Composite Solutions for Consumer-Driven Supply Chains: How to Control the Service-enabling Ecosystem?

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1 Introduction

Throughout the past decades the global economy has migrated from vertically integrated enterprises towards specialized enterprises interoperating to create end-to-end value to their customers. Step by step, these transformations alter traditional supply chains, centering customers and their increasing need for individual end-to-end solutions (Kagermann et al., 2008; Basole et al., 2008; Cherbakov et al., 2005; Li et al., 2002). Electronic procurement (e-procurement) for example allows for business-to-business purchase and sale of supplies and services over the Internet. Particularly in markets seeking for cost reductions like in the automotive market, e-procurement has been widely adopted. Platforms like General Motors' SupplyPower, Covisint, which is operated by European and American Manufacturers, or the Bosch dominated SupplyOn represent efforts for building electronic supply chains, integrating e-procurement and simultaneous engineering (Howard et al., 2005). As these authors show, e-procurement has become favorable to suppliers and manufacturers through transaction cost reduction, improved strategic planning and transparency, control over spending, reduced paperwork as well as improved supplier and business process development. However, caused by the raising power of customers and consumers relative to the manufacturers and retailers that serve them, sustainable competitive advantage is increasingly determined by both operational efficiency and delivering unique customer value (Porter, 2001). In consequence, the relationships among companies change. Business networks also referred to as business ecosystems or business value nets emerge, enabling companies to deliver faster innovation to customers and consumers at lower costs by sharing investment, assets, and ideas. The resulting rapidly increasing market dynamics (Datta et al., 2004; Accenture, 2008), in turn, is stressing established companies' investments in rigid "built-to-last" supply chain processes. Market demand is calling instead for fluid, "built-to-adapt" networks in which each company focuses on its differentiation and relies increasingly on its partners, suppliers, and customers for complementation (Kagermann et al., 2008).

The emergence of modular product and service architectures in software design emphasizes this trend (Jetter et al., 2009), providing the technical foundation of realizing more dynamic and flexible ways of creating customer value. They enable both customers and consumers to compose the solutions or service combinations that best suit their needs by mixing and matching multiple modular product and service components (Baldwin & Clark, 2000) with the base value of a platform offer. In line with

Gawer (2009), we conceive a platform as "a building block, which can be a product, a technology, or a service that acts as a foundation upon which other firms can develop complementary products, technologies or services". It "consists of an architecture of related standards, controlled by one or more sponsoring firms" (West, 2003) and is - by itself - worth very little. However, as the lowest common denominator in a value net it provides leverage for its multiple complementors. This approach allows for sophisticated, cost efficient composite solutions provided by 'consumer-driven supply chains'. We characterize these supply chains 'consumer-driven' as the services complementing the platform offer are built based on loosely coupled supply chains of services, provided by an 'open pool of autonomous service providers' (Cherbakov et al., 2005), which we will refer to as 'service-enabling ecosystem'. Beyond doubt, this shift in conjunction with an increased autonomy of service enablers (Basole & Rouse, 2008) has tremendous implications on economic value creation and capture in distributed ownership within these supply chains. Facing these transformations, it becomes clear that the ability to operate effectively in business networks is about to become critical to sustaining competitive advantage in a commoditizing global economy (Kagermann et al., 2008). This raises new challenges for companies engaged in distributed forms of consumer-driven supply chains. In particular:

(a) How to orchestrate a value net of independent but interdependent service providers, complementing the core platform offer to deliver reliable end-to-end customer value?

(b) How to strategically stimulate and channel external efforts of service supply to continuously provide the customer with an adequate variety of services complementing the core offering?

(c) How to ensure sustainable service quality optimization?

In the sequel, we will consider these questions from the perspective of the platform operator. Its challenge is to orchestrate a complex self-organizing web of direct and indirect relationships between independent actors to co-create and deliver value (Gawer & Cusumano, 2002; Datta et al., 2004), while the value of the total offering is determined and driven by the consumer (Cusumano, 2008). According to Church et al. (2008), the platform's market success, adoption, and profitability is determined by indirect network externalities: Principally, it applies that the more service enablers join the value net in order to supply complementary services, the more valuable the platform becomes to consumers, as a greater variety of services attracts more consumers. This dynamics, in turn, causes more consumers to adopt the platform and more complementors to enter the business ecosystem (Cusumano, 2008). The mutual dependences between platform owners and their complementing service enablers make clear that the success of a business network depends on constant service optimization, innovation and renewal (Gawer & Cusumano, 2002). The challenge of how to ensure continuous service optimization and the supply of strategically relevant innovations of suitable quality has yet not been addressed - neither in the research stream of lead user incorporation (von Hippel, 1986) nor in the resulting research stream of Open Innovation (Chesbrough, 2006; 2007; Chesbrough & Crowther, 2006). Research on service networks conducted e.g. by Zeng et al. (2003) or Blau et al. (2009) has rather focused on short term value optimization through efficient composition of existing services. Academic approaches oriented at sustainable quality optimization through "more sophisticated governance rules" as claimed by Hagiu (2009) are missing. Alike, managerial control concepts to steer new hybrid organizational forms such as platform-based business ecosystems are missing (Berry et al., 2009).

