I GranDSI-BR

Grand Research Challenges in Information Systems in Brazil 2016 - 2026

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Rita Suzana P. Maciel

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Grand Research Challenges in Information Systems in Brazil 2016 - 2026

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Foreword

Over the last decade, the Brazilian Computer Society (SBC) has been concerned with prospecting the main research challenges in the area of Computer Science in Brazil, through the seminar "Grand Challenges in Computer Research in Brazil" (2006, 2009 and 2014). The positive impact of this initiative has opened new paths for research and organization of events around these themes, as well as concrete development of actions by the scientific community on the topics covered in the seminar. Inspired by this, scientific communities from different computer science domains within SBC have worked to identify their major research challenges too.

Considering the growing maturity of the Information Systems scientific community within SBC, the Information Systems Special Commission (CE-SI) launched the Seminar on Research Challenges in Information Systems in Brazil - GranDSI-BR in 2016. The aim of this seminar was to prospect the Information Systems research issues that would be relevant for Brazilian science and society in the next 10 years (2016-2026).

This ebook contains the results of this seminar; chapters written by researchers of the Brazilian Information Systems scientific community. The challenges described in this ebook are a reflection of the prevailing ideas of the Information Systems community on the area. It is hope that they will inspire and guide the direction of Information Systems research in Brazil in the coming years. We would like that these challenges serve as guiding principles for the development of projects which will produce significant scientific advances with both technological and social impact in Brazil.

Clodis Boscarioli, Renata M. Araujo e Rita Suzana P. Maciel

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Chapter 1 Introduction

Clodis Boscarioli, Renata M. Araujo, Rita Suzana P. Maciel

Information Systems (IS) have been one of the main agents of economic growth and social transformation in Brazil and in the world in recent decades. It is clear that they will persist as such in the coming years. The importance of IS to the functioning of today's organizations and society justifies the debate on guidelines and an agenda for IS research, which is widely carried out both in Brazil and internationally.

The area of Information Systems research understands computing as a means or instrument for solving problems in the real world, society and organizations. Its applied and multidisciplinary character makes it a challenge, requiring a deeper reflection not only on the constructed technologies but also on their unfolding when applied in practice. The establishment of a common vision of the challenges faced by the area is necessary as a way of directing efforts towards the real solution of the country's great current problems.

1.1. The GranDSI-BR Seminar

The Research Challenges in Information Systems in Brazil - GranDSI-BR - seminar called the Brazilian scientific community and national industry to answer the following questions:

- What are the challenging IS research domains and problems in Brazil?
- What are the IS challenges for solving problems in these domains?
- What are the challenges in developing, using and analyzing the impact of IS in solving problems in different domains?
- Which IS challenges are independent of specific domains? What are the specific issues of the IS artifact itself (such as integration, complexity, and utility) which need to be addressed?
- What are the challenges of the IS research area considering its development in the future? How should the area position itself to achieve its goals, particularly in Brazil?

To this end, the characteristics of a Research Challenge were defined, based on previous definitions proposed by SBC:

- It should be geared to significant advances in the field and hence to science, rather than based on incremental results of existing progress.
- The research to address a challenge should go well beyond the work and results that can be developed and achieved in a conventional individual research project.

- The research progress must be incremental and evaluated so that its progress can be analysed and necessary changes to the research strategy can be made.
- The success of research should be able to be evaluated clearly and objectively.
- Challenges are possibly multidisciplinary in nature and in solution opportunities.
- Challenges emerge from a consensus of the scientific community to serve as a long-term scenario for researchers, regardless of funding policies or short-term issues.

The first stage of the prospection of research challenges in the scientific community comprised a call for the submission of challenge proposals by the scientific community, industry professionals and experts in the field. Proposals could be submitted freely, limited to 3 pages, containing (at least) the following items: i) what was the great challenge proposed; ii) what were the specific context(s) related to the challenge and its relevance in the national and/or international context of Information Systems research; iii) what national initiative the challenge was it related to (if any); and iv) ways of assessing the progress of the proposed challenge.

18 proposals were submitted and evaluated by the organizing committee, according to the following criteria:

- Relevance to IS: if the proposed challenge was clearly identified and aligned with the research area in Information Systems.
- Scientific progress: if the challenge points to significant advances in the field and, consequently, science, rather than based on incremental results of existing progress.
- Coverage: if the research identified by the challenge goes beyond the works and results that can be developed and achieved in a conventional individual research project.
- Progress evaluation: if the proposal presents a way of evaluating the community research progress addressing the challenge in an incremental way, so that its evolution can be analyzed.
- Perception of success: whether the success of this challenge can be assessed clearly and objectively.
- Multidisciplinarity: if the challenge requires multidisciplinary views.
- Sustainability: whether the challenge represents a possible consensus of the scientific community to serve as a long-term scenario for researchers, regardless of funding policies or short-term issues.

Of the 18 proposals, 15 were selected for presentation, discussion and consolidation during the seminar in May 2016, during the Brazilian Symposium in Information Systems, in Florianópolis, Santa Catarina, Brazil. The Seminar lasted one day. 13 of the 15 proposals were presented by their authors who attended the event or participated by videoconference. A brainstorming session was organized with the whole audience so as to deepen and align the proposals among participants. These reflections led to the identification of four major themes, defining the major challenges for the area [Araujo, Maciel and Boscarioli 2017].

1.2. Challenges Overview

The major challenges identified by the IS community led to the issue of how to conceptualize, build and evaluate a new generation of information systems to cope with the increasing technical complexity and social diversity of the contemporary society.

Challenge 1 - Systems of Information Systems. In the open, globalized and connected world information systems not only support a high diversity of application domains, such as business, health, and crisis response but perform several tasks and complex functionalities. Systems-of-Information Systems (SoIS) are a specific type of Systems-of-Systems (SoS) that presents new challenges for Information Systems (IS) development and research community. SoIS exhibits all SoS characteristics with an additional strong business nature. SoIS are made up of several IS that combine their capabilities.

Challenge 2 - Information Systems and the Open World Challenges. The world is a network. The challenge is to understand its dynamics and to propose, build and understand the impact of information systems to support it. A long list of aspects should be considered when associating information systems to the open and virtual world. These include: mobility, collaboration, empowerment, interoperability, knowledge sharing, scalability, transparency, privacy, security, flexibility, value, reliability, diversity, licensing… the list is endless. New technology trends also must be taken into account: open and linked data, social networks, multi-agent systems, just to mention a few. The open world is true and necessary for different application domains, from service provision to innovation, including society's access to information, and participation, both in the public as well as private sectors. Different relationships between consumers and providers are emerging. Anyone can be a producer, anyone can be a consumer in the open world. New ecosystems arise from this connected world and new approaches to designing and providing information systems to support these ecosystems are needed, challenging Brazilian legislation, government, industry and market production processes and people's behavior, education and culture.

Challenge 3 - Information Systems Complexity. Current and Future Information Systems comprise several components. These components could be other systems, software or sensors hosted on different computational platforms. Due the diversity and quantity of components IS are becoming more and more complex. In the context of information systems, information exchange and interaction between users frequently occurs across heterogeneous environments. Interoperability is a key requirement to support activities in heterogeneous environments efficiently and effectively. Additionally, concerning information technology infrastructure for information systems, virtual support and development platforms are changing the way customers interact with data and applications.

Challenge 4 - Sociotechnical View of Information Systems. Information systems are not just software or people using software. They are the full integration of people and technology and the multitude of relationships that arise from this integration. Information systems today and in the coming years cannot be designed, developed, researched, used or learned without consistent approaches to address the complexity of the sociotechnical system that our society is and will continue to be. Effectively solving of information systems problems means developing competencies in IS research, education and in the professional community to fully understand what a sociotechnical view is, and to consistently apply interdisciplinary methods and practices in order to understand and solve real world problems.

1.3. Book Structure

In order to consolidate the challenges identified during the seminar, the authors were invited to elaborate extended versions of their proposals, based on the discussions held at the workshop. The extended papers underwent a peer review process to reinforce the characterization of proposals as challenges and were finally organized as chapters in this digital book.

In Chapter 2, Graciano Neto et al. draw attention to Smart SoIS, a subcategory of SoIS. Besides (i) managerial independence; (ii) operational independence; (iii) distribution; (iv) evolutionary development; and (v) emergent behavior inherent from SoS characteristics, Smart SoIS also have two novel dimensions: (vi) evolutionary or dynamic architecture, and (vii) full interoperability. An assessment model named SoISAM (Smart SoIS Assessment Model) is established as a reference to classify the level of development of research in Smart SoIS to address this challenge in the next years. Bernadini et al., in Chapter 3, discuss Smart Cities, an example of SoIS. Smart Cities should possess several "smart" dimensions such as Smart Economy, Smart Mobility, Smart Environment, Smart People, Smart Life and Smart Governance. They present a general landscape on Smart Cities from IS perspective to address this challenge.

Araujo proposes in Chapter 4 the discussion of the new requirements brought by the open world to information systems specification, design, implementation and evaluation. Information systems can be seen as new digital information ecosystems based on the epistemological view of cyberdemocracy. Siqueira et al. (Chapter 5) call the IS community to embrace the challenge of developing, managing and evolving linked open data innovative ecosystems. Maciel et al. discuss the challenge of defining methodologies and technologies for public electronic participation in Chapter 6. In Chapter 7, Nunes et al. draw our attention to the need to focus on information transparency and how information systems should cope with it. Silva et al. (Chapter 8) discuss the challenges faced by small IT companies in providing services to Brazilian public administration agencies.

Maciel et al. (Chapter 9) argue that full interoperability - the interoperability support required by a system, a system of a system and platforms such as Cloud or IoT (Internet of Things) -is a key aspect of dealing with IS complexity, and the research community needs to explore new interoperability models. Carneiro and Paula (Chapter 10) point out that Cloud Computing (CC) is a promising technology for software development, changing the way customers interact with data and applications. Switching to the cloud means giving up incumbent information systems practices and facing the initial perception of losing control of data which in a previous scenario had been stored on local servers. Strategies for CC adoption, calculating the cost-benefit of the adoption and selecting CC providers are highlighted as challenges.

Cafezeiro et al. (Chapter 11) argue in favor of a sociotechnical approach to knowledge construction in information systems. This idea is supported by Pereira and Baranauskas (Chapter 12) when affirming that the technical, social, legal and ethical problems in the development and use of information systems arise from a narrow understanding of information systems which separates its role in the complexity of the social systems where people interact. Maciel and Pereira (Chapter 13) discuss the cultural and technological scenarios needed to address the phenomenon of death and the urgency for the design of solutions for the digital legacy of deceased users as an example of one sociotechnical challenge. Finally, Silva et al. (Chapter 14) focus on the relevance of Data Science for the area of Information Systems and the challenges to carrying out effective research and education in this field.

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Challenge 1 - Systems of Information Systems

Chapter 2

Smart Systems-of-Information Systems: Foundations and an Assessment Model for Research Development

Valdemar Vicente Graciano Neto, Flavio Oquendo, Elisa Yumi Nakagawa

Abstract

Software-Intensive Information Systems (IS) have supported many application domains. Recently, they have been connected to form synergistic arrangements of IS known as Systems-of-Information Systems (SoIS). Each IS cooperates with its own capability to compose more complex functionalities that could not be delivered separately. However, SoIS have sometimes been conceived from a static perspective, with a low degree of flexibility in their architecture and with high costs to support a proper interoperability of their constituents. The main contribution of this chapter is to step forward, proposing a new type of SoIS named Smart SoIS, i.e. an SoIS that presents a dynamic architecture and full interoperability. Dynamic architecture guarantees that the architectures of SoIS can change over time, rearranging themselves (adding, changing, or eliminating constituents) to keep the SoIS in operation. Full interoperability supports transparent interoperability, which can be achieved spontaneously and instantaneously, exploiting capabilities of the constituents to accomplish missions assigned to the Smart SoIS. We also present foundations for Smart SoIS, and a model to assess the evolution of the research and technology for Smart SoIS over the next few years.

2.1. Introduction

Information Systems (IS) have been the cornerstone of several business endeavors. They are often software-intensive systems in the sense that software is a dominant feature that intensively impacts the entire system development life cycle and the delivered results [ISO 2011]. IS have supported a great diversity of application domains, such as business, health, and crisis response [Goldschmidt 2005, Procaci et al. 2014, Santos et al. 2014; 2015]. Currently, IS have been under pressure to offer more complex functionalities. In turn, they have been constructed to be domain-specific with a set of increasingly narrowed functionalities. As a result, the engineering of complex functionalities has shifted to a perspective in which multiple IS have been combined to interoperate, achieving results that add value to the client [Boehm 2006]. These types of systems are termed Systems-of-Information Systems (SoIS[1]) [Carlsson and Stankiewicz 1991, Breschi and Malerba 1997, Saleh and Abel 2015, Majd et al. 2015]. SoIS are a specific type of Systems-of-Systems (SoS) that poses new challenges for IS development and research. SoIS exploit individual functionalities offered by their constituent IS to build complex functionalities that cannot be delivered by any of these IS separately. Significant investment has gone into subsidizing SoIS engineering. For instance, Saudi Arabia is investing 70 billion dollars in smarter cities and, in South Africa, a 7.4 billion dollars smart city project has been conducted [Cerrudo 2015]. However, their smooth operation is of paramount interest as faults can have a significant impact. Hence, it is important to investigate how to construct SoIS for them to be trustworthy, i.e. SoIS that are able to keep operating despite failures or threats. Constituents will be required to form a SoIS spontaneously in response to new SoIS missions, an ability termed as *full interoperability* [Maciel et al. 2016]. Moreover, to maintain operation despite occasional changes, dynamic architectures will be required as well. These new SoIS must be *smarter* in the sense that they must comply with such requirements.

This set of essential characteristics gives rise to a novel class of SoIS termed *Smart SoIS*. This is a special type of SoIS that, besides the essential characteristics of a SoS [Maier 1998], accomplishes two additional dimensions: full interoperability and dynamic architecture. In this scenario, research directions must be established to support a deeper investigation of this new context, eliciting the main challenges that must be addressed to comply with these requirements. In this chapter, we establish foundations for Smart SoIS, a forthcoming and distinguished class of SoIS that exhibits a particular set of characteristics that should be addressed by the scientific community of IS in the next few years. We briefly outline the foundations of SoIS in Section 2.2, firstly explaining what an SoS is, and after advancing the discussion for SoIS and Smart SoIS. In Section 2.3, we establish characteristics that must be accomplished by Smart SoIS. In Section 2.4, we establish a model to assess the level of development and research in Smart SoIS over the next few years. Finally, we present our concluding remarks and perspectives for future work in Section 2.5.

2.2. SoIS: Systems-of-Information Systems

Systems-of-Systems (SoS) are based on a set of independent systems, so-called constituents, available and predisposed to accomplish a given set of missions by means of interoperability among them [Maier 1998]. Functionalities offered by constituents are often referred to as capabilities [Boardman and Sauser 2006, Dahmann et al. 2008]. SoS share important characteristics [Maier 1998]: (i) managerial independence, i.e. constituents are owned and managed by distinct organizations and stakeholders (ii) operational independence, i.e. constituents perform their own activities, even when they are not accomplishing one of the SoS missions (iii) distribution, i.e. constituents are dispersed requiring connectivity to communicate (iv) evolutionary development, i.e. SoS evolve due to the evolution of their constituents,

1 For sake of simplicity, SoIS will be used interchangeably to express singular and plural.

environment, and/or missions and (v) emergent behavior, i.e. complex functionalities emerge from the interoperability among constituents. Remarkable examples of SoS include smart cities, smart grids, smart buildings, and a range of smart-* systems [Fitzgerald et al. 2013].

A SoS is called *smart* when it presents self-* characteristics (self-adaptation, self-healing, and self-management) [Giese et al. 2015]. The five characteristics assigned by Maier make SoS have a dynamic (or evolutionary) architecture, i.e. the constituents of a Smart SoS can be changed according to the operation of the SoS. Dynamic architecture has been considered a necessary characteristic for SoS [Boardman and Sauser 2006, Fitzgerald et al. 2012, Andrews et al. 2013, Weyns and Andersson 2013, Batista 2013, Romay et al. 2013, Graciano Neto et al. 2014, Nakagawa et al. 2014, Nielsen et al. 2015, Oquendo 2016]. Constituents can be added, for example, to improve the performance of a capability that is provided; other constituents can fail and be substituted; and some of them can leave the SoS spontaneously, requiring a reorganization of the remaining constituents to keep the SoS in operation and the missions being accomplished. However, self-* abilities and dynamic architecture have not been considered as intrinsic characteristic of SoS in broadly accepted definitions.

In particular, when a set of interoperable IS exhibits all SoS characteristics, they can be considered an SoIS. The term SoIS first appeared in the 1990's [Carlsson and Stankiewicz 1991, Breschi and Malerba 1997], and has recently emerged again [Saleh and Abel 2015, Majd et al. 2015]. From this perspective, SoIS exhibit a strong business nature. These authors claim that SoIS should (i) be concerned with the flow of information and knowledge among different IS (ii) address the impact of the interrelationships between different SoIS (SoIS as constituents themselves) (iii) be responsible for generating information from emergent SoIS (iv) tackle information interoperability as a key issue. SoIS are made up of several IS that combine their capabilities. Virtual Organizations are a potential instance of business supported by SoIS. They comprise several distinct organizations that spontaneously get together, working cooperatively (including their systems) in the context of a specific project for a well-defined period of time, such as six months or two years, leaving the SoIS after that. Movements such as Clean Web in which social network software and information technology are articulated to solve issues related to natural resource constraints also represent trends in SoIS.

Interconnection of IS to achieve more complex functionality is not a recent topic [Wiederhold 1992, Carlsson and Stankiewicz 1991, Breschi and Malerba 1997]. In fact, these arrangements of IS have been constructed over the last decades with differing names and distinct purposes. Complex Systems [France and Rumpe 2007], Ultra-Large Systems [Feiler et al. 2006], and Federated Information Systems [Tu et al. 2011, Graciano Neto et al. 2014] are some examples that have emerged to represent classes of software-intensive systems made up of a set of IS. The main difference between a SoIS and these other types of systems is the level of independence of their constituent systems. Constituent IS still exhibit independent operation when not contributing to the accomplishment of global missions [Falkner et al. 2016], whilst Federated IS and other classes that combine IS often have IS exclusively dedicated to the purposes of the larger systems.

SoIS that inherit the peculiarities of SoS are supposed to be not only a permanent structure but also a phenomenon triggered by some stimulus. Other types of systems assembled with pre-existing systems are specifically designed to be part of a new complex system or they are engineered/refactored to be a permanent part of a much larger system. Constituents are not necessarily designed to be part of an SoIS, and they also have an independent existence. There are distinct requirements that must be fulfilled regarding constituents: they must be engineered to interoperate among them (as other similar large systems do), but they also need to have an independent existence. Nevertheless, SoIS must be as trustworthy as SoS. They are required to deal with the dynamics of the architecture, requiring another constituent to work when one fails, and self-adapting their structure to keep to the accomplishment of a mission even when external events threaten the stability of the SoIS. To deal with these requirements, new characteristics are added to SoIS, giving rise to a new class of systems named Smart SoIS, as we discuss in the next section.

2.3. Towards Smart SoIS

Besides the five inherent SoS characteristics, Smart SoIS also have two novel dimensions: (i) evolutionary or dynamic architecture, and (ii) full interoperability. We discuss each one of the characteristics and their particularities for Smart SoIS below:

Independence (decoupling) of constituents. Constituents in a Smart SoIS are decoupled IS, which have an independent existence, operation, and purposes, but that occasionally offer their capabilities to contribute to the accomplishment of a mission of a Smart SoIS. Constituents can be enterprise information systems, decision support systems, social networks, or any other type of IS.

