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Abstract. Service research has evolved into an interdisciplinary research field that bridges diverse disciplines, including information systems (IS) and marketing. Nearly two decades ago, the service system concept was introduced as a foundational abstraction in service research, drawing on ideas from the service-dominant logic (S-D logic) of marketing. Despite its widespread adoption in service-based IS research, the service system concept lacks a solid theoretical foundation, resulting in conceptual ambiguities and overlaps with related constructs, such as service ecosystems. Moreover, it has largely remained a static analytical lens, insufficiently addressing dynamic service phenomena, including value co-destruction. To address these limitations, we propose Luhmann's systems theory (LST) as a robust explanatory framework for conceptualizing service systems as autopoietic (self-creating) systems in which communication serves as the fundamental mechanism that drives value co-creation. We derive five theoretical propositions from this re-conceptualization that clarify conceptual ambiguity and allow researchers to explore dynamic service phenomena in greater depth. Due to the general approach taken by LST, our conceptualization provides a theoretically grounded and interdisciplinary foundation for advancing service research.

1 Introduction

Over the recent three decades, research interest in service and the service sector has steadily grown across disciplines, including marketing, information systems (IS), mechanical engineering, computer science, and many more. Reflecting a general shift from production economies towards information and service economies (Castells, 2010), two powerful academic initiatives guided the interdisciplinary service research over the last two decades in particular: First, the service-dominant logic of marketing (S-D logic) reframed the dominant conceptualization of value creation, moving it from goods exchange to service-for-service exchange and challenging classical economic concepts that regarded service as unproductive labor (Vargo & Lusch, 2004). Second, the introduction of the service system concept substantiated IBM's quest to establish a new science of service as an academic discipline that educates future leaders to create value, resolving the duality of goods and services with a unified paradigm for value creation (Chesbrough & Spohrer, 2006; IBM, 2011; Lusch et al., 2008). Together, these initiatives left a strong legacy, establishing a new vocabulary for interdisciplinary research on service, management, and marketing.

During this time, the service system concept was proposed as the fundamental unit of analysis in service research, defined as "a configuration of people, technologies, and other resources that interact with other service systems to create mutual value" (Maglio et al., 2009, p. 395). However, the concept's theoretical underpinnings remained unclear, providing only loose references to general systems theory (GST) as a "foundation for thinking about the formal structure of service systems" (Jim Spohrer et al., 2008, p. 8). Perhaps due to this lack of theoretical embedding into a general theory about the structures and dynamics of systems, the concept has since drifted in its meaning and purpose. Taking an "institutional and dyad-to-network-to-systems turn" (Vargo & Lusch, 2016, p. 6), recent works particularly highlight the importance of a service ecosystem perspective "to allow a more holistic, dynamic, and realistic perspective of value creation, through exchange, among a wider, more comprehensive (than firm and customer) configuration of actors" (Vargo & Lusch, 2016, 5f). In this context, a service ecosystem is generally understood as a "relatively self-contained, self-adjusting system of resource-integrating actors connected by shared institutional logics and mutual value creation through service exchange" (Vargo & Akaka, 2012, p. 207), emphasizing their complex and dynamic nature and the relevance of institutions (rules and norms) for co-creating value (Letaifa & Reynoso, 2015; Vargo & Akaka, 2012). Entities as diverse as cities, industries, and market organizations can be understood as both service systems (Jim Spohrer et al., 2008) and service ecosystems (Sarno et al., 2024; Vargo & Lusch, 2017), leading to ambiguities if these concepts can be used synonymously or if they refer to different levels of aggregation (Barile et al., 2016; Pöppelbuß et al., 2022; Storbacka et al., 2016; Wieland et al., 2012). Hence, profound inconsistencies seem to remain in defining and operationalizing service systems as a basic abstraction of service research (Brozović & Tregua, 2022; Frost & Lyons, 2017; Mustak & Plé, 2020). This is problematic for interdisciplinary research at the intersections of service research and information systems, as a uniform understanding and vocabulary are lacking to define what a service system is and is not.

To harmonize service system conceptualizations across disciplines, various contributions have been made to establish aspects of different systems theories in service research (Barile et al., 2016; Ng & Andreu, 2012; Jim Spohrer et al., 2008; Vargo & Lusch, 2016) following up on a service system's initial reference to GST (Maglio et al., 2009). GST is a powerful yet abstract super theory that strives for universality (Boulding, 1956; von Bertalanffy, 1972). Its concepts have proliferated in many academic disciplines (Löbler, 2016; Maglio et al., 2009), providing a unifying theoretical lens for service research across disciplines (Wieland et al., 2012; Xu, 2000). A particular strength of systems theories is that they enable the analysis and design of wholes, complementing reductionist research approaches (Ng et al., 2011). A system theory lens enables a better understanding of the complexity and indeterminacy of service systems and service ecosystems (Barile et al., 2016; Ng & Andreu, 2012), which could help resolve current conceptual ambiguities.

However, these approaches have overlooked properties of service systems as social systems, which differ substantially from the properties of technical systems as focused in, for instance, complex adaptive systems or the viable systems approach (see the appendix for a comparison of different strands of systems theories). Therefore, we propose revisiting, extending, and substantiating the original concept of the service system concept with Luhmann's system theory (LST), a particularly comprehensive and well-known theory of social systems that has been largely overlooked in information systems and service research so far. LST provides a novel perspective on service systems by viewing them as autopoietic social systems, that is, self-reproducing systems with communication as their central reproduction mechanism. Adopting this theoretical stance, we address the following research: What implications does LST offer for conceptualizing service systems?

We answer this question with a re-conceptualization of the service system concept as an autopoietic system in which benefactors (service providers) select and utter pre-selected resources as value propositions to be understood by beneficiaries (service customers) as value-in-use, altogether completing a communication process that is subject to time. The novelty of this definition is that it focuses on communication as the central mechanism that constitutes the value co-creation among any set of benefactors and beneficiaries within a reciprocal relationship. The dynamic properties of service systems govern the reciprocal acts of communication among these actors over time. Communication between service systems can also lead to the emergence of higher-order service systems, which can be understood as service ecosystems on a higher level of aggregation. As such, service ecosystems and service systems are self-similar, i.e., they use the same mechanisms and theoretical properties.

This paper offers three core contributions. First, we revisit and extend current conceptualizations of service systems with the lens of social systems, developing theoretical propositions that align with the principles of LST. The propositions lead us to develop an updated definition of a service system, answering calls in the literature to apply system theory concepts to service phenomena (Maglio et al., 2009; Mele et al., 2010; Ng et al., 2011; Tracy & Lyons, 2013). Second, we discuss the scholarly value of this re-conceptualization for advancing information systems and service research in fundamental ways (Rai, 2017). Our conceptualization helps identify the interplay of different aspects, such as (technological) resources, communication, and service, providing service researchers with a more detailed analytical lens. Communication is the central mechanism behind value co-creation, which sheds new light on dynamic service phenomena, such as value co-destruction and the emergence of institutions. Focusing on communication as the central mechanism provides aesthetic value as powerful simplicity to ensure successful service interactions between providers and customers (Rai, 2017). Third, the notion of service systems as social systems also has implications on digital innovation, service design, and service systems engineering, emphasizing recent works, e.g., (Vink et al., 2021) that render service systems and service ecosystems not fully designable but rather emergent in the here and now.

The paper is organized as follows. Section 2 reviews the foundations of systems theories in the service discipline before introducing foundational concepts of LST. In Section 3, we build on LST's concepts to develop five theoretical propositions, leading to an updated conceptualization of service systems as autopoietic systems with communication as the key mechanism that is required to provide and capture service. Section 4 discusses the implications of this re-conceptualization for service research. Section 5 concludes the paper with a call for more interdisciplinary research based on LST's conceptual foundations.

2 Theoretical Foundations

2.1 Systems as a Theoretical Lens in Service Research

1.1.1 The Notion of a System

An abundance of system conceptualizations has been discussed in various disciplines (Adams et al., 2014; Friendshuh & Troncale, 2012), creating considerable ambiguity about the properties of a system (Malecic, 2016). This confusion also relates to the plethora of research streams springing from the science of systems (Boulding, 1956; von Bertalanffy, 1950), which has, in turn, inspired approaches such as cybernetics (Ashby, 1991; Wiener, 1948), the system-of-systems concept (Ackoff, 1971), autopoietic biological systems (Maturana & Varela, 1980), autopoietic social systems (Luhmann, 1995b), complex adaptive systems (Gell-Mann, 1994; Holland, 1992b), organized behavior systems (Alderson, 2006), viable systems (Barile & Polese, 2010a), systems thinking (Checkland, 1999; Emery et al., 1978; Weinberg, 1975), amongst many others.

As regards the very notion of a system, the Latin systēma and Greek sustēma are the word's origins, which can be translated as a composition of parts or a set of things or ideas (Oxford Dictionary, 2025). Over a hundred systems definitions have been proposed since (Sillitto et al., 2018), spanning fields as diverse as philosophy, social sciences, natural sciences, and engineering (Rousseau & Calvo-Amodio, 2019). A system is generally recognized as a whole, comprising elements and relations between them (Rousseau & Calvo-Amodio, 2019; Sillitto et al., 2018). A system is most fundamentally defined through its elements, which are purposefully connected (von Bertalanffy, 1971). Accordingly, a system is defined as "a set of interrelated elements [...] composed of at least two elements and a relation that holds between each of its elements and at least one other element in the set." (Ackoff, 1971, p. 662). From this definition, each of a system's elements is connected directly or indirectly to every other element in the system , while the system's properties emerge from the interplay between its elements (Ackoff, 1971).

1.1.2 Systems Theories in Service Research

Systems theory has been taken up in many of the academic disciplines that engage in service research, including marketing, economics, computer science, information systems, engineering, and social science, to name just a few (Maglio et al., 2019). Wieland et al. (2012) suggest that GST, or the viable systems approach (VSA), can support exploring the dynamic and complex nature of service systems. Similarly, Barile and Polese (Barile et al., 2012; 2010a; 2010b) adopt the VSA lens and elaborate on conceptual overlaps between S-D logic, VSA, and service research. Viable systems aim to survive in their environment by dynamically interacting with all relevant entities that offer critical resources for their function and viability (Badinelli et al., 2012; Beer, 1972). Barile and Polese (2010b) also track the roots of VSA to earlier contributions to systems theory, e.g., to GST by von Bertalanffy (1950) and Luhmann's (1995) theory of social systems, and call to investigate the dynamics of service at a system's level based on systems theory. Furthermore, Wieland et al. (2012) recognize that service ecosystems are complex service systems, similar to complex adaptive systems (CAS), which are "composed of interrelated parts, interacting with its environment, subject to resulting feedback effect, evolving over time adaptively to fit the pressures imposed on it" (Holbrook, 2003, p. 2). A CAS exhibits self-adjusting capabilities often described as structural adaptations, which emerge in response to environmental change (Onik et al., 2017). Recently, Vargo et al. (2023) used CAS to conceptualize service emergence as an institutional phenomenon in service ecosystems, referring to feedback between the interactions of system elements (which for them are actors and resources) and the outcomes of their interactions (value-creating activities, service-ecosystem properties). Still, none of these conceptual lenses from systems theory has been used to re-conceptualize the notion of a service system itself.

