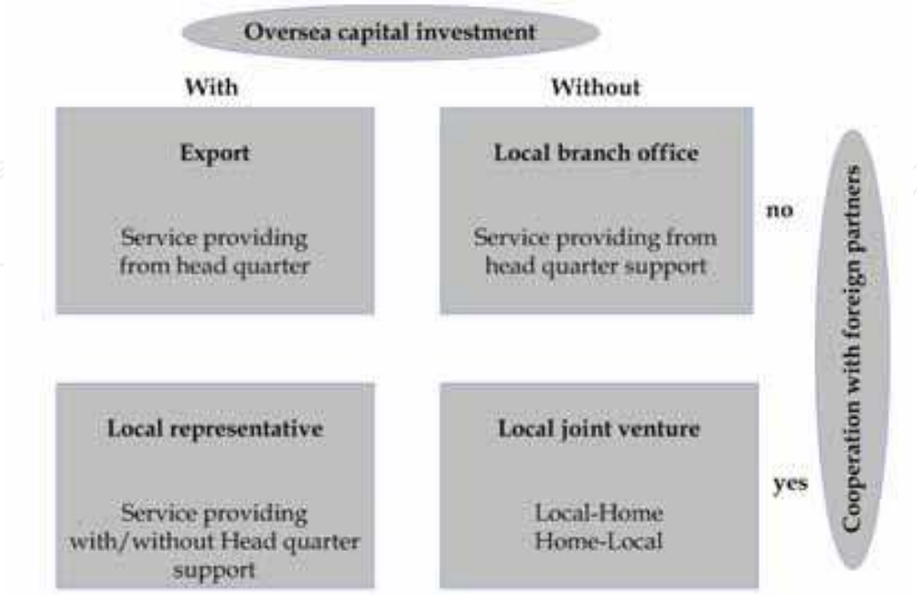

Fig. 4. System frame of distributed cooperative service

Following system frame shows form of a local service provider, with which the specific kind of business form can be established for a new service market (Fig. 4).

4.2 Type of resource distribution

Within the centralization of a service organization, the organization is structured as an unit to summarize all tasks for service providing. It can be regarded as a service central or service staff from which services are provided for customers worldwide.
In terms of decentralization of service organization tasks are assigned to several organization units, also known as local office respectively. All service units consist of a service network (Fig. 5).

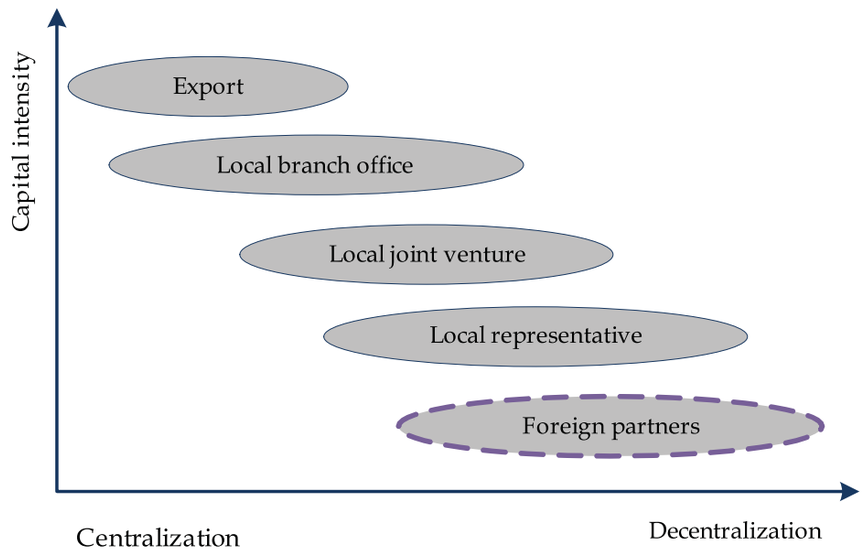

Fig. 5. Centralization level of local service provider

The service centralization occupies the competence advantages that local providers can use from head office. Further it is possible to advance the communication and coordination between local and homeland and not to mention the fact that the head office achieves almost every service feedback as service know-how is given. Unfortunately it takes a long reaction time to market abroad and it is proved to be difficult to forecast customers' demands and low flexibility.
Service decentralization leads decentralized local provider plan, coordination and operation of service provision. The provider can respond to the customer's demands quickly. In contrast to the centralization it can offer high flexibility and quick supplying of spare parts. As a disadvantage, lack of communication between local service provider and different markets will lead to lose an amount of feedback information regarding as know-how.