In this paper, we aim at closing this gap. We focus on platform-based business ecosystems and more specifically, on the service-enabling ecosystem, that have already adopted aspects of self-organization. The perspective ranges from pure IT- or service-centered solutions, e.g. by StrikeIron or PayPal, to actual material supply such as Amazon or Ebay. We begin most fundamentally by reviewing the shift from classical supply chains to more dynamic value net designs. In chapter 3, we analyze the changed requirements on control in dynamic supply chain designs with the help of system theory. Subsequently, we categorize the resulting control mechanisms and discuss them at examples in chapter 4. Finally, we draw conclusions and end with calling for a reference model for consumer-driven value chains. Our considerations are based on the assumption that service orientation and value net structures will materialize in industry and their respective supply chains. Although being discussed controversially (Fox et al., 2000) we see confirmation to our point of view in recent trend analyses by Accenture (2008), Goldmann & Sachs or Gartner (Jetter et al., 2009) and relevant academic publications, such as Jetter et al. (2009), Schramm (2006), or Cherbakov et al. (2005).

2 The Shift from Classical Supply Chains to Value Nets

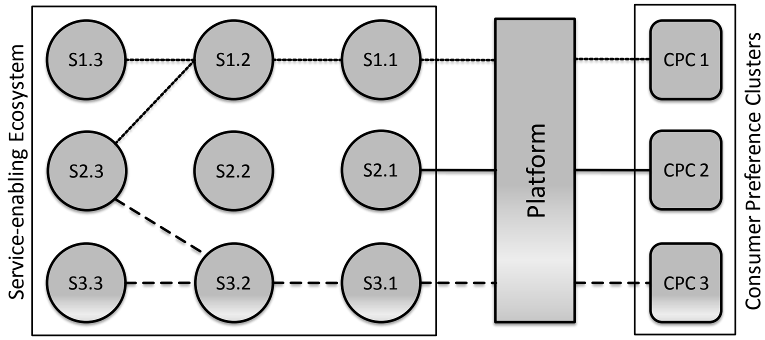
The IT sector is undergoing a major restructuring process, where according to business analysts, an important share of formerly transactional business designs will be replaced by Software-as-a-Service (SaaS). Examples are IBM's shift from a software supplier to a globally-integrated service enterprise (Jetter et al. 2009) or the media-covered success of Salesforce.com. Financial service providers are also strongly embracing the Internet as infrastructure for value creation. Today, all credit card companies are firmly Internet-based. Companies like PayPal complement these services through new email-based payment solutions. In addition, boundaries between market segments disappear. Microsoft is "working with industry leaders eBay Inc., Equifax and PayPal to offer customers online integrated services for Microsoft® Office Small Business Accounting" (Microsoft, 2006). E-commerce-based providers such as Amazon or Ebay are creating entirely new brands of trade within their ecosystem. The consumer's role is becoming much more central to the supply chain with an increased volatility of preference patterns. Consumers "demand product and service customization, speed and high levels of quality of service, all in a seamless fashion and preferably from a single provider. In many instances, consumers will only use and continue using products and services, if their value preferences and criteria are met or exceeded by the services provider" (Basole & Rouse, 2008). Demand and preferences change rapidly, driven by demand for innovation, flexibility and shorter time-to-market (Cherbakov et al., 2005). Market requirements may even change while the product is still under development (Iansiti & MacCormack, 1999). New and flexible development and innovation mechanisms are needed in response to this enforced dynamism. To be able to cope with these new requirements without losing the focus on core competencies, companies started delegating the process of value generation into the supply chain (Schmidt, 2000), limiting themselves to a role of substantiating basic value contribution. This process cannot be reduced to simple outsourcing decisions but leads to renewed strategies of innovation and added value creation, forcing companies to open their business models in order to benefit from the value creation and the resulting pace of innovation outside the company borders (Chesbrough, 2006; 2007; Chesbrough & Crowther, 2006; Degushi, 2004; Gassmann, 2006; Reichwald & Piller, 2006).

Today, most supply chain structures have started softening with respect to the supply chain concept as defined in the SCOR-Model (Supply Chain Council, 2009). Responding to the respective requirements of flexibility and dynamics in supply and innovation, the value net concept finds increasing approval. A value net is defined as a digital supply chain "to achieve both superior customer satisfaction and company profitability. It is a fast, flexible system that is aligned with and driven by new customer choice mechanisms" (Bovet & Martha, 2000). In the following, we will further elaborate the important characteristics of value nets and respective platform-mediated business designs.

2.1 Structure

As depicted in figure 1, the complete business ecosystem embraces the platform operator, complementary service enablers, lead producers, competitors, consumers and other stakeholders. We define 'service-enabling ecosystems' as that part of the overall business ecosystem that takes account of the service enablers only. Service Value Nets (SVN) can be read as instances of business ecosystems, consisting of service enablers, the intermediary, the consumers as well as their respective relations within one period of composite service generation and consumption. The intermediary in SVNs and the provider of a base value is called platform operator. He mediates between service consumers and service enablers. Figure 1 depicts the basic value constellation for consumer-driven supply chains in business ecosystems.

Figure 1: Business Ecosystem



For further clarification of figure 1, consider a setting that consists of a service platform that mediates between a first tier of services and a set of service consumers: A first tier service (S1.1, S2.1, S3.1) may be a basic service (S2.1), or a complex service (S1.1, S3.1), aggregated from sub-services (e.g., S1.2). As we consider service-enabling ecosystems to be open pools of services the service-enabling ecosystems comprise both services that are consumed in an SVN (e.g., S2.3) and those that are not involved in any type of business transaction (e.g., S2.2).

