Degree of Encapsulation as a Key Concern in Analysis and Design for Service Systems

Full Paper

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Abstract

Concepts related to sociotechnical and totally automated services should play a role in systems analysis and design because every organization operates through internally directed service systems and because much the world GDP involves services for customers. This paper explains how the concept of encapsulation proves a crucial design variable for both sociotechnical and automated services. This paper defines the term service and explains how the degree of encapsulation is related to structures for delivering services, using outsourcing as an illustrative example. It shows how encapsulation-related design decisions appear in a service life cycle model. It presents a detailed operational metamodel that describes service systems and shows how aspects of the metamodel provide operational interpretations of ideas that are important in service system design. The implication is that the concept of encapsulation should be included in analysis and design methods and tools.

Keywords

Encapsulation, service, service system, analysis and design

How Degree of Encapsulation Matters for Service Systems

The paper's goal is to extend the computer science concept of encapsulation into the broader realm of systems analysis and design (SA&D) for service systems, which usually can be modeled as IT-reliant work systems. Coverage of service systems in SA&D is important because the operation of every organization occurs through internally directed service systems and because over 75% of the GDP of advanced economies is in the service sector. Accordingly, ideas that are important for service systems and that can be incorporated into or added to existing methods and tools could play an important role in SA&D.

We define *degree of encapsulation as the extent to which the status and operation of an entity (anything from a software module to an organization) is invisible to and impenetrable by customer entities that receive and use whatever it produces*. That idea is important as a design variable for managers and analysts involved in analyzing and designing any service system, regardless of whether it is internally or externally directed. Typical internally directed service systems perform systematic activities related to hiring, corporate planning, payroll processing, and provisioning and maintenance of IT resources for employees. Typical externally directed service systems perform systematic activities related to taking customer orders, delivering product/services, and providing customer support.

In all of the internally and externally directed examples above, managers and analysts need to answer the fundamental SA&D question of the extent to which service customers will have visibility and access to the provider's service system and the extent to which the provider will have visibility and access to the customer's systems and activities that use whatever the customer receives from the provider. Service oriented computing addresses this question by assuming that there will be no mutual visibility, i.e. that communication between automated client programs or modules and server programs or modules only occurs through coded messages whose content and format are predefined. The client has no other visibility or access to the server's status or activities and vice versa. Typical sociotechnical service situations provide much more visibility and access. Typical examples include a consultant interacting with a customer organization to define a new software application, or a hospitality organization trying to

provide an enjoyable experience for its customers. Substantial visibility of the customer is often required in those cases, and customers often want some amount of visibility of the providers as well. The mutual interaction, visibility, and other access in those cases absorb time and generate time-related expenses for salaries, facility usage, and other cost items. The challenge for both managers and analysts is to identify the benefits and costs of different levels of visibility and interaction for both providers and customers.

This paper is a step toward expanding the traditional scope of SA&D. If the goal is to improve business performance, then SA&D needs to engage directly related topics and should produce recommendations about the structure and operation of service systems. That involves much more than software. When service systems are sociotechnical, changes in application software usually require corresponding changes related to processes and activities, expectations of service system participants, information created and used, and product/services produced. Where customers participate directly in service system activities (e.g., in medical care, education, custom software development, and other interaction-intensive services) the changes may also involve new responsibilities and new expectations of the customers themselves. Ignoring any of that could result in system-related recommendations that will be ineffective in practice.

Goal and Organization. This conceptual paper addresses a gap in current SA&D knowledge and methods. It builds on past research related to service, service systems, and work systems. As has been noted many times in leading journals, there is no formulaic "methodology" for doing conceptual research. For example, an *MIS Quarterly* article about theory construction (Rivard, 2014) makes no effort to describe a methodology or n-step procedure for conceptual work. Instead, it focuses on topics such as motivation, definition, imagination, explanation, presentation, cohesion, and contribution. Related ideas appear in Hirschheim (2008), in Rowe (2012) and in Grover and Lyytinen's (2015) discussion in *MIS Quarterly* about why formulaic scripts should not be expected in theory development research.

