Translational Systems Sciences 2

Kyoichi Kijima *Editor*

Service Systems Science

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Translational Systems Sciences

Volume 2

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In 1956, Kenneth Boulding explained the concept of General Systems Theory as a *skeleton of science*. The hope was to develop something like a "spectrum" of theories—a system of systems which might perform the function of a "gestalt" in theoretical construction. Such "gestalts" in special fi elds have been of great value in directing research towards the gaps which they reveal.

There were, at that time, other important conceptual frameworks and theories, including cybernetics. Additional theories and applications developed later, such as synergetics, cognitive science, complex adaptive systems, and many others. Some focused on principles within specifi c domains of knowledge and others crossed areas of knowledge and practice, along the spectrum described by Boulding.

Also in 1956, the Society for General Systems Research (now the International Society for the Systems Sciences) was founded. One of the concerns of the founders, even then, was the state of the human condition, and what science could do about it.

The present Translational Systems Sciences book series aims at cultivating a new frontier of systems sciences for contributing to the need for practical applications that benefit people.

The concept of translational research originally comes from medical science for enhancing human health and well-being. Translational medical research is often labeled as "Bench to Bedside." It places emphasis on translating the findings in basic research (*at bench*) more quickly and efficiently into medical practice (*at bedside*). At the same time, needs and demands from practice drive the development of new and innovative ideas and concepts. In this tightly coupled process it is essential to remove barriers to multi-disciplinary collaboration.

The present series attempts to bridge and integrate basic research founded in systems concepts, logic, theories and models with systems practices and methodologies, into a process of systems research. Since both bench and bedside involve diverse stakeholder groups, including researchers, practitioners and users, translational systems science works to create common platforms for language to activate the "bench to bedside" cycle.

In order to create a resilient and sustainable society in the twenty-first century, we unquestionably need open social innovation through which we create new social values, and realize them in society by connecting diverse ideas and developing new solutions. We assume three types of social values, namely: (1) values relevant to social infrastructure such as safety, security, and amenity; (2) values created by innovation in business, economics, and management practices; and, (3) values necessary for community sustainability brought about by confl ict resolution and consensus building.

The series will first approach these social values from a systems science perspective by drawing on a range of disciplines in trans-disciplinary and cross-cultural ways. They may include social systems theory, sociology, business administration, management information science, organization science, computational mathematical organization theory, economics, evolutionary economics, international political science, jurisprudence, policy science, socioinformation studies, cognitive science, artificial intelligence, complex adaptive systems theory, philosophy of science, and other related disciplines. In addition, this series will promote translational systems science as a means of scientific research that facilitates the translation of findings from basic science to practical applications, and vice versa.

We believe that this book series should advance a new frontier in systems sciences by presenting theoretical and conceptual frameworks, as well as theories for design and application, for twenty-first-century socioeconomic systems in a translational and trans-disciplinary context.

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Service Systems Science

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Preface

The present volume illustrates a rich and promising research field in service, service systems sciences, which approaches service by combining and fusing two strands of sciences: the science of service systems and systems sciences of service. They overlap with a complementary emphasis.

Although ideas of service are not new at all, it is absolutely necessary now for us to cultivate a new frontier of service research. Indeed, the scale, complexity, and interdependence of today's service systems have been driven to an unprecedented level by globalization, demographic changes, and technology developments. The rising significance of service systems implies that service innovation is now a major challenge to practitioners in business and government as well as to academics in education and research. A better understanding of service systems is definitely required.

Many individual strands of knowledge and expertise related to service systems exist, but they often lie in unconnected silos. However, these no longer reflect the reality of interconnected economic activities. For example, manufacturers of engineering products adopt service-oriented business models while health care providers learn lessons from modern manufacturing operations. Indeed, there are wide gaps in our knowledge and skills across silos.

In response, service science, management, and engineering (SSME), or in short, service science, has emerged during the past decade as a transdisciplinary research field that aims to clarify, analyze, and design the structure and process of service systems.

