

Chapter 1

Service, Knowledge Economy, and the Transformation of the Digitally Connected World

What is the big story about service? Of course, the service sector is huge and can make or break a nation's economic competitiveness. Of course, e-commerce and other digital services propel the growth of knowledge-based economies. And of course, the knowledge services of innovation breed new economic activities and enterprises, and spawn further innovation. But, is that all? What is new here — that we do not already know — that requires a new service science? The field of service studies is indeed very old. However, the newness may be the realization that what we already know is just the beginning of an emerging story. The unknown then, is, *how the story will continue to unfold and what will result, all through service.* For example, if computing is being made a service (as the industry says so), then should manufacturing, energy, and agriculture also incorporate the service paradigm as a means to improve and even reinvent themselves? How does service characterize the ongoing transformation of knowledge-based economies? We observe that the scientific nature of the transformation is the pervasive connection of the world through digitization, and the transforming power of scaling through such digital connections. *Service makes digitization, scaling, and transformation happen.* We submit that in the best case of humankind where reason prevails, the story should progress to new genres of service transforming manufacturing, agriculture, energy, healthcare,

and all other sectors of the economy, as well as the traditional “service sector”. The transformation should have the promises to make the economy more *sustainable* and *equitable*, as well as *efficient* and *advancing*; so a new service-led revolution will result, reminiscent of the industrial revolution. A new science will consolidate results in the field and support the change. This book focuses on a *service scaling and transformation theory* for enterprise *design*, and asks how the big story will continue.

1.1 We Need a New Service Science

Service is a well-defined concept, but service science is not. In fact, the notion that the world needs a new service science could be perplexing. To many, the science of service already exists, in the form of knowledge accumulated over thousands of years from the continuing practices of service activities. The knowledge, in the eyes of the beholder, could refer to the scientific studies of service operations, systems, technologies, enterprises, and industries, in the literature of management (e.g., retailing, marketing, and finance), engineering (especially industrial and systems engineering), and science (mathematics and computing), as the substance of the service science. In this view, service science is an umbrella name for all these results — i.e., a horizontal encompassing of vertical scientific disciplines according to certain common characteristics such as an orientation towards service practices. As such, the service science has a natural-born research paradigm to accompany it — the application-dominated theory building and proof, to meet the requirements of a philosophy of science. This view renders any call for a new service science, based on the sheer size of service alone, to be scientifically ambivalent or even outright frivolous. This argument is well-supported in the field.

In fact, people can also question the value of a new service science from purely perceptive angles. For example, is service progressive? The notion of developed versus developing countries is historically tied to the level of industrialization. In this context, the developing world often equates a huge service sector in its economy to the lacking of industrialization: a sign of backwardness with some class stigma.

In fact, service practices in these two worlds do differ a lot even for the same genre (e.g., in terms of professional identity), not to mention the differences in the types of service industries that each features. Therefore, the dominance of service in GDP (70–80 percent in the US, EU, Japan, and Singapore; 50–70+ percent in most other, populous countries including China, India, Russia, and Brazil) *per se* is not a scientifically precise indicator of an advanced economy, let alone a proof of service being the driver of progress. Advocates of service in the developed world need to work harder to establish their case: Whether service holds the key to global competition and the future progress of humankind; or it just follows the lead of breakthroughs elsewhere, such as technology and industrialization? Is service the locomotive of the economy, or the load on the locomotive? (Read: does service deserve a new science?) In any case, people could suggest that, what can be done on service has already been done, and what will come for the economy may not come from service.

Then, why are many serious people, in the industry and academia alike, urgently calling for a new service science, as evidenced in the Cambridge Paper by a service coalition (Cambridge 2008)? Why has there been a never ending parade of many other compelling calls under various popular banners in recent years, that consistently suggest the need for new basic scientific knowledge similar to the call of a new service science? They are unequivocal evidence affirming the existence of major basic gaps in the accumulated body of knowledge. One could recall the popular outcries of the challenges of the productivity paradoxes (e.g., the investment on information technology versus the lack of gains on productivity in the service sector), of the information revolution, and of the digital economy. The tenacious boon of the Web that society continues to enjoy in the aftermath of the bursting of the IT Bubble of the 2000s also offers a strong case. It clearly suggests that the widely perceived change due to the Internet is real, fundamental, and sustainable notwithstanding the proclaims that e-business is full of hype. The field has not provided sufficient scientific explanation to account for the discrepancies.

On the technical front, one could mention the emerging Web science (e.g., due to Tim Berners-Lee) and networks science (e.g., attributable to Duncan Watts) as proof of the need for new scientific knowledge. They intertwine with service systems although they each pursue their own causes. Corroborating this also is the well-known large-scale challenges to the fields of management, engineering, and science which are direct results of new service practices on the Internet and other cyber-infrastructures. For instance, the basic concept of firms, which underlie virtually all management theories and models, is struggling to accommodate the changes. A firm, according to economics, is an (optimal) embodiment of transaction costs for economic activities, and offers definitive divisions, controls, and ownership of resources, production factors, and outcomes. However, an array of significant new activities ranging from social networking to e-business and global supply chains goes beyond the rigid boundaries of firms. The practices of virtual, complementary, and globally extended enterprises have become commonplace of late. They alter the traditional academic landscapes of business strategy, marketing, and organization, to name just a few within management.

Similarly fundamental challenges also abound in engineering, especially industrial and systems engineering. Traditional results in these areas tend to assume some steady states for their solutions; e.g., the production systems and service operations studied will reach a prolonged “normal and stable” regime for a period of days, weeks, months, or even years, during which some generalized solution algorithms and decision rules can apply without constant adaptation. Systems and operations are optimized according to these states. However, new service systems and operations in, e.g., e-commerce and consulting, tend to defy the premise of steady states and feature a whole different set of conditions, since they target individual user needs and real-time usage patterns. These conditions include constantly evolving and even customized parameters (individual client information and demand), real-time and comprehensive engagement of concurrent operations (e.g., massive Web-based ordering and production), and time-delayed or prolonged asynchronous

interactions between system elements (e.g., distance learning). The resultant regimes, therefore, have to accommodate perpetually transient states (i.e., there is no steady state to optimize or analyze) and multi-modal real-time data streams (i.e., system inputs are convoluted from distributed online sources). Operations research, statistics, and some other disciplines of engineering have to re-examine some of their founding premises in the face of these new regimes. New robust results are in order.