This paper proceeds as follows. It defines the term service and explains how encapsulation is related to structures for delivering services, using outsourcing as an illustrative example. It shows how encapsulation-related design decisions appear in a service life cycle model that encompasses many service concepts that are rarely associated with SA&D. It notes that services are produced by service systems, which are work systems. It summarizes work system theory (WST). It presents a work system metamodel that can be used to model service systems in more detail than is possible with WST per se. It demonstrates how the concept of degree of encapsulation is reflected in the metamodel, and how aspects of the metamodel provide operational interpretations of ideas that are prominent in service science, which has developed enough in one decade that there is an INFORMS journal called *Service Science*. The conclusion summarizes why the concept of encapsulation should be considered when analyzing and designing service systems, and hence why that concept should be applied in systems analysis and design methods and tools.

The Link between Service and Encapsulation

A nagging issue in service science is lack of a single, universal definition of service that is useful across all service contexts. Alter (2012, pp 24-26) presents and explains a series of published definitions of service, all of which are useful in some contexts but not in others. For example, Vargo and Lusch (2004b) explain why the "IHIP" characteristics (intangibility, inseparability, heterogeneity, and perishability) that are often associated with services actually do not do a good job of distinguishing services from goods.

This paper uses a simple, dictionary-like definition that applies almost everywhere: "Services are activities or groups of activities performed with the intention of providing benefits for others." (Alter, 2016). With that definition, almost every economic activity (including the creation or modification of physical things) can be viewed as a service regardless of whether it is directed toward internal customers within a firm or toward external customers. That is a central reason why service ideas should become part of SA&D.

Degree of Encapsulation as a Service Design Variable

This paper's introduction defined the *degree of encapsulation as the extent to which the status and operation of an entity (anything from a software module to an organization) is invisible to and impenetrable by customer entities that receive and use whatever it produces*. This topic is related to widely discussed debates about whether services necessarily involve customer-provider interactions, coproduction, and value co-creation. The degree of encapsulation for a service or service system can be described along the following dimension:

- **No encapsulation**. Customers are extensively involved in most or all service or service system activities, as in physical therapy services, tennis lessons, and other highly coproduced services.
- **Customer participation beyond providing guidance**. Active customer involvement in front stage activities occurs along with backstage activities by the provider. An example is a software development project whose customers document requirements and participate in discussions and negotiations, but have no visibility of how program testing is executed.
- **Customer guidance only**. Customers interact by stating preferences and possibly reviewing progress at various points, but the production work is done with little or no customer involvement. Housecleaning and gardening services are examples.
- **Total encapsulation**. A totally encapsulated service is launched by a request or condition, is executed with no direct customer involvement or visibility, and produces an outcome that the customer receives and uses. This basic idea of service computing is expressed in the Unified Service Description Language (USDL) (Oberle et al. 2013). A totally automated example is a search engine. The customer provides the search terms, clicks a search button, and receives a response without knowing exactly how and where the answer was produced. As explained in Oberle et al. (2013), USDL also was designed to cover sociotechnical services such as process outsourcing in which the customer periodically conveys a set of transactions to an outsourcing provider that performs the transactions and returns information about the outcomes without providing visibility of how that work was done.

The following hypothetical examples illustrate the different degrees of encapsulation described above. All involve MegaCorp, a large company that outsources graphical design work to ServCorp, an outsourcing vendor for design work and related projects. The examples illustrate different types of outsourcing projects that ServCorp performs for MegaCorp with different pricing schemes and outcome expectations.

- **No encapsulation**: a totally collaborative project in which MegaCorp and ServCorp employees visit each other's sites as necessary to develop the project guidelines and to allow MegaCorp's employees to participate extensively in the project. The desired result is a product that fully satisfies MegaCorp's needs, reflects ServCorp's unique expertise, and transfers some knowledge to MegaCorp's employees.
- **Customer participation beyond providing guidance**: a graphical development project, in which a limited number of MegaCorp employees visit the ServCorp office several times to work collaboratively to specify a graphical design product whose complex specification process requires ServCorp's expertise. MegaCorp can review and criticize the work in process in two interactive sessions during the process. Additional interaction, if necessary, will be a chargeable item.
- **Customer guidance only**: a project in which MegaCorp uses a ServCorp's web site to communicate expectations about graphic designs for a set of brochures that require generic photos and diagrams selected from ServCorp's huge graphics repository. MegaCorp employees use a catalog on ServCorp's web site to identify the types of designs and subject matter that they want. MegaCorp employees speak several times with ServCorp's production supervisor to confirm that the request is understood and makes sense. After the specification is agreed-upon, ServCorp produces the product and sends it to MegaCorp, which has no access to ServCorp's internal activities in fulfilling the request.
- **Total encapsulation**: a project to convert 1000 images from one format to another and to make sure that quality is not degraded. This type of project is one of the items on ServCorp's service catalog for its graphic design customers. The customer sends a formatted message containing the images and ServCorp returns the reformatted images within one week. MegaCorp has no access to information about ServCorp's internal activities in fulfilling the request.

