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Introduction to the Special Issue on Exploring Service Science for Data-Driven Service Design and Innovation

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Service science was launched by IBM about 15 years ago in an attempt to integrate different knowledge domains contributing to the study and better understanding of service systems. From the start, it was clear that the organization, design, operating, and development of service systems had to be based on a new conceptualization of service in the context of systems, on relationship governance, and on new, data-driven techniques of value generation.

To address such demanding theoretical issues in the search for a better understanding of service systems and value creation, the service community was inspired by a multidisciplinary approach capable of catalyzing scientific contributions proposed by researchers coming not only from IBM, but also from academia and experts in information technology (IT), management, marketing and consumer behavior, sociology, computer science, engineering, and many other disciplines.

Beginning in 2004, a relevant worldwide community has grown, engaged in this long-lasting process of defining the research boundaries and scientific goals of service science. The IESS (*Exploring Services Science*) workgroup, part of this community, organizes annual events dedicated to fundamental research in the service science domain, information and communications technology (ICT)-based development and functioning of service systems, and implementing solutions for new services.

Stimulating service innovation represents one of the 10 overarching research priorities, structured in three layers—strategy, development, and execution priorities—by the Center for Services Leadership Report for the science of service, and one of the three service development priorities (CSL 2010). This research framework comprises nine permanent research priorities; in each of them, technology's role is evident, and therefore leveraging technology, data science, and ICT to advance service represents a pervasive service priority with focus on the following:

- building business models for new service technologies (e.g., smart services, cloud computing, contextual service system, manufacturing service models);
- accelerating the adoption of new, service-oriented technologies (e.g., IOS (Internet of Services), wide-scale interoperability, agent-based web services, mobile services, cloud services);
- enabling agility and integration through service-oriented architecture and service platforms (e.g., semi-heterarchical service-oriented architecture (SOA), Enterprise Service Bus, ontology-based service platform, service-oriented agent framework, social networks); and
- capturing and delivering service-oriented information for real-time decision making (e.g., big data analytics, product intelligence, IoT (Internet of Things), micro service composition).

Advancing these technology-related topics in consonance with service science concepts, service systems principles, and value creation goals is an important research priority for the future, which engages many ecosystem partners in business and technology alignment through service-oriented architectures and service platforms (Spohrer et al. 2015).

The 7th International Conference on Exploring Services Science—(IESS1.6), held in Bucharest on May 25–27, 2016 (<http://www.iess16.cimr.pub.ro/>), gathered academic researchers from all over the world, balancing different categories of scientists and lines of research from various perspectives: business oriented versus technology oriented, fundamental versus applied, system science foundation versus computer science support and data orientation.

To approach service science, management, and engineering subjects from these multiple innovation perspectives and to guarantee a cross-cultural approach to service science issues, topics of interest were defined at IESS1.6, including the following: service exploration processes, business transformation through service science, new service business models, modeling of service consumer needs, service design methodologies and patterns, IT-based service engineering, service orientation in the digital enterprise, modeling and design of IT-enabled service systems, product-service systems, service innovation strategies and solutions, service sustainability, governance of service systems, service system networks, and education and skills for service design and management.

The theme of this special issue of *Service Science* with papers invited from IESS1.6 is “Exploring Service Science for Data-Driven Service Design and Innovation.” The articles included bring contributions to the digital transformation of services, showing how advances in data and information technologies—SOA, agent-driven web services, big data insights, Internet of Things and Services, mobile technologies, cloud computing, social networks, and cognitive computing—contribute to increasing the viability and agility of service systems, amplifying the customer relationship, and innovating product-service systems by pervasive sensor data usage and product intelligence. In what follows, we provide a brief description of these contributions in the broader context of IESS community research.

Developing Conceptual Models and Languages for the Systematic Exploration of Service-Related Processes

In this special issue a discrete event modeling approach, incorporating the viable systems approach (VSA) of the knowledge building and maintenance process in a public university, extends the work in Oltean et al. (2016) from the perspective of its management board as internal governance. Consonance as potential for value of education and research must be attained followed by resonance when the academic value is produced and offered. The process model is created in a general theoretical framework and, being grounded on the concepts of service science and VSA on one side (Barile and Polese 2010), and on the powerful approach of discrete event control theory on the other side, is general and can be considered a meta-model of a road map for decision making, adaptable to particular management specifications in concrete public universities. The resulting modeling instances can be implemented and tested in adequate process simulation tools such as SysML (Friedenthal et al. 2006) or MEGA Process BPMN on HOPEX platform (MEGA 2017).