Science, especially computational science, faces perhaps even more pronounced challenges. The field is increasingly exposed by the lack of theory to design, prove, and predict the performance of complex computing applications. As the complexity continues to explode, many fear the previous theory could implode. For example, concerning applications in natural sciences, how to fuse astronomical amounts of data from numerous sources using vastly differing measures, models, and technologies, to collaborate on the studies of the human being, the earth, and the universe? These studies are, by definition, multi-disciplinary and far exceed any one group's ability to comprehensively investigate them. In the realm of service, how to reliably collaborate amongst proprietary members of virtual global enterprises that involves thousands or perhaps even millions of databases, business processes, and individuals to swap files, retrieve data, and inter-operate algorithms, on demand? A root cause to the computing problems is simply the fact that computer science is built on the basis of single-machine models of the von Neuman machine and Turing machine. Controlling massively distributed computation on the Internet is beyond the charge of these models. In addition to this scaling up problem, service is utterly personal and hence requires scaling down, too. This personal dimension can tease technology and make researchers' eyes twinkle: just consider the enormity of the reward, and challenge, of really personalizing Internet search engines account for the user's context and perform with pinpoint accuracy. This example articulates simply that service requires personable intelligence to cocreate value.

All these technical challenges are not limited to service applications, nor caused exclusively by service. However, the innovations in

service, foremost among them being Internet-based enterprises, have singularly heightened the issues and constantly been pushing the envelope. It is these new economic activities that have brought to the fore virtual firms, real-time and transient regimes, and large-scale collaborative computing. On balance, they all reflect the scientific challenges of the changes in knowledge-based economies, and hence resonate on the same need for a new service science. Therefore, a reasonable argument seems to be that the “traditional service science” is not sufficient for the new, knowledge-based practices of service. It follows that a new service science will address these new basic results; and an accurate approach to developing it is to focus expressly on the *common scientific characteristics of new service practices*. With this, the remaining question is the value of (new) service.

The answer starts with our experience in our Web-centric society. Given the support of the Internet in our lives, one has to wonder, is it not true that knowledge-based economies are based on (new genres of) service and led by innovations in service? Is it not true, then, that the value of a new service science is its pivotal contributions to the understanding and promotion of service’s leading role for a knowledge-based economy?

To contemplate further, we recognize that service is not necessarily a homogeneous concept. The perplexity of service may be rooted in its double nature: *There is service; and there is digitally connected service*. Service may include many pre-industrial revolutionary activities, such as hair-cutting, cooking, and theatric performance. Digitally connected services, on the other hand, as exemplified by social networking, e-business, and digitization of systems, are definitely post-industrial revolutionary. If an economy is dominated by service, then the society may either be enjoying the leisure created by mature industrialization, as in the First World; or, be lagging behind industrialization as in the Third World. However, if an economy is dominated by digitally connected services, then the society is unequivocally signaling its transformation of industry, agriculture, energy, health-care, education, government, defense, and all other sectors, as well as service *per se*, into a new, knowledge-based mode of production for a better future. Digitally connected services are philosophically a class

of service, but this class is new and progressive, worthy of a new science to guide its transforming power toward sustainably prosperous knowledge-based new economies. The new service science will explain the transformation and growth where the linear extrapolation of the previous knowledge for service does not.

A small part of the overall effort by the field towards such a new service science is reported in this book: the *theory of service scaling and transformation*. We provide an overview of its basic concepts in the next section.

1.2 Service Scaling and Transformation: A Conceptual Overview

The book is about service scaling and transformation. It originated from the author's intellectual curiosity in a scholarly commotion: An industry-academia coalition led by IBM started an initiative of promoting a new service science in around 2005 (see the IBM Service Science, Management, and Engineering [SSME] Conference 2006 — Murphy *et al.*, 2006; where the call now includes design [SSMED]). A number of scholarly conferences, special issues of academic archival journals, and individual scholarly papers have since responded to the call to address the gaps in scientific knowledge about service research and innovation (e.g., Anderson *et al.*, 2006; Bitner and Brown, 2006; Cherbakov *et al.*, 2005; Chesbrough and Spohrer, 2006; Davenport, 2005; Dietrich and Harrison, 2006; Gautschi and Ravichandran, 2006; Hsu, 2007a; Hsu and Spohrer, 2008; Lovelock, 2007; Lusch and Vargo, 2006; Maglio *et al.*, 2006; and Tien and Berg, 2006; Spohrer and Riecken, 2006; Spohrer *et al.*, 2008; Spohrer and Maglio, 2008; and Zhao *et al.*, 2008). The recent Cambridge Papers (2008) represents an effort by some members of the coalition to provide a common reference point for the emerging field. We adopt the basic definitions of service provided there. Specifically, *service* is defined as the *cocreation* of value between *service systems* (customers, providers, etc.), and *service systems resources* (the dynamic configurations of people, technology, organizations, and shared information) connected internally and externally by *value propositions*.

As such, *service innovation is realized in the design of service systems to implement new value propositions.*

A fundamental question remains in these documents: What is the definitive intellectual nature of today's service — who cares and why care? The answer will directly determine, scientifically, why the previous results can or cannot sufficiently address the need of service science, and prescribe how to prove it. It may be that a service science is mainly an integration, synthesis, and formalization of the accumulated results in the service-related fields to date. Or, it may also be that the new science is a distinct new discipline that requires a new fundamental scientific field characterized by new research paradigms and education programs to advance its knowledge. Both views enjoy significant support in the coalition.

A moderate view, which avoids an outright judgment of the dichotomy, is provided in Hsu and Spohrer (2008) as follows: When practitioners are calling for a new science to guide their efforts to systematically innovate and improve service quality and productivity, they see existing academic disciplines as knowledge silos, each with something important to contribute, but nonetheless with only a piece of the puzzle. The most successful sciences (physics, chemistry, and biology) all provide models at the appropriate level of abstraction to deal with the phenomena (entities, interactions, and outcomes) relevant to their emergent layer of the complex systems that exist in the world. Economics and anthropology come closest. However, judgment of value from a customer-perspective involves psychology and marketing. Measurement of value from a provider-perspective involves computer science, management of information systems, industrial and systems engineering, operations disciplines, and more. The new service science is envisioned to integrate these knowledge silos and fill in gaps with new basic results.

This book goes one step further from the above view to attempt formulating a continuum of knowledge for a new service science (*the pyramid view* — see Chapter 2). We start our contemplation on the intellectual nature of service with some empirical, and pragmatic questions: Why do practitioners need a new service science? Where

have the previous results come short? What is the economic mission of the new science?