Managerial independence of constituents. Multiple organizations and stakeholders can hold and contribute with their IS to form a Smart SoIS.

Evolutionary development. IS inherently evolve the Smart SoIS, which changes according to new requirements, new IS joining and leaving the SoIS, with evolving missions, and evolving their own architecture.

Emergent behavior. Such behaviors are a holistic phenomenon manifested as results of the interoperability among constituents that produce a global result that cannot be delivered by any one of them in isolation. It is worth highlighting that emergence can be deliberately and intentionally designed [Boardman and Sauser 2006], i.e. SoIS engineers are the major players for creatively exploiting functionalities delivered by the constituents, assembling them for innovative purposes. In Smart SoIS, other types of emergent behaviors can be found, such as information-intensive capabilities that form emergent behaviors that add value to business, positively impacting users being supported by these systems.

Distribution. To achieve the required interoperability and to address emergent behaviors, a strategy must be established to support communication and data exchange among IS of a Smart SoIS. Shared databases, mediators, middleware, and an enterprise service bus are some classic examples of means to support it.

Evolutionary (dynamic) architecture. A Smart SoIS remains in operation by adapting its own architecture during the accomplishment of a mission. If we consider an SoIS made up of several

IS, some of them may stop working for some reason (due to cyber-attacks, for example). A Smart SoIS must be able to explore capabilities available in a set of constituents still in operation, rearranging them to maintain the mission accomplishment in progress. As a consequence, the constituent IS and connections are not stable (from an architectural perspective). It is necessary to investigate how to provide this type of ability in the context of Smart SoIS by designing mechanisms to support rearrangement of their dynamic architectures and self-adaptability abilities required for such purposes.

Full interoperability. It is a more complex and broader concept, which comprises the spontaneity of forming a Smart SoIS according to needs that emerge, in a transparent manner for the user, abstracting issues, such as middleware, network, data exchange (representation and transport), and communication support details. To achieve this, the IS must support instantaneous interoperability with any other type of IS which is available, exchanging information among themselves, and being able to contribute to the accomplishment of missions. Moreover, they must be capable of arbitrarily forming a Smart SoIS under a new demand. This characteristic is itself a challenge [Maciel et al. 2016].

Hence, the main challenge that we face for the next 10 years is *to conceive Smart SoIS that comply with the aforementioned characteristics*. When we achieve this milestone, Smart SoIS will become feasible and trustworthy, being conceived fast and on demand, with the IS being selected at runtime according to pre-established restrictions. To aid in the assessment of the evolution of the research in Smart SoIS over the next few years, we propose an assessment model, discussed in the following section.

2.4. An Assessment Model to Evaluate the Progress of Research into Smart SoIS

We established an assessment model named SoISAM (Smart SoIS Assessment Model) as a reference to classify the level of development of the research in Smart SoIS over the next few years. We adapted it from technology assessment standards, such as Technology Readiness Levels (TRL) [Shishko et al. 2004, Mankins 2009] and SOA Maturity Model [OMG 2005]. The former corresponds to a method proposed by NASA and the Department of Defense (DoD) of the United States to assess the maturity level of a particular technology. The latter provides guidance to measure progress and the adoption of SOA.

In our model, a *level of research development* is assigned to the state of the art in Smart SoIS according to the nature and maturity of the evidence and results towards real Smart SoIS. We established nine research development levels. SoISAM 0 is the lowest and SoISAM 8 is the highest. Associated to them, we defined metrics to support the assignment of a level to given research in Smart SoIS, and the type of evidence that is expected for each level of maturity. Additionally, a SoISAM level is considered achieved when metrics show that the respective type of evaluation and expected deliverables, e.g. publications, prototypes, patents, and tools, are available in the state of the art and practice.

Each one of the maturity levels has specific characteristics. These are discussed considering the force of the evidence that supports results being reported by publications or products. The SoISAM levels are:

- **SoISAM 0 -** This is the lowest level of maturity. It establishes foundations for Smart SoIS. Results reported are mostly based on position studies. Background and principles are raised to construct a consistent theory for Smart SoIS. Studies propose perspectives of research and challenges. There is no empirical validation.
- **SoISAM 1** – When research achieves this level, toy examples and proofs-of-concept are implemented. Characteristics of a Smart SoIS are tackled separately. Preliminary research starts to communicate the existence of prototypes that address one or more characteristics of a Smart SoIS. Methods, techniques, and tools are planned, and parts of them are implemented.
- **SoISAM 2** – Prototypes of tools, models, and methods already support the carrying out of case studies. Case studies are designed and conducted. State of the art covers prototypes of Smart SoIS with preliminary results on supporting dynamic architecture and full interoperability, besides the other five inherent characteristics of SoS. Exploratory research is carried out.
- **SoISAM 3 –** Preliminary experiments are performed and prototypes of Smart SoIS exhibit all the characteristics required. Prototypes of tools, models, and methods are used to validate and verify predicted functionalities of Smart SoIS in the laboratory (*in-virtuo*). Simulations are conducted to evaluate the software and hardware aspects of Smart SoIS. Reference architectures for Smart SoIS are established.
- **SoISAM 4 –** Prototypes of Smart SoIS are constructed and tested in representative environment. Since a simulation is performed in level 3, at this level, a real prototype is constructed and tested. Tests are still laboratory-based, in a controlled environment and on a small or medium scale.
- **SoISAM 5 –** Real Smart SoIS are conceived and tested in the environment. After validation of the expected results in the laboratory, tests are carried out en masse in a real operational environment.
- **SoISAM 6 –** The results of research are transferred to industry. Patent filing is required, methods, techniques, and tools are well-established, and companies start the production of Smart SoIS on an industrial scale.
- **SoISAM 7 –** Industry is already producing IS with full support for the spontaneously creation of Smart SoIS on demand. Smart SoIS are accessible to the population as public services, entertainment products (e.g. toys and games), or personal products.
- **SoISAM 8 –** Smart SoIS are already part of everyday life. Even non-programmers are able to form small-scale Smart SoIS using a set of interoperable IS, and public entities construct reliable Smart SoIS applications to improve the quality of human life. Smart SoIS are everywhere, becoming pervasive and well-adopted, fostering, for instance, sustainability and health. Many options of technologies are available and new business models come into existence which rely on Smart SoIS.

Table 2.1. Metrics associated to maturity levels for SoISAM

Maturity Level	Type of Evidence	Supporting Metric
SoISAM 0	Publications as position studies proposing models based on Smart SoIS concept.	Number of publications that introduce or adopt the concept of Smart SoIS.
SoISAM 1	Toy examples and proofs-of-concept	Number of publications that communicate first essays on providing operational examples and simple Smart SoIS.
SoISAM 2	Case studies	Number of publications that report results of case studies carried out to measure specific parameters, comparing them to predictions or real cases, establishing a relationship between what is expected from Smart SoIS and what is achieved in that point of research.
SoISAM 3	Experiments *in-virtuo*	Number of publications that report experiments with computer-based models. In these experiments, the behavior of the environment with which the Smart SoIS interact is described as a model and represented by a simulation.
SoISAM 4	Experiments *in-vitro*	Number of publications and number of operational prototypes of Smart SoIS created in the laboratory.
SoISAM 5	Experiments *in-vivo*	Number of publications and academic tools available, supported by the results of experiments carried in the laboratory, under well-defined restrictions, and with operational prototypes that cover all the characteristics of a Smart SoIS, and that are tested in a real environment. This level of development can be demonstrated by real Smart SoIS in operation.
SoISAM 6	Transfer of research results to industry	Number of initiatives, projects, patents, and publications that report the beginning of the production of Smart SoIS in industry.
SoISAM 7	Industrial large-scale production	Number of commercial tools available to support the construction of Smart SoIS.

SoISAM 8	Smart SoIS pervasiveness	Number of publications, technical reports, and data delivered by such publications that communicate Smart SoIS being formed spontaneously and number of IS being sold that achieve full interoperability.

Table 2.1 summarizes the research development levels of SoISAM. Each level has a specific type of empirical evidence that must be reported to support the level achieved. In parallel, specific metrics are established for each level. Each metric details the elements that will be assessed. The elements, e.g. publications, patents, and tools, are used as parameters to classify the type of evidence that is available and being reported, such as case studies, experiments, or large-scale production.

2.5. Final Remarks

We presented an overview of the research challenges to be addressed by the IS community over the next few years. We propose a new type of SoIS named Smart SoIS that, besides having the inherent characteristics of SoS, also exhibits other two important features: dynamic architecture and full interoperability. Under this reality, software-intensive IS should be able to voluntarily form new Smart SoIS, according to new demands. Our proposal is in alignment with START (SofTware ARchitecture Team) research group of ICMC/USP (Instituto de Ciências Matemáticas e de Computação/Universidade de São Paulo) together with ArchWare, a French multidisciplinary scientific research group that integrates IRISA (Institut de Recherche en Informatique et Systèmes Aléatoires) working on the development of SoS in remarkable application domains, such as health and emergency response and crisis management. Additionally, our proposal is in alignment with another Big Challenge for IS: Full Interoperability [Maciel et al. 2016].

Smart SoIS will become substantially more relevant for society. Flood monitoring [Horita et al. 2015], healthcare systems [Rodríguez et al. 2015], smart cities [Lytra et al. 2015], and crowdsourcing systems for emergencies and crisis situations [Santos et al. 2014; 2015] are some instances that show the pervasive, multidisciplinary, and crosscutting impact of them in the forthcoming future. We must research, synthesize results, and elaborate new theories and technologies to support the efficient development of these new SoIS appropriately. It is necessary to deal with issues related to modeling, design, and simulation of Smart SoIS architectures, definition, elaboration, and specification of missions, and design of mechanisms to deal with emergent behaviors. We must comprehend how we can develop Smart SoIS to address the phenomenon of spontaneously joining IS on demand, contributing to the missions to be accomplished by SoIS.

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Chapter 3

General Features of Smart City Approaches from Information Systems Perspective and Its Challenges

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Abstract

The Smart City (SC) idea has attracted increasing attention due to fast growth of urban centers. SC concepts require more complex and higher quality services for their citizens, most of which are supported by Information and Communication Technologies (ICTs). In order to tackle this emergent topic, different e-government systems and technologies have been used for several urban services, such as mobility, economics, healthcare, education, among others. Such systems can be part of Systems of Systems (SoS), which have an intrinsically challenging developing process due to complex aspects, such as infrastructure issues, data and subsystems integration, and data management in decision support systems (DSS) for all stakeholders. Therefore, the use of innovative technologies must be addressed, and this chapter outlines the general landscape on SC approaches, discussing issues from Information Systems (IS) perspective considering different concepts available in the literature. This work also highlights current and forthcoming challenges for this IS area, including design, implementation and deployment of such systems, as well as a method to evaluate an SC from an IS perspective.

3.1. Introduction

The world is undergoing dramatic change in its demography. The urban population will grow about by 2.3 billion over the next 40 years. By 2050, around 70% of its population will be living in large cities. If this growth does not happen in a systematic way, important issues may arise, such as difficulties related with waste management, resource availability, air pollution, traffic congestion, deteriorating infrastructure, among others. Therefore, better living conditions require a deeper understanding of Smart Cities approaches (SCs) in order to take advantage of available technologies associated with aspects of urban life. Such technologies enable improvements in quality of life in an orderly and sustainable way.

Different cities may require distinctive approaches to SCs, i.e. the Brazilian Network of Human and Smart Cities (RBCIH – *Rede Brasileira de Cidades Inteligentes e Humanas*, in Portuguese), founded in 2015, presents its own requirements [RBCIH 2016], considering the specificities of Brazilian cities. This network initially included eleven cities with their respective institutes of science and technology, joining both government and research groups. Technological aspects are considered by RBCIH to deliver positive impacts on security, health and other city-related services, as well as possible social impacts, i.e. improve quality of life of their citizens. Improvements are mainly related to e-government maturity model, implementation and use of computational tools to allow public transparency and participatory government. In the latter locals take part in the decision-making process regarding solutions for their city, in such a way that citizens and government join a virtuous cycle. Consequently, for Brazilian cities, the main idea is to promote SC initiatives to improve the quality of services provided to its citizens, as well as guarantee their participation in the government decision-making process.

The purpose of this chapter is to present the general features of SCs, highlighting challenges to the Information Systems (IS) perspective. This work provides (i) an overview of concepts and approaches for SCs, as well as IS related technologies and methods (ii) challenges in the area of IS within the scope of the SCs, from creation to implementation and (iii) insights on analyzing the impact of such systems on citizens.

This chapter is organized as follows: Section 3.2 presents concepts related to SCs. Section 3.3 presents a general view of SCs from the IS perspective. Section 3.4 discusses IS challenges that make the implementation of solutions for SCs effective. Section 3.5 describes a method for an ongoing evaluation of how these challenges will evolve. Section 3.6 presents the conclusions of this chapter.

3.2. Theoretical Concepts

3.2.1. SC Approaches

The term “Smart City” firstly emerged in 1997 in the Kyoto Protocol. Concurrently, since 1999 the term “Digital City” has been widely cited in literature due to widespread use of the Internet. However, it was only in 2010 that the term “Smart City” became widespread. According to [Cocchia 2014], a city is a Digital City when it follows digital policies to supply electronic services to citizens using the Web, Cloud Computing and the Internet of Things (IoT); it is a Smart City when it follows sustainable strategies for sustainable and innovative usage of their own natural resources; and it is a Digital-Based Smart City when it follows sustainable strategies using technologies applied to digital cities. In this case, a Digital City is an Information and Communication Technology (ICT) component using a SC strategy. In a broader perspective, Pardo and Taewoo (2011) present the concept of SCs as a combination of different aspects, organized in three dimensions:

i. **Technological**, which considers the use of infrastructure, especially ICT, to transform and improve quality of life and work in a city. This dimension includes the concepts Digital City, Virtual City, and Information and Ubiquitous City.
ii. **Human**, which considers people, education, learning and knowledge, since they are key factors to turn a city smart. This dimension includes concepts of Learning City and Knowledge City.
iii. **Institutional**, which takes into account governance and politics. Cooperation between stakeholders and institutional government is very important to design and implement SCs initiatives. This dimension aggregates concepts of Intelligent Community, Sustainable City and Green City.

On the other hand, [Lee et al. 2013] and [Dameri and Rosenthal-Sabroux 2014a] present the SC concept based on six main dimensions: Smart Economy, Smart Mobility, Smart Environment, Smart People, Smart Life and Smart Governance. Alternatively, Giffinger and Gudrun (2010) states that: "a city is smart when their investments in human and social capital, in urban transport and ICT infrastructure allow a sustainable economic development and a better life quality, with a wise management of natural resources, throughout a participatory governance". Thus, projects in SCs should have overlaps among these dimensions. For instance, a new public transport system based on low carbon emissions leading to positive impacts on mobility as well as a sustainable use of the environment.

Cocchia (2014) describes SCs from a different perspective, considering the following core components:

i. **Land**, meaning the geographical area in which the city is located;
ii. **Infrastructure**, meaning a large element including all physical components and materials of a city – buildings, streets, transport facilities, and so on;
iii. **People**, including all citizens, not only residents, but also those who work, study or tourists; and
iv. **Government**, meaning politicians who have the power to govern the city.

The following characteristics enable these components to become smarter [Dameri 2012]:

- **Effectiveness**, related to the ability of the city to effectively meet public and private services for different groups (citizens, companies and non-profit organizations) and for different categories of citizens (students, workers, elderly people). The subjective role of each stakeholder in a smart definition should be included, i.e. a city is not smart by itself, but only when its initiatives create public value to its citizens.
- **Environmental considerations**, related to the ability to measure impact of city growth in environmental quality in urban areas. One of the main pillars of SCs is to prevent even greater environmental degradation. The main impacts are related to energy consumption, water and air pollution, traffic congestion and land consumption. Thus, a SC acts to reduce these aspects to preserve the quality of the environment.
- **Innovation**, which indicates that a SC should make use of all the latest technologies to improve the quality of its main components, to deliver better services and reduce

environmental impacts. Therefore, technology is a central aspect of SC, used in initiatives for improving the life quality in the city.

A smarter land means cleansing the land, air and water as well as reducing land consumption for new construction, environmental recovery, among others. Smarter infrastructure means serving citizens in a more effective way, responding to their needs. In addition, SCs should make use of cutting-edge technologies, ICT and mobile devices to provide electronic services and information. Smarter people mean that citizens are more aware of city goals and rules when using city technologies, improving urban land quality, infrastructure and services. It also means an easier way to access the Internet and mobile devices, and a wider digital inclusion of people. A smarter government uses ICT and available technologies to implement electronic government and democracy in order to improve the quality and accessibility of public services and make citizens more satisfied with local administration.

A common aspect in these approaches is organizing the concepts in different dimensions to construct a framework for SCs. Brazilian cities differ in size and number of citizens in terms of both financial and technological access. Therefore, building a framework specifically for Brazilian cities, can also define strategies for larger countries with similar Brazilian characteristics, such as India, USA, Russia and China. However, each city may require distinctive solutions, considering the prioritization of municipal issues, defined by its local strategic plan. Furthermore, the definition of targets and indicators can enable citizens to assess the public value of applied initiatives, guiding both ongoing and future strategies to make a city smarter. Measuring public value should be the ultimate goal of a SC, which requires that projects and initiatives should at least be indicated by citizens. However, public value is a complex concept, because it includes the definition of values of different types [Dameri and Rosenthal-Sabroux 2014b]:

- Social and economic values, which are difficult to reconcile, and sometimes may be opposed to each other;
- For different stakeholders, who have different expectations that are not always compatible;
- Regarding different dimensions of life cycle, requiring comprehension of the real needs and priorities of citizens.

A framework for transparency proposed by Leite and Cappelli (2010) deploy such aspects, allowing a virtuous circle of understanding between government actions and population issues. Further discussions are present in the following section.

3.2.2. Open Data, Public Transparency and Maturity Model for SCs

Transparency in the public sector is a vital factor in strengthening relations between government and citizens [OECD 1961]. After an extensive review of the transparency concept, Leite and Cappelli (2010) define transparency using the following characteristics:

a. Complete information: all information must be available without restriction;
b. Objective information: the information directly responds to questions asked;

c. Reliable and quality information: information is correct, fair, consistent and accurate;
d. Easy access to information: the mechanism used to access information has a proper response time and proper functionality;
e. Information understanding: the information does not generate doubts. Everyone can understand it;
f. Communication channels totally open: free and easy access to information.

The first step to ensure transparency is to allow access to government data, following a worldwide effort in this regard. In September 2011, the Open Government Partnership (OGP) was launched, an international initiative that aims to encourage government practices globally, such as budget transparency, public access to information and social participation. Therefore, open government data should be legally consistent with the following [Eaves 2009]:

a. If data cannot be found and indexed on the Web, it does not exist;
b. If data is not open and available in machine readable format, it cannot be reused; and
c. If any legal provision does not allow replication, the data is not useful.

Terán, Kashina and Meier (2016) propose a maturity model for Cognitive Cities. The authors emphasize the importance of interaction between government and citizens, and present an e-government framework (e-gov) to ensure electronic empowerment by the population. According to the authors, first level of a maturity model for e-government of a SC is characterized by e-Information, i.e. there is a top-down one-way channel to provide relevant information to citizens about public policies, projects and news, among others. Examples of cities at this level are those with web portals in their municipalities.