The goal of the example is to help in visualizing the range of possibilities in relation to different degrees of encapsulation. A similar range of possibilities exist in many other IS/IT outsourcing situations, ranging from running IT infrastructures to producing and maintaining software. Notice how the notion of *degree of encapsulation* as a design variable is quite different from a binary, yes/no view of encapsulation.

Service Value Chain Framework

Typical issues related to encapsulation are incorporated into Figure 1, a service value chain framework that identifies typical categories of service activities and responsibilities. Each element of this framework is important for many, but not all services and service systems. The entire service value chain for a service

can be viewed and analyzed as a single work system, as will be explained later. Alternatively, different subsystems in Figure 1 (such as provider preparation or negotiation of commitments) might be analyzed as separate work systems.

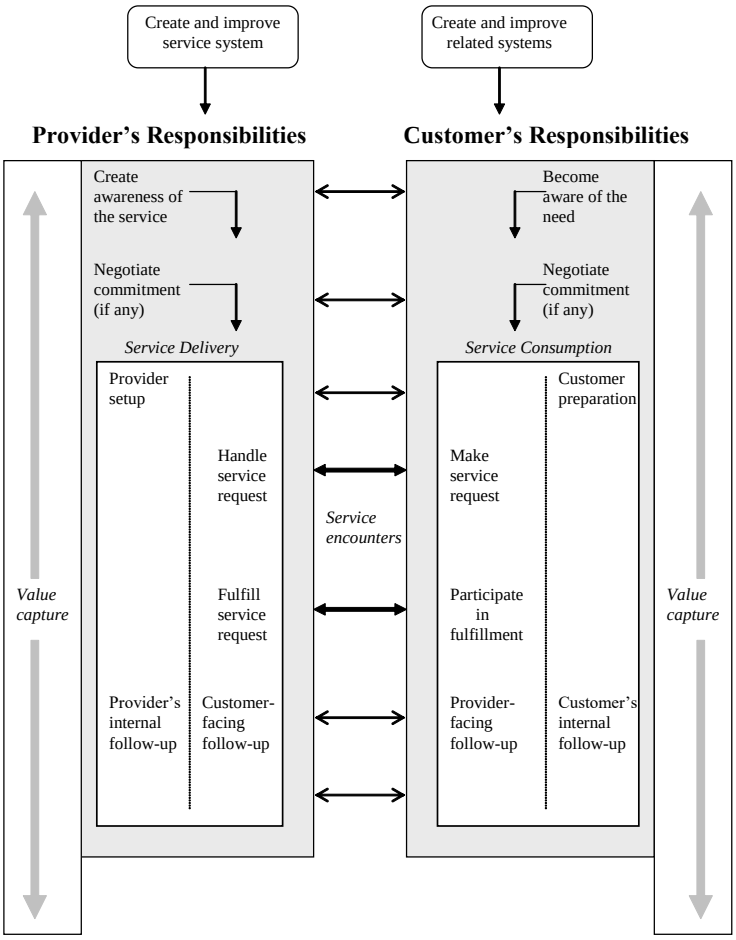


Figure 1. Service Value Chain Framework (Alter, 2010)

The bilateral form of the service value chain framework is based on the widely accepted observation that services generally are coproduced by service providers and service consumers (Alter, 2010). The form and content of the service value chain framework express a series of assumptions related to service. In the following list, the symbol "**E ➔➔**" precedes comments relevant to encapsulation.

- **Importance of activities and responsibilities.** Understanding services requires attention to activities and responsibilities of both service providers and service customers.

