Transforming value creation networks – a case from the industrial automation sector

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Abstract

This paper focuses on the transformation occurring in the value creation networks in the industrial automation sector. The main underlying factor for the change is the growing importance of software as a part of the automation systems. Our perspective in the network analysis is the original equipment manufacturers' (OEMs) point of view. We start by discussing the key concepts related to value creation networks, and continue by presenting the main findings of our empirical study that involved both interviews of industrial professionals and a survey of automation-related literature and Web sites. Based on the empirical data, we identify a three-tier architecture of automation systems, and emphasise its significance in understanding and analysing the occurring changes in the value creation networks. It is concluded that further research is required to specify the proposed value creation principles, drivers and dynamics within the networks, although initial indications are promising.

1. Introduction

The industrial automation sector, one part of the electrotechnical industry, can be characterised as so called high-tech business (cf. e.g. Rogers 2001; Gronhaug and Möller 1999; Möller and Rajala 1999; Rajala 1997). Automation companies provide a wide range of devices and systems based on integrating computing into electromechanical components and products. In general, the industry's customers seek for improving their operational effectiveness by using automated machines, systems and processes. Traditionally, discrete parts manufacturing, machine and process automation systems have been separated from each other, although this mode is changing due to common base technologies used in the most systems. Moreover, the sector is facing considerable changes due to the growing amount and importance of computer software – not only hardware and electromechanical parts. To illustrate this, one of the managers interviewed in our study proposed that after a few years the volume of software is going to be 80% of overall system deliveries, leaving only 20% for hardware. At present the situation may often be vice versa.

A considerable number of industrial automation companies is not yet familiar with the business logic of software buying and selling (Seppänen, Helander, Niemelä and Komi-Sirviö 2001). Therefore, one of the present managerial challenges in the sector is how to acquire commercial software products and components, as opposed to develop software in house. However, because software will eventually play a more and more central role in automation systems, the borderline between the automation sector and software-related ICT sectors becomes blurred. Ultimately, automation companies may need to decide not only how to buy software, but also how to start selling their own software products.

Based on our empirical data, Figure 1 illustrates the current industrial sectors closely related to automation systems: they involve electronics, automation, software and ICT industries, as well as a rather versatile service sector.

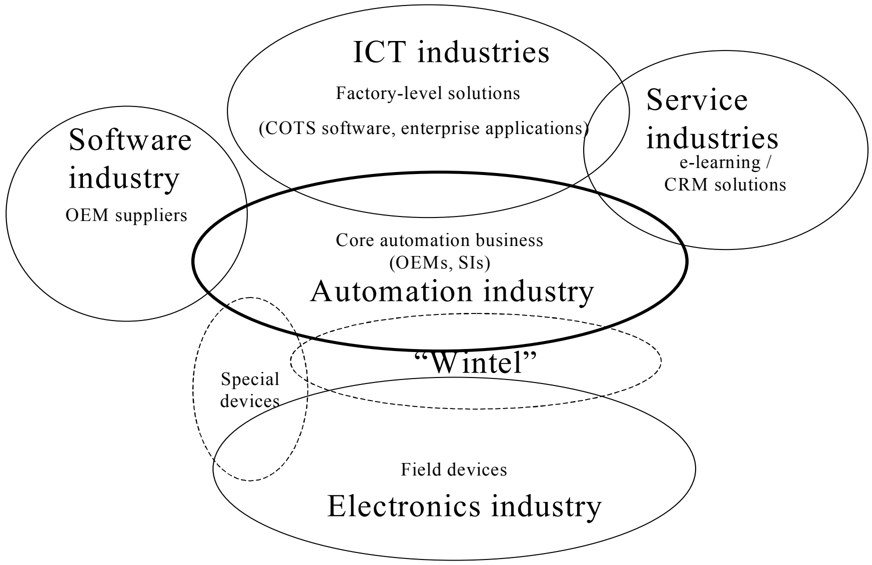

Figure 1. Industrial sectors related to the development of automation systems. ("Wintel" stands for computing platforms based on Intel hardware and Windows software)

The aim of this study is to identify the transforming value creation within the networks in the industrial automation sector. We have chosen the viewpoint of OEMs, and aim at answering to the following question: *"What kind of changes are taking place in the value creation networks from the perspective of OEM type industrial automation company?"*. By the term "industrial automation OEM" we mean a company that buys components, products, subsystems and services to build automation systems for customer companies. The OEM may be a pure system integrator that does the assembly work and manages the end-customer interface. However, it can also carry out product development activities, offering for example platforms into which the components, products and sub-systems purchased from third parties are integrated (Seppänen et al. 2001).