We submit that a fundamental limitation of the previous scientific knowledge of service is its failure to explain *how service scales up, down, and transforms; and how this scaling yields benefits (economies of scale) to persons, organizations, and society*. In contrast, scaling of manufacturing is a well-established science. For example, the field of engineering provides standardization of parts, rationalization of processes, and optimization of systems to scale the production. The field of management develops strategies, organizations, and resources to guide the scaling of production. Economics explains the institutions required of the scaling. All these results have made economies of scale of manufacturing common knowledge in the field. In manufacturing, why auto makers and steel mills must strive to become global conglomerates to gain sustained and dominating competitive edge is considered self-evident. However, this is not the case with service. For service, there is little proven knowledge for similar standardization, rationalization, and optimization of resources, processes, and systems that involve, in particular, knowledge workers. Since the ensuing chapters will elaborate on this basic observation with specific topics of service science, we provide here only an overview about service scaling and transformation.

Scaling was first made a science by the industrial revolution. The story of the industrial revolution is the story of establishing an investment roadmap for solving the scaling problem for manufactured products, factory supply, and wholesale and retail distribution. Improving quality and productivity through standardization, specialization, and economies of scale have continued to this day, and have resulted in increased material wealth in a growing number of regions of the world. This product-dominant mode of production continues to dominate manufacturing and is manifested in such modern manufacturing techniques as computer-aided design, computer-aided manufacturing, computer-aided process planning, computer-integrated manufacturing, concurrent engineering, product data management, and product life cycle management. While craft production still exists, there is little

doubt that scaling the production of any physical product is largely a solved problem.

Service, on the other hand, presents some more fundamental challenges when it comes to scaling. A root cause is the simple fact that cocreation is ultimately one of a kind; and hence service, by its very definition, is philosophically inconsistent with the model of manufacturing scaling. On the customer side, each customer is complex and unique, and service activities that aim to transform the customer (education, healthcare, business outsourcing) start with each of their own initial conditions and settings (or, a unique “as is” state of the world). On the provider side, each employee is complex and unique, and service activities that require an ongoing transformation of the knowledge and expertise state of an employee (professors keeping up with advances in the field, doctors keeping up with latest techniques, business consultants keeping up with the latest technology advances) start with each unique “as is” state of the world, too. Simply put, there are no standard sets of knowledge, knowledge worker, and knowledge process to develop standard bills of materials for knowledge cocreation. The productivity of 10 knowledge workers working together cannot be definitively proven as being superior to them working individually. Adding one more knowledge worker cannot be definitively predicted to yield lower average productivity, either.

Of course, in spite of the complexity and unique challenges, many service operations (geographically distributed franchises in retail, banking, travel, entertainment, etc.; on-line services, etc.) have indeed used standardization, specialization, and economies of scale to their advantage. To a large extent, this rather direct application of proven principles from the manufacturing-originated science of scaling constitutes much of the traditional service science about service operations. Nevertheless, more and more new service operations are falling outside of the earlier conventional boundaries. In general, the more complex and innovative the service systems are, the more challenging the cocreation of value between provider and customer will become, as shown in consulting and Internet-based enterprises. For providers, the challenge of scaling profits along with revenue (i.e., diminishing the

marginal cost of scaling) is largely an unsolved problem, as compared to manufacturing. The propensity in the industry is towards its inability to enjoy any economies of scale.

A convincing illustration may come from none other than the originator of the present call for a new science of service, IBM. The company, which has been evolving from being primarily a manufacturer of computers and information technology (IT) to becoming a provider of IT and business services that exemplifies the globally integrated enterprise (Palmisano, 2006), helped the formation of computer science in the 1960s and promoted a manufacturing science in the 1980s. The new call reflects, without a doubt, on its own needs to resolve its productivity problems, open new markets, and advance the field that determines its fate. What concerns does IBM have?

One could ask what advantages does a company of 100,000 knowledge workers have over a collection of 10,000 companies with 10 knowledge workers each? The former has fixed configurations (the organization) to minimize its organizational transaction costs and accumulate resources and knowledge. However, the latter may arguably be more agile as well as being lean and mean when it comes to forming flexible task-based *virtual configurations*. Obviously, the critical success factors for large companies include how they can *share and reuse the accumulated resources and knowledge*, in *flexible task configurations*, to *reduce the learning curve* and *increase productivity* (diminish marginal cost). For smaller companies, success hinges on their ability and capacity to *collaborate, on demand*. In fact, the IT and business consulting service industry is highly fragmented with a large number of small players. This situation may be far from having reached an economic equilibrium; instead, it may be fragile and susceptible to rapid changes with a random chance of being tipped in any direction. The deciding factors seem to be which set of critical success factors will be developed faster and better. We submit that these pertain to service scaling and transformation which require new and more profound understanding of the *advantages of scale in cocreation*.

To animate the notion of a science of service scaling and transformation, we may use astronomy as a metaphor. That is, we envision service

to be a recursive artificial universe whose basic laws are metaphorically comparable to the natural universe in which we live. As such, the whole (economic) world is a universal service system, and the universe of service devolves all the way to individual persons and resources. We wish to know the physics that pulls the dust particles of service activities into rocks, planets, stars, and galaxies of interrelated, interdependent, and yet mutually dispersed service systems and enterprises, and make them revolving, evolving and expanding in the universal field of gravity of service values. The *gravitational field of value* dictates the feasibility and the economies of both the standing operation of the service universe and its continuous evolution with the coalescence reflecting the gains on value — the benefits of scaling. Unfortunately, we do not seem to know a whole lot about the coalescence and the gravitational field to scale service up, down, or transform it to gain unprecedented benefits, let alone the possible dark matter and dark energy in human society that keep people and civilizations apart. All paradoxes about service quality, productivity, and innovation seem to be related to this limitation of knowledge. To provide a technical rendition of the basic concept, in the spirit of the universe, we refer to the *intellectual nature of service scaling and transformation* as, succinctly, *population-oriented cocreation*. Its technical implications are reviewed below.

Scaling cocreation is the technical problem. If there is no science on the gaining of economies of scale for service cocreation, then there can be no science on the scaling of service, service systems, and service-based economy. That is, the field needs to be able to provide scientific guidance, substantiated with predictable results, on how to improve quality, productivity, and competitiveness *from scale*, in order for it to provide reliable guidance on how a large service enterprise may compete better than any small enterprise; or how a collection of small enterprises may compete better than any large enterprise. We formalize the above discussion into this definition: *population-oriented cocreation seeks scaling cocreation with a scope up to the population of its elements (customers, providers, systems, and resources).*

Only on this basis can there be any theory, with verifiable confidence, to tell how a large service-based economy may continue to

perform better than any upcoming economies in the global market. The case of IBM reflects this moral: size and experience may not necessarily give rise to any inherent advantages over smaller but numerous competitors; and while size may not yield productivity, it could be destined to incur prohibiting overheads. To generalize, do the USA, EU, and Japan possess any competitive edge due to the accumulated knowledge vested in their enormously mature service sector versus the emerging economies such as Brazil, Russia, India, and China, despite the lower labor costs that the latter possess? Conversely, how should the upcoming economies chart their courses in global competition and collaboration? How should any knowledge-based economy excel on the expansion of free trade agreements and the transformation towards global sustainability? These questions await a new service science for answers.