2.2 Complexity Aspects of Decentralized Management

It has been stated before that in the fast moving environment of the IT-service-platforms, innovation tends to be generated through the interplay of loosely coupled network participants. The level of complexity of such a Value Net can be described as (Basole & Rouse, 2008, p. 55):

$$C = \sum_{i=1}^{T} pt_i * \sum_{j=1}^{N} \left(-\left(\frac{pn_j}{pt_i}\right) \log_2 (pn_j / pt_i)\right),$$

T : Number of types of transaction in the network
N: Number of nodes in the network
pt_i: Probability of a type i transaction
pn_j / pt_i: Conditional probability that the j^{th} node is involved, given the transaction i

It becomes evident that with an increasing number of service enablers (nodes) and transaction types, C grows rapidly to a level of complexity which is difficult to be centrally controlled by one single entity in the classic supply chain approach.

But what is the reason for complexity being unmanageably high in some markets and low in others? With system theory we can identify market dynamics as an important impacting factor on system complexity. Evidence for this is given on theoretic grounds: Equilibrium or quasi-equilibrium systems do not show complex structures comparable to those of dynamic systems (Prigogine & Nicolis, 1977; Goldenfeld & Kadanoff, 1999). In simple words, if there was enough time, companies would not need to move value creation and innovation into the supply chain. They would have enough time to develop products and services and would amortize the respective development costs. However, if time presses, complexity evolves.

To handle this, many of the players in these markets have introduced degrees of decentralized control and respectively autonomy to the service enablers. For comparison consider a Web shop owner in Ebay or Amazon, who is to a great extent the master of his product-mix and pricing and who is fully responsible for the choice of his sub-supply chain. With regards to the above introduced formula, the reduction of nodes and transactions in the influence sphere of Ebay or Amazon drastically reduces their handling complexity.

Giving up much of the shaping influence on product-mix and reducing it to substantiating services, migrates value creating activities into the service-enabling ecosystem. It turns into a federation of capabilities where cooperation happens based on real time flows and integrated IT systems (Cherbakov et al., 2005). The integrator's role is more and more transformed from the supply chain shaper to a mediating platform operator.

2.3 Delivering Consumer-centric Composite Solutions

The consumer, who traditionally used to be considered a network externality rather than being part of the actual service production process, gains a prominent role in the co-creation of value (Katz & Sharpio, 1985, 1986; von Hippel, 1986). Illustrative examples are social platforms like Facebook which gain an important share of their value through their actual user community. In the mobile communication segment, the quantity of users within a specific supplier network defines the number of people who can benefit from free on-net calls. Additionally, the consumer increases platform value through his choice in terms of relevance and reputation (Scholten et al., 2009).

Enabling those consumer-centric composite solutions requires a platform operator to have a clear understanding of their core competencies and the new capabilities they need to develop in order to satisfy individual customer needs. In particular, companies have to decide which capabilities can be provided in-house as a substantiating value (base value) and which will be complemented by service enablers in order to provide the "whole product" (Moore, 1999, Gawer & Cusumano, 2002). At root, they need to ensure that the customer perceived value of the composite solution is greater than the sum of its parts (Davies et al., 2006). The customer perceived value - defined as the ratio between perceived benefits and perceived sacrifice (Monroe, 1991) respectively as "the consumer's overall assessment of the utility of a product based on a perception of what is received and what is given" (Zeithaml, 1988) - is subjective and individual. It, therefore, varies among consumers. To compete effectively, companies moving into customer solutions face the challenge of being required to offer a high variety of products and services. They thus increase the likelihood that each consumer finds exactly the option desired allowing each consumer to enjoy a diversity of options over time (Kahn, 1998). In the light of disparate and uncertain demand, however, it turns out too risky for a single company to carry the burden of high development costs of creating an all-encompassing variety on their own (Haas, 2006).

Thus, successful platform operators depend on robust, highly productive service-enabling ecosystems to co-create the platform's overall value proposition and to support its market adoption (Gawer & Cusumano, 2002). Therein, "the performance of a firm is a function not only of its own capabilities or of its static position with respect to its competitors, customer, partners, and suppliers, but of its dynamic interactions with the ecosystem as a whole" (Iansiti & Levien, 2002). These business ecosystems are understood as an "economic community supported by a foundation of interacting organizations and individuals [...]. This economic community produces goods and services of value to customers, who are themselves members of the ecosystem" (Moore, 1993). The participants of the business ecosystem "work co-operatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations" (Moore, 1993). They co-evolve their capabilities and roles over time, and tend to align themselves with the directions set by one or more central companies, the platform operator. Due to commoditization forces as well as indirect network externalities impacting the perceived value of a platform, a continuous services optimization, innovation and renewal is required.

Consequently, the platform operator is obliged to steer the evolution of the business ecosystem. However, given the non-linear and autonomous behavior of independent services enablers, the platform operator cannot simply demand a supply of innovative or optimized services, but has to encourage suppliers to keep on optimizing the complementary offerings and, therefore, the complete offer. In the light of increasing complexity this implies empowering and stimulating service enablers to invest in optimizing their service offerings.