Second level is characterized by the e-Consultation, i.e. there is an electronic two-way channel, giving authorities the ability to collect the opinions and comments of the population. Examples of cities at this level are those that perform electronic polls, in which the local government (prefecture) aims to collect citizens' opinions through questionnaires. The third level is characterized by the e-Talk, i.e. there are discussion channels between citizens and governments, and virtual communities are created. These channels enable public projects, ideas and plans to be discussed and commented on. As the process takes place virtually, there is the advantage of a possible participation of specialized groups, which can promote the process of opinion formation. At this stage, citizens are able to establish channels of communication, but neither participation nor decision-making is present. The fourth level is characterized by e-Participation, i.e. there is a two-way channel in which citizens can collaborate in decision making on public projects yet to be developed. At this stage, citizens can establish a greater communication, which includes features such as working in collaboration to increase participation. The first steps for empowerment are made at this stage.

The following applications are considered collaborative elements: e-mail, instant messaging, application sharing, video conferencing, workspace, management of collaborative document and version control, task and workflow management, Wiki groups (or community effort to edit Wiki pages) and blogging systems. Fifth and final level is characterized by the e-

Empowerment, in which there is also a two-way channel. Specifically in this stage, the final decision is in the power of citizens. Local government must implement what citizens decide. At this stage, citizens have the power as channels of communication are much broader and include new and enhanced capabilities for empowerment of the population.

These two frameworks, proposed by [Leite and Cappelli 2010] and [Terán, Kashina and Meier, 2016] for transparency and participation, are interesting in SCs. However, implementing (one of) them should consider a process that includes many changes in culture and philosophical aspects in cities, beyond ISs to enable these initiatives.

3.2.3. Computer Systems Architectures for SCs

According to Mulligan and Olsson (2013), most services in SCs are based on a centralized architecture, in which a dense and heterogeneous set of peripheral devices installed in urban areas generate different types of data. Such data is made available by appropriate communication technologies to a control center where data storage and information processing are performed. However, significant obstacles must be overcome for the successful deployment and implementation of business models, designed for applications and services of SCs. Most of these obstacles are related to an ongoing battle between two main system architecture schools of thought, ICT and Telecommunications for data management and service creation.

SC services tend to use components from both ICT and Telecommunications, and do not benefit from the current binary view of system architecture. For the development of SCs, business models have suggested a strategic long-term vision of evolution of this architecture. Architectural aspects are central in solutions of IoT in the SC context. A primary characteristic of an urban infrastructure for the Internet of Things (IoT) is its ability to integrate different technologies with existing communications infrastructure, to allow a progressive evolution of IoT, interconnecting other devices and implementing new features and services. Another key aspect is the need to make (part of) collected data by urban IoT easily accessible by authorities and citizens in order to improve the responsiveness of the authorities to city problems, and to promote awareness and participation of citizens in public matters.

Mulligan and Olsson (2013) discuss the evolution of an architecture to ensure more effective implementation and deployment of technologies for SCs. There are many standards for IoT struggling to become referential and most adopted by the community. However, as it is open and royalties-free, IETF (Internet Engineering Task Force) standards have been considered in first place. Zanella et al. (2014) propose a web service based architecture for urban IoT. However, a larger work for implementation and evaluation of the effectiveness of such architectures in cities remains a challenge for Brazilian cities.

3.3. A general landscape for SCs from IS Perspective

This work establishes four layers considering a general landscape including diverse SC approaches from the IS perspective. Figure 3.1 depicts these four layers. The **first layer** is the physical infrastructure that provides ICT services, including the Internet of Things (IoT) and technologies for collecting and providing Open Data. The **second layer** provides IS that must be implemented to support services to the citizens. These ISs may be (i) systems regarding to only one domain, such as a system for healthcare or education domain or (ii) complex systems, such as SoS integrating data and other systems from the first layer, and using technologies and methods from Collective Intelligence, Big Data, Artificial Intelligence, and other areas. To improve services to the citizens, it is important to provide Smart Governance, preferentially based on some Electronic Government Maturity Model, as seen in Section 3.2.2. Thus, the **third layer** is this Smart Governance, providing mechanisms to allow participation of citizens in local (city) government. These three layers may lead to smarter dimensions in cities, shown in the **fourth layer**. The general landscape is presented considering an instantiation of SC definition proposed by [Giffinger and Gudrun 2010], consisting of six dimensions, i.e., Smart Governance, Smart Mobility, Smart Economy, Smart Life, Smart People and Smart Environment. In this specific point of view, Smart Governance should not only include a government maturity model (present in the third layer) but also IT governance methodologies in all government sections. This should be considered from the first layer. It is worth noting that the fourth layer should be divided into other dimensions of interest for an adopted SC concept.

3.4. Challenges for IS in this General Landscape

3.4.1. Developing SoS for SCs

Implementing systems to meet demands of a SC is highly linked to the SoS approach (SoS), which emerged in the last decade. A system is a set of elements (or subsystems) that interact and bind themselves through an internal structure. This system concept is already universally accepted, but the definition of SoS depends on its application domain and its focus. Dersin and Transport (2014) present a survey of various SoS features. This work presents two of them that show how systems for SCs can be encompassed in the SoS approach:

- Autonomy, coherence, permanence and organization of the (sub)systems
- SoS is a complex system composed of many constituents that interact in a network structure. These constituents are often physically and functionally heterogeneous, and organized into a hierarchy of subsystems that contribute to the function of the overall system, which leads to structural and dynamic complexity. The structural complexity implies i) the heterogeneity of the constituents in different technology fields due to increased integration between systems and ii) an increase in the range and dimensionality of connectivity across a large number of constituents (nodes) which are highly interconnected by dependencies and interdependencies. The dynamic complexity implies that the system sometimes behaves unexpectedly in response to changes in environmental conditions and the operation of its constituents. Emergent behaviors can be positive or negative as they can lead to unexpected consequences. Additionally, uncertainty can be generalized in complex systems, and its quantification and propagation are fundamental aspects in the prediction and control of such systems.

  There are four other properties, known as "Maier's criteria" [Maier 1998]:

- Operational independence, i.e. each system is independent and should achieve its goals by itself;

- Management independence, i.e. each system is managed largely for its own ends, instead of considering the effects of the SoS;
- Geographical distribution, i.e. a SoS is distributed over a large geographical area, or its constituents can communicate among themselves through some network technology;
- Evolutionary development, i.e. a SoS evolves with time and experience.

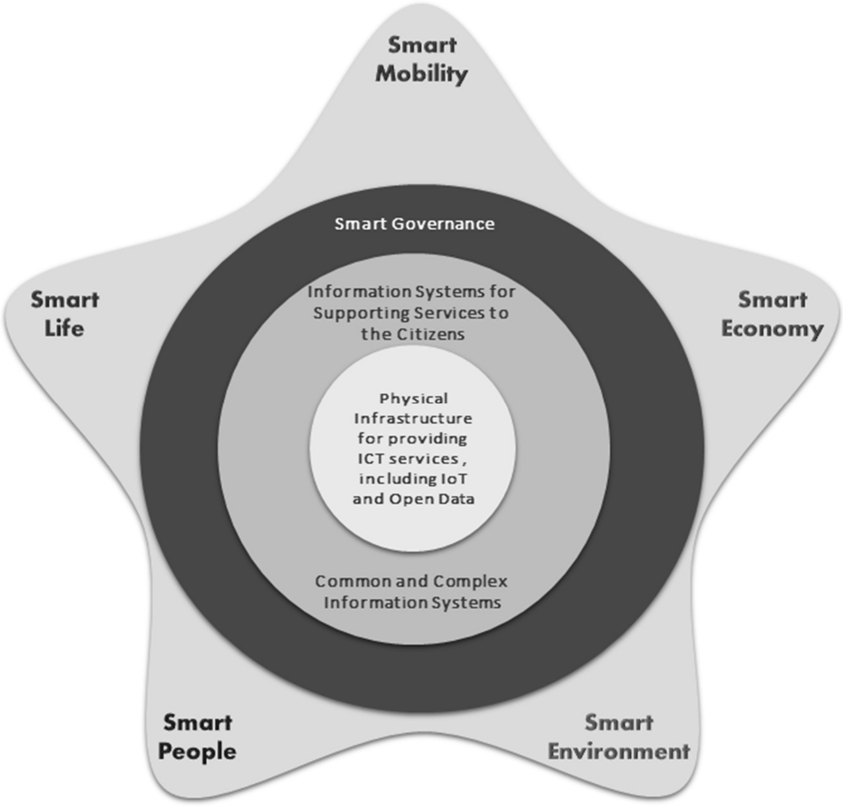

Figure 3.1 – A general landscape of SC approaches from IS perspective, considering four layers. The dimensions to be considered in a SC in the fourth layer may vary according to city stakeholders

With regard to IS, a major challenge today is to ensure that all SC systems get results considering the integration of subsystems. Over the next 10 years, an important challenge is to define models, methods and tools to support the development of SoS that allow integration of data and services from different organizations, according to the four layers and dimensions illustrated in Figure 3.1. Other challenges related to SoS development as a wider and effective SC solution are: (i) defining and ensuring the availability of useful open data for both citizens and managers of cities (ii) designing and developing systems and applications to visualize and make data available for all citizens (iii) building models, methods and tools to process and display unstructured and semi-structured data sources and (iv) defining evaluation indicators of systems that provide services to citizens.

3.4.2. Information Interoperability to support Public Transparency in SC

Several Brazilian government agencies already publish their data on the web through reports and balances so that citizens can monitor the results of government actions [Breitman et al. 2012]. This move in recent years to implement e-government and Open Data solutions in

Brazilian government levels also serves as a framework for the concept of SCs because a participatory and transparent government can only be guaranteed based on these principles. In an open data solution, all information must be classified as open, secret or ultra-secret. If information is classified as secret or ultra-secret, mechanisms for ensuring digital security must be adopted. If it is open, there is a federal effort to make this kind of information available to the public.

It is also important to adopt data formats that ensure information interoperability, such as those from the Semantic Web. In many cities, there is a lack of integration between municipal departments and the central administration. Some departments implement different access policies, while others do not share information. Initiatives aimed at integrating and/or generating data to support decision making in different municipal sectors are a challenge for the IS area, as these different areas of knowledge have their own vocabularies. Moreover, general data sources are not tailored to allow information interoperability, e.g. following Semantic Web precepts [Hepp et al. 2008].

Open data for citizens is only the first part of a SC adoption. There are many more challenges for constructing and implementing a maturity model for Brazilian cities that involves not only public transparency, as the one proposed by Terán, Kashina and Meier (2016), that provides open data and government processes in cities, but also considers other aspects of SC. One initiative is in development by RBCIH [Pereira, 2017], however, more efforts should be invested here. Last but not least important, concise and interpretable information for citizens are important factors for transparency.

3.4.3. Big Data Processing for Decision Support in SC

Urban computing is an interdisciplinary field which studies urban issues using computer technologies [Silva and Loureiro 2016]. A SC context expects that systems from distinct fields providing many solutions are interconnected: computer systems that provide data, information and knowledge are open to the public, sensor networks, networks of objects are connected to the Internet of Things (IoT), and smart grid electricity, among others. Such systems generate data in various formats – structured data, such as the one stored in relational database systems; semi-structured data, such as data available in data formats attached as RDF triples (Resource Description Framework), JSON and XML format; or unstructured data, such as data collected from sensors, climate information data collected from cameras, image format, or as text, such as comments on social networks about the quality of services in cities.

This huge amount of data needs to be collected, stored and treated. It requires techniques and methods based on machine learning, data analysis and visualization for integration and selection of this huge amount of data. Some initiatives for evaluating data visualization techniques are in progress based on the user profile, as can be seen in [Barcelos et al. 2017]. However, recommending appropriate visualization according to user profile remains a challenge, as there are many user variables to guide this recommendation. Furthermore, there are many different approaches to handling, processing and extracting useful knowledge from such data, coming from Data Science area. In addition, tools to automate these processes in cities are required. Therefore, a challenge in this context is to develop frameworks to accommodate these various solutions to improve efficiency and sustainability for citizens, by providing additional features and allowing a dynamic reconfiguration of the city data environment. These tools should support decision making without requiring knowledge about data mining and big data areas from final users. They must also consider different user profiles, such as people and government, and privacy issues when appropriate.

Pérez-González and Diaz-Diaz (2015) describe an approach where various services are offered in 26 SCs in Spain, reducing administrative costs in sectors that have implemented such services. A business model for implementing SCs concept is required [Diaz 2015], because the amount of generated data may be a source of income for cities since it can aggregate valuable information in new software as solutions to citizens. Computing colleges and business forums in Brazil generally discuss largely the implementation of SC concepts based on Digital City. However, issues related to data integration, cognitive computing, big data, ontologies, implementation and business models for systems development, among others, are still not considered the implementation of SCs usually requires a big financial investment. Building sustainable deployment models are still a challenge.

Comparing cities to understand the relationships among them is one important and interesting issue in SCs. Giffinger and Gudrun (2010) rank European medium size cities. However, comparing heterogeneous cities, such as ones in large countries, such as Brazil, India, USA and others, may be very difficult. So, one challenge is related to grouping cities according to different profile indicators, considering each specific context. Some initiatives based on clustering techniques have been proposed in literature, such as [Barcelos et al. 2017] and [Afonso et al. 2015]. However, there are challenges related to the impact of ranking when the cities were previously grouped, in many different contexts.

3.5. Progressive evaluation

This work proposes the use of the four layers presented in Section 3.3 to assess not only the level of development of a SC from the IS point of view, but also the level of evolution in challenges for SCs solutions from the IS perspective. ICT infrastructure is primary for collecting data and integrating systems. Thus, an SC from an IS perspective is at level 1 if it has a large infrastructure for supporting services to population. A SC is at level 2 if, beyond level 1, if it provides open data and other isolated IS for services, not considering their integration yet. A SC is at level 3 if, beyond level 2, it implements System of Systems (SoS) that integrate the systems and use technologies and methods from diverse computing areas, such as Collective Intelligence, Big Data, Cloud Computing, Ambient Intelligence and others, for improving quality of services to the citizens. A city at this level also provides transparency in its governmental processes. A SC is at level 4 if, beyond level 3, it provides mechanisms for guaranteeing citizen e-participation, where IS should be widely used. Furthermore, a city at this level has mechanisms available to evaluate the impact of smart initiatives for their citizens. Methods for evaluating the degree of transparency and integration of data and systems (in SoS perspective) should also be used in this case.

3.6. Conclusions

This chapter presents a general landscape on SC from the IS perspective, and some challenges related to developing IS in the SC context for the next 10 years. A scheme containing four layers was established to demonstrate the aspects that must be considered when implementing a framework of SCs into a city. The first one is related to ICT and IoT infrastructure; the second layer is related to IS to integrate data and constituent systems; the third layer is related to smart governance, including transparency issues; and the fourth layer is related to services to citizens.

The challenges, presented from the IS perspective, include research in city context related to SoS, open data and transparency, information interoperability and big data processing to support decisions. It should be noted that many of these challenges can be handled separately. However, cities offer an arena in which these challenges may appear together, causing interference among areas. For instance, integrating systems through SoS architecture may hinder transparency, as specifications for defining information classification as secure or open may lead to inconsistencies in the integration process.

These challenges involve many computing research areas, such as Software Engineering; Human-Computer Interaction; Artificial Intelligence; and Database, Information Visualization, Big Data and Data Mining. Technological development involving other knowledge areas may also occur, due to the interdisciplinary nature of a SC project. Social scientists, architects, health and mobility experts, engineers and others should be involved in tackling these challenges. Moreover, there is a large overlap among SCs challenges and challenges for Computing, listed in [Salgado, Motta and Santoro 2014]. “Data Science”, “Mobility” and “Health” are examples of this intersection, particularly important given the difficulty of collecting and processing large volumes of commonly heterogeneous data.

Finally, we argue that in order to evaluate evolution in all these challenges and thus categorize a smart city in maturity levels, the following aspects should be assessed: (i) availability of IT infrastructure for supporting services to population (ii) provision of open data and other e-services (iii)integration among IS systems and the e-services provided by them, enhanced by the adoption of technologies such as Collective Intelligence, Big Data, Cloud Computing and Ambient Intelligence; and (iv) provision of mechanisms for guaranteeing citizens e-participation, and for evaluating the impact of smart initiatives for their citizens.

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Challenge 2 - Information Systems and the Open World Challenges

Chapter 4

Information Systems and the Open World Challenges

Renata Araujo

Abstract

This paper discusses the challenges which must be faced by the Brazilian Information Systems Research community regarding the new requirements brought by the open world to information systems specification, design, implementation and evaluation as new digital information ecosystems. This challenge is based on the epistemological view of cyberdemocracy, a conceptual view to approach these systems as digital ecosystems; a pragmatic view to describe and understand their dynamics by understanding their processes; and the desired implications or impacts on these systems´ behavior and mindset through mutual accountability.

4.1. Introduction

In 2013, during the Brazilian Information Systems Symposium (SBSI), the Brazilian research community joined a discussion panel about the challenges of the open world and implications for research and practice of Information Systems. Inspired by Dan Tapscott´s talk - *Four principles for the open world*[1] - the panel examined the viewpoint of researchers and professionals about principles on how to live and survive in the open world – transparency, collaboration, sharing and empowerment – both by enterprises and by individuals. In this panel, Information Systems (IS) researchers gave presentations about the Brazilian Access to Information Law (LAI, 2011), open data, the evolution of social network analysis (including sentiment analysis) – and how to plan and measure the maturity of cities to offer intelligent services to their citizens. Privacy was also focused on the paper, or better, our reactions to information exposure on an uncontrolled scale and at speed.

The organization of this paper, which took place three years ago in the context of SBSI,

[1] https://www.ted.com/talks/don_tapscott_four_principles_for_the_open_world_1

indicates that our community has been sensitive to the challenges of dealing with the open world. We are living in an ever more open and connected world, uncovering new opportunities both for business innovation in organizations and for the empowerment of individuals, with more autonomy and satisfaction. Managers talk about the “VUCA” (Volatility, Uncertainty, Complexity, Ambiguity) world or environments which are full of complex, unpredictable, and rapidly changing situations and the lack of approaches available to cope with it (Mack et al. 2016). While threatening at a first sight, these environments are undoubtedly the next challenge for human society to cope with, and a broad space for innovation and global problem-solving.

The effects of the open and “VUCA” world naturally brings challenges to the area of IS as new information systems must be developed and that ICT is unquestionably the layer which enables and supports them. This brings to our research community the challenge of how to understand, describe, model and build the new information systems in the open world. We are facing the complexity of building new systems which are no longer closed artifacts but rather a connected intra, inter and social organizational organism, with emerging and unpredictable behavior.

In this paper, I describe this challenge from the point of view of the cyberdemocracy concept, i.e. how to provide democracy (equal opportunities of participation and benefits), a conceptual view to approach these systems as digital ecosystems, a pragmatic view to describe and understand their dynamics by understanding their processes, and the desired implications or impacts on these systems´ behavior and mindset through mutual accountability.

4.2. Background

This section defines and motivates the reader regarding concepts which will be further interrelated to describe the challenge described in this paper.

4.2.1. Cyberdemocracy

Cybernetics (Wiener, 1948) is the interdisciplinary study of regulatory systems structure. It is closely linked to control theory and general systems theory (Bertalanffy, 2008). Both in its origins and development, cybernetics applies both to physical and social systems. Complex systems affect their external environment and then adapt to it. In technical terms, they focus on control and communication functions: both external and internal phenomena from/to the system. This ability occurs naturally in living organisms and has been imitated in machinery and organizations. Cybernetics is the science of control, the science of governance.

