DEMAND-SUPPLY CHAIN REPRESENTATION: A TOOL FOR SEGMENTING SERVICE DELIVERY AND ASSET MANAGEMENT

Jan Holmström, Timo Ala-Risku, Jaana Auramo, Jari Collin, Eero Eloranta, and Antti Salminen

Department of Industrial Engineering and Management
Helsinki University of Technology
POB 5500, FI-02015 HUT, Finland

ABSTRACT
The paper presents the use of demand-supply chain representation in organizing industrial service operations. The representation scheme opens up a way to better manage horizontal interdependencies in service operations, to ease the transfer of innovations, and to introduce economies of scale in the development of industrial service operations. The tool is presented as a design theory. First the purpose and scope of the representation scheme, its constructs, the principles of form, function, and implementation is described. The paper also provides examples, shows how the tool can be adopted in different settings, gives testable propositions for further research, and provides theoretical justifications.

Keywords: Service delivery, Industrial asset management, Segmentation tool

INTRODUCTION
Value moves change the value that that different economic actors deliver and receive from each other, often prompted by technological innovation or regulatory change (Callon et al., 2002). In industry today we frequently see two types of value moves. Firstly, companies focus on their core competencies (Hamel and Prahalad, 1990) and outsource non-core activities such as maintenance (Campbell, 1995). Secondly, manufacturing companies attempt to expand their revenue base from selling original equipment to maintaining and operating equipment. For this the manufacturer develops product-service systems where it can effectively take responsibility to both maintain and operate customers' assets (Davies, 2004; Baines et al, 2007). This is also known as Original Equipment Manufacturers (OEMs) "going downstream" (Wise and Baumgartner, 1999).
These value moves are not independent. When an OEM goes downstream it becomes easier for its customers to outsource maintenance service and other industrial asset management tasks. But also, the OEM and the customer must successfully align service requirements with the supplier's delivery capabilities (Cohen et al., 2006). The OEM needs to adjust its operations to different customers; while each customer needs to understand what information the OEM requires (Sampson and Froehle, 2006). However, the product-service system (Baines et al. 2007) as a whole needs to be designed in such a way that improvements in one part of the system are not off-set by lower performance in another (Simon, 2002; Frenken, 2006). The operations in the supplier-customer interface need to be decomposed (or segmented) in a way that allow for more parallel and less coordinated innovation.

The need for service assets and resources can be reduced when better information processing enables reorganized processes (Galbraith, 1972, 1973). For example, there is less need for manpower if preventive maintenance can be increased over repairs; customer specific spare parts inventory locations can be reduced by “pooling” spare parts across many customers. To sum up, from a theoretical point of view there are two challenges. The basic challenge is to improve information processing, and the subsequent challenge is to organize supplier-customer operations in such a way that performance can be improved with minimal coordination and trading-off benefits between customers.

LITERATURE REVIEW

The basic challenge in terms of improved information processing is for the OEM to get visibility of the installed base of equipment and develop the means to control data collection on the installed base (Ala-Risku, 2007). As Sampson and Froehle (2006) observes the customer is in a key position in the service delivery process as a supplier of performance critical information. However, compared to other suppliers’ inputs, managing the quality of customer supplied inputs is difficult, and to be efficient service need either to be robust enough to handle low quality customer-supplied inputs, or, customer-supplied inputs somehow need to be standardized to reduce the variation. Standardizing customer-supplied inputs can be achieved by relating customer-supplied information inputs to information collected beforehand by the supplier on the installed base of equipment that are serviced (Lehtonen and Ala-Risku, 2005).

Information on the installed equipment is needed as an input for the service delivery process and for performance measurement and development of product-service systems. On the operational level, dispatching for service jobs requires matching the serviced equipment characteristics with capable service engineers and spare-parts (Blumberg, 1994; Lesaint et al., 2000). Regional differences in installed equipment need to be accounted for in planning for the engineer resources (Klimberg and van Bennekom, 1997; Blakeley et al., 2003), as well as in spare-parts distribution plans (Ghodrati and Kumar, 2005; Cohen et al., 2006). Keeping track of both the installed equipment and the services performed enables valuable product performance analyses that can be used to improve quality of current and future products and services (Goffin and New, 2001; Oliva and Kallenberg, 2003; Davies, 2004; Cavalieri et al., 2007)