The concepts of "value", "value creation" and "value creation networks" are discussed in the following chapter. By "software", an increasingly important technology in automation systems, we refer to computer programs, procedures, and associated documentation and data pertaining to the operation of a computer system (cf. IEEE 1998). A "software component" is defined as a piece of reusable and independent computer program that is accessible through specified interfaces (e.g. Meyers and Oberndorf 2001; Szyperski 1997). Due to their reusable and independent nature, software components are expected to make software development more effective by offering cost and time savings and quality improvements. The component-oriented view to the software needs in industrial automation is in part justified by the emerging standardisation and modularity of automation systems. Because OEMs integrate and assemble systems from individual parts and products purchased from external vendors, the component-based approach to software fits well with their business logic. Most automation systems are already based on standard mechanical, electrical and hardware components, and the same is very likely to happen to software. Depending on the granularity of the software components, it may be reasonable to speak about products rather than components. However, the fact that these products are usually not any stand-alone software applications, should be kept in mind.

2. Value creation and networks

Value creation is one of the key areas of interest in the current research of business relationships (Normann and Ramirez 1993; Anderson and Narus 1998; Anderson and Narus 1999). A variety of views on the topic has been presented (cf. e.g. Lapierre, 1997; Möller and Törrönen, 2000). In fact, "to create value" can be seen as the very basic aim of any business. According to a rather general view, the concept of *value* can be regarded as the trade-off between benefits and sacrifices (Parolini 1999; Walter, Ritter and Gemünden 2001). Some authors define value purely in monetary terms, whereas others use a broader definition, which also includes such non-monetary revenues as competence, market position, and social rewards (Walter et al. 2001). In this paper we will follow the broader definition of value. The role of software in automation systems would be extremely difficult to characterise only by monetary terms. First of all, there are no standard means to calculate the value of a piece of software incorporated in a larger system. A "small" program can be of "vast" importance for the system, such as a novel machine control algorithm or a greatly improved process parameter measurement function. Furthermore, the concept of value creation can be looked from the function-oriented point of view, as Walter et al. (2001) suggest, or from the process point of view (e.g. Storbacka, Sivula and Kaario 1999). We have taken the process-oriented view, because we wish to study how value is created, delivered and consumed in an industrial sector where several interacting parties are jointly involved in producing a complex systemic offering.

Business networks have been widely discussed especially in the industrial marketing and management literature. Network studies have varied from each other e.g. by their unit of analysis, prescription/description, structural/dynamic, methodology and network components (Easton and Håkansson 1996) and by alternative perspectives hidden by the use of different metaphorical concepts (Alajoutsijärvi, Eriksson, Tikkanen 2001). Additionally, differences between "network organisations" and "networks of organisations" (i.e. the macro networks) have been emphasised, based on the assumption whether or not the network could be set up and managed by a single actor (Möller, Rajala and Svahn 2002; Tikkanen 1998). In this paper we agree with Möller et al. (2002) when they argue that although strategic nets cannot be managed in a strong sense, the management of nets is a relative issue as the challenges of control and coordination vary a lot in different types of the value systems. In our empirical data, especially OEMs seem to play a more central role in networks than other actors – such as individual component suppliers – that are involved.