The concept of Democracy (“demo+kratos”) is a government model where the power of making important political decisions comes directly from the citizens, or in its most usual form, through elected representatives. The history of democracy refers to a set of historical processes and has a difficult definition, grounded on the notion of a political community where all people have the right to equally participate, debate and decide on political processes and, in the modern sense, in which certain rights are universalized from the principles of freedom of expression and human dignity. The concept of democracy, although closely linked to legislation and constitutionalism, is not limited to legal equality, and also depends on democratic access (i.e. the same for all) to spaces and social benefits.

The principles of Cyberdemocracy are grounded on the assumption that, in the open world provided by ICTs, information transmission, connection and reconfiguration by individuals leads to collaboration, plurality, openness, empowerment and governance. The idea is that the more we produce, deliver, distribute and share information, the more intelligent (in the sense of governance) and aware a society will be. Cyberdemocracy is a term meaning the collective intelligence which arises through public opinion and empowerment through the use of technology, leading to better levels of governance of social and organizational systems. According to Lemos and Levy (2010) the relationship between communication (social power) and technicality (power of action) is on the basis of this new political dimension, bringing every individual connected through technology into a new relationship with space and time, a new dimension of living together.

4.2.2. Digital Ecosystems

The ecosystem concept has its roots in the field of biology (Dhungana and Groher, 2010) meaning a community of living organisms (i.e. plants, animals and microorganisms) together with non-living components (i.e. water, air and soil), and the relationships among them and with the environment, interacting as a system (Smith and Smith, 2012).

The concept of ecosystems has been used in technological contexts giving rise to the Digital Ecosystems concept (DigitalEcosystems, 2007). Digital Ecosystems comprise enabling technologies and approaches to promote endogenous local development and knowledge sharing processes which provide services based on ICTs which are adapted and customized for individuals and business networks. Digital Ecosystems is an emerging paradigm for technology and social innovation. They can be defined as a self-organizing digital infrastructure with the aim of creating digital environments for organizations (or other agents) connected through networks, providing support for collaboration, knowledge sharing and the development of adaptive and open technologies.

Digital Ecosystems are open communities, where there is no permanent need for centralized or distributed control. Leadership can be structured or fade away in response to the needs of the environment dynamics (Boley and Chang, 2007). Digital Ecosystems promote changes in traditional communication patterns, where organizations stop acting as isolated islands, to be part of a highly connected ecosystem by means of engagement techniques provided by ICTs (Armano, 2012).

Boley and Chang (2007) summarize the essential characteristics of Digital Ecosystems, inspired by the field of biology, based on the concepts of agents (entities integrated into an environment or community by their own interests) and species (different kinds of agents): (i) *Openness, Interaction and Engagement*: Openness refers to a transparent virtual environment, in which interaction among agents occurs, aiming at the welfare and the engagement with others to obtain opportunities and share resources. Sometimes the community must come together to defend itself against external threats. The agents will not be able to survive unless they recognize that they are interdependent regarding other species in the ecosystem and are willing to cooperate with them. (ii) *Balance*: Balancing means harmony, stability and sustainability within an ecosystem. If any species becomes disproportionately stressed or divided, the entire ecosystem may collapse. However, a single point of failure does not need to lead to disaster, but can give rise to a new equilibrium of the ecosystem as a whole. (iii) *Grouping and loose coupling*: The species comprise an ecosystem by choice. Its members share culture, social habits, interests and similar goals. Each species preserves the common environment, being proactive and responsive for their own benefit. At the same time, the agents are aware of the benefits of collaboration, there being a common mutual interest between the parties. They are enthusiastic in participating in community work. They are therefore able to live together in community and support each other for the sustainability of the ecosystem. (iv) *Self-organization*: Each species is independent, self-empowered, self-prepared, able to defend itself and survive through self-coordination. The digital ecosystem agents can act independently, make decisions and fulfill responsibilities.

4.2.3. BPM and Social BPM

Organizations have long focused on Business Process Management initiatives (BPM) (Dumas et al, 2013) for customer satisfaction by improving the efficiency of their internal process management. Public and private organizations have addressed the management of their processes in order to improve productivity and quality. Business process management is considered an important approach in organizations, helping with tracking, data generation and operational process performance measurement reviews to improve efficiency.

Business process management comprises a set of methods conceived to help organizations to model and manage their business, in addition to a continuous improvement process lifecycle entailing the following: (i) *Process identification*: comprises the understanding of the internal and external organizational environments, especially concerning organizational business strategy. Key processes are identified, as well as their weaknesses and opportunities. Processes are prioritized, and the tasks needed for their implementation described. (ii) *Process discovery*: processes are modeled and documented as they are executed in the organization (AS-IS). (iii) *Process Analysis*: processes are quantitatively and qualitatively evaluated concerning their performance. (iv) *Process redesign*: the necessary changes to solve the problems identified in the previous phase are designed in a new process model (TO-BE). (v) *Process Implementation*: the redesigned processes are implemented in the organization, which involves training, and in most cases, automation. (vi) *Monitoring and Control*: process execution data is collected to evaluate if process performance addresses the previously identified needs. Managers can make decisions based on process behavior, observing whether outcomes are kept as expected or whether deviations can be observed and addressed.

Social and participative approaches to BPM, so-called Social BPM (Erol et al. 2010) (Fischer, 2011), have been suggested as an organizational strategy to balance the rigidity of defined processes with the flexibility of social interaction, and as a strategy to provide innovative ways of integrating clients into process definition and execution using social software and its underlying principles. Social BPM technology integrates organizational information systems, business process management systems (BPMS), social media and organizational communication and collaboration tools (Intranets, email, organizational social networks) in order to broaden collaboration among organizational professionals and clients in distinct phases of business process management (Mathiesen et al. 2012)

4.2.4. Accountability

The concept of accountability, in public administration, is associated to the process of being called "to account" by some authority for one´s actions. It has a number of features (Mulgan, 2000): (i) It is *external*: the account is given to some other person or body outside the person or body being held accountable. (ii) It involves *social interaction and change*: the one calling for the account seeks answers and rectifications, while the one being accounted responds to and accepts sanctions. (iii) It implies *rights of authority*: those who call for an account are asserting rights from a superior authority over those who are accountable. Accountability has been seen as individual responsibility and concern for the public interest (*responsibility*). It is the means through which democracies seek to control the actions of governments (*control*), the extent to which governments pursue the needs of their citizens (*responsiveness*), and it is applied to the public discussion between citizens on which democracies depend (*dialogue*).

4.3. The Challenge(s)

In a time when we are living the technological disruption enforced by convergence of collaboration, mobility and large volumes of data, the challenge to the IS research community is how to promote the integration of these technologies to balance both the need for control as well as opportunities for emergent behavior and innovation. In a world where accountability is a cornerstone, where diversity is considered a need, not a desire, and innovation and multidisciplinarity are key to the solution of the complex problems affecting humankind (ONU, 2015), our world must be open, connected, accessible. Its main actors (individuals and organizations) must be able to organize themselves without the specific need for an expected or foreseen structure, control or order (Shirky, 1998), in a democratic manner through the use of available technology (cyberdemocracy). In the context of the social environment, which will undoubtedly become even more complex in the next decades, corporations and social organizations should open themselves further than they had previously imagined to solve new problems they will face in the near future (CriticalFriends, 2007).

4.3.1. Information Ecosystem Development

The scenario described above means that building information systems for the open world requires approaches which should be able to cope with the growing complexity of these cyberdemocracy or electronic social governance environments, concerning their scalability, flexibility and adaptation. The main challenge faced by the IS community is therefore how to understand, specify, implement, evaluate information systems which might support these new digital ecosystems in the open world.

In Magdaleno and Araujo (2015), we suggest an approach from the digital ecosystems perspective, which provides a conceptual framework for the proposal of computer system development methodologies oriented to the governance of information systems in the open world. We suggest the concept of Open and Collaborative Government Information Systems (SiGACs) - systems covering people, machinery, software and processes to collect, transmit, process and disseminate information in order to enable, support and increase participation and interaction among organizations, public bodies and society to achieve higher levels of self-governance.

Traditional approaches to information systems development tend to focus on organizational contexts, based on environment observation, process modeling, understanding of users´ needs, turning them into system requirements which can be managed, designed and codified into system artifacts by a team of specialized developers. Approaching new information systems in the open world means that traditional development approaches will need to be enhanced to consider not only the organizational contexts but broader ecosystems which include organizations, individuals, and technologies which interact in the open world. We need new approaches, conceptual frameworks, methods and tools to observe, model and develop the relationship among species and agents of these new ecosystems and how to identify their dependencies and objectives considering ecosystem requirements for balance, openness, engagement, grouping, loose coupling and self-organization.

New development frameworks, programming languages and services continuously enable individuals to design and develop simple applications without the direct need of developers. Large volumes of data and information available in the open world together with the possible simplification of development activities should empower individuals to build their own applications or products, changing and impacting the ecosystems they live in. We need research initiatives to foster ordinary people´s ability to build applications, manipulate data and evaluate its impact. Additionally, new participatory design approaches involving large groups of users should be discussed and explored as a way to improve participation, engagement and innovation. Those are the activities leading to opportunities for technological and social innovation (Tidd et al. 2008), an important component for the sustainability of our world[2].

4.3.2. Open and Collaborative Processes in Information Ecosystems

In the open world, business and organizations will only remain competitive if they learn how to manage their processes in this new connected and open scenario. Meanwhile, the organizations´ internal environment should develop interaction and collaboration among its professionals, and connected to the external environment in order to assure the performance of their business/work processes with more complex tasks, with less bureaucracy, more autonomy and quality.

We, as IS researchers, must dedicate our time to investigating how to increase and to strengthen the ties between organizations and their external environments, delivering better services and establishing an effective dialogue among them by using technology, especially information systems. We should ask a) how to make individuals, society and institutions cooperate and search for ways to effectively share and build upon common objectives b) how to integrate institutions and individuals as collaborators in managing constantly improving processes c) how to build solutions that can help individuals gain access to the way in which organizations work and behave d) how to help individuals and organizations produce

[2] http://www.pnud.org.br/ods.aspx

collaboratively and remain connected in new virtual and memory spaces by putting aside old relationship spaces –usually opposing.

The possibilities of extending the technology and culture of process management to an organizational external environment through Social BPM is perceived as one step towards improving organizational openness and transparency and improving consumer participation. However, relationships in new ecosystems are not restricted only to organizations and to their clients and cannot be analyzed from the unique viewpoint of an organization. A network of interconnected processes among ecosystem agents should now be identified, discovered, modeled, implemented, analyzed and monitored and new approaches for doing so are expected to come. Furthermore, in order to effectively include ordinary people into process management activities, process technology should be extremely simplified and must naturally assure engagement, grouping and flexibility for loose-coupling.

4.3.3. Accountability in Information Ecosystems

The concept of accountability here is not used as a synonym of transparency, but as an endeavor for the democracy pursued by new IS in the open world. Accountability in the open world does not only mean a public administration obligation to render information transparent to citizens or private organizations to their clients. It also means accountability – responsibility, control, responsiveness and dialogue – which must emerge among all participants in the new information ecosystems in the open world.

To guarantee balance, engagement, self-organization, grouping and engagement, the new ecosystems in the digital open world will naturally require accountability interaction among their agents, as a way to dynamically balance their need for trust. As researchers in IS, we should work on approaches and solutions to understand accountability as an important aspect for the internal regulation of an ecosystem.

How should each agent provide external accountability about itself, seeking for responsiveness and dialogue? What should each agent expect and count on from other agents, depending on their relationships and interactions? How can each agent and the ecosystem itself determine different responsibilities for accountability as well as possibilities and limits for control?

4.4. Progress Evaluation

The progress assessment of this challenge includes: (i) monitoring the research on this theme (number of conferences and publications) (ii) monitoring the dissemination of research artifacts (methods, processes and products) (iii) monitoring of technological diffusion on the subject (software records and patents) (iv) monitoring projects and initiatives concerning real digital ecosystems in the open world conducted together with the research community and (v) establishing IS specification development and evaluation standards in this context.

4.5. Relationship with Brazilian Initiatives

As specific goals for the advance of this challenge, we highlight the definition of effective alternatives for modeling, construction and evaluation of these ecosystems in different application domains. Clearly, these goals will be greatly improved if there is interaction with other scientific areas within and outside the Computer Science area, such as Software Engineering, Data Bases, HCI, Management, Sociology, to cite a few. The Brazilian Workshop on Distributed Software Development, Software Ecosystems and Systems of Systems (WDES, 2016) is a research community initiative to discuss research results and experiences in these areas, and it is workin on with the challenge presented here. In 2016, iSys – The Brazilian Journal on Information Systems (iSys, 2016) – produced several special issues concerning different themes specifically related to this challenge, such as: business process management, innovation in IS and eGovernment, showing the increasing interest of our community in the open world. The scenario discussed here also evolves from previous challenges identified by the Brazilian Computing Society (SBC, 2006), in particular: Complex Networks for Collaboration and Information Management over Big Data, Challenges in Applied Computing, and Reliable Web Systems Development, from which different progress evaluation procedures can also be used. Additionally, other challenges related to the open world have been discussed in the context of the Brazilian HCI community (GranDIHCBR, 2012) through different challenges, such as: Future, Smart Cities and Sustainability, Accessibility and the Digital Divide, Ubiquity, Multiple devices and Tangibility, and Human Values.

4.6. Final Remarks

Democracy is an endeavor pursued by society, not exactly to find absolute equality, something which nature has already shown to be impossible, but to find balance and guarantee welfare. Democracy is not just a political or a public administration matter, but also a challenge for the management of private organizations and social communities. The open world provided by technology should lead to opportunities of mutual governance and balance by means of cyberdemocracy.

Information systems can no longer be seen as just organizational internal artifacts, web systems or mobile applications. A broader systemic view must be embraced by the IS research community to understand the new dimensions of information systems as digital ecosystems and how to use this view to provide completely novel approaches to the design, development, use and evaluation of information systems in the open world, facilitating processes, empowering people, generating trust and establishing new self-organization and governance eras.

The community must also be open to the emergence of unknown or already known aspects affecting the development of these ecosystems, such as privacy, empowerment etc. though not directly mentioned in this paper.

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Chapter 5

Information Systems based on (Linked) Open Data: From Openness to Innovation

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Abstract

There is a trend towards making data and services available worldwide. As reuse is encouraged and transparency becomes a requirement, an important characteristic that has been discussed is providing open data and services. An evolving cycle is therefore created as new open data and applications based on the previous ones are developed. In addition, open data and services are moving towards a linked approach, which improves semantic expressivity and provides better machine processing. However, publishing and consuming linked (open) data and services in the Information Systems context present several challenges in the development, management and evolution of linked open data innovative ecosystems. In this chapter we present the context and challenges for these ecosystems and call the Information Systems community to embrace them.

5.1. Introduction

Open data is "data that can be freely used, re-used and redistributed by anyone - subject only, at most, to the requirement to attribute and sharealike" [Open Data Handbook 2016]. Government agencies seeking benefits in terms of public transparency and improved services to the population, in a pioneering way, support, fund and help to disseminate initiatives that leverage open publication and consumption of data.

Recently, open data initiatives have been encouraged by global movements, such as the campaign from the International Aid Transparency Initiative[1] on the transparency of spending records. It is also noticeable that the concept of public (or governmental) open data [Chignard 2013] is considered as a common property, just like scientific ideas. The Open Government

[1] http://www.aidtransparency.net/

Partnership[2] has made the open data initiative become a strong trend, and open data portals of several governments are available[3], such as *data.gov*, *data.gov.uk*, *open.canada.ca*, *data.gov.ru* and *dados.gov.br*. The Brazilian Federal Public Administration (BAPF), through the Brazilian Access to Information Law[4], in its 8th article, recognizes the need for making government data available in open format.

Although governments are publishing open data, they are using separate portals, in different locations and in multiple formats, hindering the access and use of information efficiently by users. The main issue cited as a barrier that limits the ability of stakeholders to interact with new information is the ability to search for and discover the right information [Bizer 2009]. As a result, it is necessary to focus on how to effectively generate, structure and search (linked) open data [Isotani and Bittencourt 2015].

However, once the data is open, further developments and actions are needed to solve problems, innovate and reach the full value potential. Therefore, it is necessary to invest in strategies, initiatives and tools to increase the availability of data open for exploitation by citizens, government agencies, industries, scientific communities and other stakeholders. According to Isotani and Bittencourt (2015), several companies, governments and research institutes have driven efforts to make data available and produce Web technologies that allow the creation of an ecosystem of data production and consumption with the objective of speeding up the discovery of new knowledge and adding value to any information freely available on the Internet. Moreover, they also point out that an ecosystem based on open data will only succeed when the data are adequately represented, structured and linked. It would allow both the automation of the production of these data and the consumption of them by machines, adding value and meaning to the data collected.

Open Data Ecosystems have not been formally defined as well as linked open data ecosystems or innovation[5] ecosystems (based on linked open data). The idea described by McKinsey (2009) is to transform open data into valuable tools. Gama and Lóscio (2014) consider the collaborative nature and the diversity of actors (government, application developers, small and medium enterprises, startups, civil society, universities, funding agencies and investors). They also consider the open-data-as-a-service (DAAS) platform as a fundamental component which could promote the integration of the different actors, allowing the development of products and services based on open data that can provide practical benefits to users. According to Davis (2011), an open data ecosystem could help identifying and evaluating possible

[2] http://www.opengovpartnership.org/

[3] More open government data catalogues can be found on http://dataportals.org/

[4] The law is available in Portuguese at: http://www.planalto.gov.br/ccivil_03/_ato2011-2014/2011/lei/l12527.htm, more on the law and how to access information is available at: http://www.acessoainformacao.gov.br/

[5] According to the Oslo manual [Mortensen and Bloch 2005], in summary, innovation is an invention that generates value (financial/social). Technological process innovation is the adoption of technologically new or significantly improved production methods, including methods of product delivery. Then innovation ecosystems based on linked open data must focus on generating value from linked open data.

strategies that open data initiatives can adopt in seeking the realization of the promised benefits of open data. Lee (2014) describes the open data ecosystem elements as: data audit, dataset selection, address and map data, data privacy, licensing, publishing high-quality data, data access, data discovery, supporting public bodies, engaging data users, encouraging economic reuse and evaluation. However, it is also important to sustain the ecosystem, which is based on open data ecosystem principles (support, standardized, demand-driven, transparency and related to other open data initiatives) and challenges (privacy, governance, operational change and usage) leading to the open data ecosystem impact.

Furthermore, according to Shadbolt et al. (2012), although the issue of making data available for public use and creating an open data culture and mindset is of utmost importance, the open data movement is still in its infancy in terms of achieving the expected economic benefits. Companies and industry, seeking innovation and competitive advantages, have been making private data open as well as investing in programs that foster and exploit their use [Kapoor et al. 2015]. Therefore, with the increasing adoption of open data by different entities, the benefits obtained from the open data initiative go beyond improving government operations: open data are not only capable of providing public transparency, but also of generating information for better decision-making, promoting competitiveness and innovation [Isotani and Bittencourt 2015]. According to Lee et al. (2014), open data are a resource with value and promise for goods and services, considered a prerequisite for the creation of value [Chan 2013] and for the creation of innovative products, services and business models.