4.3 Cooperation and coordination of service provision on target market

Methods of supply chain managements (SCM) offer solutions in direct coherence with the problems of spare parts supply and maintenance logistic. A supply chain can be defined as a chain and most likely a network of different organizations, which work together in order to

develop a product or service needed by end customer. Collaboration of all undertakings within a value chain is centre of a supply chain. This means that supply chain forms an alliance between network partners and tries to coordinate these bonds. The continuous adjustment to demands of end customers is a main characteristic of a supply chain and supply chain management (Scholz-Reiter & Ranft, 2000). In these terms, supply chain management aims goal of integrated scheduling, simulation, optimizing and control of goods, information and money, which flow along lines of a value chain between customer and commodity providers (Corsten & Gössinger, 2001).
These keynotes may also be assigned to cooperation of maintenance, because same targets are aimed at coordination of maintenance. Supply chains, which are formed out of these keynotes, will be called service supply chains (SSC). In this article reference scenarios for cooperative provision of maintenance services are introduced based on the assigned ability of SCM.
In order to ensure the manageability of observation of these scenarios, only Supplier 1 (1-tier) and supplier 2 (2-tier) are being observed within a network (Fig. 6).

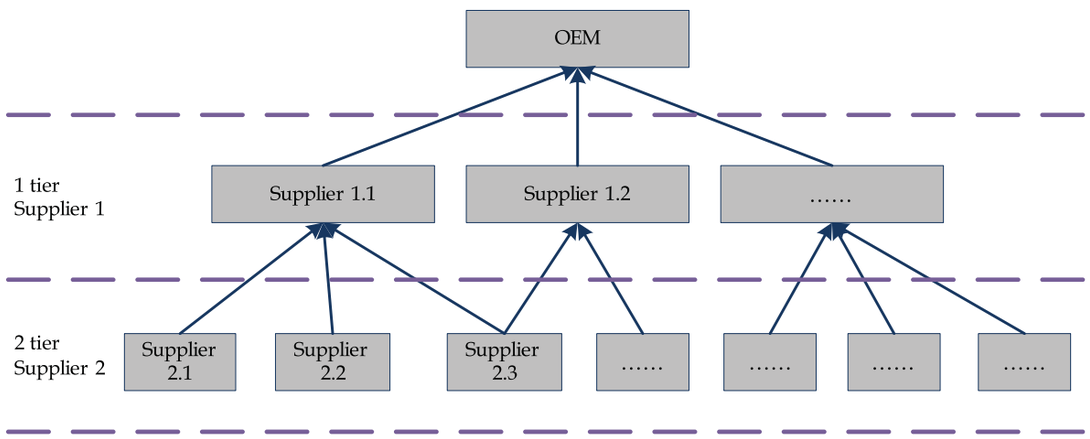

Fig. 6. Service delivery hierarchy

For operator of a complex machine, the machine maintenance including inspection, attendance and repair is an important factor, which has immanent influence on the purchase decision. This article consequently focuses on fields of maintenance logistics and spares parts supply, which is often related to maintenance logistics. Consequently the business of spare parts supply has to deal with temporal, regional and quantitative combination of spare parts with damaged primary product. The aim of maintenance logistics is the temporal, regional and quantitative combination of maintenance staff with required qualification, with the damaged primary product in order to provide maintenance services. Consequently a frictionless and safe spare parts supply would have an imminent importance for the assurance of availability and the conservation of value of the provided complexes machines. The continuous and accurate logistic of information and documentation, which is easy and fast to handle, is a precondition for the efficient accomplishment of the spare parts supply as well as maintenance logistic.

5. Reference scenarios for the cooperative provision of maintenance services

The reference scenarios consider all contingencies starting at bilateral relationship of customers and OEM, integrations of provider by OEM and ending at self coordinated maintenance supply by equal supply chain partners.

5.1 Scenario 1

The first scenario (Fig. 7) is strongly oriented to flow of materials along the value chain. In the case of maintenance, the OEM is the only contact person for the customer within a supply chain. This condition is based on grounds that collaboration of OEM and customer is formed during the course of purchase of a product. Most likely this happens quite earlier. The advantage of this scenario in the view of customer is transparent commissioning. The OEM adopts the responsibility for provision of maintenance services for end customers. Spare parts are provided by the supplier to the OEM. The OEM deputes his maintenance staff in the case of an assignment with access to suppliers' spare parts or own spare parts and performs the requested maintenance services. In order to fill the stock with spare parts a flow of information between OEM and supplier is precondition.