Depending on the visibility it has to the installed base the OEM must learn to operate a range of horizontally differentiated service delivery processes. It must be able to deliver products and services according to customer order when there is no visibility to the installed base. When visibility is available the OEM needs to combine product and service delivery pro-actively and perhaps start delivering advanced product-service systems where it can take responsibility to both maintain and operate customers’ assets (Baines et al, in press). This horizontal delivery process diversity needs to be segmented and standardized so that it becomes possible to introduce process innovations effectively and to maintain scale efficiency and ensure that customers receive the level of service they pay for (Cohen et al., 2006). Free-riding quickly becomes a problem when different customers are served by the same resources but are not segmented according to their demand for service levels (e.g. reliability, response time, spare part availability. When going downstream an OEM who previously focused solely on improving product delivery needs to widen the scope to improving efficiency over the life-cycle based on visibility and control of the installed base.

A common approach to describe differences between how to operate with different customers is value stream or process segmentation (Lovelle, 2001; Wood, 2004.) It is based on Porter’s value chain (1985, pp. 33-63) and business process engineering concept (Hammer, 1990; Davenport and Short, 1990). Specifically for service encounters the service blueprint is used in practice (Fließ and Kleinaltenkamp, 2004). The difficulty with these process approaches is the focus on the sequence of operations and participants. Workflow fixes the sequences and if the sequence changes it is handled as a separate process.

In addition to workflow it is possible to describe value adding operations and specifying whom and how these operations are to be performed by describing the interaction between objects (Petrie and Bussler, 2003). Object interaction embeds control in objects and can deal with different sequences of operations and interacting with different participants without the need for defining a new process. However, interaction schemes are cognitively more difficult to grasp than workflows and have primarily been developed and used in object oriented programming (Gamma et al., 1995).

In service blueprinting there is in addition to workflow also an element of object interaction. The customer, onstage contact employee, back stage and support processes interact across the "lines" of interaction, visibility, and internal interaction. In a similar vein the demand-supply chain (Holmström et al, 2000) representation attempts to combine elements of workflow and object interaction in supply chain management. The demand and supply chain are described separately and each represented as value chains. The interdependency of demand and supply is then described as an interaction between demand and supply.

Demand-supply chain representation has been used for segmentation in grocery retailing (Småros et al., 2000) and project delivery (Collin, 2003). It has also been used to identify missing supplier capabilities in spare parts delivery (Auramo et al., 2004). The objective of this paper is to conceptually develop the demand-supply chain representation so that it can be useful in a new context, i.e. to support value moves and segmentation in service operations more generally.

METHODOLOGY

We approach the use of the demand-supply chain representation as a means-ends proposition (Simon, 1996). The methodological starting point of the research is to change the context and goals while keeping the representation scheme more or less fixed. The representation scheme is presented in Hoover et al. (2001), and the change of context is from product delivery and the supply chain to industrial service operations. Such research that attempts to transfer concepts and tools between contexts is solution spotting (Goldenberg et al., 2001) and is based on abductive reasoning (Dubois and Gadde, 2002; Paavola, 2006).

Means-ends propositions in the area of management information systems research are called design theories, and their structure can be elaborated in detail (Gregor and Jones, 2007). We will in this paper present the introduction of the demand-supply chain representation in the context of service operations according to the 8-point structure of a design theory of Gregor and Jones (2007) as shown in figure 1.

First we describe the demand-supply chain representation in terms of its purpose and scope, the constructs, and the principles of form and function. Next, we move on to implementation and present the principles of implementation, expository instantiations, and artifact mutability. The propositions presented in the paper are not yet empirically validated and it is important to understand them as propositions in need of practical testing and empirical evaluation. Note that in order to develop and make discoveries a scientific domain needs in addition to empirical research also research that presents testable propositions (Klahr and Simon, 1999). To conclude, theoretical implications are discussed. We describe a set of testable propositions and show how the proposed tool works by reference to an underlying kernel theory, that is system decomposition theory (Simon, 2002; Augier and Sarasvathy, 2004; Frenken, 2006).