In our quest to explore social system features of service systems, we follow numerous authoritative calls to substantiate core concepts of service research with systems theory (Briscoe et al., 2012; Lusch et al., 2016; Mele et al., 2010; Ng et al., 2009; Wieland et al., 2012; Xu, 2000). Connecting with the overarching lens of systems theory might also enable service research to bridge boundaries between disciplines (Larson, 2016; J. C. Spohrer et al., 2011). In the extant research, the VSA (Beer, 1984), structuration theory (Giddens, 1984, 1990), and LST (Luhmann, 1995b) were proposed as particularly suitable approaches (Löbler, 2016) (see the appendix for a comparison). Further advances have been made toward providing a stronger embedding into systems theory (Godsiff, 2010; Polese et al., 2017; Vargo & Akaka, 2012). However, these approaches only focus on specific theoretical angles and selected properties of systems rather than re-conceptualizing the service system itself. Undoubtedly, digging deeper into the extensive body of knowledge of systems theory offers great potential to advance our understanding of the service system concept's nature and mechanisms (Barile & Polese, 2010b; Löbler, 2016; Peters et al., 2020; Wieland et al., 2012).

2.2 Luhmann's Systems Theory

2.2.1 Prospects of Luhmann's Systems Theory for Service Systems

After carefully considering and contrasting different system theories and approaches to systems science, we posit that LST (Luhmann, 1995b, 2002, 2013, 2018) provides a promising and fresh perspective on the service system concept that has been largely overlooked so far (except for Löbler, 2016). This theoretical approach is promising as it recognizes the social properties of service systems. Based on the concept of autopoiesis, which describes living systems (i.e., organisms), Luhmann established a sophisticated general theory of social systems that are abstract and self-reproducing in nature. Autopoiesis refers to the ability of systems to create and maintain themselves through the continuous regeneration and actualization of their elements. Luhmann's edifice of ideas is considered one of the most—if not the most—developed theoretical bodies dealing with systems theory (Albert, 2016). For instance, Luhmann's ideas have also been taken up prominently in the IS field to examine how technology reconfigures human-technology relations (Demetis & Lee, 2018) and in organization science to justify Eigenzeit as a new lens on the temporal complexity of organizing (Blagoev & Schreyögg, 2025).

LST enables us to view service systems through the lens of autopoiesis (Maturana & Varela, 1980, p. 101), highlighting dynamic mechanisms such as self-reproduction, operational closure, and self-organization. These properties allow service systems to maintain their identity by generating and regenerating their core elements—service—through their own internal operations. Since a service system focuses on service—"the application of specialized competencies (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself" (Lusch & Nambisan, 2015, p. 161)—it differs from allopoietic (technological) systems involving tangible resources, while autopoietic and allopoietic systems can interpenetrate (overlap).

Still, LST is consistent with the properties of service systems. First, the concept of autopoiesis fits well with the idea that service systems are self-contained and self-adaptive and have self-X features, like self-organization (van Assche et al., 2019), which service research aims to elucidate (Vargo et al., 2023). Second, LST focuses on abstract rather than concrete systems (Luhmann, 1995b, p. 442), which fits well with the claim to use a service system as a basic abstraction (Jim Spohrer et al., 2008). LST's abstract conceptualization also aligns with the proposition that "services are exchanged for services" (Vargo & Lusch, 2004, p. 7), reflecting Bastiat's (1860) great economic law. Third, LST can consider the overlap that has been proposed between social systems and service systems (Edvardsson et al., 2011; Wetter-Edman et al., 2014), even if it departs from the current service system conceptualization in which elements with different system references, such as "people, technologies, and other resources" (Maglio et al., 2009, p. 395), have been merged into one single service system concept. In contrast, LST emphasizes separating different system elements—such as service, communication, or resources—into different systems. While these systems can still interpenetrate (overlap), LST is mindful of separating different types of elements, enabling researchers to investigate the mechanisms with which these elements play together. We conclude that LST provides a theoretical view consistent with current service thinking and introduces new theoretical angles into the scientific debate.

2.2.2 Foundational Concepts of Luhmann's Systems Theory

Luhmann's extensive writings provide numerous theoretical concepts. We group core concepts as static and dynamic to convey an easier understanding (Table 1). Static concepts refer to the structure of a system, whereas dynamic concepts refer to mechanisms of autopoiesis. Although the list of concepts we review in this paper is extensive, we still omit some LST concepts (e.g., bounded rationality and double contingency) that we consider less significant for this paper. We visualize the concepts in Figure 1 and summarize them in Table 1. At the end of each paragraph, we refer to the LST concepts of service systems.

Regarding static concepts, systems constitute themselves by establishing a difference from their environment (Luhmann, 2013, pp. 29–30). Each system has a guiding difference that exhibits a system reference, defining a single type of element in this particular system (Luhmann, 1995b, p. 177). For instance, elements of action systems are action elements; elements of communication systems (which equal social systems) are communication elements (Luhmann, 1995b, pp. 137–175); this implies that the single type of element permissible in a service system is service elements. A system boundary demarcates a system towards its environment (visualized as thin double lines in Figure 1). → **The system boundary demarcates a service system from other service systems or systems of other kinds in its environment.**

Systems consist of elements and relations mirroring a dynamic structure in time. Luhmann implicitly views events (Allport, 1940; Morgeson et al., 2015) as the underlying element of an evolving system on which higher-order systems (e.g., action systems, communication systems) can be built. More specifically, social systems are communication systems that consist of communication elements, referring to elements of actions and thus to elements of events (Luhmann, 1995b, 104,139). When an event is interpreted as action, an action system emerges; if actions are interpreted as communication, a communication system (= social system) emerges (Luhmann, 1995b, pp. 164–

171). → **Service systems emerge when a beneficiary understands communication as valuable, which implies that a system that solely facilitates communication (= social system) must be in place.**

Systems become complex when elements (e.g., events, actions, communication) can no longer be linked directly to every other element in a system (Luhmann, 1995b, pp. 20–24). This means that events can belong to a (sub-)system and might also belong to environments of other systems. Therefore, it is essential to "distinguish between the environment of a system and systems in the environment of this system" (Luhmann, 1995b, p. 17). → **Service systems can interact with other systems (e.g., other service systems) while remaining distinct from their environment.**

A system's environment is always more complex than a system itself (Ashby, 1991). Each system can be disassembled into sub-systems, thereby marking itself as an environment of its subsystems. When reuniting the subsystems through communication, a system emerges again as a whole (Luhmann, 1995b, p. 7). Overlaps of different (sub-)systems refer to interpenetration. Interpenetration is an inter-system relationship concept between systems situated in the same environment. It means the same elements can belong to multiple systems simultaneously. In Figure 1, systems A and B share some elements, while these elements connect and form relations between them. Hence, service systems can have underlying elements that they share with other systems. → **Service systems can interpenetrate with other types of systems.**

The concept of self-description serves to describe a system's observed elements. Referring to the difference between a system and its environment, a system must have and uphold a description of itself (Luhmann, 1995b, p. 9; Rosen, 1977). The system's description mirrors its guiding difference (e.g., service) to stand out from its environment and describe its behavior. Internally, this description enables a system to define its own rules for ordering, selecting, and processing information (Luhmann, 1995b, p. 165). → **The guiding difference of a service system is the distinction of whether a communication is meant to be and perceived as a service.**

Systems are self-referential (Varela, 1975). A system refers 'everything' originating from the system's environment (e.g., selected information) to its own elements (self-reference). Every system operation has elements to refer to and build upon. Still, systems are open to environmental influences, even operationally closed, as their environment cannot directly intervene in a system's operations (Luhmann, 1995b, p. 444). Because of this operational closure, a system must generate its complex operations (its dynamic structure) to handle interference originating from its environment. → **Assuming that service systems are self-referential and operationally closed, they cannot be designed from the outside but only through selection and observation.**

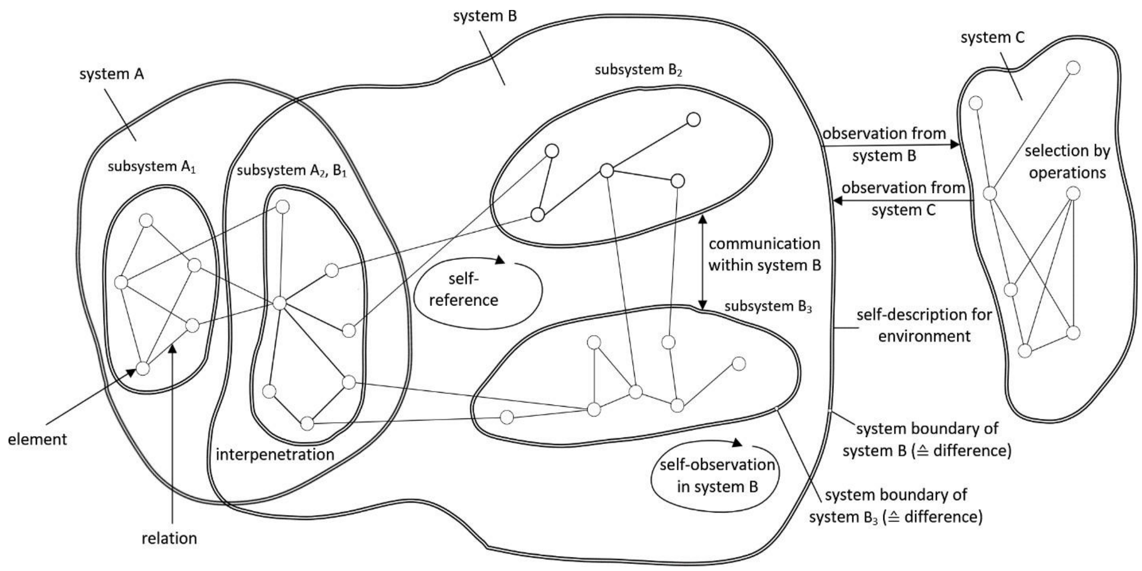

Figure 1: Outline of selected core concepts of LST, building on Luhmann (1995)

As regards the dynamic concepts of LST, observing refers to indicating and distinguishing between important and unimportant environmental irritations (Luhmann, 1995b, p. 65). Through observation, the system's environment is used to re-adjust a system's boundaries and identify which elements belong to the system. A system can observe itself and other systems in its environment. For simplicity, an actor—seen as an external system—can observe other systems. Depending on an observer's vantage point, observation can take place as first-order observation (inside the system; internal observer) or second-order observation (outside the system; external observer) (Figure 1). → **Service systems can be observed internally (e.g., from the perspectives of benefactors and beneficiaries involved in service exchange) and externally (e.g., by external actors not involved in the service exchange).**

Systems are self-organizing. This means that system elements arrange themselves depending on the current system state. As soon as elements A and B form a connection, they determine the positioning of a further element C. By adding more elements, the system starts to self-organize its elements. As an autopoietic system, a system reproduces itself through its own elements. → **The determinants of self-organization are reflected by the institutional arrangements (i.e., the rules, norms, and symbols) that are shaped by and shape the service system's structure.**