  E➔➔ Greater overlap of provider and customer activities and responsibilities decreases encapsulation.

- **Front-stage and back-stage.** Services often involve front-stage and back-stage activities by service providers and customers.

  E➔➔ Totally encapsulated services involve no front-stage activities other than exchange of coded messages between customers and providers.

- **Coproduction of services.** Some of the service definitions cited in Alter (2012) and other service literature say that services are necessarily coproduced by service providers and service customers. For example, most medical care in everyday life depends partially on the quality of the doctor's diagnosis and partially on the patient's compliance with whatever the doctor prescribes. Similarly, the success of an outsourced data center depends jointly on the outsourcing vendor and the service customer.

E➔➔ Increasing the amount coproduction usually decreases the degree of encapsulation.

- **Internal and external customers.** Basic ideas about services are largely the same regardless of whether services are directed at external customers, internal customers, or both.
- **Customer experience.** The experience that typical customers associate with acquiring, receiving, and benefiting from a particular service affects customer satisfaction.

  E➔➔ The degree of encapsulation may affect the customer experience positively or negatively.
- **Service encounters.** The quality of service encounters between service providers and customers is often a key determinant of customer satisfaction.

  E➔➔ Interpersonal service encounters reduce the degree of encapsulation.
- **Beyond fulfilling a request.** Although the fulfillment of a service request is typically viewed as the core of the service, activities related to awareness, negotiation, setup, handling of the request, and follow-up impact customer perceptions of service quality and ultimately affect customer satisfaction.

  E➔➔ Even if the fulfillment step is totally encapsulated, the other steps may involve a high level of interaction and mutual visibility.
- **Negotiated commitments.** Many service situations involve delivery of services based on negotiated commitments under which the service may be requested and delivered repeatedly. For example, the outsourcing literature often notes that the quality and thoroughness of negotiated mutual commitments is a key determinant of whether service relationships will meet needs and will be cost effective.
- **Preparation.** Preparation by providers and/or customers prior to each instance of service delivery is often essential for service efficiency and effectiveness.
- **Service request.** For many services, each instance of service delivery includes an explicit or implicit service request. The handling of the service request is an important part of service delivery and often affects customer satisfaction.
- **Follow-up.** Some services require follow-up by providers and/or customers. Follow-up may be related to a single service instance (Was the installation OK?) or to multiple service instances (How responsive is your account manager?).
- **Value capture.** Customers may experience benefits as the service is produced and/or may experience benefits later. Value capture, represented by the leftmost and rightmost portions of the service value chain framework, includes the customer's experience of attaining value from the service and the provider's experience of attaining value in exchange for the customer's value.

The above concepts can facilitate SA&D for IT-reliant service systems by highlighting ideas and distinctions that a provider-centric analysis might overlook, such as:

- Customer responsibilities, not just internal production processes
- Front-stage versus back stage activities
- Benefit capture over time by the customers
- Service encounters before, during, and after the time when the products and services are produced
- The form and content of negotiations and service requests
- Preparation prior to service fulfillment by the producer and by the customer
- Producer and customer follow-up subsequent to request fulfillment