Kapoor et al. (2015) suggest it is necessary to further the creation of open data portals towards innovation ecosystems, which can eventually engage all the parts of the innovation process in discussions driven by data, through the identification of problems that might be solved and require actions to lead to innovative solutions. Indeed, the most difficult part of any innovation process is to find a solution that is desirable for the users, economically feasible and technologically doable, and therefore the search for solutions is worthwhile [Kappor et al. 2015]. As we seek to solve problems for cities, societies and businesses, we need to investigate strategies, tools and initiatives that provide a better understanding of the issue for all stakeholders in the ecosystem. In order to speed up the resolution of important problems, it is critical to invest in strategies for opening data for exploitation by citizens, government agencies, providers and other stakeholders. Innovation systems will provide tools, services, market data and applications, and collaborative environments that will enable public authorities, organizations and citizens to work together with open data and accelerate the creation of economic value.

Therefore, the central challenge proposed in this work can be summarized as: the development and management of Information Systems of innovation based on (linked) open data. It is a proposal that covers all the thematic and sub-areas of information systems since such systems will also require changes (evolution) in the types of information systems as well as new types of information systems, new information technology architectures, new procedures for the use of such systems, new business innovations, advances in the development of these systems, new cultures and behaviors.

5.2. Background

Tim Berners-Lee proposed the "5-Star rating system"[6], which ranks the degree of data openness. The more open, the greater the number of stars for the data and the easier it can be enriched:

i. Available on the web (whatever format) but with an open license, to be Open Data
ii. Available as machine-readable structured data (e.g. excel instead of image scan of a table)
iii. As (2) plus non-proprietary format (e.g. CSV instead of Excel)
iv. All the above, plus: Use open standards from W3C (RDF and SPARQL) to identify things, so that people can point at your stuff
v. All the above, plus: Link your data to other people's data to provide context

Therefore, open data is related to the linked data concept, which can be defined as a set of good practices for publishing and connecting (linking) Web-structured datasets with the aim of creating a "Web of Data" [Bizer et al. 2006]. These practices are based on Web technologies such as HTTP (Hypertext Transfer Protocol) and URI (Uniform Resource Identifier), in order to allow the reading of the linked data automatically by software agents. The Web of Data creates a number of opportunities for the semantic integration of the data itself, motivating the development of new types of applications and tools, such as browsers and search engines.

In this way, the Linked Data standards, recommendations, guidelines and good practices7 allow anyone to publish the data in a way that can be read by people and processed by machines. This is possible because data that was previously "hidden" in the "Web of Documents" is now becoming accessible thanks to the use of the standards for linking data. As a result, everyone (humans and machines) may work more efficiently together.

The W3C Data on the Web Best Practices[8] [Lóscio et al. 2016] provides best practices related to the publication and usage of data on the Web designed to help to support a self-sustaining ecosystem: As data should be discoverable and understandable by humans and machines, the best practices facilitate interaction between publishers and consumers.

According to the 'Data on the Web Best Practices' [Lóscio et al. 2016], the main benefits of applying the best practices are:

- **Comprehension**: humans will have a better understanding about the data structure, the data meaning, the metadata and the nature of the dataset.
- **Processability**: machines will be able to automatically process and manipulate the data within a dataset.
- **Discoverability**: machines will be able to automatically discover a dataset or data within a dataset.

[6] http://5stardata.info/en/

[7] For following the news on the W3C activity on Data on the Web, please access: https://www.w3.org/blog/data/

[8] First public working draft published on February 24th 2015. Latest published version available at: http://www.w3.org/TR/dwbp/

- **Reuse**: the chances of dataset reuse by different groups of data consumers will increase.
- **Trust**: the confidence that consumers have in the dataset will improve.
- **Linkability**: it will be possible to create links between data resources (datasets and data items).
- **Access**: humans and machines will be able to access up to date data in a variety of forms.
- **Interoperability**: it will be easier to reach consensus among data publishers and consumers.

5.3. Related Worldwide Issues

The challenge is related not only to publishing and using (linked) open data, or the whole (linked) open data ecosystem, but also to its evolution to sustainable (linked) data open systems of innovation. In order to achieve such a scenario, it is necessary to advance on the state of the art and practice, not only from a technological point of view, but also from different perspectives such as government, business and community. Although it might be considered a worldwide challenge, the Brazilian IS research community can contribute and lead some of the solutions.

Despite the benefits of open data, there is a major problem when it is necessary to relate different data or when the amount of data is excessive for human interpretation. If the data were structured and linked in such a way that a computer could process them, the necessary tasks could be automated [Barros et al. 2011]. In this case, some issues arise, and can be summarized in how to manage, collect, model, standardize and consume data properly.

Cowan et al. (2014) list some issues related to open data:

- ensuring that all data that should be open is open
- finding and accessing open data
- providing the right tools to use open data
- keeping open data current
- ensuring privacy of individuals and property
- capturing open data sources
- supporting data redundancy
- sustaining the cost of storage, delivery and maintenance of open data
- governance of restricted data that is open for the purposes of a secure community of practice application.

Considering that the use of the open data serves some purpose for someone, Lindman et al. (2013) present some research questions regarding (linked) open data services from different perspectives: technologies, information, processes and activities, products and services, participants, customers and environment. Their questions cover several issues such as: availability, interoperability, heterogeneity of platforms as well as of users' devices and contexts, upgrades, security, privacy, standards' definition and compliance, timeliness, data format transformation, conceptualization of data and data services, business drivers, quality evaluation of apps, services categorization and application areas, motivations for data owners and providers, business models, service innovation and co-creation, incentives to developers, information asymmetry, skills and knowledge, description and discovery of services, differentiation of services, and so on.

Open data initiatives (including open data ecosystems) focus on making data open and (re)useable. On the other hand, Kapoor et al. (2015) state that it is critical to invest in strategies that will open not only the data, but also the space of problems, i.e. open data ecosystem need to evolve to support the innovation workflow, thus becoming systems of innovation. Consequently, some issues arise, such as the need for analytics, social and collaborative capabilities, ideation, evaluation and creation of solutions, which would require a system of engagement and system of insight.

According to Kapoor et al. (2015), "systems of innovation will provide tools, services, data/app marketplaces and collaborative environments, which allow public authorities, organizations and citizens to work together in the open data landscape, and accelerate the creation of economic value".

5.4. The Challenges

This chapter addresses two main challenges that include the issues raised worldwide and specific Brazilian specific demands: (i) Enriched and Linked Open Data and (ii) System of Linked Open Data Innovation. Although complex, the latter challenge can be seen as a consequence (or evolution) of the former.

5.4.1. Enriched and Linked Open Data

This challenge focuses on evolving open data portals (such as *dados.gov.br*) and portals of transparency in order to produce data with quality and improve transparency. It aims at improving open data quality and integration through a careful process of enrichment and data linking. In this challenge, all the issues related to linked open data ecosystems are considered.

Suggested projects:

- Integrated search and interoperable access to (linked) open data
- Systematic mapping of data portals (such as *dados.gov.br*, portals from several states and municipalities, as well as from industry) and their datasets
- Quality models for (linked) open data and open data services
- Quality analysis of the open datasets
- Conceptual framework for the Linked Open Data
- Development and evaluation of ontologies for open data enrichment
- Open data transformation to 4 and 5-stars
- Quality analysis of Linked Open datasets
- Open Data as a Service (DAAS) solutions
- Validation of DAAS solutions
- Analysis of acceptance and use of (linked) open data.

5.4.2. System of Linked Open Data Innovation

This challenge focuses on boosting the system of innovation based on linked open data. Therefore, it aims at providing the necessary infrastructure for supporting the investigation and understanding of problems and opportunities, then the actions to elaborate the solutions, the development of the related products and services, and finally the feedback and evolution of the system. In this challenge, all the issues regarding systems of innovation are considered.

Suggested projects:

- Analysis of requirements to systems of linked open data innovation
- Development of the workflow for a system of innovation
- The linked open datasets integration to the system of innovation
- Projecting the self-sustainable system of innovation
- Modeling and implementing the innovation indicators within the system of innovation
- Building a control and feedback mechanism within the system of innovation.

5.5. Progress Evaluation

The assessment of the progress of this challenge may consider: (a) monitoring the research evolution on the challenge (number of publications and their correspondence to the related goals and issues); (b) monitoring the dissemination of linked open datasets (data and services, including respective quality, use and innovative products and services); (c) monitoring the technological state of practice (software landscape evolution); (d) monitoring the innovation aspects (software registers and patents); and (e) establishment of standards, recommendations, guidelines and good practices within the context of this challenge.

Perhaps a maturity model for evaluation of the system of innovation based on linked open data could also support the assessment. However, in addition to considering the evolution of open datasets through the 5-star system, it is also necessary to analyze the degree of innovation it promotes.

5.6. Final Remarks

Once open data is disseminated, whether by government initiatives or industry, a new movement is expected to leverage public services (promoted by democratic governments or citizen demands) and technological advances that will propitiate the evolution of business and public management. The progress is aligned with the evolution of the open data towards the innovation promoted by linked open data, i.e. the system of innovation.

The proposed challenge is aligned to the “Brazilian grand challenge: productivity”. As presented in the reports of the 3rd Seminar of Grand Challenges in Computer Science Research in Brazil[9], Prof. Silvio Meira suggested that “in order to become competitive in the world market, we must create and develop technology […], aligning importance and relevance, in order to not waste time and resources developing useless technology and knowledge”. By investing in systems of innovation based on linked open data we have the chance to effectively accomplish

[9] http://www.sbc.org.br/documentos-da-sbc/send/141-grandes-desafios/802-grandesdesafiosdacomputaonobrasil

this. The availability of open data in Brazil, together with services that make effective use of these data, will promote innovation generated by the demand of citizens, government agencies, industries, scientific communities and other stakeholders. Open data is mentioned in several parts of these reports.

Regarding the report on the Grand Challenges in Computer Science Research in Brazil – 2006 – 2016[10], the challenge described in this manuscript advances the grand challenges including:

1. **Information management in large volumes of distributed multimedia data**: the open data proposal comes precisely to support the management of information in large volumes of data available on the Web, in order to promote better structuring, representation, access and consumption of data.
2. **Computational modeling of artificial, natural and socio-cultural complex systems and the human-nature interaction**: the availability of data on the Web as linked open data has promoted the development of new computational models of complex systems.

4. **Participatory and universal access for Brazilian citizens to knowledge**: it is perhaps the challenge of computing that will be affected most by linked open data, since the availability of such data will allow and promote greater access and participation for Brazilian citizens to knowledge.
5. **Technological development of quality**: available, correct, secure, scalable, persistent and ubiquitous systems: the linked open data will promote research on environments, methods, techniques, models, devices and architectural and project standards capable of assisting designers and developers of large software and hardware systems to achieve these goals.

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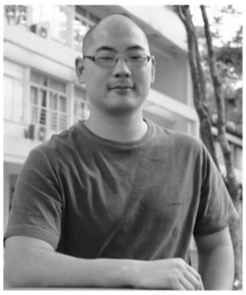

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Chapter 6

Methodologies and Technologies for Citizen Participation

Cristiano Maciel, Claudia Cappelli, Cleyton Slaviero

Abstract

This paper discusses the challenge of defining methodologies and technologies for public electronic participation (e-participation) so as to make methodologies and technologies allies during the implementation of systemic strategies in governmental organizations.

6.1. Introduction

Citizenship is the practice of rights and duties of an individual in a State, providing him/her with the opportunity to actively engage in the government of people. In modern societies, citizens have been increasingly pursuing their rights, thus making citizen participation a pressing need [Maciel, 2008]. As models of citizen participation suggest, access to information is the first step towards achieving the democratic participation of citizens so that they can be heard and have the power to make decisions. To this end, participation must necessarily be supported by information transparency. When Considering the need for information transparency and access, it is necessary to plan processes in a way that a citizen can understand procedures done by governments along with information thereby generated, so that to he can be an active participant - a key feature of citizenship.

To make this participation viable, along with information access, promoting processes such as discussion, voting and deliberation around each demand of society is also needed. When mediated by technology, there is what is called e-participation or e-part. Public participation is defined by Rowe and Frewer (2000) as the consultation and involvement of public members during decision-making, via public activities managed by organizations or institutions which are responsible for the development of policies.

To characterize democratic participation and e-participation, multiple frameworks and classifications have been proposed. One of the oldest is a classification called the “ladder of participation” [Arnstein 1969], containing 8 levels (or degrees) of participation. Its initial degrees (manipulation, therapy and information) are equivalent to an anecdotal level of participation. The government has all the influence and citizens are “educated” according to governments’ own interests. At the following levels (consultation, conciliation and partnership), citizens have their voices heard, but the final decision remains in the hands of their representatives. At the final levels (power delegation and public control), citizens are not just consulted but their opinions also have decision power in political processes. This one can be compared with the classification described in the book about promises and problems in e-democracy [OECD, 2001]. Here public participation is organized into three main levels: information: (comparable to the three initial levels of the ladder of participation), consultation (comparable to the intermediate levels of participation) and participation (comparable to the last two levels of the ladder of participation). Another classification proposed by the International Association for Public Participation (IAP2) splits participation into involvement, in which there is the guarantee that opinions are listened to and considered by representatives; collaboration when government and citizens collaborate to make decisions); and delegation, when citizens make the final decision).

The research by Gomes (2004), inspired by IAP2’s classification, suggests five levels of participation that explicitly consider the point that the relationship between governments and governed is performed through social interactions or, at least, through the Web (Figure 6.1).

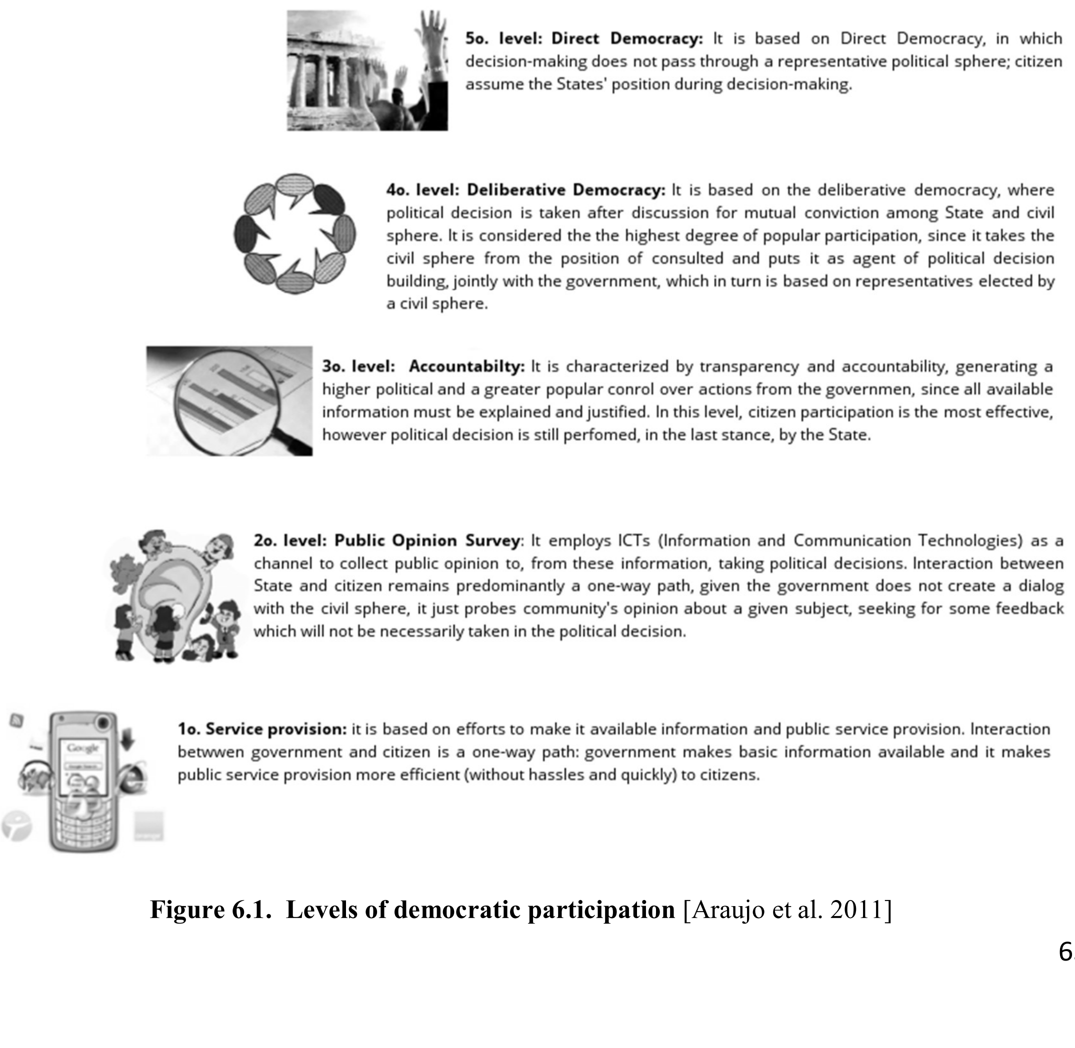

Figure 6.1. Levels of democratic participation [Araujo et al. 2011]

The term e-participation is used to describe the use of Information and Communication Technologies (ICTs) to promote citizen engagement, turning them into active participants in decisions which influence both themselves and the society around them. Throughout the literature, e-participation and e-democracy definitions are alike. However, e-democracy encompasses wider aspects, such as the information availability and citizens' consultation, areas considered primary aspects of e-democracy [Islam 2008]. In this framework, e-participation describes citizens' engagement as active participants of the democratic process, at a more advanced level of relationship between citizens and government than information and consultation levels. From another perspective, according to Maciel et al. (2011) e-democracy is the use of ICTs and Computer Mediated Communication (CMC) to intensify active citizen participation and support collaboration between distinct actors such as citizens, governments, civil society, among others, in the elaboration of public policies.

In Brazil, the traditional development of e-democracy has been following a relatively predictable and traditional course: information is offered, some online services are provided and there are attempts at participation from citizens using many technologies. When engaged via social networks, citizen participation challenges the public administration. On the one hand, this mobilization enables easy and quick engagement [Muriana et al., 2013]. However, it enables the proliferation of unverified news and opinions [Pinheiro et al., 2015]. Additionally, the rich dataset created in these networks is unstructured, and although it opens the door to citizen (mis)information, it does not favor consultative and deliberative processes, such as those discussed by Maciel et al. (2009). The Brazilian Federal government has been promoting initiatives with the Chambers of Deputies and Federal Senate in attempts to organize such information using pools and public consultation about sensitive topics, as well as creating environments to promote discussion around these topics. These environments can be seen as open discussion spaces, if we consider the distinct methods for promoting citizen participation, such as those proposed by Rowe and Frewer (2000): referenda, public hearings/pools; public opinion surveys; rule negotiation; consensus conferences; panels or popular juries; public consultation committees and focus groups.

In the electronic government ranking defined by UNPAN [UNPAN, 2014], Brazil is not among the top countries at any level of participation (e-Information, e-Consultation and e-Decision making), despite the many efforts of the government in the digital area. This demonstrates the need to investigate how ways to increase engagement of citizens in e participation.

Brazilian Computer Society (Sociedade Brasileira de Computação – SBC) has indicated "participative and universal access of Brazilian citizens to knowledge" as one of the five biggest challenges for the 2006-2016 period [SBC, 2006]. In this challenge, among other things, technological and educational barriers which hinder access and interaction have been discussed. The aim of this challenge is to propose systems, tools, models, methods, procedures and theories capable of addressing the issue of Brazilian citizens' access to knowledge, a basic premise for them to practice their citizenship. This challenge also adds that this access must be universal and participative. The citizen is not a passive user who only receive information but also engages in the generation of knowledge. It has been argued we need to develop technology which allows and motivates user participation to tackle this (SBC, 2006). However, this requires multidisciplinary competences and relationships with other knowledge areas outside Computer Science in order to establish systems and methods which support the definition of a digital culture for citizen access and participation.

