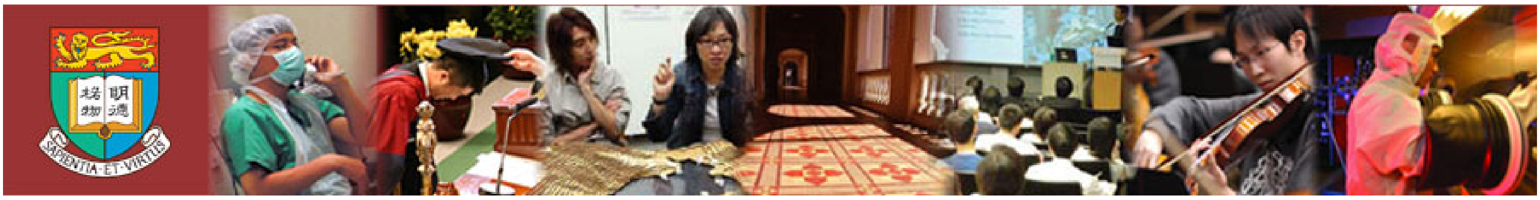

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On a Unified Definition of the Service System: What is its Identity?

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***Abstract*—In this paper, a unified definition of the service system is proposed. The motivation of this research effort is based on our observation that there are diverse definitions or descriptions of the service system in the literature and they have not provided an identity of the service system. Our goal to define the service system is thus to establish its identity. The most salient feature in our definition is the introduction of three subsystems in a service system: infrastructure, substance, and management. The substance flows over the infrastructure under the constraints of management. A service is established at the moment when the substance interacts with the human to cause a change in the human's status or state under a protocol, which further meets the human's request and need. With this new definition, a service system can be distinguished from other systems, such as manufacturing system, agricultural system, and product system. The new definition will be useful to classification of various service systems and various theories for service systems, which is the key to knowledge management for service systems and to optimization of design and management of service systems.**

***Index Terms*—Function-behavior-structure, network, service system.**

I. Introduction

A SYSTEM is a group of connected components. *System dynamics* refers to changes in a system with respect to time and event [1], [2]. There are many different types of systems. All systems are useful to humans or serve humans to a certain degree and in a certain way. From a point of view of economy, a system can broadly be classified into three categories: agricultural systems [3], manufacturing systems [4]–[6], and service systems [7], which are further relevant to agricultural economy, manufacturing economy, and service economy [8]. Over the last two decades, the major economies have seen a shift in emphasis from manufacturing economy to service economy [9]. Different service systems, such as healthcare and medical systems [10]–[12], enterprise information systems [13]–[16], transportation systems [17]–[19], and human-machine systems [20], have played significant roles in our society. The 2007 report by the International Labor Organization indicates that, for the first time in human history, worldwide service jobs (42%) outnumbered jobs in agriculture (36.1%) and manufacturing (21.9%). Further, while developed nations and their economies are dominated by the service sector, developing countries also start to assess their role in the service economy [21]. To understand these changes, a further understanding of the nature of the service system becomes timely and important.

The earliest usage of the term *service system* is in a book titled *Stochastic Service System* [22]. The emphasis of this book is to use a mathematical approach to studying telephone systems, especially the telephone traffic congestion problem. Obviously, despite the name *service* used in the book, there is no sense of service economy as in this paper. The earliest research on the service system, which has the same concept as that in our paper, was conducted by Levitt [23] and Mills and Mober [24]. They attempted to apply the manufacturing concept to the service concept. Their motivation and idea can be well understood from a point of view of economy. Subsequently, researchers have studied the service system from different angles [25]–[29]. The service system has evolved into a new discipline today. Further, there are different names or labels that have something to do with the service system, e.g., service engineering [30], [31], service science, management and engineering [32], and service systems engineering [26]. The forums on services including conferences and journals have spearheaded since then.

However, there is still an ongoing debate on what the service system is and why there is a need to distinguish a service system from other systems; in fact, these two questions in debate are related. A well known example which may reflect this debate is that *Fortune Magazine* has given up its attempt to differentiate service firms from manufacturing firms since 1993 after many years of publishing both the *Fortune* Industrial 500 and *Fortune* Service 500 [33]. *Fortune*'s movement may lead to the view that there is no need to

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TABLE I
DEFINITIONS OF THE SERVICE SYSTEM

	Definition	Literature	Category
1	With a service process, the customer provides significant inputs into the production process.	[33]	I
2	A service system is a voluntary and human usable system, that is, a usable system that contains a significant level of people or organizations as components during operation and needs voluntary engagement of an external person/organization to produce value.	[28]	I
3	A service system is a work system that produces services.	[34]–[36]	II
4	A *service system* is defined as a value-coproduction configuration of people, technology, other internal and external service systems, and shared information (such as, language, processes, metrics, prices, policies, and laws).	[7]	III
5	A service system is defined as a dynamic configuration of resources (people, technology, organizations, and shared information) that creates and delivers value between the provider and the customer through service.	[21]	III
6	A service system is a composite of agents, technology, environment, and/or organization units of agents and/or technology, functioning in space-time and cyberspace for a given period of time.	[37]	III

consider service as an independent economy entity. However, is that the case?

