Chapter 13
A Multilayer Framework for Service System Analysis

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Abstract As service science evolves as a discipline, an important ongoing focus for research has been modeling and representing entities as service systems in order to understand, represent, and innovate within service systems. Recently, there has been interest in exploring how data and data analytics are enabling service innovations within more traditional organizations. In this chapter, we present and evaluate a multilayer framework and analysis technique that can be used to describe an organization as a service system. The framework characterizes service systems within institutional arrangements, identifies key service system components, and describes the service ecosystem, internal relationships, and value-cocreating interactions. To test and validate the framework, we present the results of using the framework to analyze a mining company as a service system and identify ways in which data-intensive technologies can be used to integrate service innovations within it.

Keywords Service systems · Analysis · Frameworks · Data-intensive systems

13.1 Introduction

An important and consistent goal of service science is to improve understanding of and innovation in service systems though the application of management, scientific, and engineering techniques (Spohrer and Maglio 2008; Maglio et al. 2009). Being able to represent organizations as service systems is an important step in understanding service systems and is necessary for improving and innovating within them. There have been several frameworks proposed for representing entities as service systems (see, for example, Katzan 2009; Spohrer et al. 2012; Lyons and Tracy 2013; Glushko 2013).

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In their review of the literature published up to 2011 on service systems and service system elements, Lyons and Tracy (2013) synthesized several existing definitions and ontologies of service system elements together into a single framework (hereafter referred to as the Service System Framework). Since that time, there have been considerable advances in service science research and organizations such as manufacturing and commodity based entities are increasingly using data-intensive techniques (artificial intelligence (AI), internet of things (IoT), bots, augmented reality, etc.) to transform to service businesses. There has also been growing research interest in how advancements in data analytics and data-intensive techniques are impacting service systems (Breidbach and Maglio 2013; Herterich et al. 2016; Borangiu and Polese 2017; Lim et al. 2018a; b). These changes and advances necessitate an update to the Service System Framework.

We started with the service system components in the Service System Framework and mapped the results from a recent systematic literature review (Frost and Lyons 2017) onto the concept matrix template of Webster and Watson (2002). The conceptual foci of the articles reviewed on the subject of service system elements were then analyzed and recorded in the concept matrix. From this conceptual analysis, we developed a Multilayer Service System Framework (MLSSF) that is an evolution of the 2013 Service System Framework. In this chapter, we present the Multilayer Service System Framework and show how it can be used to analyze a mining company that is innovating through data-intensive clean technology.

13.2 Multilayer Service System Framework (MLSSF)

The MLSSF, depicted in Fig. 13.1, is arranged in five layers: ecosystem, system, architecture, component, and typology. Each is described below.

13.2.1 Ecosystem and System Layers

The MLSSF explicitly recognizes the distinction between service ecosystems and service systems, positioning the ecosystem on a layer of abstraction above its constituent systems. The system layer decomposes into every element in the framework other than the service ecosystem, and although the only elements present on the system layer are service systems, the system layer must contain multiple service systems in order to analyze the service ecosystem.

13.2.1.1 Service Ecosystem

The service system and service ecosystem concepts are often scoped and defined with extreme similarity or perceived interchangeably (see Barrett et al. 2015;