Service science is strongly motivated to bridge the gaps by providing the science of service systems. Its vision is to discover the underlying logic of complex service systems and to establish a common language and shared frameworks for service innovation. To this end, a transdisciplinary approach is explicitly employed for research and education in service systems.

Service science puts the emphasis on commonalities and interdependencies between goods and services rather than on differences. Service science defines service as general, as value co-creation interactions among entities through which various values including social, economic, cultural, and even emotional values emerge. Service-dominant (S-D) logic, the main underpinning logic of service science,

maintains that the roles of providers and customers are not distinct but rather are both just symmetric resource integrators for the co-creation of value.

Service science defines the service system as dynamic configurations of people, technologies, organizations, and shared information that create and deliver value to customers, providers, and other stakeholders. Many service systems also have changed, from the supplier value chain to the value network of all stakeholders. Furthermore, because value co-creation interactions between entities are modernizing rapidly primarily because of information technology, service science especially pays attention to modern value co-creation mechanisms based on a growing repertoire of IT-enabled business models and approaches.

To deal with complexity, interactions, and the network of, in, and among service systems, we need to take a more systemic view. "Complexity" is derived from the Latin verb *complecti*, meaning "to twine together", while the noun *complexus* means "network". The word "system" comes from the Greek *systema*, which means "a whole composed of many parts". Hence, these words and ideas are themselves closely related and their interdependency is evident.

"Systems sciences" defines a system as a whole composed of parts and then focuses on investigation of how and what properties emerge from interactions and the interrelationship among the parts. Because systems sciences offers a way of thinking in relationships and interaction and theories and models to address complexity, it is legitimate to develop systems sciences of service by explicitly focusing on systemic properties of service and service systems. Dr. Jim Spohrer, one of the advocates of service science, maintains that service science itself is a specialization of systems sciences that seeks to provide an evolutionary account of service system entities and their increasingly sophisticated value in co-creation interactions.

As a volume of the Translational Systems Science series, this book emphasizes, in particular, a translational systems sciences perspective when the authors are approaching service, service systems, and service innovation. Indeed, the book employs systems sciences as a common framework or common language not only to approach service in a holistic way but also to take a transdisciplinary approach aiming to explain, analyze, design, and support service systems and their evolution.

The editor and his group have organized International Service Systems Science Workshops and Symposia at the Tokyo Institute of Technology annually since 2008 to discuss, communicate, and share the cutting edge of knowledge and experiences about service systems science with pioneering researchers and practitioners from North America, Europe, and Asia. All of the contributors to the present volume have attended the workshops at least once so that they have contributed their chapter from the perspective of sharing the basic idea of service systems science.

The book is divided into two parts: Part I, "Service Systems Research Perspectives", and Part II, "Service Systems Practice".

In Part I there are six chapters. In Chap. 1, "Social Value: A Service Science Perspective", Jim Spohrer, Haluk Demirkan, and Kelly Lyons analyze the concept of social value from a service science perspective, assuming that social value is of great interest to governments, foundations, non-profits, and corporate social responsibility organizations, and is a central focus of many policymakers.

A bridging framework for social value and individual value is presented along with some future research directions.

In Chap. 2, "Translational and Trans-disciplinary Approach to Service Systems", Kyoichi Kijima examines research schemes of service systems science from a translational systems sciences perspective. The author illustrates service systems science by emphasizing a translational approach, where processes from logic to theory and modeling are connected all the way through actual practice, and then introduces some typical reference models in service systems science including the value orchestration platform model.

In Chap. 3,"Service Artifacts as Co-creation Boundary Objects in Digital Platforms", Anssi Smedlund and Ville Eloranta introduce the concept of service artifacts, which are boundary objects created by the digital platform owner that engage the end user and facilitate the knowledge processes. The authors discuss service artifacts from the point of view of service dominant (S-D) logic and identify three categories of those artifacts. They also present examples of different types of service artifacts to illustrate their conceptual findings.