In this paper, we attempt to argue that the service system has its own identity and subsequently, we outline a response to two phenomena, namely, 1) change in world job distribution over different sectors of economy in the 2007 report by the International Labor Organization, and 2) no differentiation of service firms from manufacturing firms in *Fortune Magazine* since 1993.

The objective of this paper is to establish the identity of the service system by characterizing its unique set of attributes. The paper is thus organized as follows. Section II lists all existing definitions of the service system in the literature. Section II-A describes three systems, namely, manufacturing, agricultural, and product systems to prepare for their comparison with the service system to study the identity of the service system. Section III presents our definition along with a discussion of the difference of the service system from the manufacturing, agricultural and product systems. Section IV concludes the paper with a discussion of an analysis of the underlying reason behind the two phenomena, as mentioned in the introduction of the paper.

II. Existing Definitions of the Service System

The service system has been given different definitions from different points of view in the literature. The existing definitions of the service system in the literature are listed in Table I where the right column category is imposed by us (i.e., we further put these definitions into three categories).

The first category (Definitions 1 and 2) in Table I has the distinct feature that the human-in-the-loop is considered the key feature in a service system. In particular, Definition 1 considers the service to be a process driven by the customer. This definition can bring a manufacturing system and a product system into the domain of the service system. It is noted that the concept of customer is very broad; the generic sense of customer refers to a body of a thing that has a demand on a system, which can function to meet the demand. When the customer is an oil consumer (to an oil production firm), the oil production firm (which is a manufacturing system) then becomes a service system according to Definition 1. If one insists that the customer must be a human user, a cell phone (which is a product system) then becomes a service system, as in this case, a user is a customer, and the user's input on a cell phone triggers the work of the phone. Moreover, Definition 2 cannot distinguish a service system from a manufacturing system. Broadly, an organization that has a manufacturing business is considered to be a manufacturing system. Therefore, according to Definition 2, Boeing appears to be a manufacturing system. However, Boeing also has a service business, and Boeing can then be considered to be a service system. In short, bringing human in a system is not enough to give an identity of the service system.

The second category (Definition 3) has a distinct feature that the service system and manufacturing system have the same structure but both are capable of producing either a product or service. The so-called work system follows the definition given by Alter [34] that says: "a work system is a system in which human participants and/or machines perform work using information, technology, and other resources to produce products and services for internal or external customers."

The third category (Definitions 4, 5, and 6) has a distinct view that a service system is a complementary component of economic exchange [38]. There are two concerns with Definition 4. First, knowledge is not included. It is noted that knowledge and information are of distinct concepts [39]. Therefore, knowledge should be included in the definition of the service system alongside with information. It is noted that Vargo *et al.* [40] also realized this issue and added knowledge into the definition of service. Second, this definition is all-inclusive; as stated by the authors, individuals, families, firms, nations, and economies are all instances of the service system. The all-inclusive approach can hardly differentiate any individual systems, and it is not functional in practice. Value and value co-production or co-creation could be viewed an important feature of the service system; however, it is not a unique feature. In fact, following this definition, one can arrive at the point that all economies are service economies [40]. Definition 5 emphasizes the exchange between different economic resources and economic values [21]. This definition is also all-inclusive, ranging from individual people to businesses, nations, and even ecosystems. Definition 6 is an extension of Definition 4 by including the context and time to give a sense of dynamics.

Besides the definitions above, there are also definitions of the service system from a point of view of the nature of various services. For instance, Lusch and Vargo [41] defined that service may refer to a kind of action, performance, or promise that is exchanged for value. Krishnamurthy [9] outlined four features of a service as: 1) intangible, 2) consumed at the time it is produced, 3) provision of value-adding in different forms, and most importantly, 4) co-production. Regarding the last feature, Tien and Berg [26] explained that co-production means that the consumer and provider are communicating constantly, reevaluating the need of the customer and the manner in which the customer is being satisfied.

The above definitions in the literature are not able to distinguish a service system from other systems, such as agricultural systems, manufacturing systems, and product systems. For instance, in the agricultural system, humans and technologies are also included. Modern agricultural systems are highly automated, similar to manufacturing systems. Emphasis on technology, people, and organization for the manufacturing system can be dated back to the 1990s [42]. Further, the first and second features of service as described by Krishnamurthy [9] cannot include the transportation system that passes goods from place A to place B. The nature of co-production is the customer participation in businesses, which is not only for service but also for manufacturing [43]. It appears that an identity of the service system is still not clear.