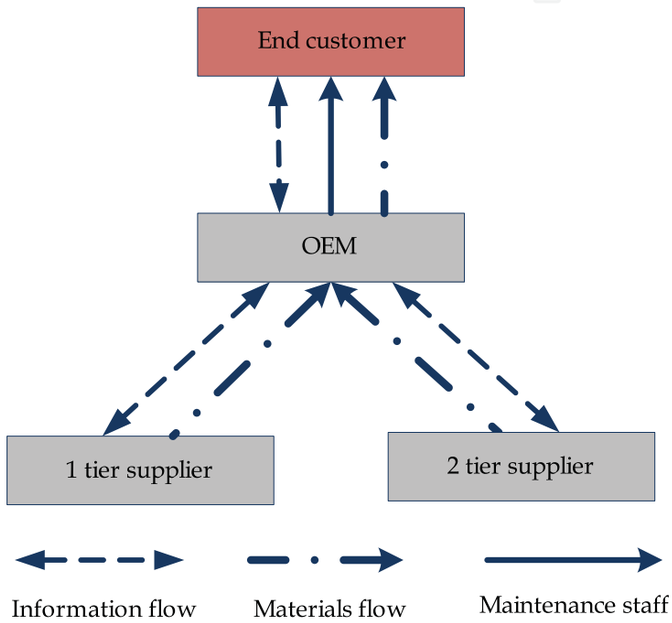

Fig. 7. Reference scenario 1 for cooperative provision of maintenance services

The supplier functions in the role of a subcontractor and can optionally be called by the OEM to perform services in form of support and professional competence. This is the case, for instance, if assistance of a supplier is needed during process maintenance process, if insolvable problems emerge for the OEM or if spare parts are requested at short notice. In this scenario, the OEM has a monopoly position.

5.2 Scenario 2

For the second scenario, the attention falls on parallels to the first scenario (Fig.8). The order acceptance and clearing happens solely by the OEM. In this case, provision of maintenance services is strongly oriented to the supply chain.

In case A, the OEM provides requested maintenance services to the customer with access to necessary spare parts of the supplier or with own spare parts. The OEM deputes the coordination of spare parts and maintenance staff. The filling of his spare part stock happens with help of information exchange or orders to the supplier. The supplier still provides his professional competence. The provision of requested maintenance services for

cases B and C of this scenario are designed differently. The customer searches contact to the OEM when need repair. The OEM verifies the assignment and estimates whether the problem is within his fields of competence. If this is not the case, the assignment is transferred to the supplier.

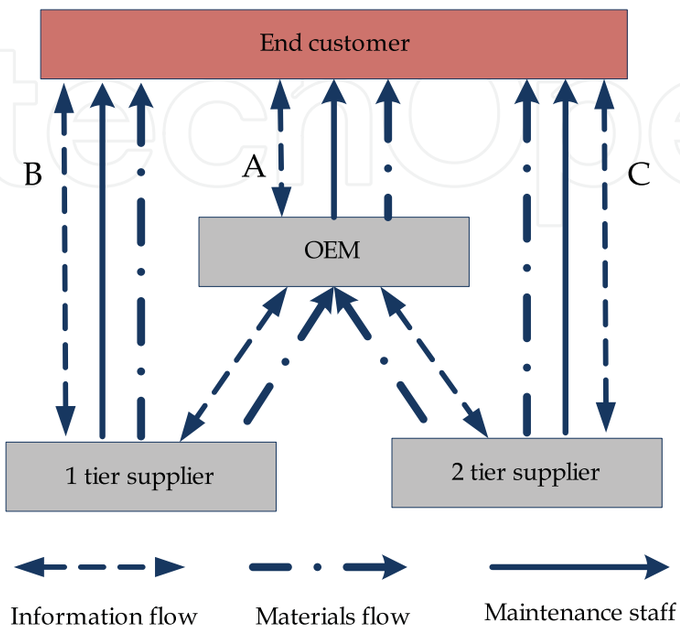

Fig. 8. Reference scenario 2 for cooperative provision of maintenance services

In case B for instance, the assignment is transferred to 1-tier. 1-tier gets the assignment and provides needed maintenance service in the name of the OEM, with the help of a coordinated spare parts supply and a deposited maintenance staff directly to the customer. 1-tier is not influenced by the OEM. The only possible intervention by the OEM happens during assistance. Assistance is, for instance, if the OEM happens to have needed knowledge about the product.