Chap. 4, "Four Axiomatic Requirements for Service Systems Research", by David Reynolds and Irene CL Ng, emphasizes the relevance of the application of a systems science perspective to service. The authors synthesize the developments in service systems research so far with the hope of clarifying some of the key concepts, and they explore some of the insights gained from what is rapidly becoming a well-developed body of literature. They state that service systems should be the "basic abstraction" of service science research and argue for four axioms that are necessary to advance knowledge in the domain of service systems.

In Chap. 5, "Social Innovations—Manifested in New Services and in New System Level Interactions", Marja Toivonen builds bridges to combine the perspectives of service, social, and system innovations based on the state of the art in research. She begins by opening up the concept and central topics of social innovation, followed by analysis with a review of user-driven innovation and open innovation.

In Chap. 6, "The Limitations of Logic and Science and Systemic Thinking—from the Science of Service Systems to the Art of Coexistence and Co-prosperity Systems", Takashi Maeno discusses the point that services are not simply an exchange of objects, acts, and money, but are, rather, complex acts with an exchange of psychological satisfaction and emotions. Then he points out the limitations of logic and science; namely, he argues that logic and science provide only a simplified model of the world, referring to the concepts of the uncertainty principle, the science of complex systems, and even the self-referential nature of logic.

Part II, "Service Systems Practice", consists of four chapters. In the first three chapters, service systems practice in terms of the public sector, healthcare, and the private sector are discussed in that order. The final chapter uniquely argues that "meta" service systems practice focusing on service R&D program design.

In Chap. 7, "Canadian Governments' Reference Models", Roy Wiseman explains reference models of public service for government improvement. The author maintains that well-constructed reference models, consisting of a common framework and language to describe the business of government, can assist in "doing government better".

He concludes that focusing on how governments are achieving the outcomes through their programs and services moves the discussion to a new level.

In Chap. 8, "What Is 5S-KAIZEN: Asia–African Transnational and Translational Community of Practice in Value Co-creation of Health Services", Hiro Matsushita deals with movement of transferring 5S-KAIZEN to the value co-creation activities of the service sector including health care and medical services. Kaizen ("continuous improvement") although the 5 S's (sort, set, shine, standardize, and sustain) originates in the operational management methodology of the Japanese manufacturing sector. Based on participatory observation and action research, the author presents the movement from the perspectives of systems thinking and service systems management. Improving practices applied to African health services is also reviewed.

In Chap. 9, "Creating Information-Based Customer Value with Service Systems in Retailing", Timo Rintamäki and Lasse Mitronen illustrate how information-based value creation has implications for the way retailers design and manage their customer value propositions for competitive advantage. By analyzing data from Japan, the U.S.A, and Finland, they assert that understanding the roles of different channels in the individual stages of the customer experience provides valuable input for service system development.

Chap. 10, "Service R&D Program Design Aiming at Service Innovation", by Yuriko Sawatani and Yuko Fujigaki, is unique in that it discusses service R&D program design for promoting service innovation. Although most design activities are carried out at the planning phase, the authors point out that the execution-phase activities are more important to achieve program-level objectives by strengthening the linkage of R&D and innovation. These interactions between a program and projects create values not expected at the planning phase, so that program management has to encourage these post-value co-creation characteristics.

The editor believes that the present volume, as part of the Translational Systems Sciences series, will certainly contribute to promoting the science of service systems as well as systems sciences of service with insightful findings and implications based on a translational approach.

Tokyo, Japan
31 May 2014

Kyoichi Kijima

Contents

Part I
Service Systems Research Perspectives

Chapter 1
Social Value: A Service Science Perspective

Jim Spohrer, Haluk Demirkan, and Kelly Lyons

Abstract This chapter provides an analysis of the concept of social value from a service science perspective. Social value is a concept of great interest to governments, foundations, nonprofits, and corporate social responsibility organizations and a central focus of many policymakers. Service science is an emerging transdiscipline for the (1) study of evolving service system entities and value co-creation phenomena and (2) pedagogy for the education of twenty-first-century T-shaped service innovators from all disciplines, sectors, and cultures who may become social value generators through cross functional engagements. A bridging framework for social value (as calculated by social entities) and individual value (as calculated by individual entities) is presented along with some future research directions.