3 Managerial Control in Service-enabling Ecosystems for Improved Service Supply

Previous sections have shown that controlling value creation efforts in service-enabling ecosystems has become a critical function to the platform provider. Failures can rapidly lead to reputation damage, financial losses and possibly, even to the ecosystem's decline. However, due to the lesser stakeholding power of a platform operator compared to a centrally controlled supply chain, mechanisms of management control in service-enabling ecosystems significantly differ from centralized supply chain management and control approaches. Contrarily, it is rather the adept combination of different proactive and reactive control mechanisms that promises being most successful. In the sequel, we understand management control in service-enabling ecosystems as the platform operator's efforts and activities to ensure that the behavior of the service-enabling ecosystem and the decisions made by autonomous service-providers are consistent with the overall objectives and strategies set by the platform operator. With reference to Anthony & Govindarajan (2007), we consider managerial control in service-enabling ecosystems involving the following activities:

- Envisioning and - as far as possible in a self-organized system of autonomous service enablers - planning the overall evolution of the ecosystem;
- Empowering economic value creation activities of decentralized parties within the ecosystem;
- Evaluating information about the overall system evolution as well as about emerging opportunities and threats within the ecosystem;
- Attracting service enablers to enhance the platform's overall customer value proposition;
- Ensuring strategic coherence and congruence, this means that the efforts of the participating service enablers should be consistent with the strategic intentions of the platform operator;
- Balancing the platform operator's appropriability and adoption requirements by deciding, which value creation efforts are to be done in-house and which to be complemented by external service enablers;
- Influencing the complementors' behavior, e.g. by communicating information about the ecosystem's strategic vision and investment opportunities for third party service enablers, about the terms of joint collaboration applying when selling services on top of the platform, or information about customer behavior in order to optimize service offering according to the most recent consumer requirements. Generally, it applies that the looser the network's coupling, the more difficult it becomes for the platform operator to influence quality and range of offer (Scholten et al., 2009)

3.1 Controlled Systems

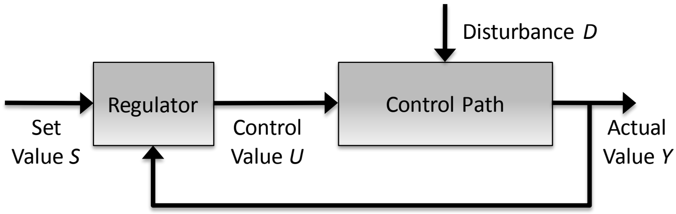
To pay respect to the highly dynamics in value nets (Bovet & Marta, 2000) and to the autonomy of the service providers in the service-enabling ecosystem (Datta et al., 2004), we make use of system theory. System Theory (also referred to as Systems Theory), as pioneered by researchers such as Wiener (1948), von Neumann (1966), Luhmann (1975) or Prigogine (1977) tries to capture complexity, self-organization, connectionism or system adaptivity in systems. Explicitly, the term "system" may refer to social, biological, organizational or technical systems.

In recent IT-focused research, Datta et al. (2004) modeled data information flow in adaptive value nets through agent-based approaches. De Wolf & Holvoet (2003; 2004; 2006; 2006a) analyzes and describes the interactions of independent players and the resulting macroscopic effects as multi-agent relationship. In this context they provide profound insight into self-organization in the context of dynamic systems. According to their findings, self-organization describes "an adaptable behavior that autonomously acquires and maintains an increased order of complexity" (De Wolf & Holvoet, 2006a). The burden of high co-operational complexity in Value Nets, as claimed by Goos (2006) or Zeng et al. (2003) can thus be substituted by less intricate and decentralized auto-adaption processes. Complex system theory, hence, provides a starting point to describe the dynamics and service autonomy of Value Nets, which classical linear process models are unable to capture. In this paper, we apply this theory to shed further light on possible optimizing processes to Value Nets and their respective performance.

In particular, we model Value Nets as controlled systems, a system-theoretical concept to apply feedback in control engineering (Föllinger, 1990). The particular challenge in Value Nets is that they are self-organized. They can therefore neither be centrally nor directly controlled or optimized. In the remainder of this paper, we will derive indirect control mechanisms that take account of the service-enabling ecosystem's autonomy as well as the platform operator's need to steer platform evolution.

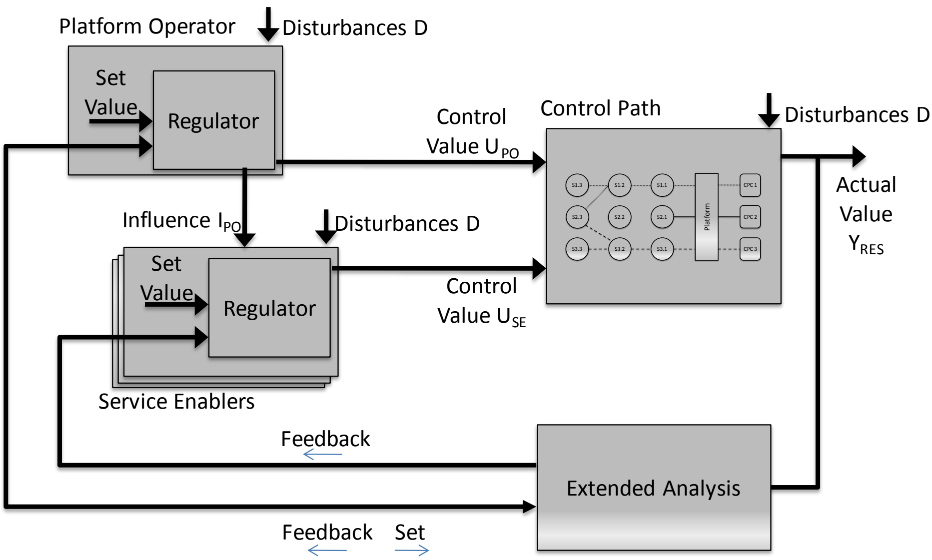
Most fundamentally, controlled systems aim at adapting the actual value Y to the level of the set value S by leveling the control path. This is done by monitoring the actual value tapped at the end of the control path (see figure 2). Then, an active regulator deducts the actual value from the given set value, resulting in a modified control value U. Based on the newly adjusted control value the new actual value is tapped again, which is where the feedback loop is closed. Since disturbances may influence the control path by random noise or a steady change in the external environment, the actual value may be disturbed. In these cases the feedback to the regulator allows for re-leveling actual and set value.