System elements are connectable and are constantly being rearranged. A system has the connective capacity to integrate new elements within its boundary (depending on observation and selection). By integrating new elements, a system's variable boundary determines which elements change or maintain their states. Elements as semantic abstractions have no permanent existence but must be reproduced continuously. That is why elements must constantly establish new connections and thus reproduce new elements for the system to exist (Luhmann, 1995b, p. 11). → **Service systems must reproduce themselves through service.**

Focusing on social systems, Luhmann considers communication as the only operation that can provide this connective capacity (Luhmann, 1995b, p. 243). Communication is a single operation in a social system that organizes elements. It consists of the synthesis of (1) the selection of information, (2) the utterance of information, and (3) the understanding of information (Luhmann, 1995b, p. 40). Communication in a social system is only initiated when observation occurs, enabling communication within the system. → **Service must rest on communication, meaning that service involves the selection and utterance of value propositions by benefactors that beneficiaries understand as valuable.**

Systems process information selectively. When communication occurs in a system, it performs selections to steer information flows to cope with the upcoming complexity. When a system observes another system and, thus, processes new information, this information is interpreted in line with the systems' guiding difference, establishing new processing conditions for the entered information (Luhmann, 1995b, p. 17). → **Communication elements originating from the environment are interpreted as service elements within a service system, while communication is necessary to uphold the service system.**

Systems operate in time. That is, relations emerge among elements to establish order over time. In this way, time allows elements to react asymmetrically to indeterminacy. As time passes, elements refer back to each other. This temporal backlink leaves behind system structures (Luhmann, 1995b, pp. 286–294), letting structural patterns emerge, ensuring relatively constant connecting lines to guide further elements (Luhmann, 1995b, pp. 345–346), creating a path dependency also known as institutions. → **Path dependency is relevant to service systems as new service elements refer back to previous service elements, which are previous service experiences.**

In autopoietic systems, elements self-organize themselves with the help of the current system structure (Luhmann, 2013, p. 76). While observation occurs, structures are built to set the system's elements in motion, initiating their self-organization. Structures ensure the cohesion of the elements and are necessary for the system to operate, which means maintaining its elements and relations (Luhmann, 1995b, p. 134). Systems can be structurally coupled to other systems, depending on their own operations, without merging with other systems. Instead, each system remains operationally closed, meaning it functions based on its own internal processes and logic. Still, a system can be "irritated" or influenced by another system, adapting its behavior or structure. For example, social system structures are structures of expectations manifesting in the form of patterns that guide social action. Relations and structure differ (Luhmann, 1995b, p. 283) in the sense that structures are time-related and thus complex, while relations are not time-related, applying a more static perspective on systems elements. → **Service systems guide service exchange, which are patterns of resource integration.**

Selections made by the system re-enter the system and determine future communication, as well as other selections made in this system (Luhmann, 1995b, p. 125) that are observed. Whatever is observed, the observer "reintroduces the distinction of observer and observes into the object of observation" (Luhmann, 1995b, p. 120). This leads to circularity in the selection process within a system, creating a path dependency (structure) of element creation (Luhmann, 1993b). → **Service elements re-enter the system to bridge time until the service composition is fully understood.**

Table 1: Selected Core Concepts of LST (Luhmann 1995, 2002, 2013, 2018)

LST Concepts	**Core Statement**	**Description**
Static Concepts		
Systems as being different from their environment (system reference)	Systems constitute themselves as being different from their environment.	Systems can only exist as a distinctive identity in relation to an environment (Luhmann, 2013, pp. 29–30). A system is always clearly distinct from its environment, constituting itself as being different from its environment (Spencer-Brown, 1994). Each system has a *guiding difference* towards its environment, indicating its reference and way of processing and selecting information.
System complexity (elements and relations)	Systems become complex when elements can no longer be linked to every other element.	Complexity arises if two elements can only be connected using other elements in between(Luhmann, 1995b, p. 24). Complexity refers to (a) the number of elements, (b) the number of relations among the elements, (c) the difference between elements and their relations, and (d) the temporal change of relations in a system (Luhmann, 2013, p. 124). The environment is always more complex than a system (Ashby, 1991).
Subsystems (systems differentiation)	Systems consist of elements that have relations and can exhibit subsystems that have their own environment.	Sustaining a difference from its environment, a system can further differentiate itself by establishing subsystems, each constituting an environment within the system. Reuniting the subsystems by resolving the differences, a system emerges again as a whole (Luhmann, 1995a, p. 7). As a result, a system of a higher-order emerges (Luhmann, 1995a, p. 22).
Interpenetration and system boundary	Different systems can build on the same elements, but systems do not have identical element relations.	Interpenetration is an inter-system relationship between two or more systems sharing the same environment. It describes the use of the same elements at the same time in different systems. When there is a system boundary, the system references differ, and accordingly, the selection mechanism within the system and the relation configuration between these elements are also different (Luhmann, 1995a, pp. 214–215).
Self-description	Systems create and use self-descriptions to identify and handle their elements.	The concept of self-description refers to a system describing itself—and its behavior—in an environment (Luhmann, 1995a, p. 456). Internally, it helps the system to keep its own rules for ordering and processing information (Luhmann, 1995a, p. 165).

Self-reference	Systems can only handle information in relation to themselves.	Every system operation presupposes its own elements to refer to and to build upon. Thus, new elements are being created by building on previous elements only (Luhmann, 1995a, p. 437).
Openness and operational closure	Systems are open to influences from the environment but, at the same time, closed to distinguish themselves from their environment.	A system draws its boundaries and stabilizes itself by constantly deriving information from its environment and establishing its own internal relations (Luhmann, 1995a, pp. 48–50). In this way, a system is open and closed at the same time. It is open to the possibility of making selections from the environment and closed in that it uses only its own internal operations within the system (Luhmann, 2013, pp. 63–70).
Dynamic Concepts		
Observing and observer	Everything in a system must be distinguished and identified by an observer.	Observing is defined as the "formal terms of distinction and indication" (Luhmann, 2013, p. 105). A system observes to carry out distinctions in this system or in relation to its environment. In this way, a system determines the elements that belong to it. Observation is equal to the operative distinction of what elements belong to a system (Luhmann, 2013, pp. 101–120).
Self-organization	System elements arrange themselves depending upon the current system state.	As soon as element A and element B form a connection, they determine the role of a further element C. By adding more elements, elements relate, and the system starts to observe its own elements. Observing then triggers a self-organization process (Ashby, 1991), and the system communicates internally to carry out its autopoiesis (Luhmann, 1995a, xxix-xxx,34).
Structural coupling	Systems can be structurally coupled, depending upon the operational processes of the other system.	Systems maintain distinct boundaries while selectively integrating external influences and aligning their operations. They can be influenced by the processes of other systems, which can lead to changes in internal behavior or structure while retaining their distinct identity (Luhmann, 2002, pp. 83–101).
Communication	The system communicates to establish new connections in the system.	Communication is the process of making selections within a system. While selective operations presuppose a description in the form of an utterance, an utterance is itself a performed selection. In this way, communication is a threefold process consisting of information, utterance, and understanding (Luhmann, 1995a, pp. 140–143).
Selectivity and information processing	Systems select and process information by using their structure.	Information is created and occurs only in systems (Luhmann, 2013, pp. 92–93). The flow of information functions as a selection mechanism to indicate and create new system elements (Luhmann, 1995a, p. 40) by using its own system structures.
Operating in time	Systems constantly change their state and the relations of their elements over time.	A system constantly reconstitutes itself by actualizing its relations and elements. As time passes, it sets further conditions for elements and their relations, which can only be updated at the next point in time. A system constantly forms new relations and elements, choosing between repetition and change. Some elements are reproduced, and others disintegrated, creating new element relations (Luhmann, 1995a, pp. 39–48).

Re-entry	What has already been observed in a system serves as a distinction for what is observed later.	A peculiarity of observation is that the observed is re-entered, as the observer forms part of the observation. Whatever is observed, the observer "reintroduces the distinction of observer and observed into the object of observation" (Luhmann, 2013, p. 120). This is how subjectivity is installed in systems.

3 LST as a Foundation for Service Systems

3.1 Five Propositions for Re-conceptualizing Service Systems

Subsequently, we use LST to re-conceptualize the concept of the service system. We develop five theoretical propositions guiding this process, culminating in an updated definition of the service system concept. Theoretical propositions are testable statements deductively derived from theory, in our case, from LST. Similar approaches have been frequently used to develop the foundational premises and the axioms constituting S-D Logic (Lusch & Vargo, 2006; Vargo & Lusch, 2004, 2008, 2016). Still, LST cannot be readily applied to re-conceptualizing service systems, but there is a conceptual gap between both strands of research because Luhmann never explicitly dealt with service systems as systems in the sense of the LST. Also, Luhmann did not consider technology, such as IT artifacts or information systems, in his conceptualization of systems—which he viewed as social systems—but treated them as allopoietic components that need to remain in a system's environment. Subsequently, we provide this missing link, drawing from the rich conceptual foundations to identify implications for re-conceptualizing the service system concept.

We illustrate each proposition with the example of connected mobility, a smart service system based on a digitally networked car (Beverungen et al., 2019). A smart car is equipped with various sensors that identify its internal properties (e.g., velocity, state of charge) and surroundings (e.g., road conditions and other vehicles in the car's proximity) to self-adjust its velocity. It offers remote access for the manufacturer to retrieve usage data and make system diagnoses. The data are also used to optimize the car's autonomous functions since autonomous driving depends on data from numerous vehicles. The car also provides users access to additional services like remote upgrades, predictive maintenance, insurance services, and autonomous driving.

1) Service is the only guiding difference of a service system.

LST states that systems have one single system reference that constitutes them as difference from their environment. This system reference also defines the type of element part of the system. From an LST point of view, the sole system reference of a service system is service, making service its only element type. As an abstract system, a service system comes into being only if a human observer interprets other types of elements, such as resources, actions, or communication, as service. While a service system is operationally closed, service can also relate to elements of other systems (e.g., action systems, communication systems) through interpenetration. For a service system to emerge from these other element types, a beneficiary must observe these elements, and a complete communication process—consisting of selection, utterance, and understanding—must be present.

Service systems can include nested structures, i.e., they can comprise service elements that are service systems themselves. The boundary of a service system is dynamic in the sense that a service system can connect to other element types, incorporating these as service. However, these elements can only be included as service in a service system due to the premise of a singular system reference (Luhmann, 1995b, pp. 135–136). "Systems are selected, not as a bunch of objects, but as ordering perspectives from which a relationship between system and environment is accessible" (Luhmann, 1995b, p. 136).

An LST view implies that other element types cannot be part of service systems but must remain elements of other system types. For instance, a system of living beings can only reproduce living beings, not service elements (following Luhmann, 1995b, p. 427). Similarly, resources, frequently mentioned in service system definitions—including people, technologies, organizations, and information (Maglio & Spohrer, 2013)—cannot, by definition, be elements in an autopoietic self-organizing service system. Rather, resources must be allopoietic systems "capable of producing only 'the other' rather than itself" (Zeleny, 2006, p. 12). Resources must remain in a service system's environment and can belong to other types of (allopoietic) systems (Schatten & Bača, 2010). It follows that when service systems appear to exhibit social and technical features simultaneously, we deal with more than one system. These do not intermingle but are structurally coupled. In other words, social and technical structures exhibit a difference, not a unity, since social structures are operationally closed to technical operations (and vice versa).