In the following, we give a unified definition of the service system. We start with a discussion of the agricultural, product, and manufacturing system (Section II-A), and we then present our definition of the service system and explain the distinction of the service system from them (Section III).

A. Agricultural system, manufacturing system, and product system

An agricultural system produces food. The generic architecture of the agricultural system is such that it includes humans (farmers), equipment, soils, and organization, where the organization performs the administration and management functions. Examples of the agricultural system are the rice farm system, pig farm system, and so on.

A manufacturing system produces products. The generic architecture of a manufacturing system is such that it includes humans (workers), equipment, and organization. It can be seen from this definition that the manufacturing system does not have elements provided by nature, a point that allows the manufacturing system to be distinct from the agriculture system. Examples of the manufacturing system are the iron and steel industry system, chemical plant system, and so on.

A product system is a tangible entity that performs the conversion and/or transfer of motion, force, and power. The generic architecture of the product system does not include humans but humans are certainly a user of the product system. Examples of the product system are car, cell phone, and so on.

The next section will give a definition of the service system. The systems discussed above will serve a test-bed to prove whether the new definition can differentiate a service system from a manufacturing system, a product system, and an agricultural system.

III. Unified Definition of the Service System

We define the service and service system as follows. A service is a function that is achieved by an interaction between a human and an entity under a protocol. A service system or organization or firm consists of three subsystems: (i) an infrastructure, (ii) a substance, and (iii) a management to meet demands of humans or consumers. The infrastructure is of network, and substance flows over the infrastructure. The management plays the roles such as coordinating, leading, planning and controlling, which are applied to both the infrastructure and substance systems.

Remark 1: The new definition covers both the structural and functional aspects of a service system as well as the aspect of operation management. In our definition, we do not highlight the term organization, which differs from the others' in the literature [28]. We consider that the concept of organization has been implied in the concept of the system. Organization refers to putting things together, which is exactly the nature of any system.

Remark 2: The service system as we defined is structurally generic and functionally general. The phrase structurally generic here implies that the concepts and features we capture of service systems are common for all service systems. The phrase functionally general means that all kinds of services, such as transportation of goods, health service, and travel advisory agency, are covered.

Remark 3: The substance can have four generic types: material, human or animal, energy, data, or signal. Data further make sense for information or knowledge depending on a service's receiver, especially on the effect of the service to the receiver per se. According to Zhang [39], when data is used to inform a user of something that is otherwise not available to that user, the data is called information; when data has an effect on a user such that the user enables to do something, where to do something is otherwise not possible, the data is called knowledge. The infrastructure can include both equipment and humans.

Remark 4: A resource is a physical or cognitive entity with limited availability and accessibility that needs to be consumed to obtain a benefit from it. In the context of the service system as we defined, a resource could refer to both infrastructure and substance; that is to say, we may have an infrastructure resource or a substance resource.

Remark 5: The sense of a service lies in that a human's status or state is changed to meet his or her need by operation of a system. Production of goods needed by a human is not a service, as it focuses on from a raw material to a product (i.e., goods). Therefore, an agricultural or a manufacturing system is not a service system. A transportation system that moves goods from one place to another where the customer receives the goods is a service system, as it focuses on the change of goods in its location and time to meet a human's need.

Remark 6: That the structural aspect of a service system puts emphasis on a network is to capture a situation where the points where resources meet substances typically have many and change with respect to time and space. For instance, in an emergency evacuation problem, transportation tools are resources to be put into the infrastructure system (road, bridge, etc.) [17]. Where these tools are put is to be determined depending on situations, which is in fact a part of the management decision. We require that a service system must be a network structure and have many ports linking to customers and many ports to which resources can be connected.

Remark 7: A protocol is an agreement or constraint between service providers and service demanders. A chair in a meeting room is not a service system, as there is no protocol specified per se. A chair is a product. However, a meeting service department is a service system, as there must be a protocol available between anyone who wants to use a meeting room. In this context, a chair in the meeting room becomes a part of the meeting service system, through which a part of the services (let people meet), e.g., provision of the seating function, is achieved.

Several examples of the service system based on our definition can be illustrated. A telecommunication system is a kind of service system, where infrastructure is the equipment such as cable, switch, and so on [44] and substance is the data. Management is the data flow control policy. A travel agent system is a kind of service system, where infrastructure in this case is human agent and transportation equipment, and substance is tourists. Management is planning and scheduling of the equipment and tourist. Hospitals and medical centers are a kind of service system, in which the infrastructure consists of both medical professionals and equipments, and substance consists of patients, and the management makes sense for both the infrastructure (medical doctors and equipment) and substance (patients) systems.