Furthermore, referring to the work of Möller and Halinen (1999) and Möller et al. (2002) on the four interrelated levels of network management, we position our study partly on the level of "Industries as Networks", but mostly on the level of "Firms in Strategic Nets" as the central issue within our empirical data from the OEM's point of view seems to be the capability to understand their roles and positions in the nets they belong to. The other levels, "Relationship Portfolios" and "Exchange Relationships" are not particularly addressed in this paper, although we notice that the changes in the value network can occur as well in the level of the dyad (confined dyadic change) as in the level of network (network change) as argued by Halinen and Salmi (1999). Recently in the fields of alliance and network research the discussion related to value creation has increased tremendously (e.g. Bovet and Martha 2000; Doz and Hamel 1998; Kothandaraman and Wilson 2001; Möller et al. 2002; Parolini 1999). Due to the limitation of space, we will concentrate on two rather recent research streams of *value creation networks*; the works of Kothandaraman and Wilson (2001) and Parolini (1999).

2.1 Value-creating networks

Kothandaraman and Wilson (2001) point out that all companies belong to some value creation networks (they use the term *value-creating network*), in which some companies play important roles and have influence in shaping the networks, while other play minor roles and are shaped by the networks. This kind of different positions or roles in networks have been discussed by several other researchers, too (e.g. Doz and Hamel 1998; Jarillo 1988), referring to the central actor for example by such terms as the hub-company or the nodal firm.

Furthermore, Kothandaraman and Wilson (2001) emphasise that understanding a firm's role in the context of some network requires significant empirical efforts, as firms usually do not think about network positions, but rather how they compete against similar firms. They have created a model of value-creating networks that emphasises superior customer value, core capabilities and relationships (Figure 2).

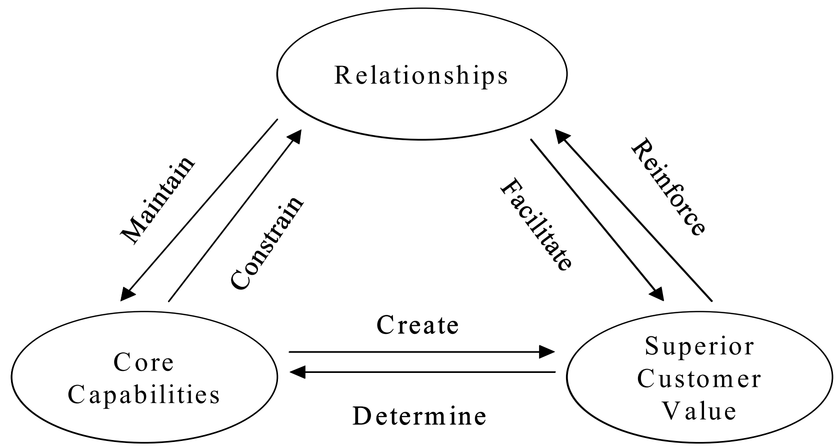

Figure 2. The model of value-creating networks (Kothandaraman and Wilson 2001, 384)

According to the model, the objective of a value-creating network is to create superior customer value. However, the extent or degree of value creation is influenced by the core capabilities of the participating firms, i.e. the capabilities create together the value. According to the authors, the value that the customer of a network wants to consume determines the nature of the participating firms' core capabilities[1] and how they are valued by the other network parties. Furthermore, the way to create the value is influenced by the nature of the relationships that the firms have with each other. Therefore, the types of relationships between network participants and relationship changes affect value creation.

2.2 Value creation systems

Parolini (1999) uses term *Value Creation System* (VCS) that is comparable to the concept of value-creating networks proposed by Kothandaraman and Wilson (2001). According to Parolini, a value creation system can be defined as a set of activities that creates value for its customers. These activities are carried out by using sets of different resources: human, tangible and intangible. Furthermore, activities are linked by flows of material, information, financial resources and so called influence relationships. Accordingly, it is important to understand that final customers aren't only receiving and consuming the value; they can also participate in creating it. Thus, Parolini emphasises the role of customers in networks also as possible producers of the value, not only as consumers.

The concept of the *value net* is utilised by Parolini (1999) as a strategic tool to make sense of the various value creation systems in which organisations are involved. The purpose of the value net is to illustrate as clearly as possible the overall value creation system, and to make explicit the value proposition and value creation principles of the network. Because the value net revolves around activities carried out by interacting network participants, there is considerable dynamics involved. Moreover, changes of value nets are caused by drivers that affect not only reshaping network activities but especially the roles and relationships of network participants.