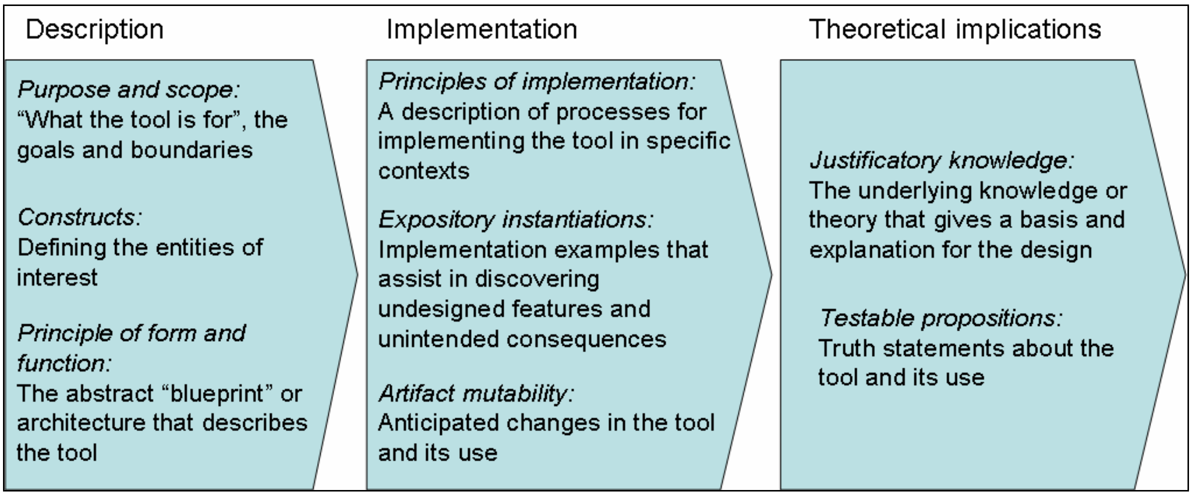

Figure 1- The structure of a design theory (based on Gregor and Jones,2007)

DESCRIPTION

Purpose and scope

The demand-supply chain representation is proposed for OEMs going downstream and for customers considering how to better outsource maintenance and asset management. The tool serves two purposes. Firstly, it facilitates the reallocation of work between the customer and OEM, specifically the movement of asset management tasks and responsibilities between customer and OEM. Secondly, the tool serves to segment service delivery in decomposable or nearly decomposable parts that can be improved without the need for horizontal co-ordination. The proposed approach can be used both by customers and suppliers of services.

Constructs

The demand-supply chain representation uses two types of constructs reflecting the workflow and object interaction representation of activities. The primary constructs are the customer demand chain and the service supply chain. The customer demand chain describes the flow of how demand is created and processed. The service supply chain describes the sequence of how resources are organized and deployed to respond to demand.

The interaction between demand and supply are described using the demand visibility point and the order penetration point constructs. The demand visibility point is defined as the point in the demand chain where the customer selects the supplier, and from which point on the customer can provide the supplier with visibility of demand. The order penetration point is the mirror image of the demand visibility point. It is defined as the point in the supply chain where the supplier allocates the resources to fulfill the customer demand.

Principles of form and function

The principle of form and function for demand-supply chain representation is to model visibility, changes in visibility, and opportunities for reorganizing the customer and supplier operations according to different levels of visibility. Consider how giving the supplier responsibility for the over-all equipment efficiency changes the relationship between an OEM and its customer (Figure 2).