In case C actions take place: 2-tier gets the assignment of the OEM and the ongoing approach is identical to already depicted approach that 1tier is engaged in this case. The supplier get the possibility to present their company to the customer by providing maintenance services. In this scenario, the monopoly of OEM is partly undercut, because the OEM loses a part of his service business to the supplier. Nevertheless it means the advantage of a competence oriented service provision.

5.3 Scenario3

The situation, in which the customer can choose his service provider, is given in scenario 3 (Fig.9). The customer forms main authority with respect to principles of the free market economy. In this scenario the equal but factually bordered service situation for all supply chain partners is approached. For the case of repair, the customer can choose the most beneficial and in his view most competent offer. In all cases the customer contacts directly the chosen supply chain partner.

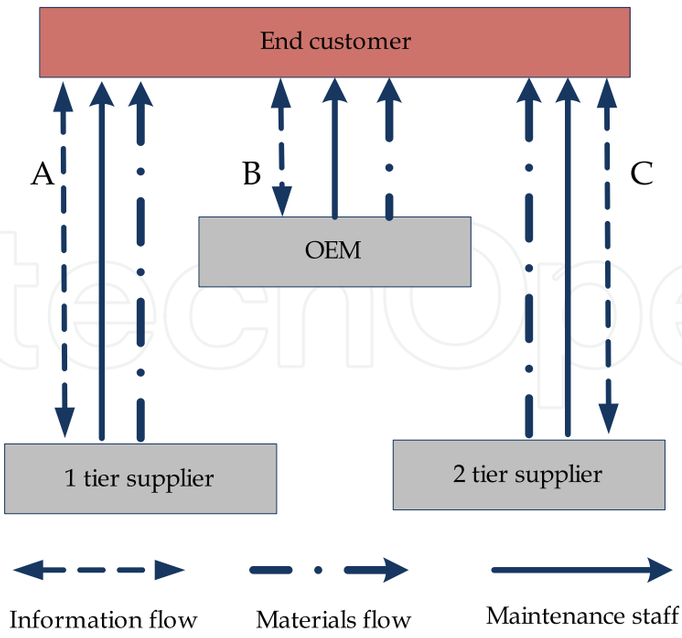

Fig. 9. Reference scenario 3 for cooperative provision of maintenance services

In case A, 1tier will be chosen. 1tier gets the customer assignment and provides the requested maintenance service with the help of his spare parts and maintenance staff. There is no influence taken by other members of the service chain.

A quite similar procedure of maintenance service is taking place in the cases B and C. The supply chain partner himself adopts responsibility towards the customer. Feedback is directly given by the customer during and after provision of the service. The condition that the customer is allowed to choose his service provider, can lead to the situation that a service provider is not requested to provide maintenance service for his product. The case will happen, for instance, as soon as the customer assigns the OEM for a suppliers' product. Even the OEM would necessarily need supplier's product in order to provide the service. In lines of a contribution oriented value chain, all parties act in form of a closed network. During the service provision these parties might be competitors. Nevertheless they are able to provide services in conjunction. This is the case if the cases A, B and C are connected.

6. Coordination during cooperative service provision

The cooperation of maintenance between numerous partners in the integrated value chain – like above 3 cases – requires a continuous interlocking of all business processes. Basic attribute is the company-wide optimization of the business process in service supply chain (Kaiser & Schramm, 2004). In the view of procedural-organization functional company oriented structures need to be converted into continuous area-wide and company-wide business processes. An appropriate instrument, which standardizes several steps within the supply chain, is supply chain operations reference (SCOR) model of supply chain council (SCC).

The SCOR model is based on the basic consideration that all supply chain assignments and activities can be relocated to the five main supply chain processes, which are planning, producing, providing, redelivering and purchasing. The visualization and analysis of the

network is simplified. During this process, the SCOR model runs through different layers. On top layer the five basic procedures are set. The basic procedures are subdivided on the next layer, which is the configuration layer. On the third layer, the design layer, it is possible for the operator to define his own processes. Each deeper layer step ending at the bottom layer leads to a detailing of previously defined processes.