This book provides a reference point for the new service science: **Service Scaling and Transformation Theory**.

The theory of service scaling and transformation is concerned with advancing values to persons, organizations, and society through new business designs and service systems by digital connections scaling. Its technical heart is population-oriented cocreation, and its technical basis of scaling to achieve the cocreation is the connection by digital means. A design science accompanies the theory to enable the service systems of population-oriented cocreation.

The design science attempted in this book strives towards a few particular goals: *reducing the learning curve, enabling task-based virtual configurations, and sharing information resources*, all with a population orientation in the context of cocreation. (They are the topics of Chapters 4, 6, and 8 respectively.) These goals are concerned mainly with enterprise level (or microeconomic level) service systems. Macro-level designs have to do with new genres of businesses. (This is the topic of Chapter 5, with a particularization in Chapter 7.) The theory addresses the macro-design topics as new concepts of transformation stemming from population-oriented cocreation. In doing so, the theory employs a basic premise: *The provision and utilization of digital connections scaling for persons, organizations, and society is a fundamental mode of service that builds and grows*

knowledge-based economies. These activities constitute digitally connected services and transform economic activities in other sectors to advance knowledge-based economies.

For example, when all information resources in the world (e.g., personal documents and photos, films and TV series, and enterprise databases and real-time environmental data streams) are digitized, then they can be connected; and all industries can be connected through these resources too, as the customers and providers of these resources. These digital connections can be the basis for cocreation of new values for persons, organizations, and society. New industries may emerge and old ones merged.

In a broad sense, the above concepts have general significance beyond the particular service scaling and transformation theory *per se*. Digitization is service, as well as the provision of new values and systems for and by digital connections. In the latter case, traditional economic sectors such as agriculture and energy may be transformed since they may reach out to end users, as well as expand to previously infeasible domains of production, such as home-based agriculture and difficult-to-recover crude oil reserves. From this perspective, *a new service science shall be concerned with the conspicuous knowledge of digitization, connection, and transformation that progresses knowledge-based economies*. With digital connections, the naturally distributed resources, systems, customers, and providers in the economy promise to become accessible, as a whole, to both customers and providers for any value propositions and scientific studies. This wholeness promises to spawn new values, including quality and productivity, in the economy — and hence its growth and even sustainability (through better and greener designs, operations, and consumption made possible by digital connections scaling — as discussed in Section 1.4). It also promises to open up unprecedented studies of the entire application domain of services to gain new population-level knowledge, through comprehensive data streams on all activities. Therefore, *a new paradigm is accompanying the new science, characterized by a population orientation* — the pursuit and sharing of the wholeness in value propositions development and scientific research alike. This is a general observation beyond the theory, *per se*, too.

The new paradigm reaches, studies, and uses the population for knowledge and application. Astronomy, again, provides a metaphorical precedence for service science in this aspect. The field used to be characterized by scientists as “*theory-rich and data-poor*” — i.e., there had been numerous astrophysics models about the universe, but not much observations and measures to either prove or disprove them. It was not until the later part of the 20th century when technology started to support deep space exploration by radio, optical, mechanical, and chemical means to generate observations that astronomy started to show scientific rigor in its results at the level of physics. The progress was also unattainable until the field started to fuse data from all sources, both real-time and archived, to collaboratively study the population — i.e., connections of all modes of data resources pertaining to the universe. Service is also theory-rich, data-poor. The population orientation may open up new possibilities of study.

Formally, we recognize these two concepts from the above discussion as the philosophical core of the new service scaling and transformation theory of the book: *digital connections scaling* and *population orientation*. They substantiate population-oriented cocreation. Chapters 3 and 4 formally define and elaborate on them respectively. They are also significant to our general vision of a new service science beyond the theory *per se*, as Chapter 2 proves in postulating the nature of a new service science. Below, we delineate the theoretical foundations of the design theme of service scaling and transformation from a value perspective i.e., we ask what is the basic value of digital connections scaling; why the value can be designed; and how to design innovation and transformation with digital connections scaling.

1.3 Design Visions: Service-Led Transformation for Advancement, Sustainability, and Equitability

The theory of service scaling and transformation is about design: designing value (innovative value propositions and cocreation) via digital connections scaling. Therefore, we first establish the relationship between digital connections scaling and design. It helps to start by painting a picture for digital connections from the traditional concept

of service, especially the notion of cocreation. Digital Connection is a paradigm by which the customer, provider, and supplier resources are configured to realize certain value propositions. The way it is designed and implemented can help classify and characterize the types of service systems that co-create and deliver the service. In the broadest sense, the customer of a service can be a person or an enterprise (service system), and different customers can join forces with each other on demand if the utility that they gain from the service justifies this. The provider of a service can also be a person or an enterprise (service system), and different providers can collaborate on demand as well. Moreover, the service offerings of the providers can be inherently associated or even integrated with manufactured goods at many levels (e.g., leasing a car, the operation/maintenance of a power plant, and the provision of computing services on a platform). Examples of traditional service offerings include person-to-person, location-based services such as hair cutting and gardening; warranties and after-sale services for automobiles and machinery; and services and operation contracts in heavy industry. More recent service industries include consulting, telecommunications, finance, transportation, etc.

The previously mentioned *digitally connected service is now formally defined to be services that employ the digital connections scaling (DCS) model for their own service systems or their customers' service systems*. Digitally connected service can scale more cost-effectively, while traditional services cannot. For example, a physical therapist performs the exercise service in isolation and a fixed grain-size of interaction, but connected knowledge workers could draw information resources of multiple grain-sizes from all over the world to assist the jobs at hand. In a similar way, hairdressing is not scalable, but the promotion and continuing education of hairdressers by distance learning is; personal one-to-one counseling most often has to be synchronous (i.e., both the customer and the provider must be connected at the same instance of time), but an **ASP** (application service provider) of enterprise processes can perform asynchronous processing; and new papers are not personalized, but in-car information services such as On-Star provide person-centered assistance. Therefore, digitally connected

services are further characterized with digital sharing of resources, service scalability, asynchronous co-production, and personalized assistance, when compared to traditional services. The basic platform on which the scaling of digital connections is enabled is societal cyber-infrastructure.