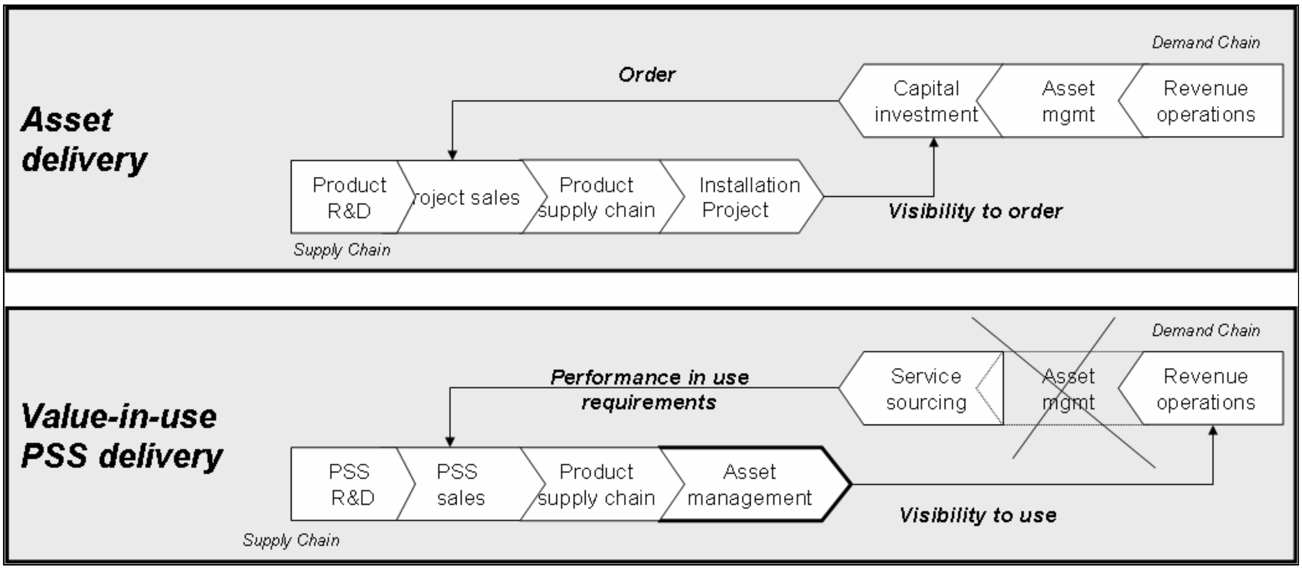

Figure 2- Principles of form and function: value moves involved when a supplier goes downstream and a customer outsources asset management

In a pure asset delivery model the customer selects the equipment supplier when making a capital investment and the supplier commits to deliver based on the customer order. The use of the equipment in the customer revenue operations, as well as the industrial asset management to keep the equipment in use is outside the scope of the supplier's responsibilities, and direct interests.

The value move where the equipment supplier is required to improve the effectiveness and profitability of the customer's revenue generating operations can be represented as a move of the demand visibility point from equipment purchasing to customer revenue operations. This move gives the supplier a longer time-horizon and an incentive to arrange and organize for the effective delivery of both equipment and service. Instead of asset delivery the business model is one of delivering a product-service system (Baines et al, in press).

The mechanism for improving the profitability of the customer is the prevention of problems and the transfer of work and responsibilities to the supplier. The mechanism for profitability for the supplier is the longer term business relationship and the opportunity to use resources more effectively by pooling. However, in this new set-up prevention and resource pooling requires from the supplier the ability to manage the industrial assets for the customer, which in turn require efficient information processing.

IMPLEMENTATION

Principles of implementation

The demand-supply chain representation can be used in the specific context of service operations in two ways. It can be used in an individual customer-supplier relationship, and it can be used for segmenting a set of customer-supplier relationships. The two ways of implementing require different processes.

When the tool is used with one partner the objective is to find ways to improve the interaction and the relationship. It is a search process for innovation opportunities and missing links and required value adding steps.

When the demand chains of many customers can be described using the same representation there is an opportunity for the supplier to segment and aggregate demand. Similarly when the supply response can be described using the same representation there is a possibility for a customer to segment its suppliers and standardize practices. A supplier's segmentation of customer demand chains supports the pooling of materials and value adding resources according to customer requirements. Conversely, a customer's segmentation of supplier processes facilitates the selection of suppliers based on capability and standardization of the provision of demand visibility.

Expository instantiation
For industrial services Auramo et al. (2004) illustrates the implementation process in a single customer-supplier relationship. In the study missing OEM capabilities in spare parts delivery were identified in a relationship where the customer sought to outsource its industrial asset management and the supplier wanted to expand its service business.
From the context of asset delivery, we have an example of segmentation implemented and described by Collin (2003). The implementation demonstrates how the representation of customer demand chains can be used to segment customers of project deliveries. The segmentation is then used to re-design the project delivery supply chain so that supply chain inventories are effectively pooled according to the customer capability to provide visibility to project planning and installation.
From the area of service operations we do not yet have an example of the tool being used for segmentation. Our expectation for the typical outcome of customer segmentation is that a limited number of supply chains are needed to cover the different degrees of visibility and collaboration that customers may provide. For example, the supplier that deliver products in the conventional way, as product and service packages, and as value-in-use product service systems cover the requirements of the different demand chain types.
However, implementation may also produce unexpected results and reveal undesigned ways of using the tool. In fact, Collin's above use of demand-supply representation for segmentation in the project delivery was at the time an unanticipated and novel way of using the tool.