Applying Work System Theory to Service Systems

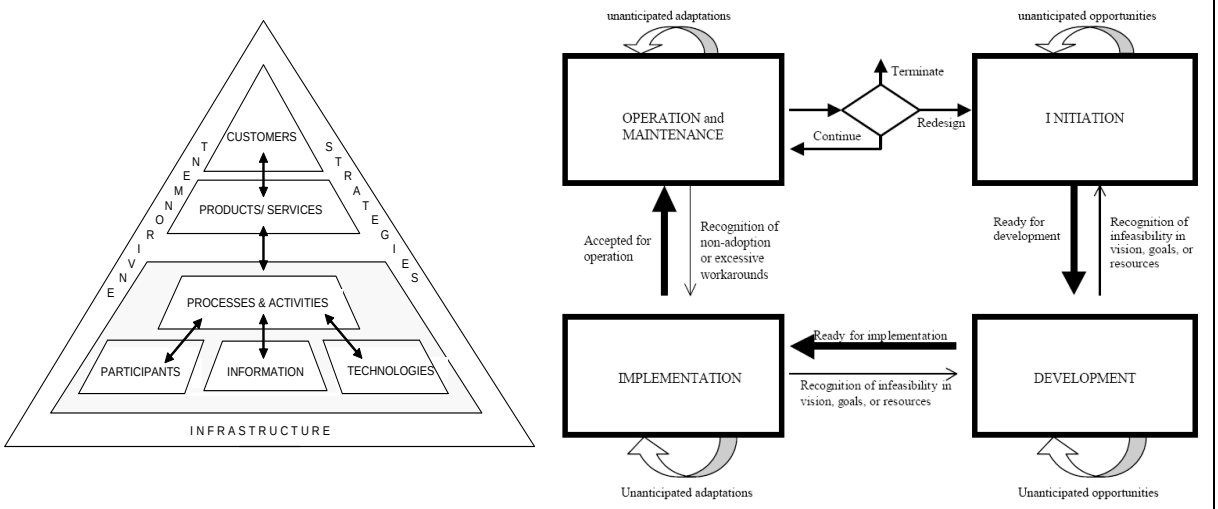
Service systems that produce non-improvised services are work systems (defined in Figure 2). Enterprises that grow beyond an improvised start-up phase consist of multiple service systems performing acts for the benefit of internal and external customers. Typical business enterprises contain service systems that procure materials from suppliers, produce products, deliver products, find customers, create financial

reports, and hire employees. Treating service systems as work systems provides a holistic way to visualize how services are enacted. This provides a path for analyzing, designing, and evaluating services.

A subset of general system theory called work system theory (WST) provides an organized approach for summarizing a service system or one of its subsystems. As shown in Figure 2, WST consists of the definition of work system, the work system framework (nine elements of a basic understanding of a work system) and the work system life cycle model (description of how work systems evolve through planned and unplanned change). The definition of work system refers to "human participants and/or machines," thereby encompassing sociotechnical or totally automated work systems.

WST is the basis of various versions of the work system method. WSM has been applied over many years by many hundreds of MBA and Executive MBA students in the United States, China, India, and Vietnam for producing preliminary management briefings that summarize a real world work system and present suggestions about how it might be improved. Sowan (2015) describes how work system snapshots, a central tool in WSM, were used by 117 nursing graduate students during 2013 - 2015 as a required part of business process reengineering assignments. WST is also the basis of a number of WST extensions that go beyond its core. Among others, these include a set of work system principles, a series of work system design spaces, various versions of a work system metamodel that reinterprets the work system framework in more detail, and a theory of workarounds. The metamodel will be discussed in the next several pages.

1) Definition of work system: a system in which human participants and/or machines perform work (processes and activities) using information, technology, and other resources to produce specific products/services for specific internal and/or external customers.



2) Work system framework

3) Work system life cycle model

Figure 2. Three Components of Work System Theory (Alter 2013)

Terminology of work system vs. service system. All work systems can be described and analyzed as work systems. In this paper WST and its extensions are stated using the term *work system*, not *service system*. For that reason, explanations related to work systems in general use the term *work system*, whereas discussions specifically about service systems use the term *service system*. The term work system generally is treated as a synonym of service system because all service systems are work systems and almost all work systems in organizations are service systems. The relatively few exceptions are work systems that an individual creates to support personal needs, such as a shadow IT system that records personal customer information that is not included in the corporate CRM system.

Work system framework. This framework identifies nine elements included in a basic understanding of a work system's form, function, and environment during a period when it is relatively stable, even though incremental changes may occur. Processes and activities, participants, information, and technologies are inside the work system (service system). Customers and product/services may be partially inside and partially outside because customers often participate in activities within the work

system (e.g., patients during medical exams or customers during design meetings for custom-built software) and because product/services take shape within the work system. A work system's environment, infrastructure, and strategies are largely outside the work system but often affect its performance. Distinctions related to the terms in the work system framework are explained in Alter (2013, pp. 80-81)

Work System Metamodel

Figure 3 is the sixth in a series of work system metamodels that outline more detailed, operational views of a work system than the work system framework provides. The work system framework is useful for summarizing a work system and achieving mutual understanding of its scope and nature, but is less effective for detailed analysis. The more complete and rigorous metamodels introduce concepts required for deeper analysis. The customer work system is included in the metamodel to clarify links between provider resources and value creation, thereby illuminating operational interpretations of resources and value creation in service-dominant logic (Vargo and Lusch, 2004a, 2008), a theory from marketing.