Strategic sourcing—a sub-process of procurement—is defined in Rafati and Poels (2016) as a strategic process for organizing and fine-tuning the focal firm’s resources, competencies, and capabilities internally and externally through interactions with suppliers, buyers, and internal and external customers, to achieve (sustainable) competitive advantage or survivability, which in turn results in value as superior profitability or long-term viability. To create the conceptual model that describes sourcing alternatives in line with value-driven management, a domain specific modeling language is defined by the CARS (Capability-Actor-Resource-Service) conceptualization of strategic sourcing. The model-driven strategic sourcing approach can support strategic sourcing decision makers to achieve value creation targets (e.g., innovation through finding new customers, services, products and partners; sustainable competitive advantage and long-term partnerships) by providing an IT-based capability portfolio (extended by considering both the demand and supply sides) and a dependency portfolio (extended by considering all potential suppliers in the market).

A methodology is proposed in Hunke et al. (2017) to identify business model patterns by applying mathematical methods, such as the Principal Components Analysis, *k*-medoids clustering, and the silhouette coefficient as quantitative evaluation measure. The approach identifies and extracts patterns from data in four steps: (1) data preparation, (2) data analysis, (3) validation, and (4) interpretation.

Value Creation From Data Science-based Insights

Data-based services use data science tools to provide insights, which assist the decision-making process to create knowledge and increase value and several approaches aimed to attain these goals (Wang et al. 2016, Kwong et al. 2016), are reported in the literature. The data-driven design of customer-centric services is based on multicriteria data and information access, processing, and knowledge extraction for decision support in four phases (Meierhofer and Meier 2017, Borangiu et al. 2014):

Investigation. Define the service request and application context for which the customer’s insight must be known. For this, the customer’s profile can be modeled to demonstrate needs in the different contexts, roles, and interests.

Design. Create the solution for the sequence of service operations; formulate accordingly the value proposition to meet the customer's terms retrieved in phase 1, which provides relevant value to the user. To reach the service-level agreement (SLA), the requested service is set up and configured considering customer and supply-chain information; comparative evaluation of similar services offered by the competitors; constraint optimization planning, scheduling, and allocation algorithms and techniques; service performance evaluation using history of value and perception data gathered from previously delivered services and past customer behavior.

Test and iteratively improve the service solution or value proposition. Select and use consolidated data about the requested service: value-type data (e.g., quality, timeliness, cost, risks) and perception-type data (e.g., customer satisfaction and attitude, market share, innovation perspective).

Operational deployment of the service including marketing. Data science-based tools are structured in Meierhofer and Meier (2017) into nine categories according to their role in creating service value and providing specific service design patterns: clustering, profiling as description of behaviors and deviations detecting, co-occurrence grouping, similarity matching, prediction, data reduction, classification, regression, and causal modeling. These data-based insights are then correlated with the service design phases to provide value.

An example of value creation from data science-based insights is offered in Miguéis and Nóvoa (2016), which reports an analysis of the content provided by online customer reviews, giving important information concerning the key determinants from a user's perspective of the hotel service quality provided, and justifying the attributed service's rating. The objectives of this study are two-fold: (1) use text mining techniques to analyze the user's generated content automatically collected from hotels in a certain period, and, from this analysis, derive the most frequent terms used to describe the service; (2) predict the aggregated rating assigned by reviewers based on the terms used, and, at the same time, identify the terms showing high predictive capacity. The last five data mining concepts listed previously are therefore used in an aggregated rating prediction model based on the terms used by the reviewers.

A *data acquisition strategy for analyzing uncertainties in service contracting* is proposed in Schmitz et al. (2017) to obtain more accurate estimates of costs and revenues when designing service or product-service contracts with suitable prices that can assure predefined profit targets; create customized contracts that take into account the specific uncertainties induced from proposing a service to a particular customer and identify uncertainty drivers; diminish the impact of uncertainty in service contracting by reacting more effectively to adverse aspects and events, which assumes forecast development of uncertainty drivers. This data acquisition strategy is considered as a plan to acquire data sets with more observations and more variables at a higher level of quality for improving the analysis of uncertainties regarding a specific business objective.