Digitally connected service describes many new business designs in knowledge-based economies, as well as many service innovation models that seek to create new value propositions and transform previous service systems. However, scaling service systems with digital connections pose significant challenges in system design and engineering (e.g., the previously discussed large-scale challenges). If the DCS model only exacerbates the problem, then, regardless of the merit of its intuitive logic, digitally connected service can only be a pipe dream or mere fancy talk. Therefore, one needs to address a critical basic question before embracing digitally connected service: Is DCS practical? That is, does DCS promise to contribute to the new service science required, and hence be able to promise to drive new innovation and transformation with new genres of service for knowledge-based economies?

We condense the previous discussion of the scientific challenges into these two basic issues: the unique characteristics of service, such as the one of a kind cocreation of value; and the large-scale nature of digital connections scaling. We might add that the properties of service also include the heightened complexity of it being more difficult to predict demand than in, e.g., manufacturing. However, how much of the problem is logically intractable and how much of it can be facilitated by proper design via DCS? Recall that the large-scale challenges exist in the field with or without the DCS model (e.g., the needs of science and national defense), and the drive to resolve them is already a national priority. Thus, we may consider these challenges as enabling factors for the new digitally connected service, rather than the inherent fallacies of DCS. Ironically, as it turns out, the DCS model, with proper design can actually facilitate the unique problems due to the one of a kind cocreation nature of service.

As stated above, digitally connected service possesses a significant promise amenable to scientific design, viz., it is integrated with physical

systems which implement the digital connections. That is, the practice of DCS is based on some (common or sharable) digital environments, such as the societal cyber-infrastructure, which is manageable. Therefore, its productivity is measurable and controllable at least in part by the efficiency and effectiveness of the digital connection systems. In other words, *the DCS approach promises to turn some of the traditional uncertainty in service to certainty, and integrates the mature science of scaling proven in manufacturing and elsewhere into the new service science in a logically consistent way.* This is not the case with previous results on the design of service systems.

It follows that, although value cocreation is one of a kind, and even intangible, the system of cocreation is not. This system focus provides a *design handler* for the otherwise difficult to handle problem. Needless to say, the design science here is consistent with the design science everywhere to the extent for which digital infrastructure accounts. The new service science can now inherit the previous results as well as new results (e.g., due to the new population orientation) for digital connections scaling, and focus new efforts on new service cocreations, such as value propositions for digital connections scaling and new models of digital connected service. Consequently, we expect digital connections scaling to provide an approach to developing a design science for the new service science that the field needs, with digitally connected service becoming a direct beneficiary of the studies.

Many existing efforts of service design, mostly due to proprietary industrial results, show limitations in scope, consistency, or analysis when it comes to service quality and productivity. In general, the service systems design worldview has three important stakeholder perspectives: customer (creation of value for the customer), provider (improvement of productivity for the provider), and authority or societal (renovation of interpersonal interaction for society, where the person is both the customer and the provider, and value is perceived as an aggregate for the whole population). The provider side (industrial models) has received a great deal of attention (such as the component business modeling [CBM] and key performance indicator [KPI] from IBM — see Nayak *et al.*, 2007 and Sanz *et al.*, 2007), which may also include

demand chains and hence incorporate some aspects of the customer dimension. Although they are proven to be sound and effective, these leading results still show gaps in designing customer values and tend to come short on cocreation, especially when considering the population orientation. They may also show limits in driving high-level activities to low-level (software) assets, and back up again. With these gaps, the synthesis of these differing levels of development may be left to individual projects. A dual but more significant phenomenon is the limited ability to reuse their accumulated assets and to reduce the learning curve by tapping into past practices.

The combined effect is that these results do not provide detailed roadmaps with predictable performance to guide the improvement of service quality and productivity. Accomplishing such roadmaps requires deeper scientific understanding of the characteristics of service systems and generic design theories, methods, and techniques suitable for them. This observation leads to the population modeling effort reported in Chapter 4, which extends the previous results towards such a design science for reducing the learning curve in service system design. Chapter 6 continues the development and presents a design methodology for cocreation information systems, which enable task-based virtual configuration of service systems. Chapter 8 concludes the development with a particular market design to support population-wide on-demand collaboration of independent information resources. They constitute a new design science using DCS.

Now, we shift to *innovation*, i.e., how digital connections scaling may shed light on the transformation of the old economic activities and the creation of the new. This is the macro-level of innovation concerned with business designs. In contrast, the micro-foci address system designs as discussed above. *Innovation gives design a purpose, and is measurable by value propositions.* From this perspective, the DCS model is also recognized as a basic method of design for innovation to achieve transformation for knowledge-based economies.

We must admit that although the conceptual formulation of the DCS model as presented in the book is new, the practices of (some)

DCS in the field are not. In fact, the raw ideas of digital connection have been behind the transformation of many traditional services of late. For example, e-commerce transforms retailing from relying exclusively on direct personal contact for real-time transactions to opening up to remote, impersonal processing. Even such personal services as health care and education are proven to be amenable to digital connection. The transformation has even made it difficult to distinguish some service offerings from manufacturing. Examples include designer medicine and IC design foundry which cater to individual clients, as well as leasing and contractual operation of generators, aircraft, and other major industrial equipment by the maker for the user (Dausch and Hsu, 2006). These DCS practices have also created whole new genres of economic activities that characterize the so-called new economy which range from industrial exchange (e.g., Glushko *et al.*, 1999) and application service provider (ASP — see Tao, 2001) to business designs for globally integrated enterprises.

Clearly, the transformation has given rise to new types of (extended) firms, production functions, and mode of production for our economy, as a result of these new major economic activities. To enumerate more specifically, the connection of (person) customers and providers has resulted in B2C (retailing), transaction portals, on-demand business (demand chain integration), public exchanges, and digital government. The connection of providers has led to B2B (procurement), consortia, private exchanges, ASP, and supply chain integration. The connection of customers facilitated the connection of persons and thereby opened up the space for peer-to-peer social networking and information resource utilities. These well-known stories are now converging to create even more potent new stories of the synthesis of social networking with e-business, and beyond. Have we seen enough — i.e., is the parade of new business designs nearing its end, or is the march just beginning? What will come next? Is the DCS concept only another superfluous term with empty substance, or does it actually add value in facilitating our deep investigation? Chapter 5 analyzes this topic, and Chapter 7 provides an application in the domain of Smart highways.