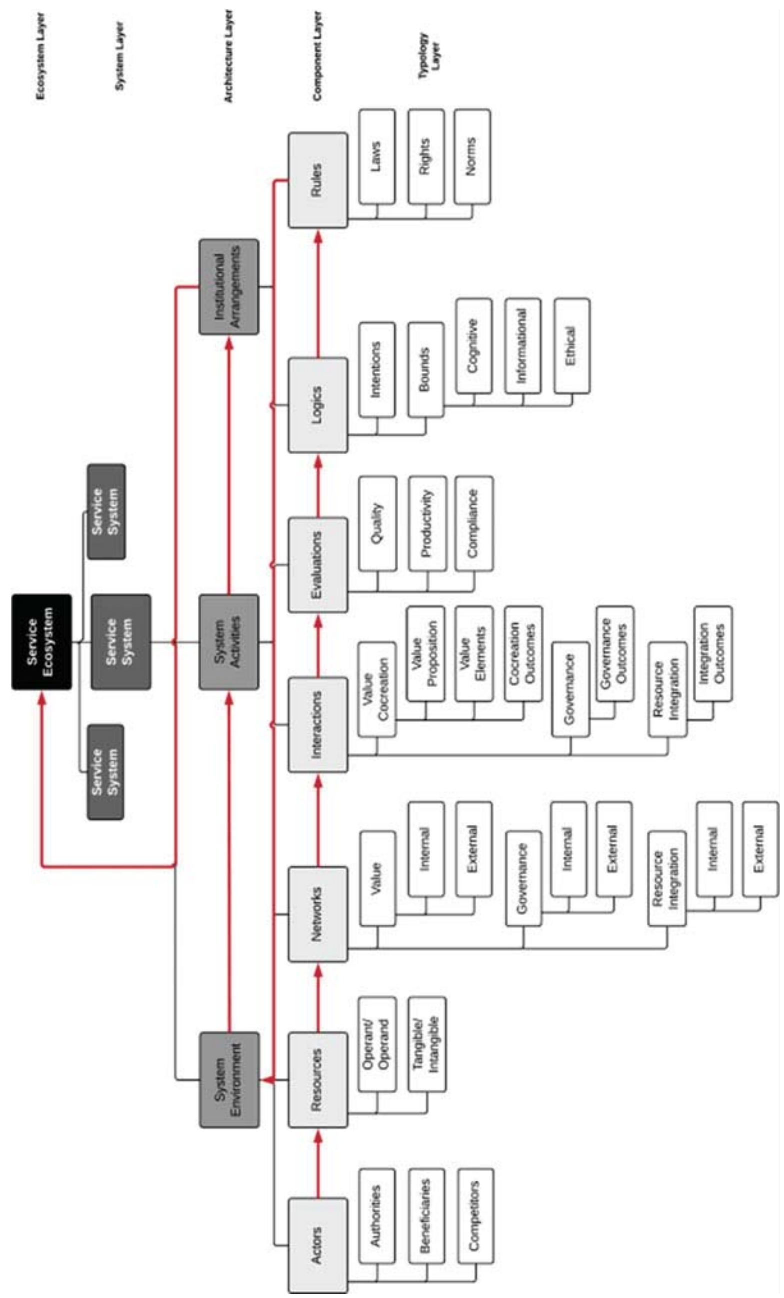


Fig. 13.1 The multilayer service system framework

Kutsikos et al. 2014; Mele et al. 2014; Wan and Zhang 2013), prompting a suggestion that future studies should more firmly demarcate the boundary between service systems and service ecosystems. The MLSSF demarcates such a boundary, observing Frow et al.'s interpretation of the service ecosystem as a "higher level system [relative to a service system]" (2014, p. 332) and Akaka and Vargo's claim that the service ecosystem enables "interaction within and among service systems" (2014, p. 371). Therefore, a service ecosystem necessarily contains more than one service system and could theoretically contain a large number of service systems. In fact, within a service ecosystem, we see the evolution of new types of service system entities and the growth of new types of entities each with its own architecture (Spohrer et al. 2012). This is especially relevant as artificial intelligence (AI), internet of things (IoT), bots, augmented reality, etc. transform the service landscape.

13.2.1.2 Service System

The definition of a service system posed by Maglio et al. is suitable for further clarifying the boundary between the ecosystem and system layers: a service system is thus observed as "an open system (1) capable of improving the state of another system through sharing or applying its resources . . . and (2) capable of improving its own state by acquiring external resources" (2009, p. 403).

13.2.2 Architecture Layer

The architecture layer and the concept of a service system architecture is not to be confused with notions of service-oriented architectures or business architectures for services—those concepts are rooted in bodies of literature which intersect with the service science literature, but are not endemic to the service system abstraction. In this context, a service system architecture is understood as a structured assemblage of interdependent components which perform a distinct, synergistic function when conjoined.

Three service system architectures reside in the architecture layer: the system environment, the system activities, and the institutional arrangements. Each of these architectures join together an assemblage of components to fulfill a function beyond the power of any one component. It is through the interdependencies and interactions that exist among the architectures that the service system as a whole attains the structure required for the system's components to operate. The three interacting architectures describe: (1) the *system environment* or "stuff" that give it the ability to be or act as a service system; (2) the *system activities* that get carried out in its role as a service system; and, (3) the *institutional arrangements* that define the ways in which it conducts itself as a service system.

13.2.2.1 System Environment

The system environment is a structured collection of static elements (resources, actors, and networks) which provide the preconditions and venue required for interaction and evaluation. The elements in the system environment (for example, the identities of actors or the reach of networks) are only "static" in a snapshot of the service system; the environment gradually evolves through iterative interaction and evaluation, but its growth moves more slowly than the rapid and frequent movements found in the system activities architectural component.

The concept of the system environment is essentially an adaptation of Lusch and Nambisan's (2015) conception of a service platform. Lusch and Nambisan define the service platform as "a modular structure that comprises tangible and intangible components (resources) and facilitates the interaction of actors and resources (or resource bundles)" (2015, p. 166). The system environment possesses all of those qualities: it is modular, containing resources as one of its classes of components; it is a structured assemblage; its component networks not only facilitate interaction, but provide the venue in which actor-resource interactions occur. However, the service platform is conceived of as a limited stage for service innovation rather than service provision and it does not afford any interaction types other than resource integration interactions. It functions as an expanded version of the service platform, providing the structure and functionality needed to support resource integration, value cocreation, and governance interactions, as well as evaluations. Additionally, a system environment is a more appropriate analogy for the concept than platform, conjuring a vision of the setting in which activities and relationships are embedded.

13.2.2.2 System Activities

The system activities is the full universe of relationships which exist among actors, resources, and networks within a given service system whereas a service ecosystem is a collection of service systems with its own higher-level activities architecture which includes the lower-level service activities of its constituent systems. The system activities architecture should not be confused with networks, which are components of the system environment architecture. Networks are bridges between actors or between actors and resources, whereas the function of the system activities is to enact the actual interactions and evaluations which cross those bridges.

13.2.2.3 Institutional Arrangements

The institutional arrangements architecture and its components are defined as a set of institutions "nested in multiple levels of social systems" (Vargo et al. 2015, p. 67). In turn, an institution is a set of "humanly devised rules, norms, and meanings that enable and constrain human action" (p. 64). Each actor in a service system brings their own institutions to the system, collectively assembling institutional arrangements. Examples actor types (each with their own institutions) include authorities, beneficiaries, and competitors. Important types of authority actors are federal or national governments which have powers of coercion associated with their institutions.