Parolini (1999) focuses on discussing the meaning of value and on typing and characterising the activities of value networks. Based on her value net concept, but without yet going into detailed analysis of value creating activities, we have defined the framework shown in Figure 3 for studying value creation drivers, principles and dynamics in the industrial automation sector.

[1] For more detailed discussion about capabilities and value creation, see the work of Möller et al. (2002)

Value creation principles	**Value creation drivers**
- Structure of the network - Size of participants	- Supplier value proposition - OEM value proposition
- Division of labour - Specialisation of activities - Type of control	- Supplier goals - OEM goals
- OEM-supplier relationships - Supplier-supplier relationships - End-customer relationships	- Typical problems
Reasons to create, Needs to change, Changeability, Accessibility **Value creation dynamics**	

Figure 3. Value creation principles, drivers and dynamics.

Because we are especially interested in the change of value creation principles, the framework rests on value creation dynamics – involving not only the reasons to create and change the network, but also the possibilities to restructure the network, in practice. Since OEMs and their suppliers form the core of the network, their goals and expected value propositions are important drivers for value-creating activities – but the drivers involve many problems, too. Instead of any detailed analysis of the value-creating activities, we have taken a somewhat broader view to the value creation principles, consisting of the key characteristics of the network (structure, size, types of relationships) and the overall organisation of the activities (division of labour, specialisation of activities, type of control).

3. Value creation networks in industrial automation: an empirical study

We have studied value creation in networks established by industrial automation companies, emphasising the viewpoint of OEMs as software purchasers and integrators. We gathered empirical data about the networks of automation companies operating in Finland from Fall 2000 to Winter 2002. The data was gathered both by an extensive review of secondary sources, such as Internet and professional books and journals, and by a series of qualitative semi-structured interviews. The latter resulted in primary case data composed of altogether about twenty interview records, including interviews of researchers having dealt especially with software-related topics in automation system development and industrial interviewees representing companies developing process, production and machine automation systems. Some of the companies are multinational corporations, whereas others are considerably smaller domestic firms. The profile of the companies varied also regarding their independence. Some of the companies were R&D or engineering units of bigger corporations, others were independently operating firms. Most of the companies represented the OEM perspective, but there were also some supplier-side companies.

3.1 Changing value creation principles in the industrial automation sector

One of the key insights in the empirical data regarding the changing value creation characteristics of the industrial automation sector is that automation companies are increasingly building *horizontally segmented value networks* that revolve around a three-tiered system architecture consisting of so called *field devices* (measurement instruments, device controllers, manipulators and actuators), the *automation system core* (the key automation functions, such as machine control, discrete parts assembly or continuous process control) and *factory-level systems* (software and ICT solutions that associate lower-level automation processes to logistic, customer service, etc. higher-level business processes). In practice, the industrial sectors involved in automation system development and deliveries shown in Figure 1 become together based on this three-tiered system architecture.

Figure 4 drawn based on Kothandaraman and Wilson (2001) illustrates the horizontal segmentation of value creation networks in the automation sector. In particular, both the core capabilities of network parties and their relationships must be associated with each other horizontally. The relationships can be characterised as “Supply” (component, product and platform suppliers), “Integrate” (OEMs) and “Usage service” (system delivery, installation, maintenance and support firms). The core capabilities of these parties involve, correspondingly, electronics, automation and ICT & software.