The metamodel reinterprets each element of the work system framework in a more detailed way. For example, information becomes informational entity, technology is divided into tools and automated services, activities are performed by three types of actors, and so on. The bottom of Figure 3 notes that many attributes of each entity type are hidden in the one-page representation.

The metamodel's entity types and relationships provide an abstract description of how work systems (and hence, service systems) operate. Rigorous SA&D that considers service system concepts requires abstractions at the metamodel's level of detail and integration. Selected relationships in the metamodel are listed below, with entity types in bold and comments related to encapsulation treated as was done earlier. The relationships listed are those most relevant to understanding the importance of encapsulation or that help set the context. Relationships that are not listed have less bearing on encapsulation issues.

- **Enterprises** and **value constellations** consist of **work systems**.
- **Work systems** always contain at least one **activity**. They may contain one or more **business process(es)** if a set of **activities** is sufficiently interrelated and sequential to qualify as a process.
- **Activities** use **resources** to produce one or more **product/services from activity** that may be used as a **resource** for subsequent **activities** and/or may contribute to **product/service offerings**. A **product/service offering** may combine multiple **product/services from activities**. Thus, only some of the **product/services from activities** are included in **product/service offerings** that are received or used by **customer work systems**, and hence by **customers**.

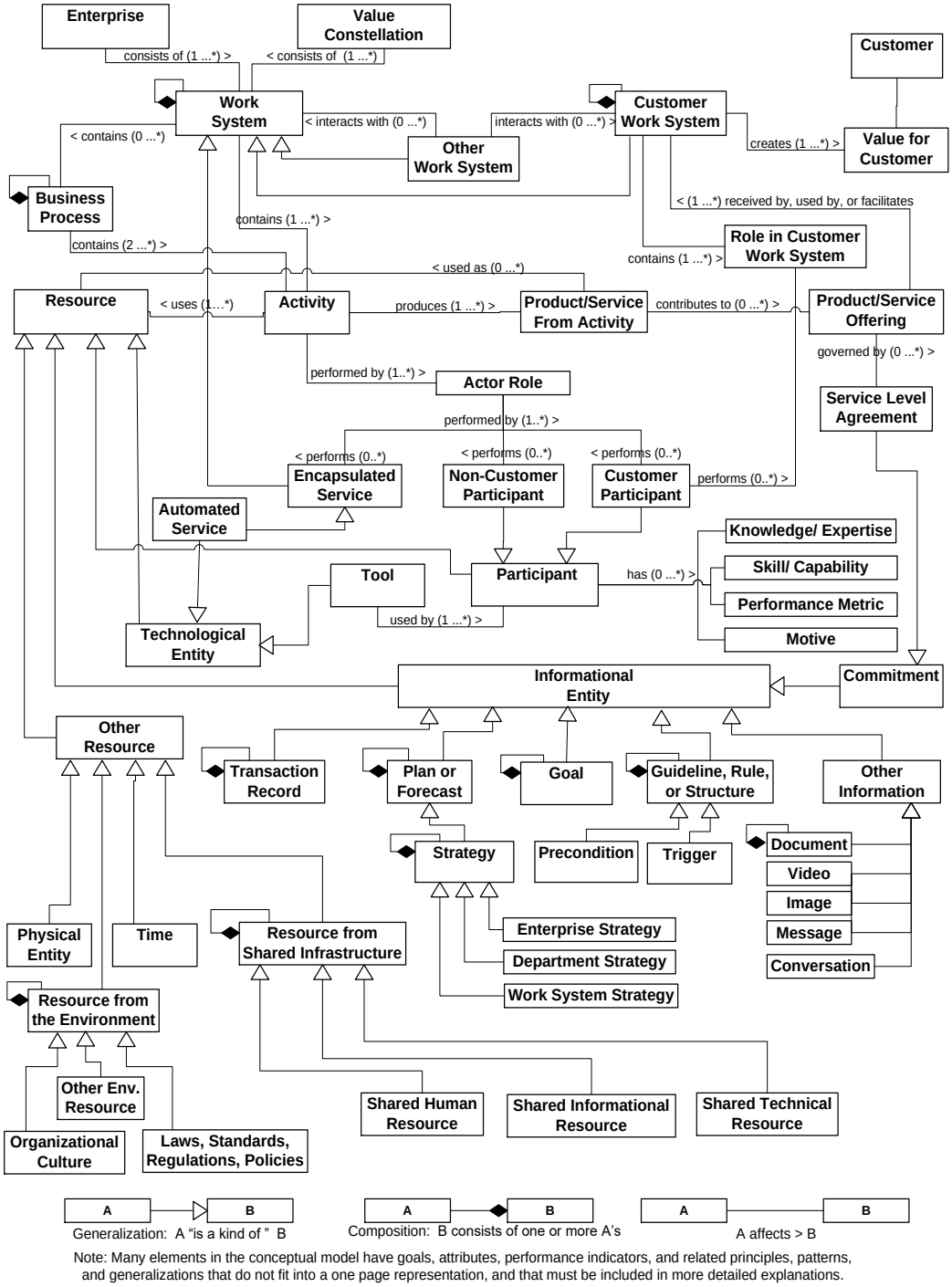
  E➔➔ None of the internal activities within a totally encapsulated service system are visible to customers. Product/services produced are basically boundary objects that are transferred to customers.
- **Product/service offerings** may or may not be governed by a **service level agreement** that is a type of **commitment.**