This perspective profoundly differs from current conceptualizations of service systems that include elements irrespective of their system references. We posit that differentiating element types and system types that play a role in service science makes an LST-enabled conceptualization of a service system a sharper theoretical lens since specialized phenomena can be attributed to a single system reference (e.g., looking at resources or actions), while others can be viewed as an interplay of systems that display different system references. For instance, differentiating actions (action systems) from service (service systems) can enable researchers to identify how service is interpreted from actions in processes of communication; this view enables researchers to identify why service is sometimes successfully co-created, and sometimes remains unsuccessful, while the underlying actions remain the same.

Taking the example of connected mobility, this proposition implies that neither the beneficiary nor resources like a car or the computing infrastructure are elements of a service system. Connected mobility emerges from a beneficiary's observation and understanding of the interplay of elements with other system references—such as actions, information, and people—as service, constituting a service system. When these elements are combined (e.g., when traveling), and a beneficiary observes and understands this combination as service (e.g., appreciating their arrival or enjoying their travel), a service system emerges, overlapping with the other systems. The service system can be nested, combining service elements on different levels of abstraction—the entertainment system, the interior, the state of charge—all of which can be observed and understood as service.

2) A service system emerges from understanding information as a service.

LST states that systems are operationally closed, limiting them to using their own operations. Still, systems can interpenetrate (overlap) with other system types, allowing them to deal with other types of elements. When different systems interpenetrate, elements (e.g., action, communication, or resources) can be observed and unified into new system elements (e.g., service). LST posits that observation is a selective operation (Luhmann, 1995b, p. 184) that focuses on a system's environment, interpreting the environment as resources destined for setting up communication. Because of operational closure, a service system cannot make causal interventions in its environment but must remain inside its own system.

From a LST perspective, a service system can be understood as a higher-order system in which service emerges from combining other abstract elements, such as action elements, communication elements, or events. Pointing beyond a socio-technical systems view that joins different element types into the same system (Bostrom & Heinen, 1977; Ropohl, 1979), service systems are supra-systems that overlap with other systems (i.e., social and technical systems). While different types of systems are environments for each other and cannot interact directly, the more abstract service system can establish a relationship between them, presupposing the process of observation that distinguishes and identifies the combined elements as service. LST refers to this overlap between service and social systems (Akaka & Vargo, 2014a) as interpenetration (Luhmann, 1995b, pp. 214–217). Resource integration includes two steps: observing resources in the environment and selecting communication by purposefully indicating (i.e., viewing the other elements as) service. Put differently, beneficiaries integrate resources (Bruce et al., 2019; Peters, 2016; Zimmermann, 1933), thereby building the structure for service (Barile et al., 2016; Barile et al., 2012).

This proposition serves to glue together different element types that matter to service, such as people, actions, information, and resources. Still, it highlights differences among these elements, emphasizing no causal relationships between them. Since resources, actions, and people need to be observed and coded as service by a human observer or beneficiary before service emerges, the sole presence of these elements is no guarantee that service will eventually emerge. Similar observations have long been made in service research. For instance, S-D logic highlights that "value must always be determined by a beneficiary," while the traditional IHIP criteria emphasize the perishability of services, referring to the inability to store services for future use, which makes timely resource utilization critical for value creation (Lovelock & Gummesson, 2004; Zeithaml et al., 1985). Concerning this issue, LST introduces strong theoretical concepts and mechanisms to the debate, enabling researchers to elucidate the detailed mechanisms at play.

In the connected mobility example, the service system emerges when a beneficiary observes and understands the combination of resources (e.g., car, data, maintenance, route, state-of-charge) and actions (e.g., autonomous driving, directions, recommendations) as service. The service system establishes a new relationship that connects elements from systems with other system references (e.g., information systems, action systems) because a beneficiary observes and understands this relationship as value-in-use (e.g., traveling). Observation and understanding are the prerequisites for benefactors and beneficiaries to integrate their resources, constituting a service system that emerges from coding these elements as a smart mobility service. If, however, a car remains standing in a garage, the same resources remain unobserved and do not lead to a service system emerging.

3) Communication is the core mechanism driving value co-creation.

In LST, the only suitable operation for social systems is communication (Luhmann, 1995b, p. 243), which is the synthesis of the selection of information, the utterance of information, and the understanding of information (Luhmann, 1995b, p. 40). Communication occurs only when an utterance is observed and understood (Luhmann, 1995b, p. 165). For this reason, communication goes beyond actions since actions can remain unobserved and, therefore, unnoticed. Different types of systems (e.g., living systems like humans or social systems like organizations) can observe service systems in their environment; observations are subject to limited interests, structures, and the information processing capacities of observers (as observing systems).

For service systems, value propositions can be viewed as information offered to stimulate value co-creation (Eggert et al., 2018). Value propositions might remain unredeemed for a time, waiting to be observed by beneficiaries. They might also be bound to resources or fade away (Hill, 1999) if non-observed. While the actual assignment of value-in-use to a service element depends on observation, value is co-created only if the communication process is complete. Beneficiaries observe events (e.g., value propositions selected and uttered by the benefactor) in their environment, which they understand as valuable, interpreting them as action, communication, and, finally, as service. Because of differences in observation, the same value proposition might create different value-in-use for different observers or even fail to do so. Service-for-service exchange is initiated when an observer outside a service system engages in value co-creation through their actions, which need to be observed and understood by others. Utterances serve the utterer (benefactor) as a promotion to describe themselves, thus confirming (re-entering) their distinction from their environment. Simultaneously, observers (beneficiaries) bring their distinctiveness to the system, re-interpreting the benefactor's utterances. In this way, value is co-created, setting up new conditions for service communication. However, as service systems are selective and remain indifferent towards most of their environment, many actions are not observed and understood and are not interpreted as service. Transforming 'events' related to 'actions' into 'service' based on 'communication' is the constitutive function of a service system.

Focusing on communication as information, utterance, and understanding (Luhmann, 1995b, pp. 140–143) has profound implications for our understanding of service systems. Current conceptualizations of service systems point to different mechanisms of system reproduction (As' ad et al., 2024; Fehrer et al., 2024; Ojasalo & Kauppinen, 2024; Vink et al., 2021). We posit that viewing communication instead of action as the basic mechanism of service system re-production provides a much sharper theoretical lens. Action is a weaker concept than communication since actions can remain unobserved and fail to have any effects on others (Luhmann, 1995b, p. 165). Adverse phenomena in service research, such as value co-destruction, could be analyzed in terms of failing or incomplete communication processes, which would provide a new angle to the debate that goes beyond the actions performed by benefactors and beneficiaries.

Considering the example of connected mobility, a predictive maintenance service is a value proposition that is selected and can be uttered by a car company as a benefactor. Customers may interpret this utterance differently, creating variety in their understanding of the value proposition. While some customers understand the value offered by predictive maintenance, leading to a service system emerging, others do not understand it to be valuable or even fail to observe the value proposition. Since the communication process remains incomplete in the latter case, the resources and actions of benefactors are not identified as service.

4) Service systems are autopoietic systems that reproduce themselves through service.

LST distinguishes autopoietic systems (which reproduce themselves) from allopoietic systems (which produce something other than themselves, e.g., machines) (Maturana & Varela, 1980). An autopoietic system withstands environmental irritations by changing its internal structure, thus maintaining its guiding difference and creating new elements. Autopoiesis implies that a system reproduces only using internal operations. Nevertheless, an autopoietic system can use allopoietic components to reproduce itself (Maturana & Varela, 1980).

As an autopoietic system, a service system reproduces service since systems can only reproduce their own elements (Luhmann, 1995b, p. 11). Technology (Akaka & Vargo, 2014b), such as smart products (Beverungen et al., 2019) or software applications, are allopoietic components (i.e., resources) that remain situated in a service system's environment, while a service system reproduces itself through (new) service being observed. Digitalization allows service systems to handle greater complexity by leveraging IT-driven processes, mitigating the complexity gap, which is the disparity between a system's capacity to process and manage complexity and the increasing intricacy of its environment. This gap arises when the dynamic nature of external influences exceeds a system's ability to adapt or process information efficiently. By integrating advanced technologies and IT-driven processes, service systems can enhance their capacity for observation, communication, and structural adjustments, thereby bridging this gap and maintaining operational effectiveness (Robra-Bissantz & Schlimbach, 2023).

For service systems, an autopoietic service system implies that a service system persists as long as beneficiaries and benefactors observe each other, and thus, communication takes place between them. The ongoing communication creates a cumulative service experience subject to path dependency. That is, the actors refer to potential previous service encounters (or communicative events) when interacting. A service system collapses if the actors cease to observe and understand the other's value propositions, irrespective of their actions.

For instance, no mobility service can exist without a beneficiary understanding its benefits or a manufacturer who wants to offer smart connected cars. Operand resources like the actual car, data, or information systems are allopoietic elements that remain situated in the environment of the service system, waiting to be observed.

5) Due to their reliance on communication, service systems are subject to time.

LST assumes that communication is threefold—selecting, uttering, and understanding information—while systems incessantly change their state and the relations of their elements over time. Selection, utterance, and understanding can happen at different points in time; for instance, an utterance can bridge time when actions that are one means to utter information resonate long enough, waiting to be understood. Since communication is subject to time, a system is always in an asynchronous state and can never operate entirely synchronously. Hence, utterances require a time delay to be understood (see also Hill, 1977), and this time offset is permanent.

For service systems, binding value propositions to service is subject to the time required by a complete communication process, including information, utterance, and understanding. Since the same value proposition can be understood by multiple beneficiaries at different times, it leads to a multiplicity of service systems; while an action can happen once, value-in-use can be observed several time intervals later, which might influence the value-in-use and service observed by beneficiaries.

LST highlights the crucial role of time that, as we posit, has been insufficiently addressed in service research. In most studies, time has been abstracted away, focusing on value propositions, interactions, and value-in-use as timeless concepts. For instance, neither S-D Logic nor current conceptualizations of service systems recognize time as a factor in service research. This view stands in stark contrast to anecdotal evidence of day-to-day service processes. Clearly, it makes a difference at which time you enter a hospital to receive medical treatment or at which time you consume a repair service.

Considering connected mobility, a car manufacturer might offer predictive maintenance and this value proposition to its customers. While some beneficiaries understand this value proposition up-front, others might understand it later, maybe after their car broke down. Still, others might never understand this service, leaving the value proposition unredeemed. Predictive maintenance is a value proposition that builds on always-on interactions of benefactors and beneficiaries, subjecting them to a different rhythm than classic reactive maintenance services. Thus, the respective service encounters are subject to time in different ways.