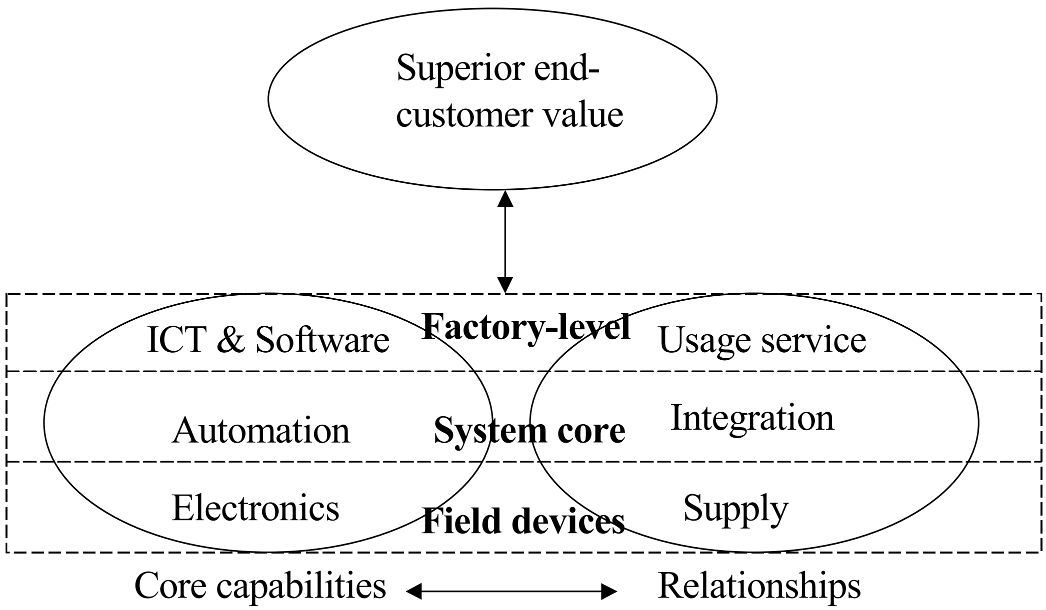

Figure 4. Horizontal value creation networks in the industrial automation sector.

Thinking of the horizontally segmented value creation networks from the viewpoint of the role of software, it is obvious that the industrial automation sector becomes more software-intensive “top-down”, i.e. the importance of software is already high at the factory level and rather considerable in automation system cores, but still quite insignificant in field devices. In other words, the factory level is already much in the hands of the general ICT and software industries, but many field devices are still non-programmable electronic products.

Both the secondary and primary empirical data indicate the same. Most automation companies make use of commercial software products and components at the factory level, and have built rather versatile business networks with firms that offer system tailoring and usage services for particular markets and types of customers. Moreover, a few independent software companies are already selling solutions to build complete system cores, too, although most automation companies still develop software for system cores by themselves, and acquire only hardware platforms from external suppliers.

However, especially some of the biggest automation companies still offer total system solutions including all of the three layers – or at least the two upper layers - by themselves. They expect that superior end-customer value is created by developing, delivering and supporting the use of entire systems. Clearly, the increasing amount of software has already made medium-size and small automation companies to change their value creation approach either to system integration (most of the interviewed companies) or to individual product supply (a few of the interviewed companies).

Referring to Figure 1, the changing value creation principles may result gradually into a situation where automation companies cease to exist, and become pure software and ICT companies specialised in solving industrial control problems using fully generic hardware platforms and commercially available electronic field devices. Some of the companies may follow the software-as-service approach (cf. e.g. application service provisioning, ASP) and focus on supporting the use rather than integration and delivery of automation software.

3.2 Types of value creation networks from the viewpoint of OEMs

It is evident based on the empirical data that OEMs play a central role in value creating activities in the automation industry, mainly because they carry out the integration work that demands co-operation suppliers, but also because they still usually own the end-customer interface due to their company brand names. For example, three process automation companies operating in Finland are recognised by all professionals in the field: Honeywell, Metso and ABB.

Based on the data, the value creation networks of industrial automation OEMs, within the context of the horizontal system layers shown in Figure 4, can be classified into three types: *Competitive, Hierarchical* and *Organic*. These are well-known also in other fields than industrial automation (cf. e.g. Luomala, Heikkinen, Virkajärvi, Heikkilä, Karjalainen, Kivimäki, Käkölä, Uusitalo and Lähdevaara 2001), and sometimes referred to as the Japanese, US and European (or strategic) network structures. A special case of the Competitive value creation system that could be called *Customer self-service* was rather common earlier. Formerly end-customers acquired automation systems almost piece-by-piece, device-by-device, and made the integration work by themselves. Thus, also small supplier companies had direct relationships with their end-customers. Referring to Parolini (1999), end-customers were active value creating parties, but the activities that they carried out involved system specification, acquisition, integration, installation and use.