Figure 2: Feedback Control System in Control Engineering



Given these introductory considerations on feedback control systems, we are now able to design a feedback control system for SVNs, that are likewise constituted by the interconnected entities control path and regulator (see figure 3). The SVNs (services, platform and consumers) represent the control path CP of the feedback control system. In pursuit of the methods of control engineering (Föllinger, 1990), the actual value is tapped as raw data to generate feedback to multiple service enablers or the platform operator.

Figure 3: Conceptual Model of Feedback Control in SVN

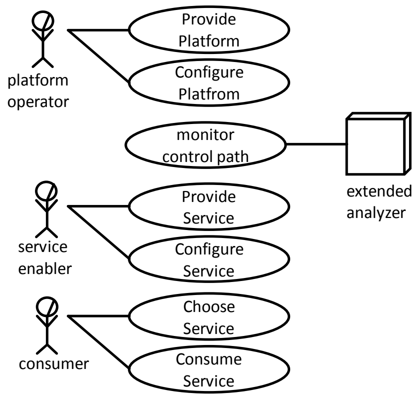


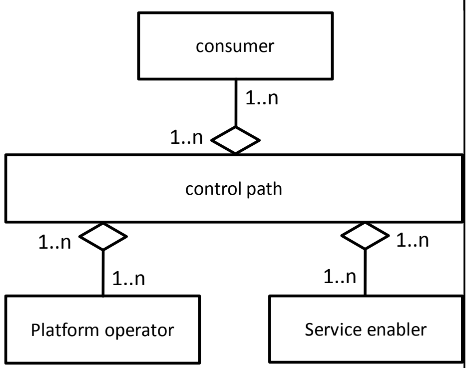
Based on received feedback on his actual performance and in alignment with his commercial goals (set value), each service enabler now may readjust his service proposition. While his service offering is placed within the control path, he is an outside spectator, influencing the process through the modification of his respective service. The set screw for service parameter modification is depicted in an imaginary component, called regulator. Hence, the network self-organizes. Service enablers may modify their value proposition in one or more of the SVN's services (within the control path) by internal "process transformation" (Bernet, 2000) or through a selective replacement of their respective supplying services. This then causes a "system transformation" (Bernet, 2000).

Similarly, the platform operator is part of the loop. Platform operators differ from service enablers, as they possess a configuring power on the extended analysis component (see figure 3). In some platform designs, the platform operator may also exert direct or indirect influence mechanisms (I_{PO}) on service enablers. These influence mechanisms do not affect the regulator directly like the feedback-loop but act on each service enabler as a whole. Thus, they might even influence the service enablers' set values.

In figures 4a) and 4b) we analyze the control path in depth. It can be understood as the space in which services, platform and consumers create the service value nets supplying the composite solution. Figure 4a) describes the tasks accomplished by each actor. The platform operator provides and configures the platform. The service enabler provides and configures the services and the consumer finally chooses and consumes the services. The extended analyzer is a component that we introduce to analyze service enabling and consumption patterns. The class diagram (4b) summarizes our understanding of the control path.

Figure 4a): Control Path, Use Case Diagram ***Figure 4b): Control Path, Class Diagram***





To unambiguously describe the control path, we can now formalize it as CP:

$$CP := \{\exists PO_i \wedge \exists SE_j \wedge \exists C_k\} \mid Y = f(U_{PO}, U_{SE}, D)\} : PO_i \subseteq PO;\ SE_j \subseteq SE; C_k \subseteq C; \{U_{PO}, U_{SE}; D; Y\} \subset \mathbb{R}^n$$

PO:	Set of platform operators	Y:	Denotes the actual value
SE:	Set of all service enablers	U_{PO}/	Control values by the PO
C:	Set of consumers	U_{SE}:	and individual SEs
D:	Denotes the disturbances		

Although, the model and reality provide scope for several platform operators within the same controlled system, we limit our consideration in this paper for the sake of simplicity to one platform operator. Y aggregates all relevant actual data of the system. Further, we can assume that U_{PO}, U_{SE} and D carry a whole set of data. We hence define them as vectors within $\mathbb{R}^n$.

3.2 Self-organizing and Open Systems

In the following, we elaborate on individual actors in service-enabling ecosystems. All actors have different expectations (set values) as regards the performance and quality of their service offers. These expectations may be influenced by intrinsic motivation, external stakeholders or feedback from the market. Although all participants have different goals, the macroscopic behavior of the system is coherent as it aims at producing value to consumers and profit to its providers. This is achieved in a self-organized and adaptive way. Providers (be it service enablers or platform operators) leave the ecosystem as soon as they do not see potential for the satisfaction of their goals. Others might join the ecosystem instead. Such systems are called emergent, as they evolve self-organized in a way that makes them robust against environmental changes (e.g., customer demand). These self-organized systems are characterized by a small cause, large effect principle through non-linear interactivity: The interaction of the service enablers, platform operator and consumers causes a so-called macroscopic effect – meaning a coherent behavior of the SVNs.