  E➔➔ A provider's ability to satisfy a service level agreement tends to be greater if a service is encapsulated. Increasing the extent of customer participation in activities in the service system decreases the extent to which the provider can control the outcome.
- **Resource**s used by an **activity** may include human resources (**participants**), **informational resources**, **technological resources**, and **other resources** of various types. The metamodel identifies subtypes within each resource type to minimize the likelihood of omissions in an analysis.
- Three types of **actor roles** can be involved in performing activities: **noncustomer participants**, **customer participants,** and **encapsulated services**. In medicine, a doctor is a **noncustomer participant**, the patient is a **customer participant**, and software that automatically identifies drug interactions is an **encapsulated service** that is totally automated.

  E➔➔ The metamodel refers to responsibilities indirectly. Customer responsibilities are important in service situations because customer participants often perform actor roles within provider work systems, and because value-related outcomes depend on customer work systems that produce value for customers. Both customer and provider responsibilities within a provider work system are implied by activity specifications that identify actor roles performed by customer participants, noncustomer participants, and encapsulated services. Compilation of actor roles in those categories is a starting point

for identifying customer and provider responsibilities within the provider work system. Since customer work systems often are invisible or only partially visible to providers, a provider's knowledge about responsibilities within customer work systems may go no further than guesses or beliefs.

E➔➔ Service interactions occur in any activity in which customer participants interact with noncustomer participants or the provider's encapsulated services. Using the metamodel to describe a service system reveals the extent to which that service system is highly intensive in service interactions or has few service interactions. This goes beyond generalizations about the importance of interactions.



Note: Many elements in the conceptual model have goals, attributes, performance indicators, and related principles, patterns, and generalizations that do not fit into a one page representation, and that must be included in more detailed explanations.

Figure 3. Work system metamodel, sixth version (updated from Alter, 2015)

E➔➔ Some common definitions of service assume that providers and customers necessarily coproduce services. This part of the metamodel demonstrates the limitation of assuming that services are defined by coproduction. It clarifies that coproduction occurs in any activity where both customer participants and noncustomer participants play actor roles. Defining activity as a service because coproduction is present would say yes to a 20-step process consisting of one customer request followed by 19 provider activities. It is more useful to examine the extent and form of coproduction, and ask whether more coproduction or less (i.e., less encapsulation or more) would be preferable for providers and/or customers. Changes that are beneficial for providers might not be beneficial for some customers, and vice versa.

- **Encapsulated services** may be **automated services** such as (totally automated) search engines or sociotechnical services that happen to be encapsulated, such as performing pathology evaluations.

  E➔➔ Whether totally automated or sociotechnical, an encapsulated service is launched based on a specific service request. The person or automated entity that made the request receives a response to the request but has no interaction with its execution by the encapsulated service. Encapsulated services are work systems on their own right regardless of whether they are totally automated or sociotechnical.