Keywords Service science • Social entities • Social value • Transdiscipline • Value co-creation

1 Introduction: Motivations and Goals

What is social value? This chapter provides a definition and analysis of social value from a service science perspective. As we will come to see, social entities are collectives built up from individual entities in a nested, networked fashion. To begin, we consider an example of social value in the wild.

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When geese and other migrating birds fly in V-formation, trailing birds benefit from the extra effort of the goose upfront or leader. The lead goose is efficient. As the leader becomes exhausted, a natural rotation of leadership occurs where the strongest and best positioned moves into the leadership role. How many generations of evolution of migratory birds were needed to create the genetic and behavioral patterns for this aerodynamic collaboration? What role did competition and predators play pruning the weaker trailing birds, allowing this unique form of collaboration to emerge?

In the evolution of human groups, a leader is also often efficient, who can make a way to make things run more quickly and smoothly when there are difficult choices. When no single right choice exists for individuals, leaders select a best choice—the choice of compliance, following or obeying the leader. A leader thinks of self and thinks of group well-being and often benefits most from the health and survival of the group. However, what about groups without leaders, how do they operate, and what are the pros and cons of leaders?

Let's try to answer our first question. What is social value? How can we compare the social value of leaders to the social value of such things as literacy or money? Does scale (population size) and level (*knowledge burden*[1]) matter a lot or a little? Social value is arguably created by any number of evolved or designed solutions to human challenges and opportunities. It includes social capital as well as the subjective aspects of well-being, such as their ability to participate in making decisions that affect them and others.

To answer these questions further a broad perspective on human history is needed. Service science, which is an emerging transdiscipline, provides one such broad perspective. A transdiscipline borrows from existing disciplines, without replacing them. Like any emerging science, service science provides a new way of thinking and talking about the world in terms of measurements on entities, interactions, and outcomes, but also adds diverse symbolic processes of valuing (Spohrer et al. 2011; Spohrer and Maglio 2010). Specifically, a service scientist seeks to measure the number and types of entities, interactions, and outcomes, in order to advance better methods, processes, and architectures for thinking, talking about, and shaping the world in terms of nested, networked service system entities and value co-creation phenomena, including their diverse processes of valuing (Spohrer et al. 2012). These concepts (service systems, value co-creation, processes of valuing) are rooted in a worldview known as service-dominant logic or SD logic (Vargo and Lusch 2004, 2008). In the parlance of SD logic, service systems are sometimes referred to as resource integrators and value co-creation is often exemplified in exchange. According to SD logic foundational premise (FP) 10 "Value is always uniquely and phenomenologically determined by the beneficiary." This premise

[1] The *knowledge burden* of a society (species) derives from the need to ensure that the next generation has the knowledge required to run all technological and institutional/organizational systems needed to maintain the quality of life of theirs and future generations and continue innovating, thus growing the burden (Jones 2005).

describes how the ultimate action in service exchange is in the processes of valuing is defined.

In fact, all entities, be they social entities (such as a nation, city, foundation, hospital, business, etc.) or individual entities (such as a person), each has implicit processes of valuing that they are sometimes able to make explicit and empirically evaluate against other explicit processes of valuing. Formal service system entities (as opposed to informal service system entities) can be ranked by the degree to which they are governed by written (symbolic) laws and evolve to increase the percentage of their processes that are explicit and symbolic. For example, early hunter-gatherer groups that existed before written language are a type of informal service system (social entity). However, today, modern nations have constitutions, written laws, regulations, and policies and create written reports evaluating their compliance, often further validated by external auditors. Modern service systems use information and communications technologies (ICTs) to augment their capabilities (Engelbart 1995). The augmentations create a reliance on technology (and other formal physical symbol systems), which add to the knowledge burden of society (Jones 2005). Growing knowledge with respect to ICT-related design, execution, storage, transmission, and reuse is creating opportunities for leading public and private sector organizations to configure service relationships that create extraordinary new value (Chesbrough and Spohrer 2006). More specifically, ICT provides the means to improve the efficiency, effectiveness, and innovativeness of organizations (Bardhan et al. 2010).