Feedback incites enforced reverse adaptation on the micro-level (the service enablers' offerings). The results of a first optimization (e.g., reaction on shifting consumer preferences) again will trigger feedback. Over time, the entire ecosystem will line up to a temporary equilibrium: Once there is no deviation between the service enabler's commercial goals (set value) and the actual value, the configuration stops growing until the next adaptation is initiated (De Wolf & Holvoet, 2003; Prigogine & Nicolis, 1977).

The external influence is summarized in control theory as disturbance, a term that describes an impact causing a deviation from an original set, but which is not meant pejoratively. Disturbances are influences from outside the self-organizing system such as changes in market conditions or effects caused by competitors, influx of new service enablers and consumers or impact by outside stakeholders. Disturbances are an important corrective as they bring external information and stimulus into the self-regulatory process of existing service enablers, customers and the platform. They enable the system to stay sustainably in phase with the ever-changing market. Being the interface between the complex control loop and the external world, they turn the self-organizing system into a so called "open system". Data on competition or the general market situation generated through the platform operator's business intelligence for instance is an example for external input into the control path, immediately initiating a realignment of the whole system on micro- and macro-level.

3.3 Centralized versus Decentralized Control

How then can a platform operator actively control the ecosystem of service enablers in order to effectively and efficiently provide reliable composite solutions? Acting too dominantly (e.g. through directives) might reduce the level of self-organization in a way that emergence will be hampered. Hence, robustness against changing conditions is no longer guaranteed. However, a lack of influence may lead to unmatched quality expectations or coherence with the platform operator's strategic goals.

Centrally controlled systems are subject to inertia, caused by an increased lead time (Prigogine & Nicolis, 1977). The roots are to be found in a purely reactive and hence sequential adaptation process of the service enablers to the platform operator's directives. In centrally controlled systems reverse adaptation on the micro level (meaning self-organized adaptation by the service enablers) is excluded. Any system reaction in such a constellation depends on a linear cycle, where the system's total setting time is defined by the transient process of the Value Net dominator's set points and the Value Net partner's reactive adaptation process. The dominator's advantage is a strong influence on system output and particularly on quality. As already highlighted in chapter 2, the consequence is increasingly difficult to manage network structures, the more a Value Net and its environment increases in complexity and dynamic.

Systems of decentralized control mechanisms with self-organizing service enablers show a more proactive behavior. That is faster and more reactive than a purely centralized approach. In turn, the platform operator loses influence on system output and quality.

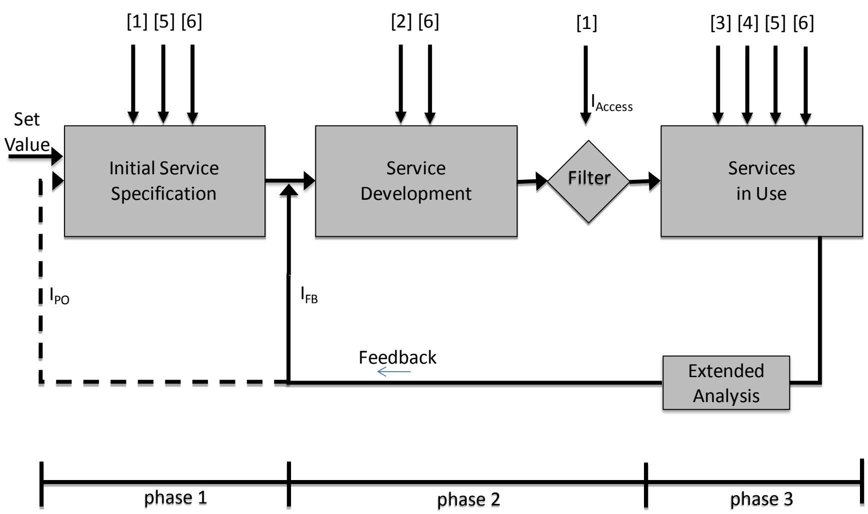
4 Control Mechanisms in Service-enabling Ecosystems

To balance self-organization and control, the application and combination of different control forms needs to vary according to the different phases of value creation, the respective situation and applicable, concrete strategic goals. This calls for a different managerial approach in open systems to successfully steer a coherent supply of complementary services on top of a platform than in traditional supply chain designs. In the sequel, we will introduce and categorize control mechanisms, which we derived based on intense market studies and discuss them at prominent examples.

4.1 A Typology of Control Mechanisms in Service-enabling Ecosystems

Control in service-enabling ecosystems can be implemented within different phases (a) while initial service specification, (b) while service development, and/or (c) while services are supplied. Figure 5 depicts a variety of optional or combinatory mechanisms, instruments, rules, and processes to control system behavior by controlling the behavior of autonomous service enablers along the distributed value creation process. In addition it shows a filtering component. By introducing an access filter between service development and the usage of services, we enable platform operators to accept or deny services for complementation of the core platform offering.