Institutional and sociological perspectives are becoming more prominent in the service science literature (Frost and Lyons 2017). Vargo and Lusch (2016) consider institutions to be the coordinating mechanisms of value cocreation. The function the service system's institutional arrangements is twofold: the arrangements infuse actors with bounded rationality and intentionality through institutional logics, and the arrangements set rules which impose social boundaries on actor behavior. Applying institutional logics and rules to actors has a cascading effect throughout the system environment and system activities, causing every resource, network, interaction, and evaluation to be shaped by the motivations and limitations infused into actors by the institutional arrangements. Through their gradual co-evolution, the system environment and activities can together reciprocate that change, re-shaping the institutional arrangements as new logics and rules are formed over the course of many interactions and evaluations.

13.2.3 Component and Typology Layers

The component layer sits underneath the architecture layer and identifies key components within each architecture (for example, actors, resources, and networks are components of the system environment architecture). Components within the MLSSF are granular, interactive constructs serving a specific purpose in performing the service system's operations. The typology layer resides below the component layer—at the very bottom of the taxonomy—and defines the typology of component types, which are the differentiating characteristics possessed by different components, and sub-types, which differentiate types. For example, resources are a key component of service systems and, in the MLSSF, sit under the system environment architecture. Resources have different types (in the typology layer of the MLSSF): operant or operand and tangible or intangible.

Together, assemblages of particular components form architectures, which reside in the architecture layer above the component layer. It should be noted that while component types are used to separate components into different conceptual categories, the relationship between architectures and components is not the same: components are integral parts of architectures which must all be present for the service system to operate, whereas types add context and features to components. Components and component types receive discussion in nearly all of the recent service science literature (Frost and Lyons 2017), and in the MLSSF, they remain as important to the service system as ever.

In total, the MLSSF identifies seven components and 34 component types/sub-types (see Fig. 13.1). The system environment architecture is composed of the actors, resources, and networks components. The system activities architecture is composed of the interactions and evaluations components. The institutional arrangements architecture is composed of the logics and rules components. In the remainder of this section we describe each component, each component type/sub-type, and how the definitions were influenced by the literature.

13.2.3.1 Actors

In the Service System Framework (Lyons and Tracy 2013), entities were defined "resource integrators that enable exchange for the purpose of value cocreation within or between service systems" (p. 21), and stakeholders were observed as "a perspective rather than an entity such that a service system entity can maintain multiple stakeholder perspectives" (p. 22). The MLSSF synthesizes the ontological features of entities and stakeholders, observing actors as intentional agents with (1) resource-processing, value-processing, governance, evaluation, and communication capabilities, and (2) distinct stakeholder perspectives. In this context, the concept of an intentional agent is derived from Lessard and Yu's re-conceptualization of service system entities as intentional agents, defined as "social entities that depend on one another to reach their goals; they thus intentionally enter in relationships with one another to improve their well-being" (2013, p. 69).

The entity and stakeholder components were sometimes regarded as ambiguous in the literature, with the components and their features treated interchangeably (see Maglio and Spohrer's (2013, p. 667) use of the term "stakeholder entities" as well as Mele et al. (2014) and Golnam et al. 2012). Furthermore, discussions of actor-network theory have been observed in service science literature (Frost and Lyons 2017), and in one article, different entity types were described before abandoning the concept altogether and adopting the language of actors and actor-networks instead (Frow et al. 2015, p. 464).

It is important to note that terminology is discipline dependent. The choice of the term "entities" derives from its preferential use in law. The term "actors" is more prominent in social sciences such as economics and behavioral sciences. In computer science, the term, "actor" refers to human and non-human actors. The use of the term entity signals that legal aspects of service systems are important; after all, the main characteristic of a person (a key resource in every service system) is rights and responsibilities and every service system has a focal resource, a person, who takes responsibility. Taking a more general perspective, we consider Vargo and Lusch's (2016) claim that institutions and institutional arrangements are "actor-generated" (p. 8) as signalling the need to develop a unified intentional agent construct in order to make the service system abstraction more compatible with institutional and sociological perspectives. The actor is such a construct, possessing intentionality as well as the resource-processing, governance, and communication capabilities.

The MLSSF includes three types of actors: authorities, beneficiaries, and competitors. Authorities regulate and control the operations of the service system, evaluating compliance, participating in governance interactions, and modifying institutional rules through governance networks. Government entities and regulatory agencies are examples of authority actors. Beneficiaries are actors which use resource integration networks and value networks to integrate resources with the assumption that doing so will ultimately result in successful value cocreation and mutual benefit. Beneficiaries can be socially contextualized as individuals, groups, organizations, communities, nations, or any other group of individuals. Previously, beneficiaries were divided between the customer and provider stakeholder types, as well as the customer, provider, and producer entity types (Lyons and Tracy 2013). However, upon closer analysis, the division between customers and providers appears to be a vestige of goods-dominant logic: in a mutual cocreation of value, both beneficiaries come to the table with a value proposition and act as customers and providers simultaneously (Vargo and Lusch 2016). When analyzing stakeholder perspectives, especially in legal or liability contexts, it is important to describe and clarify roles within the beneficiary category (that is, provider or customer).