Increasing volume of software in automation systems has reshaped value creation networks in industrial automation, according to the data that we gathered, from Competitive to Hierarchical and further to Organic. Table 1 illustrates the reasons for this change using the characteristics of value creation networks shown in Figure 3, value creation dynamics, principles and drivers.

Table 1. Comparison of the three types of value creation networks in the automation sector.

Characteristics	Competitive	Hierarchical	Organic
Value creation dynamics			
Reasons to create the network	Free market competition for the best deals, case-by-case	Division of business responsibilities: OEMs vs. chain of suppliers	Issue-based / opportunity-driven businesses, strategic benefits for the same customer
Needs to change the network	Regular needs, basically for all new system deliveries	Depends much on the growth of the business of the OEM	Depends on the emerging needs of the joint end-customer
Changeability of the network	Very flexible, also during the actual operation	Very stable	First rather flexible (creation) and then stable (operation)
Accessibility to new participants	Easy (in principle): open to newcomers, although hard to be chosen for successive deliveries	Difficult: closed, based on personal relations or informal insiders' mutual agreements	Easy (in principle): proper timing, evidence of competence matter, however
Value creation drivers			
Supplier value proposition	Win a good deal as often as possible	Ensure steady long-term earnings through the net	Earn from the emerging core competence
OEM value proposition	Optimise costs / benefits using suppliers	Make use of a well-organised resource pool	Earn from system and business integration
Supplier goals	Make an even better deal next time	Ensure one's own position, try to raise the hierarchical level	Keep finding opportunities to offer the core competence
OEM goals	Seek for new deals	Ensure resources	Become a big and well-known system /business integrator
Typical problems	Difficulties in keeping system integration in control	Corruption and ageing of the network	Unclear roles, wrongly judged "opportunities"
Value creation principles			
Structure of the network	Flat and wide	Deep and wide	Deep or flat and wide or narrow, case-by-case
Size of participants	Often small OEMs and suppliers	Big OEMs, mixed sized suppliers	Mixed sized OEMs and suppliers
Division of labour	One master, many subordinates	Hierarchical	Shared / complementary competence required
Specialisation of activities	May be rather low, but also quite high	High at the upper levels, low at the lowest levels	Rather high on the average
Type of control	First top-down (choice), then bottom-up (delivery)	Strongly top-down (several control points)	Outside-in (shared control points)
OEM-supplier relationships	Distant and short-term, suppliers to do not compete with the OEM	Close and long-term, biggest suppliers a threat to OEMs	Close and short-term or longer-term, may become competitive wrt. system integration
Supplier-supplier relationships	Competitive	Competitive at the low levels	Competition may arise, if competencies overlap
End-customer relationships	Through the OEM (usually not relevant to suppliers)	Through the OEM (mainly relevant for the biggest suppliers only)	Several direct (customer collaboration) or at least indirect (customer visibility) relationships

However, it must be pointed out that the empirical data – and therefore Table 1- does not indicate the superiority of any type of value creation network compared to each other, it merely indicates the direction of change. Obviously, the Customer self-service era with many independent suppliers of all types of individual components, products and services, no specialisation based on adjacent system layers and weak or non-existing OEMs, changed into the Competitive era, when OEMs started to recruit external suppliers for individual system deliveries on a case-by-case basis.

This kind of situation has been rather common until recently, according to the data, regarding field devices. Even today there is no single standard for field devices available, but most automation companies have ultimately chosen one the few biggest suppliers as their partners. Hierarchical value networks revolve around first-tier OEMs that have built stable supplier networks, but serve end-customers by themselves. This kind of approach is still followed by most of the interviewed automation companies, when it comes to the development of automation system cores.

However, OEMs that have moved towards pure system integrators and decided to make use of commercial factory-level system suppliers, have clearly moved towards Organic type value creation networks. Moreover, some of them have recruited specialised partners to serve customers in certain segments. Others use consultants to tailor generic software packages for specific customer needs.