To contemplate the unique, substantial value of the DCS concept, we review how it may help the field understand the popular notion of the new economy (referring loosely to all new economic designs in our society due to the Internet) by using the general concepts of connection (e.g., Kauffman, 1993; Carley, 1999; Watts, 2003; and Blass, 2004) and value proposition (e.g., Norman, 2001). Are the changes of the new economy, perhaps reflections of a constant expansion of personal reach to ever new contacts and sources of information, and the expansion of new genres of service and designs of business to utilize that reach? Also, is the reach, perhaps, a direct result of digitization, which makes heterogeneous objects compatible and thereby opens them up for all the unprecedented, large-scale connections of resources, organizations, and persons, both within and across them, at affordable cost and cycle time? Finally, can the density of value propositions in different economic activities perhaps, be explained by their differing propensities to digital connections scaling of individual production factors, processes, organizations, and systems? That is, does the gravitational field of value work on the embodiment of DCS which becomes the enterprises of population-oriented cocreation?

In conclusion, is the DCS model perhaps, capable of serving as a cornerstone to a scientific explanation of the intellectual nature of the new economy? Indeed, we recognize *digital connections scaling as a defining phenomenon* of the new economy, as described above. Since digital connections scaling is knowledge-based and its design knowledge-intensive, we embrace the term *knowledge economy*, first suggested by Robert M. Solow, to be the more descriptive equivalent of the new economy that we use as the context of the service scaling and transformation theory of the book. Chapter 9 justifies the notion with a class of production functions featuring DCS.

On this note, we may add that DCS is a more scientific concept than the popular statement that IT explains the knowledge economy. The DCS model leads to precise and theoretic propositions verifiable by scientific methods. Equally, one may assert that the DCS model is a concrete elaboration of the general statement that it pinpoints why and how IT explains the knowledge economy. The DCS propositions

are fundamentally measurable in terms of interactions among customers, providers, and resources. Investigating population-oriented cocreation through them promises to be concrete, and may orchestrate particular new results around a particular theme, e.g., value cocreation. This ability, just like its being the common denominator of many new business designs, is not coincidental: *digitization makes objects connectable and hence connections scalable* (Hsu, 2007b). What can be studied via DCS may not be attainable in traditional research paradigms without it (e.g., the general notion of connection and enterprise).

We now suggest some visions of the theory of service scaling and transformation to illustrate why we care — i.e., to contemplate some value propositions for studying and promoting population-oriented cocreation. They represent some possibilities of DCS in a digitally connected world, focusing on the values of connections of persons and organizations in the society of the knowledge economy. Again, the provision and operation of DCS — or the transformation services — are themselves digitally connected services, as are the services being transformed or created. We discuss them in the next section.

1.4 Future Service: Transformation for the Knowledge Economy by DCS

Service Transformation

Design, as discussed above, is about transformation towards gaining new basic values. A natural path of transformation using DCS is *integration of previously separated (service) industries*, to thereby develop or promote their complementary values to customers and providers. The synergism between computing and entertainment, as shown in the success story of iPod integrating with iTunes, is a prime example. This is clearly only the beginning. One will expect the eventual convergence of traditional industries, especially network television, telecommunications, Internet business, news media, and entertainment, *because their resources and systems are concerned with the same objects and subjects, and pertaining to the same life cycle*

tasks (e.g., raising a family, employment, and retirement) and needs (e.g., living, education, and socialization) of the customer's whole person. These industries all employ the same Internet and telecommunications infrastructure, and all create and use the same types of texts, photos, videos, films, and all other information resources of the same persons (e.g., customers, providers, and avatars) and organizations for the same (types of) uses in society where the businesses realize themselves. For example, digital connections scaling performed on these resources and systems can bring search engines to bear on movies, news, and homepage contents for the same persons, products, and events; and similarly bring the same into education, shopping, and even production.

The general principles are that these businesses are highly complementary in their value propositions and have already been largely digitized. Therefore, their cocreation systems may be connected: digitization makes the connection of resources and other systems elements feasible, and thereby enables them to share and scale, and reap the benefits of scale and complementary values (services). Following these principles leads to their potential possibilities: These industries will form alliance with utility and other industries related to the same life cycles of persons and organizations that can be readily digitized. In this vision, the household computer and TV are but two different devices connected to the same monitor-set-up-box system receiving content from different providers on the common cyber-infrastructure such as the Internet. Other devices and equipment, ranging from phone and camera to appliances, bathrooms, and utility control boxes, could plug in, too. For example, with a digital electricity meter that can detect the use of particular light fixtures and appliances, and a digital system that controls house electricity usage, the house owner could remotely turn on and off the lighting and appliances via the Internet.

An intriguing aspect of this DCS is *conservation*: the connections may help house owners optimize household operations and save energy, and thereby enhance the sustainability of a way of life. For example, when customers can see the current hourly electricity usage on their appliances, this may shape their behaviors to economize and

do certain chores and activities in off-peak demand periods. The awareness of population illuminates the scope and direction of new value propositions; while DCS shows the means. They make the above visions natural, and perhaps, even logically inevitable.

Finally, digital connections may liberate knowledge workers from their dependency on large firms. Combining personal infrastructural support with person-centered institutions such as pensions and home offices can prove to be formidable for empowering professionals. The fact that they can work from home may not be the biggest story; rather, the daunting prospect (for traditional firms) may be that they can work as independent enterprises which franchise with others on demand, with proper DCS support. Many consultants have already been working in this mode except that they do not generally enjoy the promises of collaboration. Further DCS may help. We refer to this possibility *home-based production*, which applies to all other economic sectors, too.

Manufacturing Transformation

A second natural path of transformation is found in *integration of service with manufacturing*, or even the visions of *manufacturing as service* and *manufacturing-based service*. From the perspective of service scaling and transformation, this path arises logically from cocreation: *integrating the utility of product with the making of product by connecting the customer with the provider at the level of the resources* that each possesses and the value that each demands. That is, expand the manufacturing life cycles to the life cycles of the customer's demand chain. The basic ideas are not new in the field: For example, the integrated products and services (IPAS) system at Rolls Royce Jet Engines incorporates their clients' jet engine operation and maintenance systems into their own jet engine production systems on a real-time basis. Similar practices have also been discussed before. They show a powerful new concept: the jet engine-centered view where information integration is conceived around the jet engine's *life cycle tasks*. This concept can be coupled with the notion of building real-time population data for optimal fleet management.

In fact, the *subject-centered view* (jet engines in this case) and the *subject population* are logically complementary; they are just two sides of the same coin for the service scaling and transformation theory.