In opposition to beneficiaries, competitors are the actors who are disadvantaged by a given value cocreation interaction, though they are not directly involved in the interaction themselves. Competitors do not necessarily have to be businesses that are financially disadvantaged by one another's value cocreation interactions—social enterprises, governments, or communities can be disadvantaged by one another's success in the sense that improved performance in one actor or group of actors compels competitor actors to improve their performance if they wish to preserve their public image. In some cases, a social enterprise, government, or community may not have the resources to keep pace with the improvements of its competitors, putting it at a disadvantage which jeopardizes its image.

13.2.3.2 Resources

The conceptualization of the resources component in the MLSSF remains the same as in the Service System Framework, "the things that are exchanged for the purpose of creating value" (Lyons and Tracy 2013 p. 20); however, the number of resource types has been significantly reduced in order to improve the usability and versatility of the framework. Access rights determine how resources can be used in the exchange. The fundamental distinction between operand and operant resources remains, and another fundamental distinction between tangible and intangible resources has been added. However, the physical/conceptual distinction from the previous framework was not included in the MLSSF due to its being difficult to interpret in many use cases. For example, information can simultaneously have both a physical and conceptual instantiation; a computer program can be interpreted as a physical object that appears on a screen after being processed as electrical signals, but it can also be interpreted as conceptual, algorithmic structure. To simplify the framework, sub-types such as people, organizations, shared information, and technology were removed. Those sub-types are examples of instances within categories and it can be difficult to produce an exhaustive list of resource instances so we do not include an instance list in the MLSSF. Using two dichotomies of operand/operant and tangible/intangible offers the framework's users more simplicity and flexibility in analysis. This does not mean that sub-types such as physical/non-physical and rights/no rights should not be considered in analyses.

13.2.3.3 Networks

Defining networks as structural clusters of pathways between actors, resources, and institutions through which interaction and evaluation occur affirms the component's role as the bridge between the system environment, system activities, and institutional arrangements architectures.

The networks component has three types: value networks, governance networks, and resource integration networks. Value networks are interpreted as the set of pathways through which value cocreation interactions can occur. Governance networks are interpreted as the set of pathways through which governance interactions and evaluations can occur between actors, resources, and institutions. Resource integration networks are interpreted as the set of pathways through which resource integration interactions can occur between actors and resources.

Each of the network types has an internal and external qualifier as its two sub-types. Internal networks can be thought of as the structures which bridge the system environment, system activities, and institutional arrangements architectures. External networks can be thought of as the structures which bridge a given service system with the system environment, system activities, and/or institutional arrangements of an external service system. In this way, external networks are the key to connecting and interfacing service systems under the umbrella of a single service ecosystem.

13.2.3.4 Interactions

Interactions are the processes through which actors exercise their capabilities to cocreate value, integrate resources, and govern. The importance of resource integration was asserted throughout the reviewed literature (e.g. in Vargo and Lusch 2016; Edvardsson et al. 2015; Laud et al. 2015; Lusch and Nambisan 2015; Siltaloppi and Vargo 2014), with Siltaloppi and Vargo defining resource integration as a process which "… captures the broad range of interactive [emphasis added] behaviors in which an actor or a service system applies knowledge and skills, in conjunction with other available operant and operand resources, to improve the state of others, and reciprocally, the state of oneself" (2014, p. 1279). The evolutionary motivation for performing high-productivity resource integration will be discussed in greater detail in outlining the evaluations component. It is clear that resource integration represents a distinct type of actor-to-resource interaction which supports value cocreation, whereas value cocreation represents an actor-to-actor interaction.

Outcomes are a feature of value cocreation interactions, not a component distinct from interactions, as the word "outcome" implies that some process (in this case, an interaction) must have preceded it. Although it is not visualized in Fig. 13.1, the breakdown of potential outcome results derived from Maglio et al.'s (2009) ISPAR model shapes the range of potential value cocreation outcomes in the MLSSF. The MLSSF divides the concept of outcomes into value cocreation outcomes, governance outcomes, and resource integration outcomes. At this time, the potential range of governance outcomes and resource integration outcomes remains unexplored, presenting an interesting direction for future research.

13.2.3.5 Evaluations

Evaluations are the processes through which actors exercise their capabilities to evaluate performance measures in order to evolve the service system in future interactions. The evaluations component is positioned within the system activities architecture because an evaluation is a dynamic relationship between an actor and another actor, a resource, or an institution; an evaluation is not a static element. It is separated from the interactions component because an evaluation can potentially be a one-way assessment or unreturned observation, in which case it is not interactive. The evaluations component has an important purpose which was not acknowledged in the service system framework of Lyons and Tracy (2013): evaluation serves as the evolutionary mechanism of the service system. Understanding how evaluation leads to evolution in service systems is an opportunity for future research.

Evaluations of quality and productivity can be conducted by any actor type, but are usually conducted by either beneficiaries or competitors. Quality evaluations typically measure the performance of beneficiaries and competitors in operating value networks and enacting value cocreation; productivity evaluations typically measure the performance of beneficiaries and competitors in operating resource integration networks and enacting resource integration. Evaluations of compliance can be conducted by any actor type, but are usually conducted by authorities. Evaluations of compliance typically measure the performance of beneficiaries, governance networks, governance interactions, and rules.