Table 2: Propositions on Service Systems as Outlined by LST

#	Proposition	Example: Smart Mobility	Theoretical implications	Foundation in LST
1	*Service* is the guiding difference and the only element type constituting a service system.	Neither actors (e.g., manufacturer, user) nor resources (e.g., a car) are elements of a service system; the service emerges from the resources' combined effects (e.g., distance traveled), subject to a beneficiary's observation and understanding.	Service systems only have service (understood as a process) as their constituting elements. Operand and operant resources used to co-create service are part of the environment.	Systems as being different from their environment (system reference) Elements and relations (system complexity) Self-reference
2	A service system emerges from establishing relationships between communicative events being observed as 'service' between abstract systems.	A service system emerges only if a beneficiary observes and understands the combination of diverse resources (e.g., car, technician) and actions (e.g., repair) as a service being performed. Service establishes a new relationship, connecting the involved communicative events resulting from resources.	Service systems are higher-order systems that interpenetrate with other systems (e.g., action systems) or resources. Service systems are built on a communication system where 'service' is communicated. The resources contributed by either actor are important; however, they are part of the service system's environment.	Subsystems (systems differentiation) Interpenetration and system boundary Observing and the observer Openness and operational closure

3	Value co-creation in service systems rests on communication between benefactors and beneficiaries.	The car and the manufacturer's resources (e.g., data, algorithms, technicians) utter value propositions that can be observed and understood by beneficiaries. Beneficiaries' utter demands (e.g., traveling) and resources (e.g., defect car), to be observed and understood by a benefactor (and vice versa). Beneficiaries may observe and understand service differently. A service system overlaps with a social system that emerges based on communication. For example, a benefactor utters and one or more beneficiaries understand each other's value propositions.	Value co-creation depends on a communication process involving the mutual utterance, observation, and understanding of information. Communication is subject to selective information processing and constrained by the attention level and the resources applied to the observation. The actions of the benefactor must be observed and understood by the beneficiary to constitute value. The amount of value co-created is subject to the beneficiary's selective information processing.	Observing and the observer Connective capacity Communication Selectivity and information processing
4	Service systems are autopoietic systems that reproduce themselves through service.	A service system persists as long as the benefactor and beneficiary communicate. A service system collapses if the actors no longer observe or understand the partner's value propositions; there can be no mobility service without a beneficiary requiring mobility or without a manufacturer who provides cars.	Service systems describe and reproduce themselves through observed service (i.e., value propositions uttered, observed, and understood) and their relations to other service elements in the system. Technical structures always remain resources that are situated in a service system's environment. Technology is an allopoietic component that is situated in the environment of a service system. A service system is not a socio-technical system consisting of people and technology, but a supra-system that interpenetrates with various actors' shaped environment.	Self-reference Self-description Self-organization Connective capacity Re-entry
5	Time divides initiated action and observed communication, allowing service to emerge.	A service system emerges when a benefactor observes and understands the value-in-use generated by the service process (e.g., a car computing a route). Benefactors can be absent while a service process is performed, e.g., a software update of their cars.	Communication and, thus, service provision is subject to time offsets due to the duration of observation and understanding. Action and communication are asynchronous, even if the time offset can be infinitely small.	Communication Selectivity and information processing Operating in time

3.2 Implications for the Service System and Service Ecosystem Concept

Building on the five theoretical propositions derived from LST, we define a service system as follows: *A service system is an autopoietic system in which benefactors (service providers) select and utter pre-selected resources as value propositions to be understood by beneficiaries (service customers) as value-in-use, altogether completing a communication process that is subject to time.*

We depict this conceptualization of a service system in Figure 2. Service requires at least two actors: a benefactor (service provider) and a beneficiary (service customer). Before a service system emerges, other types of systems must be in place, such as social systems or information systems. A service system can then interpenetrate with these systems. A service provider selects information on elements from other systems (e.g., resources) to set value co-creation in motion. This selection is then uttered as a value proposition through language or actions.

Beneficiaries must observe that a value proposition is made. As soon as the information uttered is understood as value-in-use by a beneficiary, one or more service elements are created and attached to the service system, restructuring the service system in an autopoietic process that simultaneously sets the scene for selecting new information as service. The process of selection, utterance, and understanding is subject to time. With understanding, the communication process of selection, utterance, and understanding is complete (Luhmann, 1995b, p. 40). Communication constitutes value co-creation among any set of benefactors and beneficiaries as a reciprocal relationship. The dynamic properties of service systems, i.e., re-entry, structural coupling, and operating in time, emerge from and govern the reciprocal acts of communication among these actors.

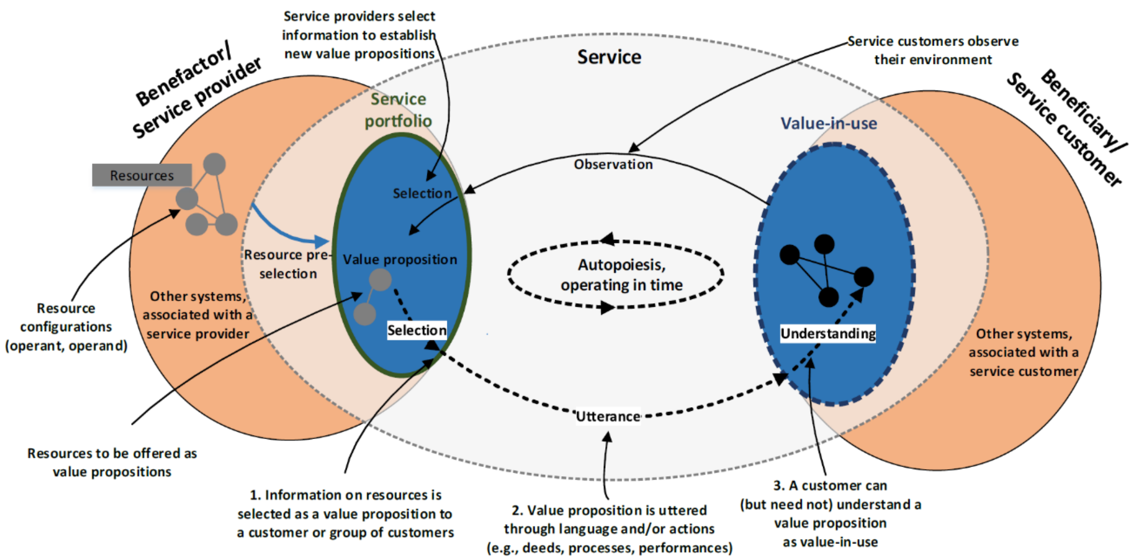

Figure 2: Conceptualizing a Service System Based on a LST Lens

We posit that service systems can be nested and connected with other service systems. We refer to the space in which this happens as a service ecosystem (Figure 3). A service ecosystem is often viewed as a “relatively self-contained, self-adjusting system of resource-integrating actors connected by shared institutional arrangements and mutual value creation through service exchange” (Vargo & Lusch, 2016, pp. 10–11). In a service ecosystem, service systems can create higher-order (super) service systems through communication, as outlined above: information is uttered by one service system and then observed and understood within another service system, interpreting the uttered information as value-in-use. We posit that service ecosystems are embedded into society as a larger system that can be seen as an environment. As proposed in LST, their relation is reciprocal: Society provides its institutional properties (Edvardsson et al., 2011) that provide irritations interpreted by service ecosystems, while service ecosystems also influence the emergence of society. In this way, service ecosystems are situated on a meso level of aggregation (Vargo & Lusch, 2017) between the value co-creation of service systems on a micro level and society (situated in the environment) on a macro level. Service ecosystems allow for identifying a middle ground for value co-creation in specific industries (e.g., retail, baking) or digital realms that reach beyond dyadic service systems, such as public data spaces.

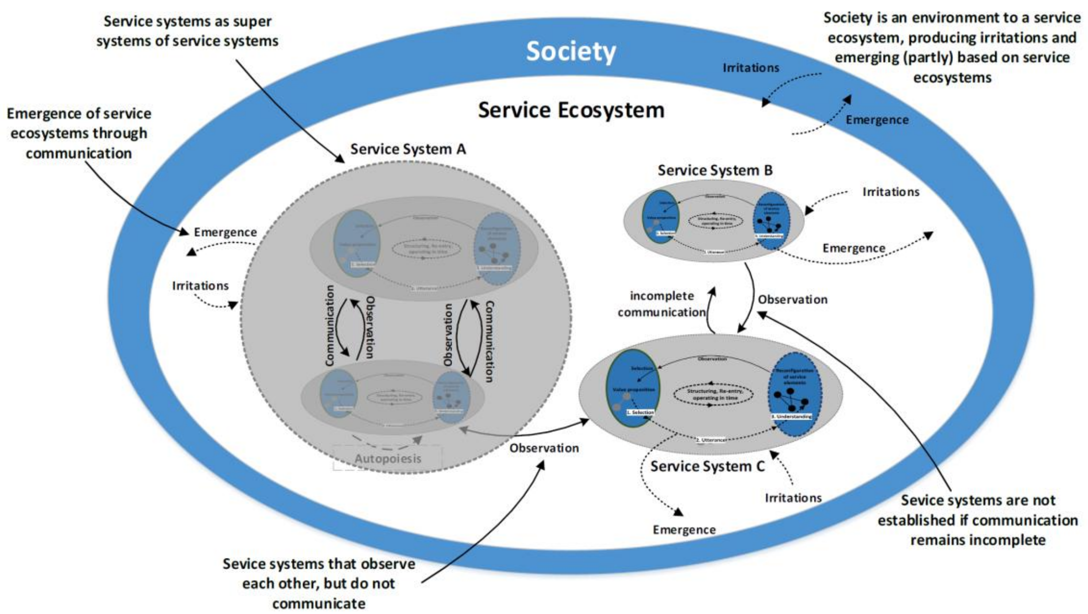

Figure 2: Service Ecosystems as a Meso Level of Aggregation between Service Systems and Society

4 Discussion

4.1 Service systems include service only, while relating to other system types

We see a crucial advantage of using an LST lens in its potential to substantiate and clarify the service system concept and its relationship with similar concepts, including service ecosystems. Currently, both concepts lack theoretical embedding and clarity, making service research ambiguous, fragmented, and self-referential, e.g., (Huotari & Hamari, 2012; Maglio & Spohrer, 2013; Maglio et al., 2009; Stanicek & Winkler, 2010). The original service system papers (Maglio et al., 2006; Jim Spohrer et al., 2008) do not provide a theoretical embedding into systems theory, even if calling on others to establish this link. As one of the most prominent systems theories, LST provides a unifying, well-developed, and widespread theoretical lens (Demetis & Lee, 2016) that has been largely overlooked in service research so far. This lens emphasizes the social system properties of service systems, bridging boundaries between academic disciplines involved in service research. An LST lens can also differentiate but still link closely related concepts of service systems and service ecosystems (cf. Figure 3). A service ecosystem is a super-system of service systems, while both types of systems are self-similar (Leinster, 2011), i.e., they use the same mechanisms and theoretical properties. This view of setting both systems into relation strongly differs from the (often implicit) viewpoint that the service system concept could be abandoned in favor of the service ecosystem concept (Brozović & Tregua, 2022; Frow et al., 2014; Vargo & Lusch, 2011). On a macro level, society is an environment that can produce irritations to be observed, selected, and processed on a service ecosystem or service system level. LST provides crucial concepts for understanding the interplay of micro, meso, and macro service layers, pointing considerably beyond more generic frameworks, limited to the interplay of service systems and their environment (Edvardsson et al., 2011).