These ideas can be combined and expanded to cover all aspects of the making and using of the products, from the user's (the demand chain) as well from the maker's (the supply chain) perspective. The integration naturally lends itself to cocreation of values for all. IBM could give away computers in exchange for the business of running and using the computer for the clients. Similarly, GE could lease power generators or sell them at deeply discounted prices in order to get the contract of operating and maintaining the machines through their life spans. Their control of the population data will give them competitive advantages (e.g., best fleet management) that few competitors in the operations service industries can match. Digitization of the control and measures, and all other aspects of the production and operation of the products, makes digital connections scaling on like-products, their users, and their producers possible; while their complementary values and benefits of scale make such scaling desirable.

As is the case of service, home-based production, or e-manufacturing, may prove to be both viable and a preferred mode of production for certain application domains. For example, craft production may be ready for transformation into independent small-scale workshops assisted by DCS. Other domains that feature small lots and self-contained production may be amenable, too. More broadly, *home-based manufacturing* may be a way to accomplish mass customization, as long as DCS can be designed without being hindered by the limits of public cyber-infrastructure (i.e., proprietary control).

Physical Environment Transformation

Digitization can also happen to natural environments — i.e., the *instrumentation of the environment*. Many scientific disciplines have already widely adopted sensors, including both wired and wireless, to monitor seismic movement, animal migration, and human traffic, just to name a few. When one considers satellites, on the one extreme, and radio-capable tags and chips mounted on moving subjects and the

earth's surface, on the other, and everything in between in both civilian and military sectors, then one can argue that the world is already being instrumented to a significant degree. The instrumentation generates real-time data streams about the "population" of the subject matter, such as planet earth and the weather. When these real-time data streams are fused with the usual aggregate, archival data customarily stored in enterprise databases, then a more comprehensive informational cyberspace of the population is constructed. In other words, the DCS model along with population orientation can proactively suggest some value propositions for progressive building of an instrumented world. Real-time data streams, enterprises databases, and subjects on the move (e.g., vehicles, cargos, and even persons) are integrated in such a world, which may open new dimensions and frontiers for unprecedented value cocreation.

The problem with the current state of instrumentation lies mainly in the lack of integration among different modes of data, and the lack of comprehensive reach to the whole populations of the application domains, especially in non-military domains. Military applications have proven that comprehensive instrumentation of the subject populations can scale down (zoom-in) to supporting individual foot soldiers as well as scaling up (zoom-out) to a whole theater, including the planning and control of global logistics. However, civilian domains still see largely segregated instrumentation and applications. New fundamental value propositions may help change this situation and the DCS model and population orientation may help develop these value propositions. For example, one can expect *all environment-sensitive industries*, ranging from transportation to energy and agriculture, to benefit from *tapping into a literally digitally connected world* and transforming themselves. The move can propagate to the rest of the economy, too. As stated above, the transformation itself, from its provision to its operation, constitutes some (new) digitally connected service. Chapters 7 and 8 present some results for possible integration of multi-modal data to support the instrumentation envisioned, with Chapter 7 also presenting a particular design of instrumentation for infrastructure to enhance global logistics, highway operations, and tourism.

Energy Industry Transformation

The energy industry offers some compelling examples of digital connections in their core production systems, such as petroleum drilling. A recent presentation by BP (the IBM Almaden Institute 2008) shows that population data (both real-time data streams and enterprise databases) help the control and operation of individual rigs at sea bed petroleum wells so significantly that the technology actually *made some previously un-recoverable petroleum reserves* in North Sea now *recoverable*. One can expect similar stories to arise in exploration, logistics, and refining. However, we must point out that BP's practices, albeit so admirable, is still short of the population premise of service scaling and transformation. That is, the population knowledge that has benefited BP seabed rigs comes mainly from BP itself and the public domain. Notwithstanding BP's noticeable share of the earth's reserve, its scope of operation and exploration may still not be sufficient to give it comprehensive population knowledge. It can benefit BP even more significantly if its knowledge is joined with the private knowledge of other oil companies. By the same argument, all companies can benefit if the public domain knowledge is further expanded by the joint effort of industry, and indeed by the joining of all other industries that can benefit from the same earth population knowledge. Clearly, there is much room on both fronts for improvement of the knowledge.

The same logic extends to alternative energy, as well. One may even expect the population orientation to help in alternative energy even more than in the petroleum industry, since the established knowledge and experience are rarer and more scattered. To generalize, we suggest that service scaling and transformation can be applied to the *core production systems* of energy and some other traditional industries by focusing on *improving knowledge at all levels of real-time planning and control*. One methodology is to seek integration and/or inter-operation of the individual elements of the cocreation systems, including the individual production factors (and information resources) and the customers and providers (and their knowledge workers). On this note, *the population orientation guides the application of*

the DCS model. This transformation covers individual grassroots production (e.g., solar panel batteries and windmill farms), fleet management (e.g., fields' coordination), and enterprise strategies (e.g., collaboration). The common value propositions, or goals, of the transformation will continuously be uplifting the production functions of the energy industry.

We wish to point out that the service scaling and transformation theory may be most significant to *home-based energy production*. Household solar panels, thermal sources, and fuel cells are just some well known examples. There is little reason why energy production should not use a distributed regime when the technology allows for distribution, since the sources are by their nature distributed — wind, sunlight, petroleum, natural gas, and thermal. The DCS model, from this perspective, is a distributed, population-oriented regime supporting such a transformation.

Agriculture Transformation

The transformation applies to other sectors of the economy in a similar way, except each may face its own peculiar constraints. Consider agriculture, whose importance to human survival is now in a state of renewed and drastically heightened global awareness. The first level of application of the service scaling and transformation theory is obvious and rather mundane: The DCS model can help build communities for the entire agricultural population in the world, which may lead to formation of digital *grassroots markets* and *support networks* for buying/selling, distribution, and other agricultural life cycle activities, as well as for the dissemination of agricultural education and cooperation information. This class of application does not push the envelope beyond the common practices of e-business and social networking; and their value may be marginal compared to the already established institutions in the sector.

However, the DCS model may reach farther and open new frontiers, such as increasing the supply of agriculture resources (e.g., “land” and labor) and thereby promoting sustainability, in the face of the rapidly increasing global demand versus limited supply. In particular, the DCS designs may facilitate the promotion of part-time farming based

on individual households in the now non-agricultural regions. It may also support new agricultural technology and packaged systems that fit home farming practices, such as *aeroponics* (above ground or hanging cultivation using LED and other efficient artificial lighting), in a similar way in which it supports utilities, appliances, and entertainment. New genres of distributors and other service providers may rise to the occasion.