Innovation is a consequence of repeated evaluation and repeated adaptation of the service system in response to evaluation. By iteratively evaluating the system's performance and adjusting intentions after the evaluation process, actors naturally evolve themselves along with the rest of the system environment, the system activities, and the institutional arrangements. Furthermore, measures that are used to evaluate service systems are an example of kind of resource within the system environment of the service system.

13.2.3.6 Logics

In the context of a service system, logics consist of the intentions of the actors participating in the system and the epistemological boundaries that constrain their reasoning. Commonsense reasoning varies with cultures, including conceptions of time. Understanding the ways in which different reasoning affects logics and intentions in service systems is an interesting area of future research. As Lessard and Yu note of the prevailing conceptualizations of a service system, “a key aspect that has not been addressed is the strategic, intentional motivations that drive service system interactions” (2013, p. 69). The logics component—and more broadly, the institutional arrangements architecture—fills that gap in the literature, granting actors with goal-oriented intentionality, rational judgment, and bounds on that rationality. More work is needed that looks into institutional perspectives in service systems such that the relationship between logics and other components can be explored in more detail, and different typological features of intentions can be specified. Lessard and Yu hint at some of those potential features in stating that the intentionality within a service system can be broken down into high-level interests, expected benefits, value propositions, and perceived value. However, for the time being, the interpretation of intentions is largely being left open to framework users, allowing for new developments in the literature to be applied to the intentions element on an as-needed basis.

Three types of bounds are identified: cognitive, informational, and ethical. These bounds on logics are borrowed from Simon’s (1976) work on bounded rationality, in which the decision-making of rational actors is limited by the cognitive abilities, the information available to them, and their ethics (conceived of by Simon as the “values” actors associate with potential behaviors, though this sense of the word would be confused with service science’s concept of values if it were imported into the MLSSF). As a result, the performance of actors in the service system is limited by their ability to process information resources (and other resources), the amount of resources available to them (especially information resources), and their ethical values which prohibit them from enacting what they would consider to be unethical or non-valuable interactions.

13.2.3.7 Rules

Rules are the social boundaries that constrain the behavior of the actors participating in the service system. They are separate from bounds on logics in that logical bounds are epistemological constraints, whereas rules are social constraints which limit the range of acceptable social behaviors. The MLSSF specifies three types of rules: laws, rights, and norms. Laws can refer to the boundaries on social behavior imposed on the public by governments, but they can also be understood more broadly as rules which “ensure compliance to regulations or policy” (Lyons and Tracy 2013, p. 21) in the context of an organization’s internal regulations and policies. Rights can be thought of as the permissions afforded to actors by authorities to access and use resources and networks. Norms are a type of rule which are not formally decreed by an authority—rather, they are culturally embedded, tacit expectations of social behavior. Including norms in the MLSSF allows for a consideration of how culture impacts the service system's interactions. It also makes the framework more closely aligned with Laud et al.'s (2015) assertion that the structural, relational, and cultural embeddedness of service system actors must be considered in order to fully understand the system activities.

13.2.4 Analysis Sequence

Descriptive analysis approaches can be strengthened with the addition of prescriptive methods, as the former describes the nature of a target of analysis and the latter specifies an ideal methodological process for analyzing it (Frost and Lyons 2017). Before beginning any service system analysis, it is important to determine the goal of analysis, scope the operational boundaries of the service system, and adjust the approach to analysis accordingly, but the analysis sequence proposed here should serve as an initial guidepost for the analysis process.

In their study of service value networks, Wang et al. (2015) prescribe an approach for analyzing service value networks which involves defining the objectives of the analysis, then identifying actors in the network, and then determining what interactions exist between the actors. Patricio et al. (2011) prescribe a multilevel service design method in which service concepts are first defined, then the service system's structure is modelled, and finally, the interactive aspects of service encounters are designed using service blueprinting techniques. In both articles, components of what might be considered the system environment are analyzed before components of the system activities. This is simply due to the nature of the architectures: it is extremely difficult to map out and analyze interactions before mapping out and analyzing the actors, resources, and networks which are performing the interactions. With the inclusion of an institutional arrangements architecture, a similar problem emerges: it is difficult to map out and analyze the logics and rules governing actors, resources, and their interactions without first identifying the actors, resources, and their interactions. Therefore, an analysis using the MLSSF should first describe components of the system environment, then describe components of the system activities and how they relate to those of the system environment, and finally, describe components of the institutional arrangements and how they relate to those of the system environment and activities.

The next decision to make in the analysis methodology is which component of the system environment should be analyzed first. Making that decision and identifying specific examples of components within the service system can be facilitated by considering how each component answers a question pertaining to the service system's operation: (1) Who operates the service system? or Who is the focal actor of the service system, or the focal role that is filled by a person who has rights and responsibilities (fiduciary rights and responsibilities) to ensure the success of the service system? (Actors); (2) What is used to operate the service system? (Resources); (3) How does the service system operate? or What are the value propositions (links in the network) that connect the service system entities, and what are the access rights to resources granted or denied by those value propositions? (Networks).

Depending on the needs of and information available in a given analysis, the "who", "what", and "how" questions may have different degrees of importance. Generally, if sufficient information about all three components is available, analyzing actors first will enable easier identification of resources with reference to the basic operational needs of the actors. Similarly, analyzing networks after resources will enable easier identification of networks with reference to basic interaction needs of the actors and resources. In all three cases, considering the bearing of component types and sub-types on the service system will yield a more fruitful analysis.