LST enables this theoretical clarification due to its hallmark principle that every system must have one single guiding difference to establish itself as different from its environment, e.g., (Luhmann, 1995b, p. 455). For service systems, this guiding difference is service. This axiomatic view departs from earlier definitions of service systems that contain multiple elements with different system references—e.g., people, organizations, information, and technology (Jim Spohrer et al., 2008). We argue that mixing up systems with different guiding differences leveraged the conceptual confusion about the service system concept and its relation with other system concepts. LST allows to zoom into the service system concept to distinguish service from other types of elements, including people, organizations, information, and technology as resources (Maglio et al., 2009) that are selected, uttered, and can be understood as service by a beneficiary, all networked to service based on the principles of a system's structural coupling (Luhmann, 2013, pp. 83–101). Of course, resources and their combinations remain indispensable for service. Nevertheless, distinguishing different types of systems—such as social systems, service systems, or maybe resource systems—enables researching the mechanisms connecting them to bring about service, where service researchers struggle to find a compelling, theoretically robust explanation of 'services activities' (Skålén & Trischler, 2024). These mechanisms are obfuscated in current definitions of service systems and service ecosystems, e.g., (Huotari & Hamari, 2012; Immonen et al., 2016; Jim Spohrer et al., 2008; Sudbury-Riley et al., 2020; Vargo & Lusch, 2008), which abstracted from their interplay. We argue that identifying how different types of systems interpenetrate and interplay to establish service allows for a more specific, nuanced, and conceptually consistent analysis of service phenomena. For instance, a human's observation using a meaning system (Luhmann, 1995b, p. 38) can be structurally coupled to a digital platform (Robra-Bissantz & Schlimbach, 2023), which is a resource. Structural coupling highlights how service systems maintain autonomy while adapting to interactions with other systems, forming dependencies that facilitate mutual influence without merging into one unified system (Luhmann, 1995a, p. 85).

Obviously, social systems and service systems interpenetrate significantly since they both rely on communication as a basic mechanism. For differentiation, we argue that service is communication that beneficiaries perceive as beneficial, aligning with prominent definitions of service (Hill, 1977, 1999; Vargo & Lusch, 2004). A social system is established through communication and precedes a service system. At the moment at which uttered information is understood as valuable, the observed system's elements become service elements, and thus, a service system emerges. In this way, communication as information, utterance, and understanding prompts a service system to emerge only if all three aspects are fulfilled and also the communication is perceived as beneficial, which aligns with current service thinking (Lovelock & Gummesson, 2004; Vargo & Lusch, 2004).

However, our conceptualization gently refutes the common assumption that social systems and service systems are completely identical, e.g., (Edvardsson et al., 2011; Löbler, 2016). Instead, our conceptualization gives service systems a narrower scope, centering on beneficial outcomes for a defined beneficiary or group. Their outcome-driven orientation makes service systems distinct in purpose and function, with structural formations directed toward generating service outcomes, setting them apart from the broader communicative dynamics of social systems.

4.2 Beyond action, communication allows for fresh investigations and introduces a new conceptualization of time into service systems

From the LST perspective, service itself is not merely an application of resources but a fundamental communicative act. This perspective diverges profoundly from the resource- and action-centric view prominent in Vargo and Lusch's (2004) foundational S-D Logic, where service is defined as the application of operant resources (knowledge and skills) to benefit another actor, emphasizing resource integration and value co-creation. Foregrounding communication complements related arguments from Edvardsson et al. (2011), who describe service systems as resource configurations (Brozović & Tregua, 2022), yet challenge their assumption that resource integration alone is sufficient to co-create service.

An LST view implies that the mechanism that binds together different types of systems is communication—including information, utterance, and understanding—not action. While the crucial role of communication has started to be discussed, action vocabulary (e.g., performances, deeds, processes, or competencies (Vargo & Lusch, 2004) is still viewed as the generative mechanism of value co-creation in mainstream service research. However, actions—unlike communication—do not include understanding (Luhmann, 1995b, pp. 168–177). Thus, current literature that focuses on actions implicitly limits service research to phenomena in which actions find resonance (Luhmann, 2013, p. 54), meaning that they are observed and understood as valuable by a beneficiary. This is not necessarily the case. Consider, for instance, a repair shop to which you do not bring your car or a TV show you never watch. In these instances, service providers apply their operand and operant resources to offer value propositions to clients. However, few service customers observe these utterances, and even fewer understand them as valuable, which is essential for a service system to emerge. In service research, which is still dominated by action vocabulary (Edvardsson et al., 2012; Skålén & Trischler, 2024), these incomplete communication processes could still be considered as service—they are consistent with the definition that service is "the application of specialized competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself" (Vargo & Lusch, 2004, p. 2).

We posit that accepting communication as the basic mechanism that creates service provides a pivotal advantage to research service phenomena in which communication processes remain incomplete or dysfunctional. For instance, value co-destruction—which is often assumed to be the consequence of untrustful actions (e.g., taking advantage of others) (Echeverri & Skålén, 2011; Plé & Cáceres, 2010; Prior & Marcos-Cuevas, 2016)—could instead be interpreted as a dysfunctional communication process that remains incomplete despite the actors' best efforts towards value co-creation. Our line of thinking proposes that value co-destruction (Echeverri & Skålén, 2011; Järvi et al., 2018; Plé & Cáceres, 2010) (Echeverri & Skålén, 2011; Järvi et al., 2018; Plé & Cáceres, 2010) might also happen unintentionally, since for instance, information about resources can be inadequately selected, insufficiently uttered, remains unobserved, or is misinterpreted (i.e., not understood properly). A system keeps exploring and testing new possibilities since "every accident, every impulse, every error is productive'' (Luhmann, 1995b, p. 116), even though they are not beneficial. However, destructive power can affect the structure of the service system, at which point they can build up new services more effectively. In this sense, fruitless paths of possibilities might retrofit dysfunctional communication structures and facilitate better ones, such that ineffective forms of value creation disappear over time while new forms emerge. For example, communication has been argued to sometimes fail on digital platforms, prompting system selection processes to restructure to meet user expectations more effectively (Robra-Bissantz & Schlimbach, 2023). Communication is cumulative, whereby it recursively builds on previous communication and constrains all future elements of communication (Luhmann, 1995b, pp. 163–171). If it is re-established, communication might also remedy value co-destruction. Since communication happens in situ, service systems would alternate between value co-creation and co-destruction, depending on how communication progresses in the very moment—here and now. We argue that through its focus on communication, an LST lens provides new vistas to study and understand this fragile and intriguing interplay (Lumivalo et al., 2024).

Another crucial implication of differentiating selection, utterance, and understanding as part of communication is introducing a new conceptualization of time into service systems. Departing from ephemeral actions (Hill, 1999), meaning that they dissolve quickly if they remain unobserved, communication allows researchers to study service subjects to long time offsets between utterance and understanding (Chandler et al., 2019). For instance, schools provide education as a valuable service that sometimes falls on deaf ears of pupils. It might be years later that they will understand their education as valuable and complete communication. Early service research has reflected similar service properties by pointing to the perishability of resources and actions (Zeithaml et al., 1985); however, it does not consider communication as a unifying concept. From a communication viewpoint, service is perishable in the sense that an utterance that remains unobserved permanently leaves communication incomplete and fails to lead to the emergence of a service system. While we do not wish to contradict the observation that the initial IHIP criteria were incomplete and lacked empirical grounding (Lovelock & Gummesson, 2004), we argue that re-investigating literature on perishability with a communication lens could help to reconcile this deprecated body of knowledge with current service research (Edvardsson et al., 2005; Grove et al., 2003; Sampson, 2010). Similar observations could be made regarding intangibility (here: service systems rely on communication, but communication might include observing and understanding selected physical actions), heterogeneity (here: understanding is subject to autopoiesis in the observing system, leading to heterogeneous outcomes), and inseparability (here: service requires communication as an inseparable process of information, utterance, and understanding, subject to time). Still, LST's focus on communication is surprisingly consistent with, yet offers pivotal insights to related work that foregrounds the non-ownership properties of service, positing "that services offer benefits through access or temporary possession, instead of ownership, with payments taking the form of rentals or access fees" (Lovelock & Gummesson, 2004, p. 20).

4.3 Autopoiesis links resources, including technology, to value-in-use

From an LST perspective, a service system is an autopoietic (self-producing) entity that emerges from a network of communicative interactions between benefactors and beneficiaries. LST posits that all elements are internally generated in an abstracted autopoietic system, and the system maintains its identity by continually reproducing itself through its own operations. This self-referential characteristic enables what we refer to as self-X features of service systems, such as self-organization, self-regulation, and self-sustaining, which others view as properties of service ecosystems (Akaka et al., 2013; Vargo & Akaka, 2012; Vargo & Lusch, 2016). Autopoiesis implies that service systems are operationally closed; they can only observe and interpret external elements through their internal operations (Luhmann, 1986). We posit that this operational closure is key to understanding why service is always uniquely determined by a beneficiary, which is one of the axioms stated by S-D Logic (Vargo & Lusch, 2016). Due to the axiomatic status of this proposition, S-D Logic did not provide a deeper theoretical foundation for this claim. An LST view, however, provides a compelling explanation that is rooted in systems theory, substantiating S-D Logic's claim.

Operational closure does not mean that a service system is cut off from its environment. Operations in the observed environment irritate the service system when re-creating its structure through a selection process (Luhmann, 1995b, p. 141). This perspective treats resources as external elements, observed and selectively integrated based on the system's internal communicative processes. Through recursive communication with their environment (e.g., feedback from customers or real-time data), service systems can autonomously adjust their processes or reconfigure their structure to optimize service quality (Barile & Polese, 2010b; Mora et al., 2009). This feedback loop is not simply a reaction but a process by which the service system actively maintains and evolves its structure based on ongoing communication (Vink et al., 2021). The system reorganizes itself internally by selectively incorporating feedback that resonates with its operational difference toward the environment, thereby supporting both the stability and adaptability of the system's structure (Barile & Polese, 2010b). This self-organizing process is fundamentally tied to the system's ability to reproduce its own elements (service) through internal operations (Mingers, 1989). In service systems, this occurs when beneficial communication is continued and internalized, and service elements emerge as new communication constructs. Existing identification structures are decisive in determining whether and how new services are created (Chandler et al., 2019). In this way, the boundary of a service system is fluid yet structurally maintained by ongoing communication. This is consistent with the claim that a service system's identity is defined not by a fixed set of resources but by the patterns of interaction and communication that sustain it (Storbacka et al., 2016). For service system design, this means that the effectiveness of, e.g., new customer data and technological changes depends on how well these inputs can be processed and selected within the system's existing communication patterns (Pentland & Feldman, 2008), which substantiates why a service system can ignore or underutilize valuable information if it cannot be linked to the system's existing structure and operational boundaries (Robra-Bissantz & Schlimbach, 2023).