- The outcome of **activities** whose actor roles are performed by human participants depends on attributes of those **participants,** such as **knowledge/expertise**, **skills/capabilities**, **performance metrics**, and **motives**.

  E➔➔ A service system's customers may want to observe skill and other attributes of noncustomer participants, i.e., possibly penetrating whatever degree of encapsulation the provider prefers.

- **Technological resources** used in an **activity** may include **tools** used by **participants** (e.g., a truck) or **automated services** that perform work autonomously after being launched (e.g., a search engine).

  E➔➔ Automated services are a type of encapsulated service.

- **Informational resources** may include many types of **informational entities** such as **transaction records**, **plans**, **forecasts**, **goals**, **guidelines, rules**, **structures**, **commitments** and **other information** such as **documents**, **video**, **images**, **messages**, and even **conversations**.

  E➔➔ Challenging a provider's desire degree of encapsulation, customers may want to know about a provider's internal plans, forecasts, guidelines, rules, structures, commitments and so on.

- **Other resources** used by an **activity** may include **physical entities**; **time**; **resources from the environment** such as **organizational culture**, **laws**, **standards**, **regulations**, and **policies;** and **resources from shared infrastructure** including **shared human resources, shared informational resources,** and **shared technical resources.**

  E➔➔ Possibly contrary to a provider's desired degree of encapsulation, customers may want visibility of a provider's organizational culture, policies, and human, informational, and technical infrastructure.

- **Customer work systems** create **value for customers** using their own resources plus **product/service offerings** produced by the provider **work system**. The assumption that customer work systems create value for customers is consistent with service-dominant logic (mentioned earlier).

  E➔➔ Providers often have little visibility or access to customer work systems that create value for customers, implying that the provider has little or no visibility of how the product/services produced by the service system facilitate value creation by customers. Lack of this information is a fundamental problem for SA&D for service systems that attempt to satisfy wants and needs of external customers.

  E➔➔ The service literature contains debates about whether value co-creation is essential or optional. Service-dominant logic says "the customer is always a co-creator of value." In contrast, the metamodel reflects the view that firms facilitate value creation by customers through provision of resources for customer use. Consistent with Grönroos (2011), co-creation is optional since suppliers decide whether and how to engage directly with customers' value-generating processes. The metamodel implies that value co-creation occurs wherever value creating activities in customer work systems that create value for customer coincide with activities in provider work systems. A yes/no evaluation of the presence of value co-creation would say yes if one or more activities satisfy that criterion. Noting that more co-creation could be better or worse for providers and/or customers, it is more useful to look at the extent of co-creation and to ask whether more co-creation or less co-creation would be preferable.

E➔➔ The metamodel does not mention the customer experience, although it provides ways to describe aspects of customer experiences. Customer experiences start during any coproduction that occurs. Subsequent customer experiences occur when customer work systems receive product/service offerings and use them to facilitate value for themselves. Thus, the customer experience includes the experience of interacting with the provider and the experience of attaining value that is facilitated by product/service offerings, whether or not the provider work system is visible to customers at that point.

Conclusion: Degree of Encapsulation as an Important Topic for SA&D

Degree of encapsulation is entwined with critical service design choices as was illustrated by the example related to outsourcing and the discussions of concepts related to the service value chain framework (Figure 1) and the metamodel (Figure 3). Those design choices include the customer's visibility and access to provider service system activities, the relative responsibilities of providers and customers, the extent of co-production, the extent of value co-creation, the form and frequency of service interactions, and the form and quality of the customer experience. SA&D methods and tools should consider those topics because they are relevant to internally directed service systems through which all enterprises operate and to externally directed service systems through which enterprises serve their external customers.

Highlighting the concept of degree of encapsulation also makes it easier to understand the reason for the serious disconnect between typical marketing and computer science views of service. Stated simply, a typical computer science view assumes that encapsulation is essential in services while a typical marketing generally assumes the opposite, i.e., substantial visibility and involvement by customers.

Thus, while the entire discussion of concepts related to sociotechnical services (rather than totally automated services) may seem somewhat removed from the typical SA&D concerns, these currently overlooked concepts need to be included if SA&D is to achieve the purpose expressed by its name and espoused by its practitioners, i.e., analyzing and designing systems and improving business performance.

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