Artifact mutability
The representation tool has been used to represent product delivery for both consumer goods and projects. It is proposed that it can be adapted to represent value movements also in service operations and the delivery of product service systems.
The artifact mutability is illustrated by how demand-supply chains can be used to represent the reallocation of work both when introducing a value-in-use product-service system in the context of service operations, and when introducing vendor managed inventory in delivery operations. Figure 2 above described how the customer transfers asset management work to the supplier when introducing a value-in-use product service system. In a similar way the introduction of vendor managed inventory eliminates and transfers work from the customer to the supplier in product delivery. In Figure 3 the introduction of vendor managed inventory is represented. The figure shows how vendor managed inventory eliminates the need for purchasing, and transfers the responsibility of inventory management to the supplier.

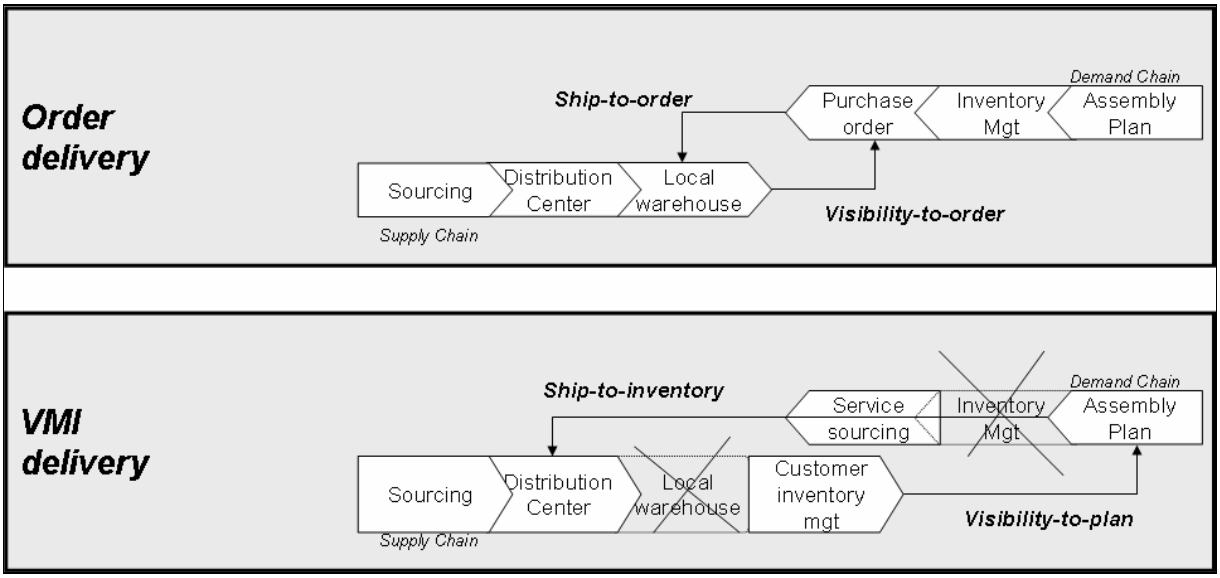

Figure 3- Introducing VMI reallocates work in the supply chain

THEORETICAL IMPLICATIONS

Justificatory knowledge

The purpose of segmentation is to divide the service operation in parts that can be independently improved, without the need for horizontal co-ordination. The theoretical justification for this proposition is system decomposition theory (Simon, 2002; Augier and Sarasvathy, 2004; Frenken, 2006).