Basically, the basic procedures can be distinguished into heterogeneous types of process, which are process types of planning, executing and infrastructure. The process type of planning considers all actions allocated to the preparation of future flow of materials. The main aim is to match the demand and the internal company abilities. Typically these are purchase planning, production planning, delivery planning and prognosis planning. This type of process is documented by the planning process. The executing processes consider all activities allocated to the order processing and further on flow of information and materials. In executing process, change in state of material, goods and all associated control activities takes place. Main processes of source, make, delivery and return are associated to this process. Infrastructural processes, which are the premises for a smooth action and affect an efficient procedure, support and manage processes of planning and executing during supply procedure. Return of a faulty primary product or excessive products of a delivery can be depicted by return process of SCOR model. In this course, this process will not be considered, this article will focus on coordination of spare parts supply.

Fig. 10 shows that each SCOR process contains a category of process on configuration layer for categories of planning and infrastructural processes (P1 to P4). In executive process types, SCOR model divides SCOR processes of source (S), make (M) and delivery (D) in three categories of processes on configuration layer.

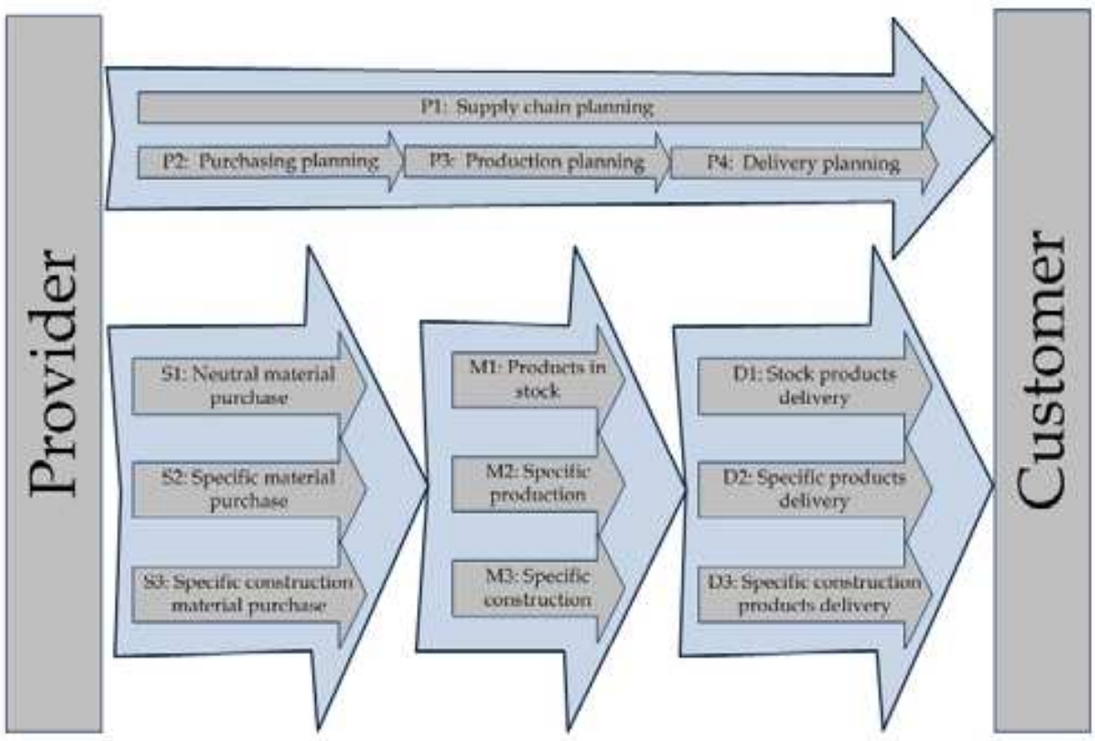

Fig. 10. SCOR process of the configuration layer (Meier et al, 2004)

During development of reference scenarios and transmission to SSC by SCOR model on configuration layer it was figured out that maintenance processes can be distinguished from the normal value chain process in the supply chain with help of a particular element. Normally supply chains have a horizontal hierarchical formation, which means that arrangement of companies in the lines of the supply chain is formed by providers (1tier, 2tier and so forth), the OEM and customers.

In these supply chains, flow of materials as well as flow of information partially runs statically (2tier to 1tier to OEM to customer). Considering the developed scenarios, it is obvious that in the fewest cases coordination of maintenance services in lines of SCC arrange itself in form of a hierarchical or static chain.