This chapter lists the challenges for methods and technologies for e-participation seeking for greater integration between academia and government agencies so that research and development of solutions may contribute to the implementation of systemic strategies in government organizations.

6.2. Relevance in the context of Information Systems

Since the establishment of the Internet worldwide, governments have been adopting strategies for the use of Information and Communication Technologies (ICT) as a tool for providing services, information and offering channels for participation of the population, thus building a model of public management called e-government or e-Gov. In this model, the use of information systems is fundamental at all levels and spheres of public organizations, whether local, state or federal.

Current complexity in terms of developing applications, especially Web and mobile, has challenged governments for the adequate implementation of e-Gov. In addition to the features required for these systems, non-functional requirements emerge as usability, security, portability, interoperability, transparency, among others, are essential for applications where the targeted public, i.e. the citizen, is universal. Nonetheless, one must consider that users today are not only consumers of information but also producers of it, in particular in environments such as social networks [Muriana et al. 2013]. Thus, the quality of information offered to these users is critical and requires the investigation of socio-technical aspects in the development of information systems.

With respect to technologies used internally by government agencies, in which the user is a civil servant or outsourced employee of that public organization, there is also the challenge of understanding cultural changes and valuing the systems which have been deployed in many organizations. In 2006, the Organization for Economic Co-Operation and Development [OECD, 2006] identified five challenges for e-democracy: i) the problem of scale (to be available for all) ii) capacity building and empowerment iii) ensuring consistency of information iv) evaluation of the effectiveness of the process and vi) ensuring continuity of the process. They also stressed that the critical factors in the development of e-democracy tools and their subsequent adoption by citizens include accessibility, usability and security.

In 2015, these challenges remained and gained scalability. The BISE Research [Eymann et al., 2015] states that personal success and participation in society is increasingly characterized by an actual interaction between people and computers to communicate and gain access to online services. It should be intuitively possible to use these services with a variety of user interfaces without any formal training or reading manuals. Besides making services usable to a wide range of people and use contexts, users must be able to anticipate the consequences of their actions. We emphasize that cooperation with other disciplines is needed to design solutions for human-computer interaction which will enable all people to use ubiquitous communication and information services effortlessly and in a self-determined way. In this context, understanding information and the usability of systems is essential, without forgetting access for all (accessibility). Designing information systems that meet these characteristics is essential.

Another interesting factor which has persisted over the years is related to electronic processes in Latin America. Padget (2005) claims that the enthusiasm and innovation with respect to these are strong, however, the population size, weak economies and the digital divide are obstacles to the development of this area when compared to the European and American context. The author further adds that the development of systems which in fact allow the participation of citizens should be the focus of research in countries seeking economic development. Electronic processes, especially the use of the Internet by citizens, are challenges for Brazil.

6.2.1. International Initiatives

There are many international experiences which can serve as inspiration for possible solutions in Brazil. One of these experiences is a set of tools created by Delib.net (DELIB, 2012) that can be used to create the multiple forms of participation. These tools are described below:

- CitizenSpace: this allows the creation and publishing of consultation of citizens by the government. It has many features: consultation management, consultation search, reports, and the possibility of adding plug-ins to add functionality. It is used, for example, by the South Australian government to centralize online consultations.
- DialogApp: this is a tool for creating spaces for the discussion of ideas. Along with the possibility of management by the government, this tool allows discussion of new ideas and we can add tags, notes and comments to them. It is used by Bristol City Council in the participatory budgeting process to raise ideas for budget allocation.
- Budget Simulator: a tool that allows the government to create participatory budgeting processes. Citizens can then propose what and how to spend in areas proposed by the government. Results can either be presented in a report or exported. The Board of Warrington City Council in England has applied this tool to gather the citizen perspectives on use of the city budget.
- QuickConsult: this is used to create online surveys, unlike CitizenSpace, which aims to be a place to publish consultation. Like other tools, it is possible to extract reports that can assist the government in making decisions. It is used by the London Fire Brigade.

Another tool that aims to support democracy is Gov2DemoSS [GOV2U, 2012a]. Gov2DemoSS is a customizable open source platform designed as a proof of concept of the use of ICT to facilitate communication, exchange of knowledge, and modernization of government services. It allows discussion of demands of citizens, using discussion forums. It also allows the creation of applications.

- weGov [GOV2U, 2012b] is a project that aims to investigate the use of ICTs to promote citizen participation through work plans. There are templates, tools and scenarios to verify the various aspects of eParticipation.
- MySociety [UKCOD, 2012] is a project that aims to create websites that allow citizen engagement. It provides websites such as FixMyStreet [mySociety, 2012a], to report problems on the streets; the WhatDoTheyKnow [mySociety, 2012b], which allows citizens to ask questions to be answered by the government, according to public transparency laws; and HearFromYourMP [mySociety, 2012c], which allows citizens to talk to government representatives.

Initiatives of e-participation in Europe are described in greater detail in Panopoulou et al. (2009). Using a template, the authors report multiple e-Participation initiatives, organizing them in e-participation areas. Most e-Participation initiatives are local and regional. It was noted that the degree of usage of participation initiatives varies given the area of interest. Advisory initiatives tend to have more users than other initiatives. Initiatives in spatial and deliberative area planning can be found in smaller quantities. The authors conclude that there has been a growth in e-Participation activities in Europe being implemented and planned. However, there are several opportunities to improve initiatives being implemented, such as transferring good practices and cooperation between regions and countries at different levels of participation.

In Germany, where popular participation has been encouraged since the 70s, discussions regarding e-participation have been from different perspectives [MAMBREY, 2008]. The author adds that there is still much to be investigated on the effectiveness of e-participation, mobilization effects of these e-participative initiatives, and tools and technologies for e-Participation.

6.2.2. Current Brazilian initiatives

In Brazil, in the context of industry, the main efforts have been made at federal level via the Participa.br portal. It is an interactive and participatory environment for public consultation that aims to provide citizens with tools to discuss public policy. This platform connects profiles, blogs and other content production instances on the Internet. Among its main goals is the idea of enabling a opinion and discussion space for any citizen or organization to make the building of public policies increasingly efficient and effective in an environment which allows you to qualify information and systematize participation. It also encourages the formation of virtual communities around issues related to social participation, along with promoting the construction of collective blogs, mobilization via social networks, hangouts and web conferences.

In general, solutions are adopted by governments at all three levels via the web. According to Maciel and Cappelli (2015) these initiatives are being conducted by providing media such as email, chats and discussion forums, still not the most effective and appropriate means. Nationally and internationally, experiences with more robust environments offering advisory and/or decision-making processes in an organized manner are still scarce [SLAVIERO, 2012], [MACIEL; CAPPELLI, 2015].

As for academic research, works such as Maciel (2008) and Slaviero (2012), developed this theme not only from the perspective of research, but in particular its application in government agencies. Besides the construction of integrated models of consultation and deliberation [(Maciel et al., 2009] and the use of ontologies for e-participation [Slaviero et al., 2012], research has been carried out and tools are being developed in order to analyze the quality of government websites that provide information, services and strategies of e-participation, through monographic work related to the Interactive Virtual Environments Laboratory (Laboratório Virtual de Ambientes Interativos - LAVI) at UFMT. Furthermore, issues related to usability, communicability and accessibility of government websites have been increasingly investigated, and research topics are targeting the use of multiple devices, especially mobile ones.

The development of a Maturity Model in Organizational Transparency has also been research topic as it is a pillar of major importance for participation. This model defines methods and practices that ensure access, use, quality, understanding and information auditability. Research on this has been carried out at the Federal University of the State of Rio de Janeiro (UNIRIO) in partnership with other government institutions and bodies [Cappelli et al., 2010], [Cappelli et al., 2013-1) (Cappelli et al., 2013-2). In this context research actions very closely linked to the information sensemaking [ENGIEL et al., 2012] and with the intention of building a citizen language [Carvalho et al., 2016] have been developed. These works seek to contribute to the understanding of processes and information delivered by the government to citizens so that, with a better understanding, they can participate more actively and practice their citizenship. The work of Diirr et al. (2011) also contributes in the same direction by discussing the importance of mechanisms supporting not always formal conversations among citizens on public processes. Another very promising area, also one of the pillars of transparency and thus participation, is the auditability of information on social networks. It is known that currently much of the citizenship activity is done through social networks and they be contaminated by unreliable facts, making this a research topic (Pinheiro et al. 2014). Experience reports with the characteristic of transparency have also been carried out together with public agencies to analyze citizen participation, as in Oliveira and Maciel (2013).

6.3. Challenge Proposal

The motivation of this work is to analyze the viability and improve solutions which may contribute to the implementation of e-participation in government systems. Despite the many already existing features and integrations available, we believe that many challenges remain.

Our proposal seeks to achieve the following goals:

1) discuss the major problems in e-participation and e-government in a long-term horizon
2) contribute to the creation of grants for the implementation of public policies in e-participation and e-government
3) contribute to education for transparency and citizenship practice
4) contribute to creating a theoretical framework for e-participation and e-government
5) contribute to the construction of mechanisms for understanding public processes for transparency and improving participation
6) promote adequate computational support for the treatment of large volumes of information in discussions, voting and deliberation
7) contribute to the auditability of information circulating on the web
8) promote better data visualization to support decision-making of citizens
9) promote maturity of discussions in participatory processes
10) attempt to identify mechanisms for participatory construction services.

To achieve these goals, the following non-exhaustive list of actions are proposed:

- to establish a current overview of e-gov and e-part research in Brazil by looking at fieldworks in research and government institutions
- to improve existing mechanisms [Engiel et al., 2012] and languages [Carvalho et al., 2016] and research new elements which may facilitate understanding of citizens regarding public processes
- to make available mechanisms for auditability [Pinheiro et al., 2014] of web data
- to implement new ways for visualizing information which may increase citizen participation
- to improve e-participation models [Maciel, 2008] which may be applied in consultative and/or deliberative processes
- to develop, test and/or systematically apply e-participation ontologies [Slaviero 2012] and other ontologies which may contribute to interoperability among systems
- to develop, test and/or apply indicators which may be used to measure the level of e-participation of citizens [Maciel, 2008], researching the use of gamification and virtual communities building strategies to increase engagement

- to build and/or improve norms and standards of issues related to usability, communicability and accessibility of e-government websites dedicated to e-participation
- to develop and test applications in mobile and IoT (Internet of Things devices to increase e-participation
- to develop patterns and indicators for monitoring websites to check for compliance to transparency guidelines
- to develop methods and patterns for the implementation of service coproduction
- to enable professionals to develop and manage models and technologies related to e-government and e-participation
- to develop competencies in distinct research methods applied to e-participation, both quantitative and qualitative
- to develop applied research in society and government issues, in a seamless and combined manner
- to perform experiments on human aspects and content modelling, including aspects of social dynamics and socially aware systems
- to develop agile mechanisms for data queries and storage of content continually generated by the citizen
- to develop mechanisms which can give citizens information about Service Level Agreements as dictated by the Letter to the Citizen.

To evaluate these goals and actions, we propose the use of mixed research methods. We must strive for both quantity and quality in the results. Quantitative studies seem appropriate to study the primary impact of the actions performed, especially regarding number of citizens and level of engagement. Qualitative studies are appropriate to embrace the epistemological aspects of citizen participation and engagement. More than just embracing the citizen in public participation, the goal of e-participation is to make the user an active participant of the public agenda. Quantitative analysis is not enough to capture the subjective aspects of this research, therefore qualitative analysis is also important.

6.4. Final Remarks

In ancient times, Athenian *agoras* were similar to what we now call direct democracy, in which citizens participated in political decisions (although to be a "citizen" at that time, certain requirements had to be met) [ARAUJO et al. 2011]. These days, direct democracy has been replaced by a semi-direct democracy, largely as a result of population growth, personal reasons, among others. The power of decision is now shared between the government and citizens, but with the latter representatively or indirectly participating in decisions. As opposed to direct democracy, in a representative or indirect democracy citizens delegate power to govern cities, states and countries to those people acting as their representatives. In some countries, citizens still can have their voice heard through popular initiatives, referenda and plebiscites, as in Brazil [AUAD, 2005]. However, there remains a need to bring together government and citizens, there being active participants in decisions giving them a voice to be heard; their opinions and desires considered [UNITED NATIONS, 2010].

Popular participation is an important axis in a democratic society. However, an analysis of the current Brazilian scenario indicates the need for methods and bold and effective technologies to provide solutions to achieve a level of participation as close as possible to direct participation. Therefore, these issues should be discussed with the Information Systems community at SBC. There is a need to design, model and develop a discussion environment and propose solutions to satisfy the demands of society and ultimately engage researchers and other stakeholders in the pursuit of an increasingly democratic society.

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Chapter 7

Transparency in Information Systems

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Abstract

Truthful information has been an important topic on transparency agendas. A considerable amount of work has been done on this theme, but transparency practices remain a challenge to society. This chapter presents the concept of transparency and discusses challenges and opportunities for research giving an overview about Information Systems applications in this area and progress that has been made in recent years.

7.1. Introduction

The growing demand for truthful information has increased around the world. The way organizations operate and provide their services and how they manage information has become an important topic for society (citizens, government and organizations).

Transparency is understood in the context of giving access to information. In government it is believed to promote democracy through participative citizens, providing them with tools to understand and use information that can help develop critical thinking on the way government operates.

In the context of giving access to government information, there is also the problem of corruption. According to the 2015 annual assessment of the Transparency International Organization[1], corruption remains a plague in the world. In 2015 it was made clear that society no longer tolerates these actions and calls for this problem to be faced by all countries. Brazil's score was 38 points (from 0 - highly corrupt to 100 - clean) and has been falling since 2012. In 2015, Brazil was the country that recorded the largest decline in this fight, moving to 76th place

1 https://www.transparency.org

out of 168 assessed. According to this organization countries that perform better share key characteristics such as: free press, access to information, citizen participation, high levels of integrity among people in power, and judicial systems that treat everyone equally and are independent of other spheres of government.

Transparency has also been seen as a challenge for private companies. Tapscott and Ficoll (2003) discuss problems such as Enron and Worldcom that only came to light when the companies became bankrupt, causing shareholders to lose large amounts because of lack of transparency. They also cite companies such as McDonalds and Coca-Cola that are organizing themselves to meet the need for customer and shareholder loyalty, and also to attract others due to recurring questions related to the manufacturing methods.

Transparency, as a transversal aspect of an organization, can be seen from a multidisciplinary perspective of possible benefits. It should provide more quality and reliability to data that is publicized to citizens, such as the source and responsible, date of creation, level of integrity, publicity mechanisms, etc. It might be discussed regarding how to provide a better understanding of processes by citizens and by proposing clarity, uniformity, completeness and auditability mechanisms. When combined with human-interface domain of research it might provide intuitiveness, user-friendliness and enhance the visualization of processes and the transformation of information at runtime.

For these reasons, transparency, or lack of it, is found at the top of public and private agenda. Organizations have been evaluated in their ability to provide trustworthy information and knowledge with transparency considering their operations, performance and results [Fung et al. 2007].

The increasing movement around this theme leads to questions about what exactly means the idea of transparency. What at first seems to be a simple idea needs a formal approach to put in practice. Therefore, it is necessary to deepen knowledge about transparency as well as the existence of methods and technologies that make it possible to establish it in organizations. Organizational transparency has been investigated in order to add social values related to characteristics such as auditability, adaptability, accessibility, usability, understanding, correctness, consistency, dependability, among others [Leite and Cappelli 2010]. The aim is to improve the view of organizational processes and information in order to provide opportunities for knowledge about them, to reduce the possibility of omission, to enable control over the products and services, to facilitate research, and to increase trust between organizations and society. In addition, providing transparency has the potential to enhance collaboration, information reuse and adaptation to the needs of societies [Martano and Craveiro 2014].

Leite and Cappelli (2010) argue that, "in order to implement transparency, society will need to address how software deals with this concept". Information and communication technologies (ICT) have changed the way of thinking and performing organizational processes. Thus, work has been increasingly supported, conducted or supervised by Information Systems (IS) [van der Aalst 2009]. Their use in different domains increases the importance of the relationship among the three pillars that constitute the computing socio-technical perspective that relates people, technology and organizational processes. The application of transparency in IS is a new and important concern when designing software that automates the delivery of services and process information, while interacting with people.

With regard to public organizations, they are being increasingly required to ensure that automated processes and information are transparent and accessible. The importance of this has also been highlighted by the increasing demand for the provision of e-government services (e-gov). E-gov is one of the aims of the Brazilian Strategy of Digital Governance (Estratégia de Governança Digital - EGD)[2]. The research on technologies applied to e-gov has increased in recent years with the promotion of transparency as one of its aims. Nevertheless, the Brazilian Government does not address this issue systematically. Accordingly to Coelho et al. (2016), transparency in Brazilian e-gov (a.k.a. e-transparency) is a subject still in the beginning of its maturity process.

This chapter aims to present the concept of transparency and its importance for the IS community, discussing and posing challenges and opportunities for research. This theme complies with the great challenges of the Brazilian Society of Computing (Sociedade Brasileira de Computação - SBC). Regarding transparency research, it relates to the "Participative and universal access of Brazilian citizens to knowledge". Regarding the use of IS for this purpose, it focuses on "Technological development of quality: available, correct, secure, scalable, persistent and ubiquitous systems".

7.2. Background

According to Leite and Cappelli (2010), “Transparency is a concept of information disclosure, having been used in different settings, mostly related to empowering of citizens with regard to their rights”. In this regard, “a wave of transparency policies has swept across Latin America over the last decade or so. Among budget and legislative transparency provisions, political finance disclosure, and open-data portals, freedom of information (FOI) laws occupy a unique space.” [Michener 2015].

In Brazil, the Access to Information Laws, Law nº 12.527[3] and Law nº 131[4], have encouraged active transparency and a growing availability of information about public organizations on their institutional sites. Nevertheless, Michener (2015) analyzed the *de jure* and *de facto* strength of Latin American FOI regimes and shows that there remains much to be done in this area from political, sociological, anthropological, and technological perspectives. It is truly an open invitation for researchers to address gaps in data and methods on FOI. Transparency can also be seen in the private context where the aim is to empower employees and employers with knowledge and skills regarding their context.

Nevertheless, transparency is not a new demand from society. Research in the area of Business Process Management (BPM) [Paim et al. 2009] and Information Technology

[2] See the EGD proposition at: http://www.sisp.gov.br/egd/wiki/download/file/Minuta_EGD. In Portuguese.

[3] http://www.planalto.gov.br/ccivil_03/_Ato2011-2014/2011/Lei/L12527.htm

[4] https://www.planalto.gov.br/ccivil_03/Leis/LCP/Lcp131.htm.

Architecture [Armour et al. 2007], [Steenbergen et al. 2007] and [Lankhorst 2013] point to the creation of models that represent the different perspectives of how an organization works. Such models are an important tool to promote the dissemination of knowledge about processes, information and continuous improvement of production and services. In this regard, researchers discuss and propose approaches on how to identify requirements when dealing with process automation support [Araujo et al. 2005], [Bittencourt 2008], [Magdaleno et al. 2008], [Diirr et al. 2009] and [Py et al. 2009]. Such approaches can also be viewed as structures that support visibility and transparency not only of organizational processes, but also of tools for identifying relevant characteristics to promote transparency of information [Cappelli et al. 2007].

It is clear, however, that transparency covers more complex issues than simply providing information and usability features. The difficulties related to the understanding, interpretation, use and verification of information can be impediments to its effectiveness [Fung et al. 2007]. The heavy use of web tools has contributed to the considerable increase in available content in the form of collective knowledge. This content, however, is needy of structure and mechanisms for the delivery, capturing and reuse of this knowledge.