Figure 5): Managerial Control Process in Service-enabling Ecosystems

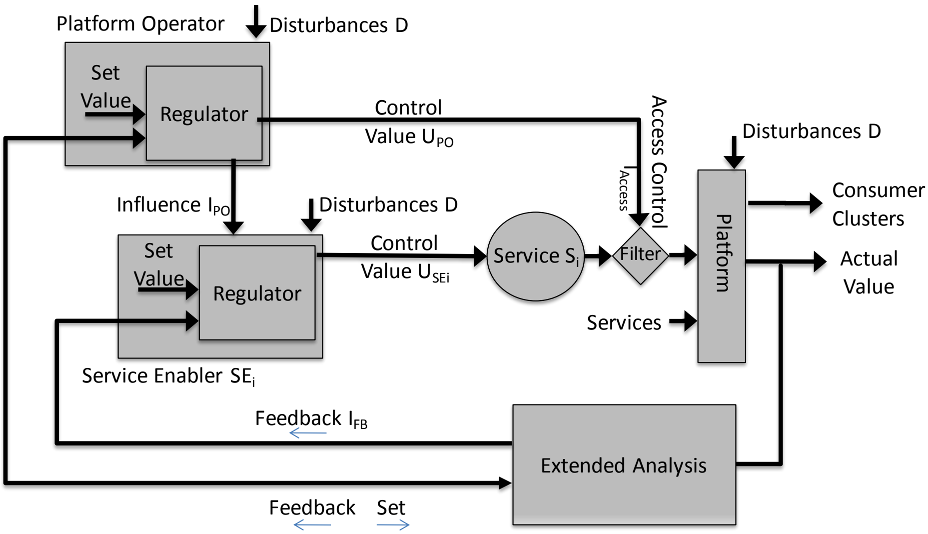


We differentiate between 6 categories of control applying to service-enabling ecosystems. The numbers in brackets (see figure 5) indicate the control mechanisms, applied by the platform operator.

- Restrictive Control [1]: Legal and quality related intellectual property agreements such as statements of rights and responsibilities, platform access regulation
- Co-regulative Control [2]: Guiding principles of service development, providing development rules or tools for coherent and observable service supply,
- Market Regulative Control [3]: Consumer based service verification and auditing
- Sanctional Control [4]: Platform access regulation
- Motivational Control [5]: Development support, community building, funding
- Informative Control [6]: Information about consumer behavior, platform evolution, value creation opportunities

Figure 6 shows the respective closed-loop system at the example of one service S_i, provided by the service enabler SE_i. The indications of the respective influence points I_{PO}, I_{FB} and I_{Access} illustrate where the types of feedback from figure 5 act upon in the example system in figure 6.

Figure 6: Closed-loop System with Management Control Loops for one Service (S_i)



4.2 Restrictive Control [1]

These mechanisms apply pro-actively prior to the supply of a service. Most of the platform operators regulate platform access and strictly define terms and conditions for service supply on top of their platform, which go beyond the assurance of legal correctness. This way, a basic coherence of the platform operator's expectations and the service enablers' deliverables is insured. To verify this, many of the platform operators offer automated entrance assessment methods. We analyzed in our explorative study those at eSigma, Xignite and StrikIron. Each service enabler has to run through an automated link-in procedure and is only allowed to participate in the service-enabling ecosystem once the assessment has been successfully accomplished. In the routine quality and interoperability-features are tested.

Ebay has established policies and rules (Ebay, 2009) for vendors. Those rules include prohibition and restrictions of items, listing practices and performance guidelines. Violation will lead to sanctions, i.e. listing cancellation, forfeit of eBay fees on cancelled listings, limits on account privileges, loss of power seller status or account suspension.

According to the company's official communication, Microsoft allows open access to its app store for service enablers. However, it has rigorous testing mechanisms for quality and suitability of "user experience" (Kretschmann, 2009)

Apple shows a strategy-driven restrictive product range management to avoid conflicts with its own base value contribution or with its own other products. Products like Google Voice were refused in July 2009 as it seemed to be in conflict with Apple's business model (Chen, 2009). Unauthorized products are technically blocked in the iPhone-environment.

With respect to security-sensitivity, ecosystem participation in the financial service industry is very restrictive. Certification is mandatory for service enablers in the credit card industry. Participation in the ecosystem of the leading credit card suppliers is exclusive for service enablers which are Payment Card Industry's Data Security Standards certified (PCI DSS). A company processing, storing, or transmitting cardholder data must be PCI DSS compliant, including secure networks, data protection systems, vulnerability management programs, strong access control, regular monitoring and testing procedures and an information security policy.

4.3 Co-regulative Control [2]

Through the provision of development rules or tools, coherent and congruent service supply is ensured and observable through-out the whole life-cycle of a service. In many cases, service enablers are required to develop products with software, interfaces and/or according to development guidelines that allow the platform operator to observe the function of the services in detail. These guidelines often go hand-in-hand with escalation routines which allow rapid reaction after early notification by a service enabler and a platform operator. Hosting the application on its own platform or infrastructure further enables the platform operator to ensure the transactional qualities like availability, sufficient replication or computing performance etc. Software-based service solutions which are stored and operated within the platform operator's domain are called native. As automated quality checks and reactive measures are much easier for native solutions, Force.com limits its quality commitment only on native third party services.

Microsoft obliges its service-enabling ecosystem to develop native solutions, meaning designed in a predefined architecture with proprietary tools and stored in its own domain (Kretschmann, 2009).

4.4 **Market Regulative Control [3]**

Through consumer based service verification and auditing and its respective publication, aspects of the service enabler's performance are made publicly visible. Many platform operators use reputation mechanisms. Whereas some are limited on a quantitative scoring approach, others like Amazon or Force.com allow descriptive reviews for services or products offered. At Ebay, high-performers, i.e. those who get a 98% score in feedback receive a "power seller" status which increases visibility and trustworthiness. In a more formalized approach, some platform operators (e.g., Force.com) offer annual informative certification for the offered services or for service enablers. The primary goal of market regulative control is to inform consumers and to put pressure on the service enabler, as his performance is made publicly visible and will impact the service enabler's financial success. However, operators like Ebay have also established reactive procedures, which could lead to sanctions towards a service enabler, if his scores are too low. In this case, market regulative control is put into a sequence with sanctional control.