Big Data, Cognitive Computing, and the Application of Data Value for Smart Service Systems

Big data enables innovative services and even new business models in the manufacturing value chain and in *product service systems* (PSS). Data integration, analytics, and cognitive computing is leading to an emerging four-stage model for contextual service systems that can be deployed across the service ecosystem from mobile to cloud (Le Dinh et al. 2016):

Gather information data. Collect all relevant data from a variety of sources and keep everything as long as possible.

Connect to create the knowledge context. Dynamically extract features and create metadata from diverse data sources to continually build and update the context.

Reason to take intelligent decisions. Analyze data in context to uncover hidden information and find new relationships. Analytics add to context via metadata extraction and use context to exploit information.

Adapt. Compose recommended interactions, use context to deliver action, and learn from customer behavior interaction patterns to improve value proposition and service context.

In the contextual enterprise, data is integrated in context-centric approach, maximizing and maintaining the value of data and analytics. Thus, the critical mass of contextualized data and insight enables automated discovery of new business opportunities and improves the service innovation process. Fused data from many sources—including social media—yields rich situational understanding, driving deep insight in market and customer behavior. Simulation, prediction, and discovery amplify the impact of those insights and map them to new business value; pervasive sensor data allow for innovative after-sales services. Future cognitive computing systems will create targeted recommendations for better value propositions. Customer transactions and social context complete the cycle and feed the contextual enterprise.

Smart services in PSS adapt to the social and operating context by using intelligent orders or products that are linked to information and rules governing the way they are intended to be made, stored, transported, or used,

thus enabling them to support or influence these operations. Intelligent products possess a unique identity, can communicate effectively with their environment, retain or store data about themselves, deploy a language to display their features, execute context and service requirements, and are capable of participating in or making decisions relevant to their own destinies.

There are two levels of product intelligence that allow for smart service: (i) information-oriented and (ii) decision-oriented (as detailed in McFarlane et al. 2013), while common threads allow customers to conduct, manage, and handle smart services using product intelligence in a static, dynamic, or autonomous way:

Static. The customer directly shapes the service; the customer directly shapes execution of the service; the customer can influence who delivers the service.

Dynamic. The customer can change aspects of the service execution; the customer can change aspects of the order during service delivery.

Autonomous. The customer's influence is automated.

Moving Classes of Processes Toward the Service Field: Servitization, Product-service Extension, Ontology-based Service Orientation of Manufacturing, Environment Conditioning, and Control Systems

Moving toward an innovative dominant logic or business paradigm requires a shift of the mindset that pervades the overall organization and the value network in which a company operates. As such, *servitization* is the gradual and consistent evolution of the entire business model of a manufacturing firm, including its value proposition, its position and role in the value creation network, its capabilities and organizational structure, and its relations with customers (Baines and Lightfoot 2013). In this context, a PSS in any of its three perspectives—product-oriented, usage-oriented, and result-oriented—can be defined as a servitized business model. The shift from product to product-service offering requires consultancy capabilities and involves the transformation of sales people into consultants who can understand customer activities and processes and have specific competences related to the provided services.

The shift from a focus on the product to a focus on the process entails an increasing importance of intangible (information and knowledge) and human resources. Indeed, service technologies are typically described as knowledge technologies, with high capacity for information processing within the technical core. Resta et al. (2016) show that ICT tools—as supporting elements for servitization—enable intra- and inter-firm communication flows and the creation of databases where companies can save information, creating a stock of knowledge.

The shift from pure goods-dominant logic to service-dominant logic led to service orientation in manufacturing and oriented the design, execution, and utilization of the physical product as a vehicle for delivering generic or specific services related to that product (in PSS). *Holonic manufacturing systems* (HMS) and *service-oriented architectures* (SOA) are currently two of the most studied and referenced solutions providing the necessary guidelines to create open, flexible, and agile control environments for the smart, digital, and networked factory. The service-oriented paradigm defines the principles for conceiving decentralized control architectures that decompose computational processes into sub-processes handled as services, to later distribute them among the different available resources.

Integrating the concepts of services into HMS gives rise to a new type of systems, *service-oriented holonic manufacturing systems* (SoHMS) that exploit repeatability and reusability of manufacturing operations. By adopting the principles of SOA into HMS, such manufacturing operations can be standardized into *manufacturing services* (MServices) possessing a proper identification and description. Thus, the service becomes the main element of negotiation and exchange among holons (Gamboa Quintanilla et al. 2016). Following the IT-based approach in a SoHMS, resources' capabilities are determined by the collection of MServices they offer. This allows a complete separation of process specification from the knowledge on the production floor, making it implementable in any SoHMS platform providing the necessary MServices with the same application service-ontology. Both SOA and HMS architectures have a fractal model that can be divided into three abstract capability layers: expose layer, compose layer, and consume layer.