Maintenance services overtake traditional steps of the supply chain for some part. The provider probably delivers his spare parts directly to customers without considering the OEM in this process. The same condition can be depicted in reference to the maintenance staff.

These conditions are based on the following situations,

- Customer demands / pressure
- Subdivided core competences
- Availability of spare parts
- Geographic problems.
- Capacity bottlenecks

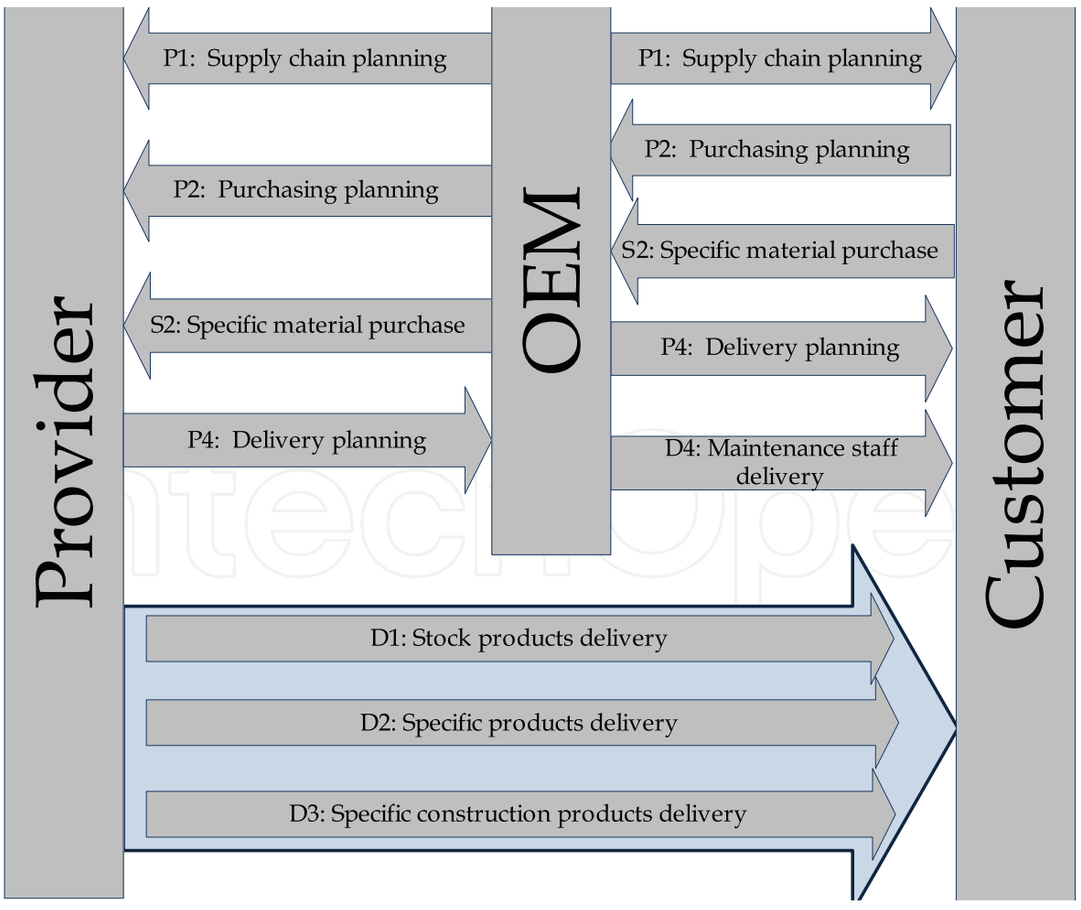

Fig. 11. Reference scenario 2 with the SCOR model

In order to ensure an accurate flow of information and, in this case, a flow of services, and make a detailed evaluation of problem zones in service provision, it is necessary to make some changes in SCOR model.
Fig. 11 shows maintenance service case B and C of the second reference scenario and depicts necessary changes in SCOR model. The OEM coordinates the service supply chain with help of the information and material flow (P1).
For the case that a spare parts purchase by the customer is needed, the OEM executes an order (P2, S2) toward the provider (1tier).
The provider plans the purchase with the OEM (P4) and delivers finally the demanded spare parts directly to the customer (D1-D3).
The OEM is overtaken within the service supply chain. Nevertheless the maintenance staff is posed by the OEM and coordinated to the customer (P4, D4) for the case of an assignment.