Progressing into the system activities and institutional arrangements, two more questions should be considered: (1) When does the service system operate? (During interactions and evaluations); (2) Why does the service system operate? or In what circumstances does a service system become established? (Within logics and rules). Analyzing interactions and their types/sub-types after networks enables identification of how the networks are used by actors and resources, and asking the "when" question can be a helpful exercise for identifying specific examples of interactions that exist in the system activities. Analyzing evaluations after interactions allows for a basic understanding to be established of how actors evolve the system by evaluating its performance across iterative interactions. The intentions of actors in evaluating and evolving the systems segues neatly into an analysis of institutional logics. Again, asking the "why" question can be a helpful exercise for identifying specific examples of actor intentions and determining the bounds of their logics. Finally, the logics can be further bounded by analyzing the rules which govern the operation of the service system and impose order upon it.

Components are the traditional foundation of service systems, and a descriptive analysis of a service system can be performed solely with reference to the component and typology layers. However, after analyzing the service system's institutional arrangements, proceeding upward to analyze at a higher level of abstraction in the architecture layer can trigger new thinking related to the overarching relationships between the architectures. If more than one service system is under analysis, progressing all the way up to the ecosystem layer will also be necessary.

In summary, the prescribed sequence of analysis has 13 steps:

1. Identify the goal of the analysis.
2. Scope the operational boundaries of the service system.
3. Analyze the actors and identify key actors.
4. Analyze the resources and identify key resources.
5. Analyze the networks and identify key networks.
6. Analyze the interactions and identify key interactions.
7. Analyze the evaluations and identify key evaluations.

8. Analyze the logics and identify key logics.
9. Analyze the rules and identify key rules.
10. Analyze the system environment architecture and describe its key features.
11. Analyze the system activities architecture and describe its key features.
12. Analyze the institutional arrangements architecture and describe its key features.
13. If more than one service system is being analyzed, analyze the service ecosystem and describe its key features.

Figure 13.1 illustrates the prescribed analysis sequence by overlaying arrows on the framework's taxonomy. After or during the analysis process, it may also be helpful to use modelling or diagramming techniques to build a better understanding of the relationships among the service system's elements.

13.2.5 Applying the Multilayer Service System Framework to a Mining Company

To test and validate the framework, the analysis was applied to a Canadian mining company using publically available information (Donohue 2017). Mining has typically been seen as a non-service industry; however, as our analysis shows, from a service science perspective, the mining company is a service system in that multiple stakeholders within the organization bring actors, knowledge, resources, and processes together to cocreate value. As an adaptive innovator (IfM and IBM 2008), the organization is the first mining company in Canada, and one of the first mining companies worldwide, to implement CleanTech into their operations by creating an all-electric underground mine (Donohue 2017). Creating an electric mine is beneficial for multiple reasons: the organization receives funding from government incentive programs; their environmental impact is reduced since electricity is a clean energy source and much quieter for operations; batteries change the way machines operate; and, this innovation will completely restructure heating, ventilation, and air conditioning (HVAC) systems underground—giving rise to new infrastructure such as electric-powered heating (Donohue 2017). Most importantly, having an electric fleet will mean that there are no pollutants released underground—making the working environment much safer for workers. Alongside reduction of waste, the company predicts a 20% increase in production once the mine is complete (Donohue 2017). Within the organization, they will break down geographical silos (individual mines) by implementing electricity as an energy source to other mines once the project is complete.

13.2.5.1 Prescribed Application of the Framework

Below, we follow the 13 steps in the prescribed sequence of analysis to analyze the mining company as a service system.

Table 13.1 Key actors

Key actors	Role	Description
Machinery Companies	Beneficiary	Provides machines, installs sensors, analyzes data provided by the mining company to improve operations of the machinery
Regulatory Bodies	Authority	Determines constraints (e.g., environmental, jurisdictional) on the ways mining can take place
Energy Providers	Beneficiary	Provides energy to the mining company, collects data on energy use, analyzes data to optimize energy use
Other mining companies	Competitor	Competes for highly skilled personnel, resources, etc.

1. ***Identify the goal of the analysis.*** The goal of the analysis is to apply the service system framework to the mining company to test the framework's ability to describe the company as a service system and to show how the analysis can help identify unique aspects of the company and its service capabilities.
2. ***Scope the operational boundaries of the service system.*** The main service system under consideration is the mining organization including its processes, infrastructure, resources, knowledge, and employees. Since the larger context of this analysis considers the company's transition to CleanTech, other service systems within the service ecosystem must be considered when discussing resources, networks, interactions, etc. because it is through these interactions and resource integrations that value is being cocreated.
3. ***Analyze the service system's actors component and identify key actors.*** Actors within the service system associated with this CleanTech project (e.g. the machinery companies and energy providers) can be considered as beneficiaries. By working with the mining company, there is cocreation of value that will result in mutual benefit. Other mining companies can be viewed as competitors—these companies are compelled to improve their performance to preserve their public image in response to CleanTech initiatives (Table 13.1).
4. ***Analyze the service system's resources component and identify key resources*** (Table 13.2).
5. ***Analyze the service system's networks component and identify key networks*** (Table 13.3).
6. ***Analyze the service system's interactions component and identify key interactions.*** Identifying all the interactions (even just the key interactions) within the scope of the CleanTech implementation would not be feasible here; however, in the context of a full analysis, it is necessary to identify all key interactions and possible outcomes. The ISPAR model is a useful tool for analyzing the breakdown of potential outcome results and the range of possible value cocreation outcomes (Maglio et al. 2009). Figure 13.2 shows a sample interaction between the company and three other service systems (regulatory bodies, machinery providers, and energy providers). There are multiple exchanges between the service systems. The company itself is broken down to show one of the many resources—the miners. This is further decomposed into the outcomes specific to the miners. Finally, these outcomes yield value—cocreated with the services