An autopoietic view on service systems profoundly departs from current definitions that view service systems as allopoietic systems, describing them as combinations of tangible and intangible components, such as technologies, people, and organizations (Maglio et al., 2009; Jim Spohrer et al., 2008). An allopoietic view excludes autopoietic-based self-X features of service systems that were declared and spread in the literature as properties of service ecosystems (Brozović & Tregua, 2022; Chandler et al., 2019; Nazemi et al., 2024; Vargo & Lusch, 2016). For instance, self-organizing capabilities enable service systems to respond flexibly to environmental changes, which is critical in dynamic or unpredictable contexts (Chandler & Vargo, 2011). Still, for a service system to be autopoietic, it must exclusively consist of service elements capable of self-reproduction (Luhmann, 1995b, 286,449). Only service elements capable of participating in recursive communication processes can contribute to autopoiesis. Thus, while autopoietic properties like self-organization and self-regulation are often attributed to service ecosystems (Vargo & Lusch, 2016), they cannot be intrinsic features of service (eco-)systems.

Recognizing service systems as autopoietic necessitates rethinking their analysis and design, particularly their reliance and selection on external elements and system boundaries. LST supplies a framework to investigate how autopoietic service system structures originate, unfold, and sustain as autonomous systems shaped by different observation checkpoints in time, not by the actions of integrating resources alone.

Viewing service systems as autopoietic systems also has profound implications for understanding the role of (information) technology in service systems. From an LST perspective, technology always functions as an external operand resource facilitating communication between service systems and their environment. As an allopoietic system, technology depends on external impulses, without which they would cease functioning (Teubner, 1989). It is seen as a neutral structure that is embedded in the social complex of meaning and, at the same time, efficiently reduces social disturbance variables that allow "faster and better-coordinated information acquisition" (Luhmann, 1997, p. 788). As a causal simplification, such systems are disjoint from their environment (Japp, 1998; Luhmann, 1990, pp. 223–228). LST centers human observation as necessary for value creation, positioning it as the defining mechanism of service systems boundary. From this perspective, observation involves not just perceiving data but interpreting it within a meaning system—a capability inherently tied to human consciousness (Luhmann, 1993a, 1995b, p. 263). We posit that observation in service systems is inherently a social operation, while technical systems can only carry out distinctions but not indicate social action that refers to a meaning system (Luhmann, 1990, 2013, pp. 101–120) and finally to quantum-induced consciousness (Langan, 2002). It follows that only consciousness-driven operations can truly observe and thus understand service. It follows that technology—as long as it remains non-sentient—must always remain an operand resource in a service system. In contrast, observation, used by consciousness, resides as (the only) operant resource within humans (Luhmann, 1992, 1993a). Endorsing this view, structuration theorist Giddens posits that we cannot evade human distinctiveness (Giddens & Pierson, 1998, pp. 82–83), which lies at the very core of observation.

This view of technology as a passive (operand) resource stands in contrast to some recent approaches towards positioning AI as a potential co-creator of value within service interactions, e.g., (Akaka & Vargo, 2014a; Demetis & Lee, 2018; Manser Payne et al., 2021). While technology enhances communication and supports decision-making, we argue that it cannot become an observer in its own right, according to LST (Luhmann, 1995b, p. 437) since it can only make a value proposition but not recognize value. It lacks the required degree of connective capacity to observe and react to undetermined environmental irritations and must, therefore, remain a trivial machine (Foerster, 1993, pp. 245–257). We posit that even if technical systems might still improve considerably, they can never self-organize as long as they lack the ability for self-reference, consciousness, and intentionality (Langan, 2002; Luhmann, 1995b; van Lier, 2013), preventing them from autopoietic self-reproduction (Maturana & Varela, 1980) and, finally, from attributing meaning and communication. In this way, information technology remains a "*functioning simplification in the medium of causality*" (emphasis in original Luhmann, 1991, p. 97), and service that relies solely on interactions with technology remains self-service. Rather than being an internal component of service systems, technology serves as both a boundary object (Razmdoost et al., 2023; Star & Griesemer, 1989) and an enabler for communication, shaping how service systems establish, observe, and differentiate in digital environments.

Still, technology remains constitutional for modern service. The relationship between technology and service systems exemplifies structural coupling—where technology impacts system behavior but remains an external influence, given the system's operational closure. This facilitation is vital for service systems, which rely on effective observation to differentiate themselves and maintain autopoietic self-reproduction. This way, the service system implements autopoiesis by evolving through self-directed processes rather than predefined, static configurations, supporting adaptability and resilience in changing environments (Robra-Bissantz & Schlimbach, 2023). Digital technologies play a pivotal role in facilitating and managing communication, highlighting their role in reflecting the service system's emergent nature (Breidbach & Brodie, 2017).

4.4 Value creation and institutions are inextricably linked by communication

Departing from the early definitions of service systems, service ecosystems were proposed as a new concept that, as the authors argued, links value co-creation with the institutions that set the rules, norms, and beliefs in which value co-creation is performed (Vargo & Lusch, 2011). Further research identified the emergent properties of these institutions as shared institutional arrangements (Vargo & Lusch, 2016). However, the extant research falls short of identifying the generative mechanisms that bring about institutionalization. While we acknowledge that, once again, actions-related vocabulary were argued to be this mechanism (Vargo & Lusch, 2016)—drawing on structuration theory (Giddens, 1984)—we refer to our arguments above to state that actions cannot be the single generative mechanism, since actions can remain unobserved, thus having no effect on establishing institutions.

From the LST view (Luhmann, 1995b, p. 139), communication is the generative mechanism for the emergence of institutions. Luhmann's main writings, in effect, deal with the question of how social relations are created and how they emerge based on communication, which—as he argued convincingly—is the only possible operation that can bring institutions as consolidation of expectations to life (Luhmann, 1995b, p. 160). In line with our observation that communication is the basic mechanism of value co-creation (proposition 3), communication is a duality that brings about value co-creation in every service system and simultaneously creates the institutions governing value co-creation. Thus, the role of communication is similar to the duality between structure and agency promoted by structuration theory (Giddens, 1984), yet relies on another mechanism: communication. This view profoundly departs from and extends current conceptualizations of institutions and institutional logic associated with service, offering new research vistas that rely on exploring the profound implications of institutionalization offered by communication.

4.5 Service systems emerge here and now, reaching beyond their design

The concepts provided by LST shed new light on the nature of digital innovation (Kohli & Melville, 2019), service systems engineering (SSE) (Böhmann et al., 2014), and service design (Joly et al., 2019). Traditionally, SSE has been viewed as purposeful acts of design that shape (some would even say: determine) value co-creation among service providers and customers, with novel IT-enabled services being a typical outcome of purposeful innovation activities (Kohli & Melville, 2019). Recent approaches highlight the importance of design for emergence (Vink et al., 2021), noticing that design cannot fully prescribe how value will be co-created. Instead, designers shall equip a service system to grow beyond their design by implementing mechanisms for their adaptation.

An LST view equips researchers with theoretical concepts to investigate how the design of other systems (e.g., communication systems, actions systems, information systems) interplays with the (hoped-for) emergence of (autopoietic) service systems based on communication. While an autopoietic view implies that we cannot engineer service systems directly, service systems engineering can "facilitate the emergence of desired value cocreation forms." (Vink et al., 2021, 172). Based on the observation that communication is the core operation for value co-creation, we clarify that this claim towards a design for emergence essentially means design for engaging in proper communication. In other words, we posit that designers can anticipate the expected interplay of resources that can then be observed and understood as service, leading to the emergence of a service system. Thus, the LST view does not downplay neither the role of design as a deliberate and purposeful action nor the role of technology as an important resource. Rather, our perspective serves to correctly identify their roles, respecting the mechanism that governs the emergence and autopoietic reconstitution of service systems.

This insight is echoed in current studies on IS design, highlighting the need to view technology not as a static element but as an active role in the structuring, emergence, and encouragement of service interactions (Breidbach et al., 2014; Breidbach et al., 2013; Demetis & Lee, 2018). LST spotlights designers cannot purposefully design a service system when it unfolds according to their own observation and communication. Similar observations have been made regarding the design of routines in workplaces (Pentland & Feldman, 2008). This focus on the indirect role of design does not contradict but updates current perspectives of SSE (Böhmann et al., 2014; Cavalieri & Pezzotta, 2012; Tien & Berg, 2003) and service design (Joly et al., 2019). Systems theory reminds us that systems engineering is inherently non-deterministic, and its outcome is neither fully controllable nor predictable, as emphasized by Vink et al. (2021). In a similar vein, Robra-Bissantz and Schlimbach (2023) argued that digital platforms evolve autonomously, often beyond designers' original intent, emphasizing that indirect design through adaptable communication structures is paramount.

4.6 LST has pivotal implications on S-D Logic's axioms

As indicated above, our re-conceptualization helps substantiate the foundational premises and axioms—unproven statements on which theory is based—of S-D logic (Lusch & Vargo, 2015). While axioms are not intended to be proven, we argue that providing a deeper theoretical foundation is highly desirable for the quest to establish a consistent and overarching service theory, as Lusch and Vargo (2006) advocate. Reviewing the implications for the five fundamental premises (FP1, FP6, FP9, FP10, and FP11) (Vargo & Lusch, 2016) reveals that our LST-informed propositions can substantiate the axioms of S-D logic while the axioms can remain fairly unchanged.

Still, we argue that the propositions provide a much-needed systems theoretical foundation (Barile & Polese, 2010a; Briscoe et al., 2012; Godsiff, 2010; Lusch et al., 2016; Mele et al., 2010; Ng & Andreu, 2012; Polese et al., 2017; Vargo & Akaka, 2012; Vargo et al., 2017; Xu, 2000) for the axioms rooted in LST that is compatible with current S-D Logic vocabulary (Figure 4).

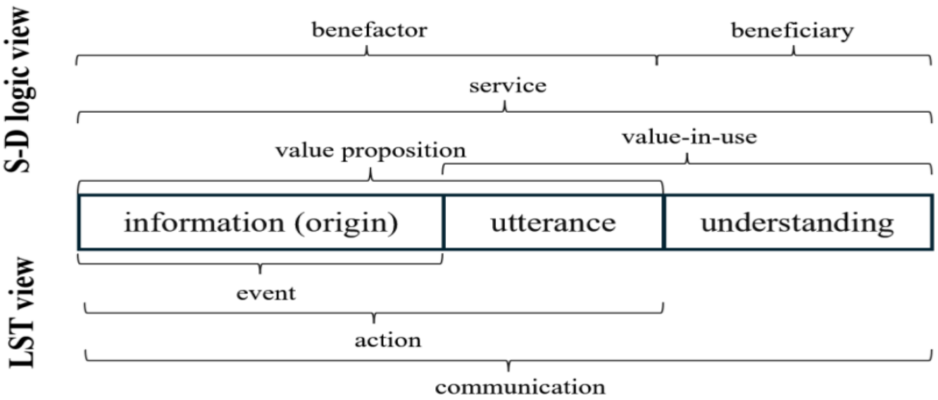

Figure 3: Service Vocabulary from the Viewpoints of S-D Logic and LST

New aspects introduced by our propositions (Table 3) highlight the crucial role of communication in establishing service as the fundamental basis for exchange (FP1) and observation as a crucial prerequisite for value co-creation through communication (FP6). Acknowledging communication's constitutive role in service, LST explains why value must always be uniquely and phenomenologically determined by the beneficiary and why this process is subject to a new understanding of the time that passes to complete communication (FP10). These insights provide new explanations for observation and communication as basic mechanisms behind resource integration (FP9).