Joining all these possibilities together, the above application of the DCS model for farmers *may increase the production of agriculture by expanding to individual households* at the grassroots, to facilitate the practices of *home-based agriculture* using the basement, balcony, and yard. Individual households — the part-time farmers — can become professionally knowledgeable in agriculture by drawing online support from digitally connected markets and communities, just like independent farmers do now. With this massive user base, it may be practical to develop new population resources for both part-time, home-based agriculture and traditional farming. These new, DCS-promoting resources may include real-time agriculture information and support services to improve the efficiency and effectiveness of the agriculture life cycle tasks. The support may expand to include, among other things, collaborative fleet management using collective experience and knowledge, and access to local, regional and world markets with all of them drawing from the pools built with a population orientation. The “agriculture information” may be delivered just like today’s weather information on TV, computer, and any other devices which may be digitally connected together.

Home-based agriculture may not appeal much to countries rich in land and other natural resources, especially North America; but it may make good sense to many other parts of the world where agriculture faces crises due to depleting land and labor supply. As the global population continues to explode and urbanization continues to swallow arable lands, a way to facilitate the *coexistence of agriculture and urban living* will definitely contribute to the sustainability of modern civilization as we know it. The DCS model can help, and it may be nothing short of transformation.

Social Networking and Business Design Transformation

The synthesis of social networking and business is a concluding vision that we present here. As we will further discuss in Chapter 5, businesses have already tapped into social networks. Prime examples include the use of blogs to engage customers and manipulate word-of-mouth marketing. More recent practices also witness companies participating in cyber-games (e.g., Second Life), Wikipedia, and the so-called “walled gardens” of popular destination sites (e.g., youtube.com and facebook.com). However, it is some of the new breeds of digital service providers, in particular Google, MicroSoft, and their counterparts, that are promoting some of the most compelling innovative new syntheses. They include embedding transactions into these walled gardens and building passages among them (e.g., acting on the social activities via the embedded e-commerce sites), integrating social networking tools with traditional transactions (e.g., e-calendar triggering cell phone calls), and turning social networking resources into e-business utilities (e.g., personal homepages and files becoming Internet content for application providers) — see detailed discussions in Chapter 5.

These practices are, again, illustrations of the basic principles of service scaling and transformation. However, they are presently confined to primarily marketing applications. By fully exploring these principles, we expect *social networking* to have the promise of *being a part of any businesses' regular business*, concerning not only marketing but also production and customer services. We expect the synthesis to reflect the *integrative support for life cycle tasks and needs of persons, organizations, and society*. In fact, to be most general in scope, we firmly envision the synthesis to lead to three coexisting worldviews of the knowledge economy: *person-centered, organization-centered, and society-centered*. The person-centered view considers the whole of cyberspace as some personal playground and living environment for accomplishing a person's life cycle tasks and needs, complete with all kinds of support and services available in cyberspace tailored to his/her style and requirements. This is to put the person in control at the center of his/her world and in his/her cyberspace. This will be an

ultimate model of the current trends of personalization found in e-commerce — more discussion is provided in Chapter 9.

The organization-centered view is similarly construed: putting the organization in control, orienting cyberspace to the organization's life cycle tasks and needs. It represents an ultimate goal for industrial e-business and on-demand business. So does the conception of the society-centered view, which highlights the common good and needs of all persons and organizations for the life cycle tasks of a society. Concerning society, we might mention that social networking is known to promote civil awareness and participation. When it is synthesized with businesses, civil concerns can influence business boardrooms more directly and be put to action more seamlessly because people can put their money where their mouths (or, in this case, their hands) are. *Conservation* is a point in case. The most efficient, most effective, and most immediately available alternative energy is definitely the comprehensive conservation of energy by all: promotion of green products, green life styles, and green public policies. Best yet, it is free. Collaborative grassroots efforts promoting conservation on the Web may inadvertently promote synthesis of social networking and businesses. They will have potential to reach out to the population of persons and organizations and become a society-centered view in action.

The above visions are, of course, just some of the more immediate possibilities that one can derive from the concepts of service scaling and transformation. However, they highlight a common mode of production based on collaboration and cocreation. To generalize this point, we might further observe that the person-centered, organization-centered, and society-centered practices clearly mark a stride to a *more equitable system of production, distribution, and shared governance*. The same physical world of cyberspace realizes itself for individual users and constituencies in virtually infinite number of views (virtual configurations), each catering to different persons, organizations, and society. These views are consistent with the basic proposition of cocreation of value between the customer and the provider, and hence drive the mode to permeate all economic activities. In this sense, the above visions help substantiate the notion of a service-led

revolution: Service makes and provides digitization, connections, and scaling to advance and transform the knowledge economy.

The transformation is expected to have a signature property of putting persons, organizations and society in control in their own respective way, characterized by value cocreation. As such, the density of value propositions that determines the allocation of resources may more accurately reflect the needs of persons, organizations, and society — such as sustainability of the world; and the service systems that co-create these values may more fluidly evolve accordingly. The traditional definitions of industries may not accurately describe the economic activities in the new worldviews. Therefore, ultimately, new taxonomies may emerge and a new basic mode of production of cocreation may become pervasive in the knowledge economy. What we call service today may become the general nature of the future economy. We discuss this vision in the concluding chapter of the book, Chapter 9.

To recap the organization of the book: Chapter 2 continues the discussion on a new service science with a postulation of its interdisciplinary nature and some basic research problems. Chapter 3 formulates the DCS model with specific postulates and propositions as the core of the service scaling and transformation theory. The population orientation and a design method attending it are presented in Chapter 4. Chapter 5 analyzes new business designs on the Web as an illustration of the theory and establishes its relevance. Chapter 6 complements the results in Chapter 4 with a particular new design methodology for the development of service cocreation enterprise information systems. Two specific service scaling and transformation designs are shown in chapters 7 and 8 respectively for particular applications. Chapter 7 delineates a conceptual framework for instrumentation of the environment for improving global network flows such as intelligent transportation. Chapter 8, on the other hand, develops a model for accumulating and sharing independent enterprise information resources in an application population, with multiple modal data that include wireless sensor networks and enterprise databases. While the first three chapters form the conceptual foundations of the book, Chapters 4, 6, and 8 constitute a design science for innovative service

systems, with Chapter 5 addressing innovative business designs and Chapter 7 a particular substantiation (application). The concluding chapter, Chapter 9, contemplates the opening question of the book: what is the big story about service? It postulates that, based on the results of the previous chapters of the book, the big picture is cocreation. It then formulates a basic microeconomic mode of production, characterized with a class of production functions, to substantiate the notion of a cocreation-based economy. The three worldviews of service scaling and transformation are also substantiated on this basis.