Often service science is framed in the context of business-to-business outsourcing services (Maglio et al. 2006; Spohrer et al. 2007). To address service design for social enterprises, refinements to the foundational concepts of service science have been proposed (Tracy and Lyons 2013). So like all early stage scientific communities, the language for talking about service systems and value co-creation phenomena continues to evolve, including approaches to incorporate the concept of social value into service science thinking (Spohrer 2009).

The emerging service science community greatly benefits from theoretical and empirical studies done by a growing number of service researchers (see Appendix). Empirical studies of the economic success of businesses that adopt SD logic have begun to appear (Ordanini and Parasuraman 2011). Some studies of social enterprises have also begun to appear (Tracy 2011; Tracy and Lyons 2013). These latter studies highlight noneconomic measures such as emotional value (e.g., reduced anxiety, increased motivation, increased self-esteem, a sense of empowerment or peace of mind) and social value (e.g., ethical sourcing) and suggest a great deal more research is needed.

The purpose of this chapter is to analyze the social value in terms of service science and provide research directions on what and how we can bridge social value and individual value.

In the next section, a short overview of social value from a conventional perspective is provided. Section 3 provides background on service science. Section 4 is an initial service science perspective on the concept of social value, and Section 5 concludes with future research directions.

2 Overview: Social Value

Psychologists have defined three kinds of individual orientations (cooperative, individualistic, and competitive) and used them as theoretical bases for many studies investigating the ways in which individuals approach, judge, and respond to others (Van Lange 1999). Van Lange (1999) conceptualizes social value orientation as that in which individuals maximize joint outcomes or maximize equality in outcomes, or both. Indeed, the leaders described in our opening section exhibit this social value orientation (Hakansson et al. 1982). However, societies are comprised of many people who have different orientations from competitive, to cooperative, to individualistic. The role of service entities such as nonprofits, governments, and funding agencies is not only to establish mechanisms to maximize joint outcomes and/or equality in outcomes but to be able to measure the resulting social value. This is a very challenging proposition when members of society have varying and conflicting systems of social values (Mulgan 2010).

The paper by Mulgan (2010) is one of the best short and practical overviews of social value from a conventional perspective. He highlights the fact that there is little agreement on what social value is even though funders, leaders of nonprofits, and policymakers are keen to measure and assess social value. The key obstacle to social value assessment is the misconception that social value is objective, fixed, and stable (Mulgan 2010). Instead, when social value is seen as subjective, changeable, and dynamic, we are more likely to be able to define appropriate social value metrics.

Mulgan (2010) notes that most people have an overly simplistic view of social, public, or civic value, which is roughly the value that national and regional social programs, foundations, nongovernment organizations (NGOs), social enterprises, and social ventures create. Over the last forty years, hundreds of competing methods for calculating social value have been created. Mulgan (2010) summarizes the pros and cons of the main approaches to measuring social value, including: cost/benefits, stated/revealed preferences, social return on investment, public/value-added assessments, adjusted quality of life/satisfaction, government accounting measures, and field-specific measures.

He also identifies several factors that explain why current measures of social value too often fail. First, value is in the eye of the beholder and cannot be assessed completely objectively. It is not possible to simply consider traditional economic principles such as supply and demand when social, psychological, and environmental factors come into play. Mulgan (2010) suggests that metrics and tools for measuring social value are useful if they help build markets, conversations, and negotiation in order to bridge between people and organizations that have needs and those that have solutions. It isn't sufficient to introduce clients and providers; an environment that encourages conversations and negotiations to take place must be created and nurtured. These environments can also help disenfranchised groups (such as homeless people, migrant workers, and people with mental illness) to have a voice in the market. These groups have social and economic needs but often do not have the resources or power to create a demand for suppliers of solutions and services.