Apart from value co-creation, communication also shapes institutions and institutional arrangements, pointing at the dualistic role of communication (FP11).

Table 3: Implications of the LST View on the Axioms stated by S-D Logic

S-D logic Axioms	Implications from an LST View
Service is the fundamental basis of exchange (FP1).	Service is the guiding difference that constitutes a service system. Communication is the generative mechanism for service.
Value is co-created by multiple actors, always including the beneficiary (FP6).	Service is autopoietic, building on communication that is observed and perceived as valuable by a beneficiary.
All social and economic actors are resource integrators (FP9).	All economic actors need to observe and communicate to co-create service.
Value is always uniquely and phenomenologically determined by the beneficiary (FP10).	Service is autopoietic, building on communication that is perceived as valuable by a beneficiary. Beneficiaries use their own operations to interpret value beyond benefactors' influence, establishing service. Communication is subject to time.
Value co-creation is coordinated through actor-generated institutions and institutional arrangements (FP11).	Institutions that govern value co-creation emerge based on communication. Since value co-creation also builds on communication, institutions and value co-creation are inextricably linked.

5 Conclusion

Service research has established itself as a research discipline in its own right that bridges boundaries between disciplines like (service) marketing, social science, computer science, information systems, and engineering. We firmly believe that no single discipline can analyze and design the mechanisms in service research fully enough to claim the completeness and generalizability of their theoretical insights. Systems theory was frequently named as the natural candidate for a theory that can serve to provide a common ground for multiple disciplines to research service, but no convincing attempt has been made so far to explore its full potential.

In this conceptual paper, we reviewed LST—a prominent and complete systems theory that applies to social systems—to identify theoretical properties that can substantiate service research. Following LST, we defined the service system as an autopoietic system in which benefactors (service providers) select and utter pre-selected resources as value propositions to be understood by beneficiaries (service customers) as value-in-use, altogether completing a communication process that is subject to time. Drawing on the assumptions that service builds on communication and that service systems are autopoietic systems, we developed five propositions that encouraged us to revisit and extend current definitions of the service system and service ecosystem concepts, taking up authoritative calls for action. Based on the extended definitions, we revisit the axioms of S-D logic with the concepts supplied by LST, strengthening their role as a common reference point in service research.

We see LST as a strong and complementary theoretical lens through which core concepts in service research can be substantiated. Still, we acknowledge three limitations. First, even when discussing many concepts of LST, we could not discuss all its aspects in detail, e.g., bounded rationality or double contingency. Further research is required to explore the implications of these concepts for service research. Second, establishing a general systems theory that unites all systems theories is a vision that has remained unachieved and might never be fulfilled. Hence, other researchers might use other systems theories to further substantiate the service system abstraction. We want to stimulate this scientific discourse as a community task to increase the theoretical validity of the core concepts used in our discipline. Third, we acknowledge that Luhmann has been criticized for abstracting the concept of autopoiesis to social systems, even if closer investigations revealed that such criticism is unjustified. Still, even LST leaves some important aspects discussed in service research unanswered. Particularly, the role of human actors in service systems and the interplay of social systems (autopoietic systems) with technology (allopoietic systems) need to be discussed further to contextualize LST in service research.

We call on subsequent research by interdisciplinary teams to explore the array of theoretical concepts supplied by LST and other systems theories more fully. We trust that doing so can provide a fresh perspective to research service phenomena—like the interplay of value co-creating and co-destruction—and serve to consolidate our body of knowledge based on the strong conceptual foundations of systems theory.

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Appendix: Explaining and Justifying the Selection of LST

LST offers a strong theoretical lens through which core concepts in service research can be further substantiated. To outline the relevance of LST in comparison to existing system theories, it is important to analyze the existing theories and derive implications regarding their similarities and fundamental differences. In this regard, we want to take a closer look at Giddens structuration theory, adaptive structuration theory, complex adaptive systems, and viable systems theory. Starting off with Giddens's structuration theory, we can outline that the primary unit of analysis is the individual actor and their agency within social structures. Structuration theory emphasizes the interplay between structure and agency. It highlights how individuals reproduce and transform social structures through their actions and practices. It sees agencies as an essential component in creating and maintaining social systems. Luhmann's system theory focuses more on the autonomy and self-referential nature of social systems as the primary unit of analysis. It examines how social systems operate, communicate, and self-reproduce through a network of interdependent subsystems. While Structuration theory focuses on the actions (routines) taken by humans that are influenced by social structures. LST focuses on communication (not action) as a central means of system reproduction. One fundamental difference that favors LST is that the structuration theory focuses on institutional arrangements over time, but LST also considers one-time encounters as service systems.

Adaptive structuration theory (AST) is the adaptation of structuration theory, which originated in IS and focuses on the structuring properties of technology. Accordingly, AST significantly emphasizes technology and its impact on social systems. It examines how individuals and groups adapt their behaviors, structures, and practices in response to technology. AST recognizes the role of technology in shaping and influencing social structures and explores the iterative process of adaptation. AST offers insights into the adaptation of individuals and social structures in response to technology but does not address boundary conditions. Hernes and Bakken (2003) argue that boundaries are essential in defining systems as the boundary is a neutral marker of where one system ends and another begins. According to Luhmann, social systems maintain boundaries. He further describes the role of boundaries as follows: ‘Using boundaries, systems can open and close at the same time, separating internal interdependencies from system/environment dependencies and relating both to each other.

These boundary conditions or constraints are not defined in AST. (Thomas & Bostrom, 2010) argue that adaptive structuration theory remains silent when predicting technology adaptation, but it offers a framework to capture elements pertinent to causing technology adaptation. Their study found even when technology structure is not a primary cause, technology adaptation can occur due to external constraints and trust and relationship inadequacies. Neglecting external constraints or boundaries can be misleading in this regard.

Similarly, complex adaptive systems (CAS) also lack the ability to define boundaries (which on the contrary is very sophisticated in LST). Similarly, (Cilliers, 2002) argues defining boundaries is not easy for CAS. The dynamic behavior of CAS reflects interactions within and between a system and its environment. Knowing system boundaries can be interesting and would help to define service-related boundaries in service systems. However, it must be considered that in CAS, multiple systems and their components can overlap, interact, and are often embedded in each other (Chu et al., 2003; Holland, 1992a).

Other than LST, the VSA does not address the self-referential aspect in a system. (Mingers & Brocklesby, 1997) argue that they cannot see anything in the theory of viable systems that implies self-production of components. In addition, they emphasize that it is difficult to satisfy the requirement of self-reference in a viable system. Therefore, Beer must include principles and axioms to maintain the self-referential property.

Applying LST makes the autopoietic features of systems theory accessible to service research. Concepts like interpenetration, operational closure, self-organization, or re-entry have no counterparts in service research yet. LST can provide common ground for research on service, but no convincing attempt has been made so far to explore its full potential. In this conceptual paper, we review LST, the most prominent and complete systems theory that applies to social systems, to identify theoretical properties that substantiate our discipline of service research.

Despite LST not receiving much attention among service researchers, we argue that its focus on social systems makes it a particularly promising theory to substantiate the service system abstraction since service systems and social systems are closely intertwined (Edvardsson et al., 2011). To us, this work appears closest to reaching the abstraction level required to establish the principal concepts of a general systems theory (Troncale, 1978, 1985) and to provide a 'skeleton of science' (Boulding, 1956). LST reveals interdependencies among systems, provides an exceptionally high level of generalization, and is predestined to be applied to other systems in other disciplines (Luhmann, 1995b, pp. 1–3). Drawing on Demetis and Lee (2018), who discussed the implications of LST for information systems, we posit that LST can also inform further conceptualizing of the service system and service ecosystem concepts. Further differences and commonalities among the theories are summarized in the following table.

Table 4: Comparison of Different System Approaches

Concept	Luhmann's Systems Theory (LST)	Structuration Theory (ST)	Adaptive Structuration Theory (AST)	Viable Systems Approach (VSA)	Complex Adaptive S ystems (CAS)
Origin	Sociology	Sociology	Information Systems	Management	Computer Science
Focus	Social systems, autopoietic systems	Constitution of society as social structure and its multi-faceted interplay with human agency	Adaptation of structuration theory for IS, focusing on the structuring properties of technology	Business organizations as systems that are managed to adapt to and survive in a volatile environment	Technical systems consisting of large numbers of actors/agents that produce simultaneous signals
Leitmotif	Social systems constitute themselves as a difference from their environment. They are restricted to using their own operations to re- constitute themselves, while they can observe and be observed by their environment. Communication is the basic operation enabling a system to re- constitute its elements and relations in a process of self- organization, making it an autopoietic system.	Social structure comes into being and is reproduced only through human action. Vice versa, social structure enables and constrains human action. Both are connected in a dynamic interplay, referred to as duality of structure. The knowledgeability of humans is bound by the unconscious and by unacknowledged conditions and unintended consequences of action. Routine is the predominant form of day-to-day social activity. Social reproduction is subject to contextualized interaction. Social identities are markers in the virtual time-space of structure. Social identities are markers in the virtual time-space of structure. Agents are knowledgeable	IT, work tasks, and the environment are sources of social structure. Thus, not all structures are purely virtual. The social structure provided by IT refers to structural features and the spirit of the feature set of IT. Interactions between users and technology are subject to a dialectic of control, in which both are shaped by the other. Appropriations refer to visible actions that evidence deeper structuration processes.	Organizations are systems that can be coordinated and managed to function in and adapt to volatile environments.	The actions of agents depend on the signals they receive. That is, the agents have an IF/THEN structure: IF [signal vector x is present] THEN [execute act y]. The act may itself be a signal, allowing quite complicated feedback, or the act may be an overt action in the agent's environment.

		about their actions and continuously reflect on their conduct.			
Definition of a system	A system constitutes itself as a difference from its environment.	No explicit definition	No explicit definition	An organization is viewed as a system	Systems are complex configurations of agents
Types of elements	Specific elements in line with a system's guiding difference	No explicit definition	No explicit definition	No explicit definition	Any
Static concepts	Super- and subsystems, interpenetration, self-description; self-reference; operational closure	Social structure, routine, context, social identities, power, agents	IT; work tasks; environment; structural features and spirit of the feature set of IT	Five subsystems required by an organization to function effectively	Agents, rules, modularity, self-similarity, openness, complexity, indeterminacy, density, connectivity
Dynamic concepts	observing and observer; self-organization; connective capacity;	Human action, rules, resources, structuration,	Structuration, appropriation	Communication, management, control, adaptability, self-regulation	Path dependence, adaptation, evolution, parallelism, conditional action, subroutines