In a similar way to OWL-S, such a framework is structured according to the need of different types of knowledge about MService in holonic systems. The knowledge is distributed among different MService perspectives, such as type, profile, specification, and implementation. The fractality of MServices is highlighted by the concept of *composite service*; a service offered as a simple process can be composed by other more granular services and so on until finding indivisible atomic services.

Multi-agent systems implement SoHMS in SOA approach; like manufacturing, service orientation is increasingly applied to large distributed automatic control and interconnected environment parameter conditioning processes (Borangiu et al. 2017).

Cloud manufacturing (CMfg) introduces service-oriented networked product development models in which service consumers can configure, select, and use customized product realization resources and services (computer-aided engineering (CAE), computer-aided reverse engineering (CARE), and reconfigurable manufacturing systems). CMfg moves from production-oriented manufacturing processes to customer- and service-oriented manufacturing process networks by modeling single manufacturing assets as services like Software as a Service (SaaS) or Platform as a Service (PaaS); all manufacturing resources and abilities for the manufacturing life cycle are provided in different service models. The IoT is core enabler for product-centric control and increasing servitization (McFarlane et al. 2013, Borangiu 2016).

Integrating Web Services and Agents in SOA Leads to Innovative Service Applications

The integration of web services and agents tries to combine the strengths of both techniques. On one hand, web services have the advantages of interoperability, flexibility in heterogeneous systems, and the ability to automate service discovery and invocation with appropriate service description; on the other hand, agents are capable of autonomous and intelligent behavior to represent the interests of their human users in an appropriate way.

The architecture of a brokering system that integrates the concepts of web service and agent for the delivery of smart logistics services is presented in Leon and Bădică (2016); JADE agents are integrated with RESTful web services, built to work best on the web in REST (Representational State Transfer) architectural style. Such a system can be beneficial to logistics companies by increasing the quality of provided services and by reducing costs. The focus is on the optimization methods used to find the most appropriate pairings between the client orders and the transport providers.

Another application of integrating mobile agents in SOA, aiming at improving after-sales services of a business organization, expands its customer base by recommending its products and services by other organizations and individuals (Alexandrescu et al. 2016). The solution is built upon a service-oriented architecture which allows businesses to share their customers and information regarding their purchases while considering the user privacy issue. Intelligent agents, which rely on product type association with dynamically weighted graphs, are employed to obtain and to process the information needed to make the suggestions. This is a novel strategy that is based on a combination of traditional after-sales methods with the affiliate marketing technique.

IT Service Management

Organizations delivering IT services often apply an *IT service management* (ITSM) framework: a collection of behaviors, skills, activities, and technologies applied by organizations to manage the creation, delivery, and support of IT-based services to fulfill business goals and customer needs. Galup et al. (2009) argue that the ITSM research field is de facto a subset of service science, for which one of the types of service resources technology takes a prominent place compared to the three other kinds of resources: people, information, and organization. An adaptation of the most used ITSM framework—ITIL v.3—is proposed in this special issue, by the extended version of Verlaine et al. (2016); this adaptation is aimed to facilitate its coexistence with the agile project management method SCRUM, opening the perspective to organize both agile and traditional project management.

Summing up, *data science* and *information and communication technologies* highly influence service systems in their formalization, modeling, design, and applications, contributing to the growth of knowledge-intensive services and strongly influencing service innovation. Transposing IT service principles and tools into the production and control domains contributes to the shift from goods-dominant logic to service-dominant logic and orients toward services important classes of processes, such as manufacturing, logistics, process control, environment conditioning, etc., simplifying the integration of the enterprise's business and technical layers. A significant growth of services results from the following: instrumenting resources, products and orders, transferring information over the Internet and processing it intelligently. Big data can be thus efficiently acquired, processed, and interpreted through data analytics and cognitive computing, making possible the creation of novel service types and applications: mobile, micro services, and DevOps (development and operations using agile and lean principles across the entire software value chain) deployed over the Internet with ICT support—web services, cloud computing, SOA, and SaaS (Peters et al. 2016, Stoshikj et al. 2016).

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