Therefore, for both public and private contexts, transparency establishes a set of aspects that suggest the existence of policies, procedures and technologies to provide not only access, but also use, quality, understanding and auditability of processes and information [Cappelli 2009]. Transparency may improve the view of organizational processes and information, while providing opportunities for knowledge about them, reducing the possibility of omission of information, enabling control over the products and services, facilitating research, and increasing trust between organizations and society.

7.2.1. Organizational Transparency

The concept of transparency seems a simple idea. However, it requires a deepening of its semantics, the existence of methods that make it possible to establish its efficiency and systematization in organizations. In addition, it requires instruments to monitor the way it is established in a particular organization to assess if it meets the organizational strategy and the needs of society [Harrison et al. 2011].

In this regard, Cappelli (2009) deals with the problem of understanding, implementing and evaluating transparency in organizational processes and information, by constructing a definition and systematization for transparency through a transparency catalog. Cappelli (2009) elaborated the Transparency SIG (Softgoal Interdependency Graph) that defines principles for transparency as characteristics represented in a non-functional requirement (NFR) catalogue (Chung et al.,2000), and operationalizations to systematize the incorporation of transparency in organizational processes and information. The Transparency SIG is composed of nodes and links as presented in Figure 7.1. Each node is a transparency characteristic, while each link represents the type of contribution among them (break, hurt, unknown, help and make). There are five groups of characteristics: accessibility, usability, informativeness, understandability and auditability. Each one is unfolded in (sub) characteristics, and for each of them, a set of operationalizations and mechanisms is proposed in order to orient the introduction of transparency in organizational processes and information. Table 7.1 presents the characteristic of traceability.

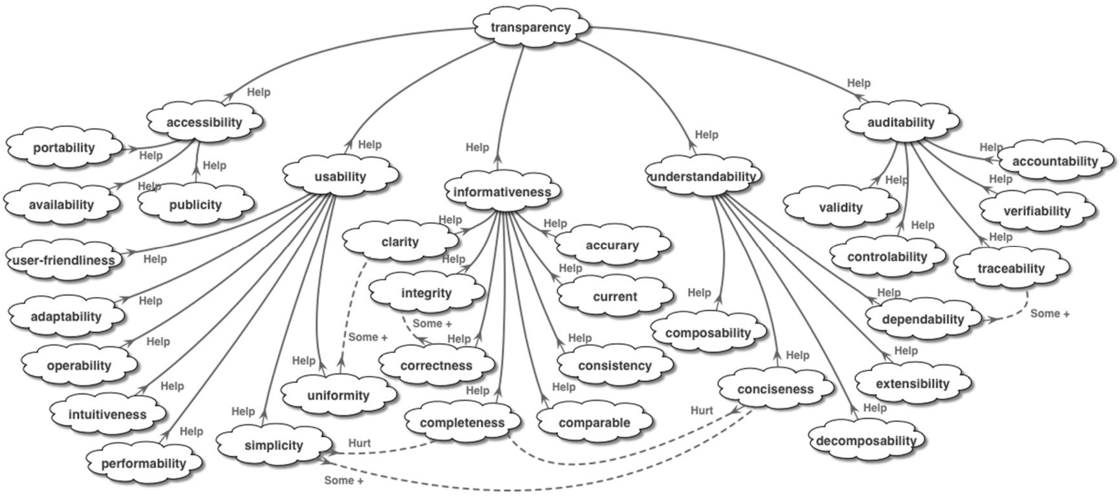

Figure 7.1. Transparency SIG [Cappelli 2009]

Table 7.1. The operationalization of traceability [Cappelli 2009]

Characteristic	Traceability
Definition	The quality of following, discover, or ascertain the course of development of something
Impact	Helps to satisfice the characteristic of auditability
Operationalization	Identify software x activity requirements Identify the context of the change Identify when changes are performed Identify the locale of the change Identify process information x instance Identify reasons for change Identify the responsible for the change Identify predecessors activities Identify successors activities Identify the changes performed in the process Identify dependencies among processes

Regarding organizational context, we may cite approaches such as that used by Carvalho et al. (2016) that aim to enable transparency during the election process at a University through a graphic model using business process modeling notation (BPMN). Engiel et al. (2015) propose a transparency lexicon using the Language Extended Lexicon (LEL) which is a representation approach to register context vocabulary, i.e. the vocabulary of a language spoken in a given context. They created a visualization tool to give more legibility to the LEL and to exemplify how it can contribute to publicizing transparency for citizens.

7.2.2. Transparency in the Software Context

The use of ICT to support execution and management of processes, access and use of information has been at the top of research agendas. The main goal is to provide better ways to support, for instance, decision making, work execution, collaboration, analysis and improvement. Therefore, ICT has changed the business process within and between organizations, in the sense that processes and information are increasingly being conducted and accessed under the supervision of IS [van der Aalst 2009].

The open information flow is highlighted in the context of ICT, and it aims to collaborate with more democratic access to information and how processes are performed [Holzner and Holzner 2006]. Therefore, transparency is seen as a NFR that IS should consider when they are being elicited, designed and implemented. Thus, transparency is seen as a quality issue that is orthogonal to the software functionality, i.e. having transparency or not will not impact what the software does [Leite and Cappelli 2010]. It spreads through different functional parts of an IS and is a new and important concern when designing software that processes information and has an interface with people.

Transparency is also seen in relation to the software itself and its development process [Serrano and Leite 2011], i.e. requirements, design project, codification, the code, test, etc. Its systematic application is still a major concern when designing systems that operationalize services and act as interface mechanisms with people.

In the public context IS designers and software engineers are being asked to address transparency. In the context of understanding political processes, during the impeachment process in Brazil, much was spoken of “pedaladas fiscais” (irregular fiscal maneuvering) and many citizens did not understand the meaning of this term, what it was and how the impeachment process was conducted. An interesting initiative was the release of a point of view of this process in an “easier” language, showing step-by-step stages of the process and its results[5]. In the context of a citizen audit, the site of the Citizen Audit of Debt[6] was created to carry out an audit of the Brazilian public debt and demand transparency about the debt process.

[5] http://especiais.g1.globo.com/politica/2015/entenda-o-processo-de-impeachment/

[6] http://www.auditoriacidada.org.br/

Several public transparency web portals such as the city of Sao Paulo[7] and Cuiaba City Hall[8] aim to stimulate society's control and ensure public transparency. “Lupa” (magnifying glass) site[9] checks the veracity of information circulating in Brazil. DataViva[10] is an open platform that provides economic data from government sectors. It promotes data transparency to help identify the best ways to diversify the production structure and promote economic development. Votanaweb site[11] contains all proposed law projects and citizens can give their opinions on them.

Research on technologies applied to e-gov has also increased in recent years, focusing on various fields of research, such as software engineering, engineering knowledge, interoperability at all levels (semantic technological) and business processes [Vitvar et al. 2010] [Pinheiro et al. 2014].

In Ambekar et al. (2015), the authors propose a multi-agent system (MAS) framework to manage the Indian Public Distribution System of food and improve transparency in actions and data. According to Chen et al. (2014), “in order to achieve information transparency, both human and the machine agent must have an awareness of each other's internal status”. They discuss transparency in human-robot interactions, in a scenario of Unmanned Aerial Vehicles. They focus on the access of information by both human and software agents. In Müller et al. (2014), how to model MAS description and enforce the provision of transparent models as a requirement is discussed. In Tanajura et al. (2013), they apply the MAS paradigm to model the management of distributed manufacturing on onshore oil fields. A benefit of introducing MAS is the transparency that agents' perspective provides to users and developers.

In Bodea and Mogos (2013), the use of MAS is proposed because it may provide a transparent negotiation process between programmers and resources managers in order to find a good solution to the problem of resource allocation. Again, transparency is related to providing access to intermediate results to all participants. In another approach, Carneiro et al. (2013) proposed an agent oriented architecture to increase effectiveness and awareness of dispute resolution of court cases by increasing the amount of meaningful information and possible outcomes that are available for the parties, using case-based reasoning techniques.

The importance of IS as the main enabler of services to society is obvious as it helps organizations to make themselves more and more present. It is also a fact that the introduction of ICT has improved transparency and access to information and processes [Bertot et al. 2010]. Therefore, when thinking of transparency in the provision of services one has necessarily to think

[7] http://transparencia.prefeitura.sp.gov.br/Paginas/home.aspx

[8] http://circuitomt.com.br/editorias/cidades/73029--escola-transparente-vai-garantir-controle-social-dos-gastos-publ.html

[9] http://piaui.folha.uol.com.br/lupa/

[10] http://dataviva.info/pt/

[11] http://www.votenaweb.com.br/

of how to deal with this aspect in the development of IS in a formal way. In Section 7.3 we discuss some challenges related to this.

7.3. Challenges

Technology solutions that automate processes and process information are sources of competitive and social advantages. There is a great concern about the collection, organization, representation, storage, processing and transmission of information, in order to promote the efficiency of decision-making, organizational management and education in general. In this context, an agenda for the challenges in transparency is discussed below.

7.3.1. Elicitation and Evaluation of Transparency Characteristics

This issue here is how to make an abstract concept such as transparency more concrete in order to define actions and forms to implement it in organizations and evaluate their level of transparency.

There is a need for methods that make it possible to implement transparency and for models to check whether the way it is implemented meets demands. In order to make the use of the transparency concept feasible, it is necessary to use methods that help to understand and plan how a transparent deployment project can be conducted and how to guide the selection and insertion of transparency mechanisms in an organization. For example, based on the Transparency SIG [Cappelli 2009], how should the simplicity or user-friendliness characteristic in an organization be implemented? Or at what level should a specific characteristic be implemented?

Several initiatives to promote the establishment of mechanisms to demonstrate transparency have been made. Some of them, such as the Sarbanes-Oxley Act[12] (SOX) [SOX 2002], the Basel Committee on Banking Supervision (BASEL Agreement)[13], the Extractive Industries Transparency Initiative (EITI)[14], the Organization for Economic Co-operation and Development (OECD)[15] and the Open Government Partnership (OGP)[16] provide guidelines for governments and civil societies on how to provide organizational transparency in specific business domains. Other organizations such as Transparency International[17], Brazil Transparency (Transparência Brasil)[18] and the Federal Government Disciplinary Board (Corregedoria Geral da União)[19] discuss this theme and create knowledge networks suggesting practices for achieving transparency.

Regarding the institutionalization of practices and evaluation, Cappelli et al. (2013) propose[20] an Organizational Transparency Maturity Model that defines an evolutionary path for

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12 https://www.sec.gov/about/laws/soa2002.pdf

13 https://www.bis.org/bcbs/

14 https://eiti.org

15 http://www.oecd.org

16 http://www.opengovpartnership.org/

17 https://www.transparency.org

18 http://www.transparencia.org.br

19 http://www.cgu.gov.br

20 https://sites.google.com/site/ciberdem/modelo-de-maturidade-em-transparncia-organizacional

the deployment of transparency in organizations and provides items for the evaluation of this implementation. The Maturity Model organizes transparency characteristics in five stages. Each maturity level combines characteristics that help the organization to reach the goal of the level. An evaluation method to measure the organization's level of adherence to a transparency level was also proposed.

Another challenge is related to provide transparency accordingly to a specific context which could be a user's profile, a specific event, a specific process, etc. The increasing importance in associating context to processes and information is related to the fact that it provides a temporal cause-effect relationship characterization between the consumer and its demands [Rosemann et al. 2008]. The authors argue that the context identification and analysis comprise the foundation for understanding the relationship between changes in the scenario of an organization and its processes. Therefore, regarding transparency, the surrounding context could be used as a parameter to select and prioritize transparency characteristics that meet their current needs.

7.3.2. Improving Transparency from Strategy to Technological Perspective

Organizations need to "describe and control an organization's structure, processes, applications, systems, and technology in such an integrated way" which is called Enterprise Architecture (EA) [Lankhorst 2013]. In essence, these data need to be modeled in an interrelated way so as to provide the organization with more reliable skills for reasoning and decision making.

However, organizations face problems regarding data awareness and quality. There are situations in which the quality of data is challenged, these include not being detailed enough, or when transparency is not desired as it may conflict with confidentiality, the data source is dubious, etc. This can affect strategic, procedural, informational, systemic or technological aspects of the organization. It poses challenges on how to comply with different interests so as to provide transparency to a specific data in all levels of the organization, from strategic to technological without the risk of inserting inconsistencies and incoherencies.

To address this issue, Santos et al. (2014) proposed treating transparency as a cross cutting concern, by defining a method for identifying and representing transparency characteristics at an EA level. They propose the use of aspects which are abstractions that aim to modularize concerns that cut across all levels of EA. There is a need to systematize the implementation of transparency through automation when developing and using EA given the high amount of information. Another challenge is related to the reuse and interoperation of transparency aspects throughout the organization.

7.3.3. Organizational Transparency through IS support

There is a need to systematize the definition of transparency requirements to generate IS that implement transparency throughout the actions they support. This means that the operationalization of transparency must start at IS design-time. Therefore, how should we design an IS in order to provide transparency to the actions and data manipulation undertaken by it? The challenge resides in how to understand and define how to translate transparency characteristics into functional and NFR.

An example of the lack of transparency in e-gov in Brazil is the distribution of judicial lawsuits which is performed by an automatic random draw. According to the National Council of Justice (Conselho Nacional de Justiça), since 2011 more than 5 million lawsuits have been processed by the Electronic Judicial Process System (PJe). By 2018 all Courts and Councils must implement PJe adding more than 20 million lawsuits. The system is being increasingly used but it is still heavily criticized because of the lack of transparency[21]. In the Superior Labor Court (TST) of Brazilian Justice Power, the electronic program that distributes lawsuits is closed to users, only the results can be accessed. It is not clear how legal and internal rules are applied. When someone wants to know why lawsuit X was distributed to Minister Y, it is necessary to audit the database, which is time consuming and mostly provides little explanation. In [Albuquerque et al. 2016] and [Albuquerque et al. 2017] the authors address the problem of how to implement transparency characteristics in e-gov through the use of MAS, based on the research of Cappelli (2009) and Leite and Cappelli (2010). The authors advocate that agent-oriented characteristics such as sociality, proactivity, communicative and cooperative abilities have a natural relation with transparency concepts which might help to materialize transparency in IS.

7.3.4. Software Transparency

Software Transparency enacts the transparency point of view of the IS development and operation. For example, the software development process should allow a person to demonstrate that the IS follows requirements. Nevertheless, software transparency is a flexible goal that is subjective and poorly understood, and is dependent on the views and expectations of stakeholders. It is up to the final users, as the ultimate interested party in the software, to say how transparent software should be.

It is necessary to be able to show the interested parties that a particular requirement is present in the code or that a code snippet contributes to one of the requirements. Even flexible goals (or quality criteria) requested by interested parties must be explicitly present in the software. Therefore, a number of challenges for the implementation of software transparency emerge and include: (i) how to provide forward and backward traceability between requirements and code (ii) how to elicit transparency requirements at software design-time (iii) how to validate transparency requirements with stakeholders considering a multi-party agreement (iv) how to explicit flexible goals in the software code? (v) how to attach the information to the produced artifacts about how they were produced, i.e. how to achieve the pre-traceability of artifacts (vi) how to treat antagonistic NFR (vii) how to select transparency characteristics based on the software context of use and (viii) how to systematize reusability of transparency operationalization mechanisms?

In order to cope with some of these challenges, Serrano and Leite (2011) proposed an approach to capture requirement patterns through argumentation by identifying on argumentation graphs the NFR operationalization needed to implement a software transparency characteristic[22]. In the context of human-computer interaction **(**IHC), some concepts of semiotics engineering such as communicability, which deals with qualification of the communication between the system designer (developer) and users, can also be used in an attempt to reduce the communication problems of the stakeholders in the development process. The aim is that, by outlining the results and the challenges for software transparency,

[21] http://www.conjur.com.br/2014-jul-12/advogados-exigem-transparencia-relacao-processo-eletronico

[22] http://transparencia.inf.puc-rio.br/wiki/index.php/Catálogo_Transparência

one can leverage the expected results and benefit from facing organizational transparency as a whole.

Software transparency challenges are also enhanced when considering large scale and globalized platforms. In bringing together various projects and products around a core software technology, these platforms originate more complex systems that integrate a network of diverse actors and artifacts, both internal and external, called Software Ecosystem [Santos et al. 2014(a)]. The need to deal with the transparency of the platform is a critical factor for quality software development. An imminent issue is how to produce / purchase software and manage business and information from ecosystems in a transparent way. This poses challenges related to: (i) how to expand the information sharing of resources, artifacts and information and develop ways to handle this in software repositories (ii) how to manage and monitor dependencies of suppliers, technologies and distributed business goals in a transparent way (iii) how to deal with access to the large volume of information required for decisions on partnerships or admission of members and (iv) how to deal with elements that interfere with or affect the success of the ecosystem and need to be investigated, as well as permissions and access levels of the actors to shared information.

7.3.5. Transparency in HCI and social networks

In HCI and social networking fields of research, transparency is also a very important requirement. Social networks consist of a set of autonomous participants, linking ideas and resources around shared values and interests [Marteleto 2001].

A user can publish any information, truthful or otherwise, to a huge and diverse public with low levels of segmentation. The dynamism of information coupled with the paradox of its relevance from the point of view of each person, the use of colloquial language, information overload and anxiety of users are the prime examples of auditability problem in social networks [Agarwal and Yiliyasi 2010]. Publication of information on social networks, without any prior assessment of the quoted source, results in an accumulation of irrelevant or not credible information [Pinheiro et al. 2016]. The reliability of information is vulnerable due to the dynamic nature of information made available on the Internet. Given this, it is essential to constantly evaluate the information sources in order to determine responsibility for authorship and update frequency [Serzedello and Engelmann 2006]. Another challenge is related to reinforcing the idea that the IT team should be concerned about the development of IS that enables usability and auditability of information. The development of tools focused on auditability are aligned with critical design issues in HCI [Pierce et al. 2015], since the developer needs to analyze the impacts the software may cause (such as cultural or ethical impacts) due to the emerging possibilities of design.

Pinheiro et al. (2016) proposed a catalog that organizes characteristics and operationalizations to support auditability of information in social networks and a guide that helps developers to build software that can evaluate information reliability. There is much still to be investigated regarding the expansion of more operationalizations, the focus on other transparency characteristics and the implementation of mechanisms to be used and tested in social networks. For example, in social networks such as Facebook, it is possible to create third-party tools such as plugins that connect the system through their APIs providing missing information auditability options. The ubiquity of social networks also increases the challenge of evaluating information credibility and may change operationalization mechanisms selected by the IT team. Therefore, studying the limits of auditability and other transparency characteristics in different programs and devices is also recommended.

7.3.6. Transparency to create a citizen language

We have mentioned some of the laws that have been put in place to guarantee transparency within organizations such as SOX, BASEL, EITI and the OGP. In Brazil, the Transparency Law [Law 2008] and the Access to Information Law [Law 2011] set limits for public organizations in publishing information.

However, besides giving access to information, to be transparent, organizations have to guarantee citizens' understanding about what is happening and how information is generated and used. Business process models may help because they comprise important information about organizational processes (e.g. actors, activities, rules, inputs and outputs). To represent process models, organizations may use a methodology [Sharp 2008] and a language. However, ordinary citizens have little understanding of these technical aspects and diagram interpretation suggested by processes modeling methodologies and this hinders the transparency, clarity and ease of interpretation of an organization's procedures. This prevents not only process understanding, but also service use and analysis. The simple presentation of a technical model may be ineffective.