4.5 **Sanctional Control [4]**

In contrast to the market regulative methods, the assessed performance has direct consequences on the service enabler. Many platform operators apply reactive methods to remove an offering from their platform. In Ebay's Verified Rights Owners (VeRO) program, the platform operator enables rights owners "to easily report and request removal of listings offering items or containing materials that infringe their intellectual property rights" (Ebay, 2009). Through semi-automated procedures, Ebay removes offerings from its platform.

4.6 Motivational Control [5]

This control approach includes measures to indirectly control the service-enabling ecosystem through incentives. Examples can be development support, community building or even funding.

An intrinsic motivation is the provision of a large consumer base. Apple was a first mover for platform-mediated apps for his own telephones. With its apple app store, it generated a turnover of 2.4 billion USD in 2008 with a commission of 70% to the respective app developers (Malik, 2009). The relevance of the ecosystem's confidence in success and critical mass is the reason why platform operators with strong or dominating market positions have an advantageous starting position through their customer base. This explains why companies like Microsoft, Apple or Salesforce.com are favored entrants into platform businesses. New players in the market like StrikeIron have to fight for a critical mass.

Amazon motivates its customers with distribution support via its platform, but also through the handling of financial and logistic transactions. Additionally, Amazon's service enablers benefit from a significant critical mass and an efficient logistics infrastructure.

4.7 Informative Control [6]

Information about consumer behavior, platform evolution and value creation opportunities is communicated. Many platform operators today provide basic feedback to their service-enabling ecosystem. Companies like StrikeIron, Xignite or Skype communicate error-feedback to their service enablers. Basic statistical feedback is only provided by StrikeIron.

Still the participants face the problem of information asymmetry (Williamson, 1981): Neoclassical theory postulates total disposability of market information to the vendor allowing for market-conform adaptation of his service portfolio (Kleine, 1995). Being positioned in a dyadic relation with the platform operator (or the next tier service enabler) constitutes a significant limitation of accessible information (information asymmetry). In consequence, services may run out of phase with the actual market demand.

4.8 Scope for Subsequent Improvement

Thus, the supply of extended user information offers the broadest ground for an improvement of platform-based control by communicating the consumers' service preferences based on their actual consumption. In order to identify service preference clusters, we suggest applying OASIS' Web Service Quality Model (WSQM). The model categorizes quality into Business Value Quality, Service Level Measurement Quality, Business Process Quality, Suitability for Standards, Security Quality, and Manageability Quality. We further divide those categories into 21 subgroups, leading to a customer's preference bundle $P = \{\omega_1 * q_1, \ldots, \omega_{21} * q_{21}\}$. In this bundle, each q_i stands for one of the 21 quality parameters and each ω_i represents the respective importance from the perspective of a specific preference cluster. The central position of the platform empowers the platform operator to track and analyze the consumer preferences directly or indirectly (Scholten et al., 2009). Clusters of consumption bundles can be built and correlated with their respective revenue. Communicating customized feedback to each service enabler will stimulate the self-organizing forces in the service-enabling ecosystem (Fischer et al., 2009).

Consumer benefit is improved through a better, faster and self-organized response to the consumers' needs. The driving force of the service enablers is the expectation of increased revenue. We foresee improved market exploitation by service enablers and the platform operator and a strengthened positioning against competitive business ecosystems. Leveraging the ability to collect, process and feedback all relevant information into the service-enabling ecosystem endows the platform operator with a tool to indirectly control its service-enabling ecosystem into the direction of higher consumer value generation.

5 Conclusion

In this paper, we reviewed the shift from classical supply chains to more dynamic value net designs based upon modular product and service architectures. It became clear that to enable consumer-driven supply chains, platform operators have to orchestrate distributed value creation efforts and ensure continuous supply, coherence and quality. However, if the platform performance deviates from the expected output, how should the platform operator react to get the system (back) on target? What are the strategic and operational means of acting on the control path to control outputs towards desired values, thus ensuring a desired level of performance? Therefore, we have introduced a control process for service-enabling ecosystems, which allows to systematically assigning control mechanisms to different value creation phases prior to, during and after service supply, categorized into six categories. Feedback loops are considered to be of particular importance: the provision of extended consumer information stimulates overall platform performance by empowering autonomous service enablers to optimize their service portfolio according to the most recent consumer needs and, therefore, to increase the customer perceived value of the overall platform solution.

To conclude, we expect that control of decentralized value creation efforts in consumer-driven supply chains will increase in strategic importance. Processes need to be put in place, by which the platform operator ensures the delivery of reliable end-to-end customer and consumer value. Although many corrective processes are automated or fed into the service-enabling ecosystem, platform operators will need to play an active role in setting and tuning control mechanisms to best align them to the platform operators' corporate goals. In this light, further research will be required to develop a reference model for consumer-driven, dynamic value nets, similarly to the SCOR-Model. It would allow visualizing, contextualizing and hence optimizing all relevant process activities required to supply composite solutions.

In future research, we will focus on developing a process framework to effectively manage the supply of platform-based complements. In addition, we will design and implement tools that apply principles of informative control and support platform operators in collecting and aggregating the necessary feedback information in the context of SVNs. Thus, we aim at developing a toolset that contributes to emergent behavior of SVNs.

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