A second factor contributing to problems with current social value metrics is the attempt to combine multiple perspectives (internal, external, and societal) into a single quantitative value. Rather than quantifying social value through a single number, Mulgan (2010) proposes a framework that can be used to rate proposals according to four dimensions concerning the concept of social value: strategic fit; potential outcomes or results; cost savings and economic effects; and risks associated with implementation of the proposal. In addition to rating the proposal on a scale of 0–5 along the four categories of value judgments, decision makers can include comments to support the ratings. Many of the judgments, ratings, and comments are made based on evidence and data available to the decision makers. The proposed framework also enables participants to include measures of the reliability of the evidence used to determine the ratings. The results of the social value judgments made using the framework are presented visually allowing multiple people to examine and question the measures. Over time, the ratings can be compared to actual social value assessments and can encourage consistency across decisions. The results can also be made public, keeping the decision-making and measurement process transparent and enabling communication across agencies.

Finally, Mulgan (2010) identifies the challenge of time as a factor contributing to the difficulty of measuring social value. For many social endeavors, value will not be realized until several years in the future and it is challenging to judge that future value against immediate costs. Using discounted rates as is done in the commercial world to value a given amount of money today according to the fact that it will be worth less in the future is not appropriate for governments and social organizations. Governments and social organizations give significant weight to the well-being of generations of society in the future so it not suitable to devalue the future social worth.

Convening stakeholders, providing a holistic view onto quantitative and qualitative points of view, making judgments (different values and processes of valuing), prioritizing issues, giving voice to the weakest in society (the disenfranchised), continuously listening and acting, managing complexity, and blending compassion with consequences are just some of the considerations. In many democracies, voters are usually willing to pay taxes for security (military, prisons, police force, and fire department), literacy (schools), infrastructure (roads, utilities), justice (courts), etc. However, other programs may be more controversial (e.g., sex education, drug treatment, homelessness, job training, housing, mental health therapy, animal rights, environmental protection). Part of the complexity is apportioning responsibilities across multiple levels—individuals, families, communities, cities, states, nations, and even continental regions such as the European Union. Another part of the complexity is the large number of cultural factors that come into play and across many hundreds of years of human history attitudes can vary dramatically.

Mulgan (2010) provides a state-of-the-art view on social value. Stepping back, a service science perspective on social value looks at how we got here. In broad strokes, a service science perspective recapitulates the evolution of our nested, networked ecology of service system entities—but before doing that let's introduce service science more fully.

3 Background: Service Science

Service science[2] draws on a great breadth of academic disciplines, without replacing them. How entities use knowledge to cocreate value is intimately tied to all disciplines, which can be thought of as societal fountains of knowledge. As disciplines create knowledge, which is woven into the fabric of society and becomes essential to maintain quality of life, that knowledge becomes part of the knowledge burden of that society (Jones 2005). What differentiates service science from all existing disciplines is that it is a transdiscipline, drawing on all and replacing none, with a unique focus on the evolution of service systems and value co-creation phenomena. Service science aspires to provide the breadth for T-shaped service innovators who have both depth and breadth of knowledge. Depth can be in any existing academic discipline, and appropriate breadth can improve communications, teamwork, and learning rates (IBM 2011). T-shaped innovators are able to bridge across disciplines applying their own knowledge depth to other knowledge areas.

A service science perspective, as we will see below, is a way of looking at the world through the lens of service science and SD logic. A physics perspective is a way of looking at the world and seeing a world of things made of atoms and forces, even though it is not possible for us to really *see* an atom. A computer science perspective is a way of looking at the world in terms of universal computing machines (e.g., physical symbol systems, Turing machines, etc.) and codes (e.g., symbols as both data and algorithms). An economics perspective is a way of looking at the world in terms of actors, supply and demand, externalities, and moral hazards. As we will see below, a service science perspective is a way of looking at the world in terms of an ecology of nested, networked service system entities and the value cocreation phenomena that interconnect them.