We further explain the difference of a service system based on our definition from the three other systems (i.e., agricultural system, manufacturing system, and product system).

A product system is not a service system because a product system is not of a network, does not have many ports to many customers, and further a product system has only an infrastructure system only. For instance, a cellular phone alone is not a service system, as it has no substance; however, when it is integrated with a telecommunication system, it carries substance, which makes it as a part of the telecommunication system that is a kind of service system. A single and integral subject or system is not a service system even if this subject or system provides a service to a customer. This is because such a system is not of network when a service is provided. For example, a human who provides a massage service is not a service system.

More recently, the concept of the product-service system (PSS) has emerged to offer a seamless integration of products and services. The PSS can be viewed as the sale of the use of a product instead of a product itself [45]. The PSS can be viewed as a specialized service system owing to its product effect, and the PSS can be viewed as a specialized product system owing to its service effect. Therefore, the PSS is neither a product system nor a service system, but an integrated system out of a service system and a product system.

A manufacturing system or an agricultural system is not a service system because they focus on transforming raw materials to products. There is a view that a manufacturing system or an agricultural system may include the transportation system from a point of view of customers [43]. While such a view may be meaningful to the end customer, the manufacturing system and transportation system are subject to different principles in design and operation management. This means that two systems need a separate attention at a point where design and management are concerned.

It is more meaningful to have an integrated system, such as manufacturing-service, product-service, and service-manufacturing-product. These integrations do not eliminate the identity of each member system but rather bring together the member systems for a better business performance. The basic rationale behind these integrated systems is that features of the member systems may have some coupled effects on the customer satisfaction and customer-perceived value. These integrated systems are both a kind of service system and a kind of product or manufacturing system.

IV. Conclusion

The concept of the service system is an emerging concept in our society. Pervasiveness of services is seen as a natural outcome of manufacturing automation and data processing automation. It naturally comes how to improve the quality of a service system. Quest to the response to this question then leads to the call to treat service as a science, technology, and engineering. We observed that the existing literature regarding the service system has not provided a unified definition. Absence of the unified definition of the service system can definitely hinder further advancement of service technology and engineering.

This paper presented a unified definition of the service system. This was achieved by taking a view of the service system from both structural and functional aspects. The goal of developing a unified definition of the service system was that the definition should be generic, general, and functional in addition to provision of an identity of the service system, distinguishable from the agricultural system, manufacturing system, and product system. It appears that our definition has achieved this goal. Furthermore, with our definition, two phenomena mentioned before can be explained.

For the phenomenon that *Fortune Magazine* has not differentiated the manufacturing firm from the service firm since 1993, the underlying reason is that the generic architecture of the service system and that of the manufacturing system are of no difference with yet the difference being in at the instance level (e.g., number of humans, degree of automation, type of machines, etc.). It is noted that a unified definition of the manufacturing system, similar to the unified definition of the service system can be found in [46]. Consequently, a company may really have both the manufacturing business and the service business, as both can produce values. Assessment of a company from its value can hardly then distinguish the value created by its manufacturing system or its service system.

For the phenomenon of a dramatic increase in the job percentage in service systems, first, this may come at some expense of the decrease of jobs in manufacturing systems and second, this may be related to the inclusion of the service system in many firms, which were originally 100% manufacturing firms in the last decades. This second point is further related to the need of coping with the decline of employment in the manufacture sector, especially in some developing nations (e.g., China) in the last decades owing to the side effect of enterprise reform. Further, dissolving one large service system that previously worked for several manufacturing firms into several small service systems incorporated by these manufacturing systems will introduce redundancy in the small service systems, thereby increasing the total number of jobs in service sectors. The third reason for the increase of the job percentage in service systems may be related to the absence of a unified definition of the service system, a proposition we hold throughout the paper. This absence can actually lead to a situation where all systems are viewed as a service system. Consequently, manufacturing systems are thus viewed as service systems, and naturally the number of jobs in the service sector will increase, while the number of jobs in the manufacture sector will decrease.

In the future, a domain model for the service system based on the new definition proposed in this paper will be studied. According to [20], [44], [46], [47], the domain model is an essential one to be built for a more intelligent design and management practice for the system concerned, regardless of what systems are—e.g., information systems [48], cognitive systems [49], etc. Another future study will be on the classification of service systems along with the theories for design and operation management of these service systems. This paper will be useful for further advancement of service science, technology, and engineering. Yet another future study will be on integrated manufacturing-service systems, as in reality, manufacturing and service systems are likely coupled to many firms. A final future study is on resilient service systems and integrated manufacturing-service systems. The significance of studying resilience for business systems is well justified in [15], [46], and [47].

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