7. Support technology of cooperative service

To build cooperative service network, the embedded Web data acquisition system should be developed to acquire the running parameters of products. Special equipment control and IT-support system are developed to found technical base for cooperative service. The major works is to build the reference architeture of IT-support system for cooperative service and to develop cooperative industrial services which support different IT system. Industrial product oriented service contents and interface standard are extracted according to industrial features to form an intermediate unrelated to specific hardware. With this intermediate, product status monitoring, system parameters transmitting, software online upgrading and audio/ video exchanging can be accomplished. A product (especially for machine tools) can conveniently switch-on cooperative service network as long as its controller meet the interface standard.

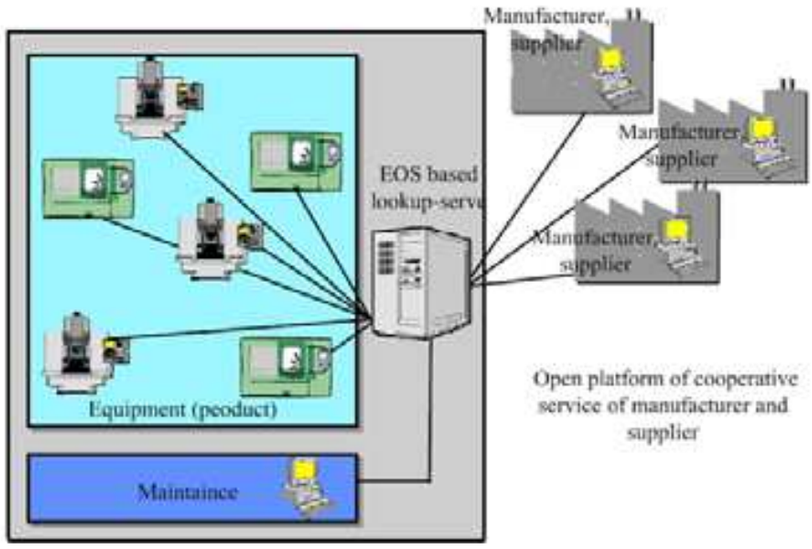

Fig. 12. Cooperative service pattern with EOS

An Embedded Online System (EOS) had been developed (Meier, 2004). Using this system, customer's machine tools can enter the cooperative service network and the service suppliers can finish some operations such as collecting running parameters, eliminating locale troubles, conducting AV conference and so forth. Cooperative service pattern under EOS is shown in Fig.12.

8. Discussion

The sequential value chain between supplier and customer was charted in respect of supply chain management. More likely it is imaginable that single steps of the supply chain are skipped and component supplier, which are more appropriate for special assignments and parts of the product-supporting service provision in contrast to the OEM, keeps contact with end customers. The flow of materials, which runs parallel to flow of information, could, even if it only partially affects the value chain, be relevant for all parties because there is to form a tie between all current information. Further on there are to coordinate delegations of staff, such as the delegation of technicians, for scheduled and not scheduled service assignments.
Regarding the different characteristics of the service and features of the global market with traditional service concepts, companies are unable to provide the machine based Life cycle service towards customers abroad with the traditional concept effectively and efficiently. This article describes a possible approach, designing a service structure of global distributed cooperative servicer based on supply chain. This will enhance the efficiencies of service provisions for enterprises, which are and intend to be active in global service business.

9. Acknowledgment

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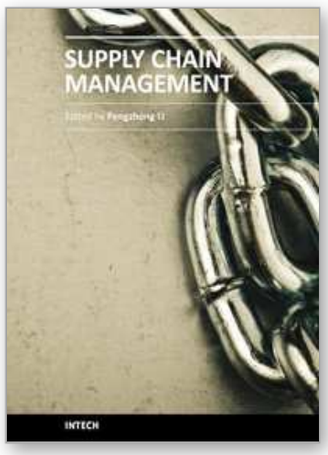

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The purpose of supply chain management is to make production system manage production process, improve customer satisfaction and reduce total work cost. With indubitable significance, supply chain management attracts extensive attention from businesses and academic scholars. Many important research findings and results had been achieved. Research work of supply chain management involves all activities and processes including planning, coordination, operation, control and optimization of the whole supply chain system. This book presents a collection of recent contributions of new methods and innovative ideas from the worldwide researchers. It is aimed at providing a helpful reference of new ideas, original results and practical experiences regarding this highly up-to-date field for researchers, scientists, engineers and students interested in supply chain management.

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