Human endeavors, such as sciences, build on philosophical foundations, and each science must first provide ontology (what exists and can be categorized and counted),[3] then epistemology (how we know and how others can replicate results), and finally praxeology (actions and how knowing matters or makes a difference)[4]. These three "ologies" explicitly or implicitly underlie all sciences; as humans, we seek knowledge of the world and of ourselves and then work to apply that knowledge through actions to create benefits for ourselves and others by changing aspects

[2] Service science is short for the IBM-originated name of service science, management, and engineering (SSME), since service science was originally conceived to be the broad part of T-shaped professionals that complements depth in any disciplinary area with breadth in SSME (IBM 2011). More recently service science has been referred to as short for SSME+D, adding design (Spohrer and Kwan 2009). Even more recently, service science has been referred to as short for SSME+DAP, adding design, art, and policy. The naming of a transdiscipline is especially challenging, and communities can debate pros and cons of names endlessly.

[3] New sciences may seem like stamp collecting or counting stamps to scientists in more mature sciences. For example, Lord Rutherford said, "All *science* is either physics or *stamp collecting.*" Service science is still at the stage of counting and categorizing types of entities, interactions, and outcomes.

[4] Thanks to Paul Lillrank (Aalto University, Finland) for this thought.

of what exists (e.g., service), in full awareness of our human sensory, cognitive, and motor limits—yet increasingly augmented by our technologies and organizations and augmented by scientifically and imaginatively derived knowledge, of both what is and what might be. However, all this knowing does create a knowledge burden which must be carefully managed (Jones 2005).

Quite simply, service is the application of knowledge for mutual benefits, and service innovations can scale the benefits of new knowledge globally and rapidly, but all this knowing does create a burden—including the burden of intergenerational transfer of knowledge.

Augmentation layers lead to the nested, networked nature of our world—specifically, as an ecology of service system entities. Value co-creation phenomena (service-for-service exchange) form the core of our human ecology (Hawley 1986). Value co-creation phenomena are also known as win–win or nonzero-sum games (Wright 2000). Competing for collaborators drives the evolution of markets and institutions and contributes to both their dynamism/stagnation and stability/instability (Friedman and McNeill 2013). Information technology, Internet of Things, big data, etc., are accelerating the ability of service systems to develop and continuously evolve and refine explicit symbolic processes of valuing, which further augment service system capabilities. Alfred North Whitehead, English mathematician, is quoted as saying: "Civilization advances by extending the number of important operations which we can perform without thinking of them" (Whitehead 1911, page 61). Augmentation layers, including technological and organizational augments, contribute to the nested, networked nature of our world and our knowledge burden (Angier 1998). Augmentation layers have many benefits, but they can also hide the extent of a society's knowledge burden.

The mature sciences of physics, chemistry, biology, and even computer science and economics can be used to tell a series of stories—overlapping and nested stories about our world and us. Physics describes the world in terms of matter, energy, space, and time, with fundamental forces well quantified across enormous scales to explain phenomena much smaller than atoms and much larger than galaxies. Physicists theorize and quantify to tell a story that stretches from before the big bang to beyond the end of time itself. Chemistry describes the world in terms of the elements, molecules, reactions, temperature, pressure, and volume. Geologists and climatologists, born of modern chemists, can tell the story of the birth and aging of our planet. Biology describes the world in terms of DNA, cells, and molecular machinery driven by diverse energy sources. Ecologists informed by modern biology tell the story of populations of diverse species shaping and being shaped by each other and their environments. Computer science describes the world in terms of physical symbol systems and other computation systems, codes, algorithms, and complexity. Cognitive scientists and neuroscientists are today working with computer scientists and others to propose stories of the birth of consciousness, communications, and culture in humans and prehuman species. Finally, economics describes the world in terms of supply, demand, externalities, principles, agents, moral hazards, and more. Economists theorize and quantify to tell the story of morals and markets, laws, and economies evolving over the course of human and even