Representing the value offering and the service delivery in terms of the demand-supply chain helps a company to divide and aggregate its partners' operations in simple and manageable chunks that can be improved independently of each other. Or, to put it another way, both asset management and service delivery can be segmented so that parallel supplier-customer solutions are "nearly decomposable" (Simon, 2002; Augier and Sarasvathy, 2004, p. 179). For example, the development of product-service systems can be developed without interfering with improvements that focus on conventional product and service delivery. Furthermore, innovative solutions can be more easily introduced in from one customer-supplier relationships to another when the total offering is represented and segmented in a more uniform way.

When it is not possible to neatly decompose service operations there is still the option to develop modular products and services and integrate these as a system (Frenken, 2006). For example, a product service system can be designed so that it integrates asset management and service delivery operations by introducing information systems for tracking the product individuals at the core of an industrial customer-supplier relationship. Tracking of the individual can be used in coordinating the processes and activities of the network members (see e.g. Kärkkäinen et al., 2003).

Testable propositions

Testable propositions can be formulated dealing with the practical relevance and effects for industrial service operations of demand-supply chain representation and segmentation of service operations. The propositions are falsified if the use of the tool is not relevant in practice or does not produce the results as outlined.

A first testable proposition can be formulated focusing on the role of asset management in value moves. The proposition is that in industrial service operations value moves can be represented as changes in responsibility for asset management and are readily modeled using the demand-supply chain representation.

Proposition 1a: The value propositions of industrial services are characterized by changes in responsibility for asset management
Proposition 1b: The changes in responsibility for asset management that describe the industrial services' value propositions can be represented as changes in the customer demand chain and the service provider supply chain.

The proposition is falsified if in practice outsourcing and downstream moves in industrial service operations do not require changes in asset management and responsibilities, or that such changes cannot be modeled using the proposed representation.
A second testable proposition is that demand-supply chain modeling of changing responsibilities helps both parties in assessing the potential for value improvements from outsourcing and downstream moves in a customer-supplier relationship.

Proposition 2: Modeling changes demand-supply chain helps transferring and redistributing responsibility between supplier and customer

The second proposition rests partly on the first proposition, i.e. that asset management work performed on the supplier and customer sides are complements, and potentially transferable. There is a potential for improving value if there are differences between the customer and supplier capabilities, for example regarding the ability to use improved visibility from remote monitoring or installed base information management systems. If no differences on the operational level can be distinguished then discussing improvements in total value by moving work and responsibilities between customer and supplier is difficult. The proposition is falsified if in practical use the demand-supply chain representation does not capture relevant differences between how the supplier and customer may operate.
A third testable proposition can be derived based on the kernel theory of demand-supply chain representation, i.e. the theory on system decomposition (Simon, 2002). The proposition is that service supply chains that have been successfully segmented as decomposable or nearly decomposable industrial service operations are more competitive.

Proposition 3: Service supply chains that are organized as decomposable or nearly decomposable industrial service operations are competitive

The assumption is that independent (uncoordinated) innovation in segmented service operations can improve performance faster than operations built according to other architectures, such as integrated and one-solution-fits all architectures. Once a nearly decomposable architecture has been implemented its competitiveness will according to the system decomposition theory increase faster and eventually come to dominate the market. This proposition can be falsified by field research finding that service operations that are organized as decomposed architectures are not more innovative and effective than tightly coupled operations. The potential role of the demand-supply chain representation in this field research is as a tool for distinguishing between nearly decomposed and tightly coupled architectures.

CONCLUSIONS

Representation of value moves and segmentation in industrial service operations can be regarded as information processing and its use as reorganization and organizational design. Thus, the tool

development presented in this paper is an example of developing information processing to improving organizational performance (Galbraith, 1973), and a potential enabler for developing core competences and more effective distribution of tasks (Hamel and Pralahad, 1990) in industrial service operations.
The reduced need for horizontal co-ordination is the theoretical basis for the improved service operations performance using the proposed representation and segmentation approach. In operations that can either be decomposed or modularized (Simon, 2002; Augier and Sarasvathy, 2004; Frenken, 2006) parallel ways of operating can be improved without cross-interference, and innovations can be more easily introduced from one relationship to another.
The significance of the proposed representation and segmentation needs to be verified in practice. If it works as intended, it opens up a way to introduce economies of scale in the development of industrial service operations. It would support parallel improvements of different types of service operations, and ease the transfer of innovations between customer-supplier relationships significantly compared to service operations that are not operationally decomposed or modularized.

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