Table 13.2 Key resources

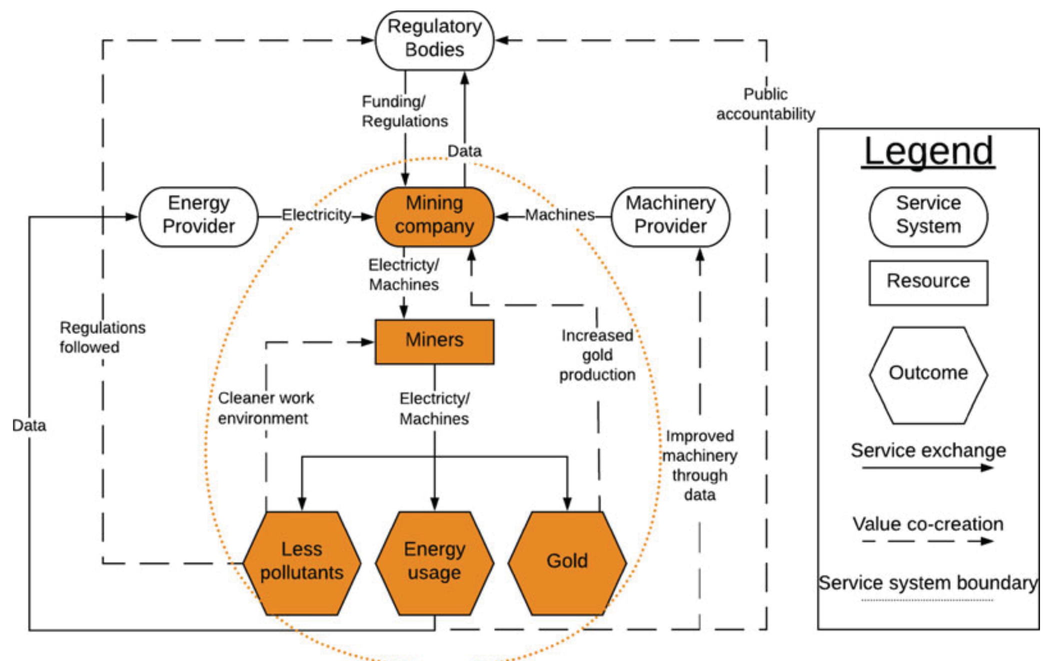
Key resources	Description	Operant/Operand	Tangible/ Intangible
Miners, data analysts, business analysts, engineers	Knowledge, skill, competencies	Operant	Tangible
Electric-powered mining machines	These mining machines will run on electricity drawn from a battery	Operant (mines for gold) and Operand (acted on by humans)	Tangible
External batteries	Used to power the mining machines	Operant (powers the machines)	Tangible
Gold	The main function	Operand	Tangible
Mining knowledge	Employees have tacit knowledge about mining and machinery	Operant	Intangible

Table 13.3 Three key networks within the service system and service ecosystem

Value cocreation	1. Increased mining production from more efficient machinery interacting with the mine 2. Consulting service interactions to carefully plan and design for a smooth implementation
Governance	1. Decreased environmental impact measured through digital monitors in machinery to comply with government standards 2. Contracts with machinery and consulting service providers outlining terms of service
Resource integration	1. Miners use electric mining machines which decrease pollutants in the mine and creates a safer working environment, data is sent back to the machinery companies 2. Data analysts take mining data gathered from machines and suggest new mining processes to improve efficiencies and increase gold output

provided by the service systems—which benefit many of the service systems. Note that the interactions and resource integrations modelled in Fig. 13.2 are by no means exhaustive.

7. ***Analyze the service system's evaluations component and identify key evaluations.*** For the three evaluation types (quality, productivity, and compliance), multiple actors are invested across more than one of the evaluation types. Table 13.4 shows a breakdown of the key actors and the associated evaluation types. For example, the regulatory bodies are most interested in evaluations of compliance (operational, environmental, data, privacy, etc.)
8. ***Analyze the service system's logics component and identify key logics.*** The variance among logics (intentionality, rational judgement, and bounds on rationality) is too wide-ranging to consider here. It is more practical to assume that all the actors are working with the organization's intentions (Table 13.5). In this scenario, the goal-oriented intentionality is applicable; however, the bounded rationality types are not applicable due to the highly theoretical nature of that element.



*Note: The service system boundary shows a partial breakdown of the mining company as a service system. In this case, the actor and outcomes are all a part of the mining company. As a part of the larger service system, the actor and outcomes are co-creating value and exchanging services with other service systems (e.g. Regulatory Bodies) in the service ecosystem.