3.3 Role of software and the value creation networks

From the viewpoint of our study, it is relevant to discuss the types of value networks from the viewpoint of the growing importance of software, keeping in mind the emerging three-tiered automation system architecture shown in Figure 4. In particular, it would be necessary to identify how the increasing software-intensity of automation systems proceeding "top-down" would affect the key value creating activities of industrial automation OEMs.

One could expect that the increasing use of commercial software products and components with standardised interfaces could lead towards more competitive OEM-supplier relationships, i.e. towards Competitive value creation networks. However, this kind of hypothesis is not supported by our empirical data. On the contrary, industrial automation OEMs seem to aim at cherishing long-term relationships with their suppliers, pleading not only to well-functioned system integration, but also to the benefits of shared product development. This involves especially automation system cores and factory-level systems, but also field device suppliers.

Based on the empirical data, supplier relationships are going to become closer in the near future, when the OEMs plan to give more responsibilities and shares of their profits to some of the suppliers, in order to build strategic partnerships. The roles of key suppliers seem thus to become clearer. However, if the suppliers operate as fully commercial product vendors, the strategic relationship is not any fixed state, but rather a continuum where the closeness of the relationship and the power of each party are changing. Therefore, the type of the value creation network may fluctuate, too.

The increasing use of commercial software products and components at the factory system level can be a strategic change for some industrial automation OEM, but mean just a yet another customer lock-in for well-established software supplier companies. Moreover, if independent software product developers will increasingly enter automation system core areas, spot market competition or mergers are going to be as likely as partnerships between the formerly separate businesses. One reason for ending into straight competition or mergers, on the basis of our empirical data, is that OEMs seem to be willing to pay rather little for software purchased to system cores, if they have not adopted the pure system integration approach – which is not that common especially in process automation yet.

Speaking of software, Organic type value systems will mean complex business networks, in which different suppliers and even several OEMs will have direct relationships with each other and the end-customer. From the empirical data we indeed found some examples of this network type. Usually direct relationships between different suppliers, especially software product and component vendors, were information exchange relationships; relationships that would involve trade-off of financial resources and actual materials between the suppliers were quite rare. Furthermore, in most cases the evolving direct co-operation relationship between the OEM's suppliers was based on the OEM's direct wishes, e.g. a need to develop software components that would be interoperable.

An important conclusion from the empirical data is that there cannot be any single "correct" type of value network. First of all, commercial software products and components are used in different ways – if at all – at the three different architectural layers of automation systems. This is why different kinds of value networks are, in practice, being formed around these layers. Secondly, there are different kinds of value network types or structures. We have been able to identify the Competitive, Hierarchical and Organic types of networks from the empirical data. Development, purchasing – possibly selling – of software will be organised in different ways in these types of networks. Moreover, the types of network in which certain companies take part will not be fixed, but will change dynamically.

4. Discussion

In recent years industrial automation systems have become more complex than ever, in part due to the growing role of software. End-customers do not anymore posses the needed knowledge and skills in acquiring, integrating and maintaining such complex systems by their own, and are thus forced to rely on the competence of system supplying companies – or, more precisely, networks of companies. From the viewpoint of the end-customer, this involves the question of how the activities involved in creating value for it should be organised among the actors involved in the overall value creation network, and what it should do by itself.

Based on the data analysed in this paper, we have emphasised the importance of the different architectural layers of automation systems in order to gain an understanding of the value creation principles and networks in the industrial automation sector. Although we have been able identify three value network structures typical in the automation sector, plenty of variation in these structures is likely to take place, depending on the change of the three architectural layers that is part caused by the increasing use of commercial software products and components.

This study has not addressed activities of value creation networks in any details, although much will depend on how they are carried out by network participants – including end-customers. The activities are crucial for the value of the overall offering produced by the network, and they should be studied in depth. Referring to Parolini (1999), the value depends less on actual realisation activities than on other types of activities, such as support and external transaction management. Many of the latter types of activities rest on the information created, shared and managed in the value network. The question of the quality of information remains to be addressed, too, in our future research projects. As opposed to an approach based on rather many interviews and an extensive amount of secondary data, the continuing research must most likely be carried out within the context of individual industrial cases.

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