Fig. 13.2 Interactions within the service ecosystem with a breakdown of actors, resources, outcomes, and value cocreation interactions

Table 13.4 Key actors and their evaluation interests

Service systems	Key evaluation interests
Regulatory Bodies	Compliance
Machinery Provider	Quality, Productivity
Energy Provider	Quality, Productivity
Consultants	All
Regulatory Bodies	Compliance

Table 13.5 Actors interacting with the mining company and their logics

Service systems	Key logics and intentionality
Mining Company	Increase mining production, decrease environmental impact
Regulatory Bodies	Decrease environmental impact, public accountability
Machinery Provider	Increase machinery sales, improve machinery production
Energy Provider	Increase energy sales
Consultants	Provide knowledge, receive experience

Table 13.6 Breakdown of rules within the mining company with examples

Rules	Examples
Laws	Employment contracts, by-laws
Rights	Miners given access to data reports compiled by data analysts
Norms	Any part of organizational culture (e.g. weekly staff meetings)

9. ***Analyze the service system's rules component and identify key rules.*** Within rules, there are laws, rights, and norms. Table 13.6 provides examples of these rules. Since the basis of the system and ecosystem is "for profit", many business dealings will be in the form of written formal contracts.
10. ***Analyze the system environment architecture and describe its key features.*** The system environment is very robust with clear distinctions between actors, resources, and networks. Each component answers an important question about the service system's operations and has a comprehensible role within the system environment. The actors and resources are all key features of the environment—which in turn means that the network is also a key component. However, the system environment is described as a combination of static elements which is not the case for the network. The constant value cocreation, governance interactions, and resource integrations would inevitably bring change to those processes (otherwise the organization itself becomes static without progress).
11. ***Analyze the system activities architecture and describe its key features.*** The system activities include the interactions and evaluations. We did not conduct a detailed analysis of the interactions (value cocreation interactions, governance interactions, and resource integration) but described a sample interaction between the company and three other service systems (regulatory bodies, machinery providers, and energy providers). We found it helpful to break down the interaction to show one of the many resources and then decompose

the analysis to a specific key resource in the service system. For the evaluation component of the system activities architecture, we found that multiple actors are invested across more than one evaluation type. The system activities architecture is a complex one that requires significant detailed knowledge of the interactions and evaluations in the service system.

12. ***Analyze the institutional arrangements architecture and describe its key features.*** The institutional arrangements architecture, consisting of the logics and rules, was a useful analysis for determining high level institutional constraints on the actors. For this architecture to have a meaningful impact, the analysis would have to look at actors individually. For example, what logics and rules motivate and constrain machinery providers when installing sensor technology? However, since logics and motivations are different for multiple iterations of the same role it is challenging to map all of the institutional arrangements architecture in this particular case.
13. ***If more than one service system is being analyzed, analyze the service ecosystem and describe its key features.*** The mining company's interactions within the service ecosystem was the main point of focus in this case study. By considering the activities within the ecosystem (not the individual service system activities), it is much easier to envision the interactions, value cocreation interactions, resource integrations, and logics. Each architecture mapped to the service ecosystem level would be extremely useful to understand a case study such as this one.

13.2.6 Reflection of the Process and the Results

An overall analysis surrounding the key features of the environment, activities, institutional arrangements, and ecosystem provides the analyst an opportunity to bring together the different components to consider how they function together. As shown above, it also provides a platform for reflection about the ease of recognizing the different components and their cohesion with the other components. We were also interested in evaluating the MLSSF for analyzing non-traditional service organizations (such as a mining company) as a service system. In the context of this service system, some of the components (and thus the architectures) were difficult to assess. Many of the resource integrations and collaborations under focus were among two or more different service systems (actors) and not within the mining company. This is an important point to note because it shows how much value is being cocreated within the ecosystem. This also suggests that some of the important aspects to consider when analyzing a non-traditional service organization are the ways in which it is situated within an ecosystem and so a focus for analysis should be at the ecosystem and system layers.

13.3 Conclusions and Future Development

A Multilayer Service System Framework for analyzing organizations as service systems was presented. The application of the MLSSF to a mining company identified the several suggestions for future development of the framework. The relationships between elements could be explained in greater detail and perhaps visually mapped out so as to better illustrate their significance. This is especially true of the interplay between institutional arrangements and all of the framework's other architectures and components—institutional perspectives have been addressed in the service science literature only recently, and the full extent of their relationships with other service system elements is not yet fully understood. As the state of the literature progresses, more detailed models of the relationships between institutions and service system elements may arise, and those models could be considered for integration into the MLSSF.

Practical applications of the framework to case studies are needed to further validate its ontology and methodological prescriptions. The findings of the case studies can then be used refine the framework.

There are many opportunities for this framework to evolve from prescriptive to evaluative. One way is to incorporate the idea of turning services and data into value and providing soft benchmarks for organizations to compare. The Lim et al. (2018a) data framework provides a good starting point for this objective by looking at the taxonomy and breaking down how value is created from data. By combining ideas from the MLSSF and the data framework, organizations could be evaluated on their position as a service system within a service dominant landscape as well as the efficiency and effectiveness of their data-intensive services.

In keeping with the ethos of service system framework, future literature reviews will need to be conducted periodically to develop evolutions of the framework and its relevancy to emerging trends.

We also identified areas for future research in service science. There is an opportunity for future studies to better demarcate and understand the boundary between service systems and service ecosystems Other areas for future research on service systems include understanding the ways in which different reasoning affects logics and intentions in service systems and understanding how evaluation leads to evolution in service systems. Finally, an area that remains unexplored is a study of range of governance outcomes and resource integration outcomes in service systems.

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