Although there are several works focusing on defining, organizing and detailing characteristics that can be applied when designing public service process models to provide more understandability to process models, much still needs to be done. A citizen language has been defined [Carvalho et al. 2016], but there remains an open invitation for research on the theme.

7.4. Progress Evaluation

Addressing transparency challenge in organizations involves quantitative and qualitative aspects. Firstly, it is necessary to encourage participation. Transparency approaches focus primarily on people in two ways: internally so they can improve organizations by leveraging their participation and externally, so they can improve the level of trust in the service and/or products that are offered. Therefore, promoting discussion at all levels of society and academia can contribute to fostering transparency among academia.

Quantitatively speaking, the growing research on transparency should consider: the monitoring of the number of publications by Academic Institutions, the number of conferences and events discussing theoretical and practical transparency aspects as well as proposing solutions for challenges as the ones discussed above, and the dissemination of research artifact monitoring such as methods, standards, processes and IS. Considering the qualitative aspects could measure the benefits that people perceive through the proposed artifacts and the level of reliability people perceive regarding the provision of electronic services with transparency skills.

7.5. Final Remarks

We have argued that transparency is a concern that IS designers must address as society requires more information and process openness. We believe that the most pressing issues when putting transparency in focus during IS designing and implementation are: (i) finding ways to provide transparency without increasing the cost of providing a service (ii) assuring transparency without interfering with system performance (iii) to enhancing computer-human interaction skills to deal with all sorts of transparency required by "customers" in a country with such diversity and plurality as Brazil.

Transparency and communication are becoming a competitive advantage because of the moral perspective and effectiveness of providing ways and meanings of how services are provided by organizations. The outcome of this is the high investment being made by Brazilian organizations in the development of ICT.

The development of mechanisms to systematize transparency in the provision of e-services is a challenge that requires the introduction of new methodologies and technologies to IS development. Furthermore, its planning and implementation should be carried out from a broad and multidisciplinary perspective with the support of approaches from domains such as the Semantic Web, Intelligent Search Engines and Social Networks.

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Chapter 8

Challenges faced by Micro and Small Organizations in Offering Products, Services and IT/IS Solutions for the Brazilian Federal Public Administration

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Abstract

Several initiatives have sought to improve software processes and services in recent years. Despite these initiatives, when the matter is related to the contracting process of the Brazilian Federal Public Administration (FPA), many obstacles are found, such as the complexity of the processes and the continuous monitoring of the control bodies. To minimize these obstacles, the Brazilian Court of Audit (TCU) recommended the establishment of the Instruction SLTI/ MPOG 04, containing guidelines for hiring IT/IS Solutions in Brazil. This chapter presents the challenges that micro and small Brazilian organizations face in providing products, services and solutions for the FPA according to these guidelines.

8.1. Introduction

This chapter presents the challenges found during research involving academia and industry regarding the supply of Information Technology (IT) and Information Systems (IS) products, services and solutions to the Federal Public Administration (FPA) by Brazilian micro and small organizations (MSE). It also suggests ways to improve the contracting processes. Despite the proposals that involve various actions between industry, academia and government, the characterization of IT/IS organizations in Brazil intensifies the challenges in the contracting processes as these kinds of organizations tend to be immature and know little about FPA demands [SILVA 2013].

In this context, several assumptions were considered to reinforce the need for emerging research in approaches for products, services and IT/IS solutions supply:

- The FPA has intensified improvements in the contracting IT/IS services and solutions process, however, the reports presented by TCU show that there are deficiencies on the part of the government agencies that make up the FPA in the use of the Normative Instruction IN/SLTI/MPOG 04 in its latest version 2014 [TCU 2015].
- The FPA has faced difficulties in using the contracting process. These difficulties demonstrate that the contracting agencies still face barriers and lack knowledge on the applicability and appropriate use of the Normative Instruction IN/SLTI/MPOG 04/2014 and the defined Hiring Process in Technology Service Management(ITSM) [TCU 2015], [SILVA 2013].
- The Brazilian IT/IS sector is largely made up of micro and small organizations (MSEs) - 94% of the sector, according to research by the Brazilian Association of Software Companies [(ABES, 2015]. These companies do not demonstrate the ability and maturity required by the processes of IN/SLTI/MPOG 04/2014. Research has shown the high degree of complexity in implementing the procurement processes for IT/IS solutions [CRUZ et al. 2011], [SILVA 2013].
- The proposal of IN/SLTI/MPOG 04 resulted from research designed to solve the common problems faced by government agencies in the hiring IT services and IS solution processes. However, these processes focus only on hiring, its phases, activities and required artifacts. Leaving aside organizations that offers these services or solutions to Brazilian (FPA) and its process.
- The processes described in the IN/SLTI/MPOG 04/2014 focus on purely technical activities. In addition, a contracting process involves agreements and/or contracts for supplying products, services and IT/IS solutions. However, commonly issues are found that go beyond technical skills and abilities and that require research and studies that support the relationship "win-win" [PMBOK 2013] for a healthy partnership to be established [SILVA 2013].
- The definition of hybrid processes to offer products and services on IT/IS to the FPA by micro and small organizations is crucial for the strengthening of Brazilian industry. Due to the representativeness of this kind of organization in the Brazilian market, research and government support is needed so that such companies can grow and build up on the market. The biggest challenge is strongly related to the fact that micro and small organizations need to adapt to the demands of the FPA so as to meet the legal requirements defined in the processes that comprise Brazilian legislation [TCU 2016].

Given this scenario, this chapter describes the challenges for micro and small Brazilian companies in providing services in IT/IS for the FPA. Besides this introductory section, this chapter is structured as follows: Section 8.2 describes the research context. Section 8.3 describes the necessary background related to research. Section 8.4 presents research challenges. Section 8.5 describes the research progress. Finally, Section 8.6 presents the conclusions.

8.2. Context

With the growing demand for Information Technology (IT) and Information Systems (IS) solutions, service providers struggle to keep up the high-quality standards required by customers [LIRA, ARAÚJO and BARROS 2008], [BRICKLEY 2001] and [BERGAMASCHI 2004].

In order to improve competitiveness and ability to deliver quality products, whether at the national or international level, it is vital that IT/IS solution providers are aligned to process efficiency and effectiveness (SEI, 2010; ISO/IEC 2000, 2011).

In Brazil, there has been a growth in the IT/IS industry despite its scarcity of resources and skilled labor [SOFTEX, 2015], [ABES, 2015]. The latest data released by the Brazilian Association of Software [ABES 2015] shows that Brazilian IT/IS Industry is positioned in 7th place in the world ranking, with investment of US $ 60 billion only in 2014. If only the Software Sector, Systems and IT services were considered, the amount totaled US $ 25.2 billion in the same year. The study also points out that Brazil is positioned in 1st place in the ranking of investment in IT/IS sector in Latin America, with 46% of the market, which in 2014 totaled US $ 128 billion in sales. Considering the software market separately, sales reached $ 11.2 billion. The IT/IS services market recorded in the order of US $ 14 billion in 2014 [ABES 2015].

In the national IT/IS market, it handled $ 60 billion in 2014, representing 2.6% of Brazil's GDP (Gross Domestic Product) and 3% of the total IT investment in the world, almost equal to the securities registered in the previous year. The Software sector grew by 12.8% over 2013. However, the services sector showed more modest growth, an increase of 7.3% over the previous year. Overall, software and services grew by 9.7%, above the clear majority of other sectors in the Brazilian economy and also above the country's GDP [ABES 2015].

Regarding Brazilian IT/IS Service Provision, the FPA is the largest consumer of goods and services [SOFTEX 2016]. It has constantly worked on developing initiatives and actions to improve IT solutions hiring processes. The Normative Instruction IN/ SLTI/MPOG 04/2014 publication was one of these initiatives, as well as the IT Solutions Hiring Guide (GCSTI). Despite this, the government's performance related to IT contract management has presented difficulties. Among these difficulties is the fact that Brazilian legislation to ensure efficient procurement processes is quite complex [TCU 2014]. Thus, problems are often encountered in contract execution, even though it follows the defined recommendations. Many of these problems are related to compliance with laws, rules and jurisprudence [CRUZ et al. 2011].

According to Silva (2013), the Brazilian software and IT/IS services industry base their processes on models, standards and methodologies such as CMMI [CHRISSIS et al. 2010], MR-MPS [SOFTEX 2015], ISO 9001 [NBR/ISO 9001 2015], ISO/IEC 33000 [ISO 33000 2015], NBR/ISO/IEC 12207 [ISO 12207 2008] and Six Sigma [TAYNTOR 2007]. These models and standards are sets of best practices for projects, products, services development and integration processes.

Regarding the average size of Brazilian companies, they are mostly classified as Micro and Small Organizations (MSEs), totaling about 94%. The MSEs were responsible for 16% of all the IT goods and services supplied in 2014. This amounted to R$ 153.0 million. Comparing the period from January to March 2014 with the same period of 2013, MSEs increased its stake in by 16% in IT sales to the Government Bodies [ABES 2015]. However, this could have been much bigger as micro and small IT/IS businesses represent over 90%, as can be seen in Figure 8.1.

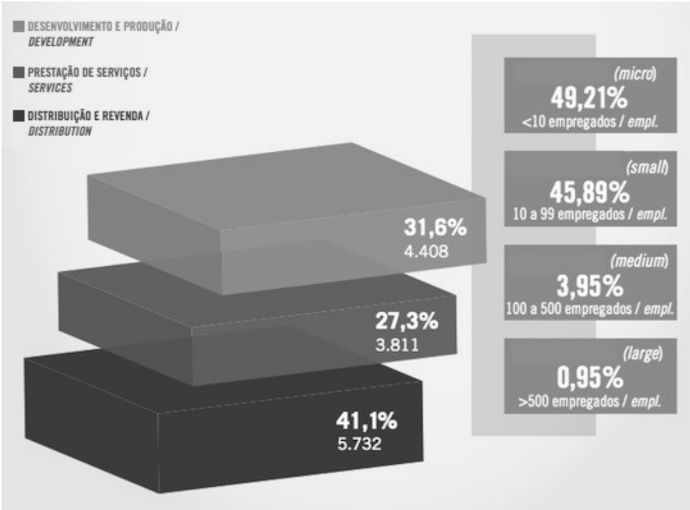

Figure 8.1. Size of IT / IS organizations in Brazil [ABES 2015]

In spite of the increased demand for initiatives to improve the software and IT service processes, the number of assessed and certified companies in CMMI models [SEI 2010] and MPS.BR [SOFTEX 2016] is low the Brazilian industry, less than 1% of certified companies with some maturity or capability level [STAPLES et al. 2007]. This is one of the biggest challenges in Brazil, since the IT industry depends on the government to remain in the market in which it operates [ABES 2015]. The Brazilian software and services market has faced difficulties in the supply of goods and services to the FPA [Cruz et al. 2011], [Silva 2013] due to the demands of compliance with legislation and regulations to provide IT/IS services and solutions.

8.3. Background

This section describes the concepts and the necessary references for understanding the proposed research challenge.

8.3.1. The Brazilian Federal Public Administration

In order to hire goods and services from the private sector, the Brazilian FPA established Decree Law Nº 200/67. This states that to improve compliance with the planning, coordination, supervision and control, the Brazilian FPA should be exempt from task execution, using, where possible, indirect execution by establishing a contract with a third party. Since procurement is required, the planning of this important administrative act becomes mandatory to meet the public interest, in order to minimize waste and the diversion of resources by using them more effectively. According to Cruz (2008), contracting is one of the most frequently used administrative acts.

The Ministry of Planning, Budget and Management (MPOG), through the Department of Information Technology Logistics (SLTI) is the government body responsible for IT/IS Solutions hiring. The SLTI uses agencies and Entities members of the System for the Management of Information and Informatics Resources (SISP) of the Federal Executive Branch [BRAZIL 2008].

To define and institutionalize IT Hiring processes encompasses complex actions involving technical and behavioral issues [BRAGA 2009], [WEILL et al. 2006]. These complexities pose a risk to the parties involved and as a result the occurrence of serious conflicts involving contractor and contracted is common [WRIGH 2004].

8.3.2. Normative Instruction IN 04/2014

The IN/SLTI/MOG04/2014 [SLTI 2015] structure provides governance mechanisms for contracting services and IT solutions, as shown in Figure 8.2.

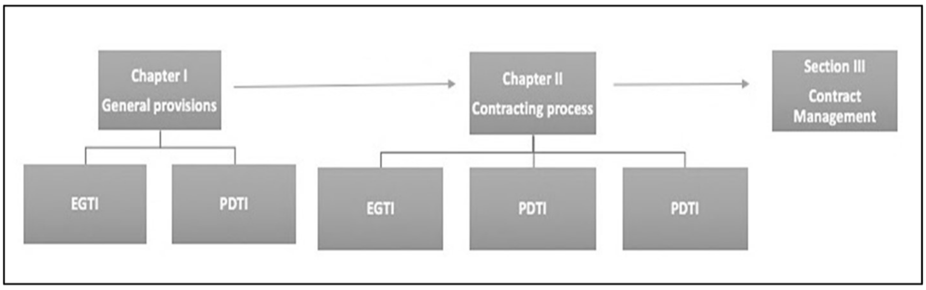

Figure 8.2. Structure of IN/SLTI/MPOG 04/2014 [SLTI 2014]

Chapter I - General Provisions - discuss the General Information Technology Strategy (EGTI), created by SISP, established by Decree 1,048 / 1994 [BRAZIL 1994]. The EGTI is reviewed annually and provides general guidelines for the FPA agencies and IT entities. Furthermore, the elaboration of a Master Plan for Information Technology (PDTI) by each agency or entity member of SISP is mandatory. The PDTI is a diagnostic tool, planning and management of resources and IT processes, which attempts to meet the information and technological needs for each agency or entity for a certain period. This document presents the evaluation and diagnosis of IT resources, the information needs identified by the government body. Moreover, it specifies the planning of investment, human resources and training, equipment procurement and IT/IS solutions hiring.

Chapter II – Contracting Process - describes the IT solutions contracting process, involving procurement planning stages, supplier selection and contract management.

Chapter III – Contracting Management - contains the elements and structure of the IN/SLTI/MPOG 04/2014.

8.3.3. FPA IT/IS Solution Hiring Guide

Public procurement related to IT solutions is guided by the IN/SLTI/MPOG 04/2014 and by the IT/IS Solutions Hiring guide [BRAZIL 2014], based on the phases and processes described in the Normative Instruction IN/SLTI/MPOG 04/2014 [CAVALCANTI 2015].

The IT Solutions Hiring Guide (GSTI – from the *Portuguese Guia de Contratação de Soluções de TI*) is a set of processes, activities and tasks for procurement of IT solutions for the FPA, which implement the definitions provided in the IN/SLTI/MPOG 04/2014 through phases that unfold throughout the process of hiring IT solutions [CAVALCANTI 2015]. The Guide, as well as the IN/SLTI/MPOG 04/2014 has three phases: (i) Planning IT Solutions Hiring (ii) IT Solution Supplier Selection and (iii) IT Solution Contracting Management, as shown in Figure 8.3.

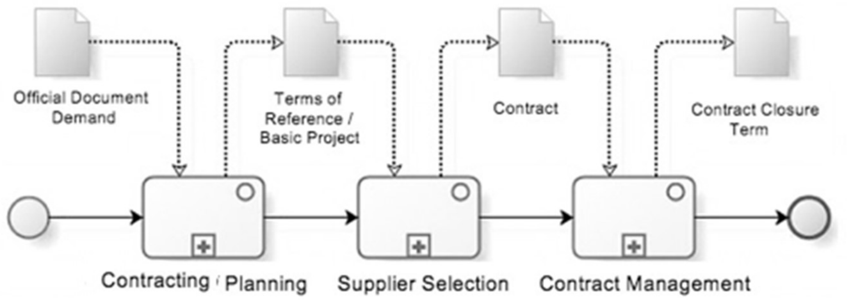

Figure 8.3. IT Solutions Hiring Guide [SLTI 2014] (Own translation)

8.3.4. Capability Maturity Models for Capability and Maturity Processes

CMMI models (Capability Maturity Model Integration) are a collection of several maturity models and a process evaluation method maintained by the CMMI Institute [GALLAGHER et al. 2010], [CHRISSIS et al. 2010, [FORRESTER et al. 2010]. The CMMI model components are grouped into constellations. Each constellation covers an area of interest, such as the acquisition (ACQ), Development (DEV) and Services (SVC) [GALLAGHER et al. 2010], [CHRISSIS et al. 2010], [FORRESTER et al. 2010].

CMMI constellations emerged from version 1.2, released in 2006, when a new architecture was introduced in the models, allowing the creation of CMMI variables that were relevant for process improvement in specific areas [SEI 2010].

A constellation is defined as a set of CMMI components that are used to build models, training materials and evaluation documents [GALLAGHER et al. 2010], [CHRISSIS et al. 2010] and [FORRESTER et al. 2010]. Among the CMMI constellations, the latest released was the CMMI for Services (CMMI-SVC) in February 2009, which extended the CMMI for Development (CMMI-DEV) and the CMMI for Acquisition (CMMI-ACQ) for the practices needed by organizations that provide services as their core business.

8.4. The Challenges

This section presents the key research challenges identified regarding the IT/IS services and solution contracting in Brazil. The challenges are related to the ability of Brazilian companies to offer IT/IS solutions to the FPA.

The challenges description format was inspired by the standard for the definition of process improvements [SOMMERVILLE and SAWYER 1997], and adapted in a format used to describe software standards [BRAGA et al. 2001]. The challenges were divided into 4 categories: i) Process definition and standardization ii) IN/SLTI/MPOG 04/2014 Structure iii) The Implementation of Good Industry Practices for software and IT/IS services and, iv) The maturity of Brazilian organizations. In addition, the challenges have been structured with the following information: Identification, Description, Classification, Related Processes in IN/SLTI/MPOG 04/2014 and Future Works. The challenges of research in IT/IS are presented in the next sections through Table 8.1 to 8.7 to facilitate understanding.

8.4.1. Process definition and standardization

This section describes the challenges related to the standardization process, which is designed to reduce process variability without sacrificing flexibility, i.e. the proper process execution considering the service provision setting and context. Therefore, flexibility is possible, making it more appropriate to the need for procurement and services provision.

Table 8.1. Challenge 1: Establishing process tailoring criteria

Identification: Establishing process tailoring criteria
Description: The IN/SLTI/MPOG 04/2014 is extensive, complex and applicable to any type of IT/IS solution procurement. The possibility to process tailoring, with criteria definition and guidelines for the adaptation according to the contract type, assists the process implementation, considering the individual needs of each contract and its context. In addition, process tailoring enables companies of all sizes to compete, without favoring companies based on their size and/or structure.
Classification: Critical
IN/SLTI/MPG 04/2014 related processes
The entire Normative Instruction with an emphasis on the phase of "Hiring Planning", in which the instruments necessary to execute the contracts are defined.
Future works: Definition of systems solution, based on project aspects, provider size and IN/SLTI/MPOG 04/2014 criteria. The solution would suggest tailoring of the process or practices necessary to support it.

Table 8.2. Challenge 2: Establishing Common knowledge base

Identification: Establishing a Common knowledge base for IT/IS services providers
Description: The IN/SLTI/MPOG 04/2014 defines document creation for services provision still at the planning stages. Documents are defined according to the needs and characteristics of each organization, reflecting their learning and organizational culture. Changing these documents demands training and adapting the work routine. Moreover, change takes time to learn and rework. A good practice is to consider the knowledge of companies providing IT/IS services because the knowledge base contains the active processes used in companies. In order to do this, it would be necessary to create such a knowledge base and demand its updating.
Classification: Intermediate
IN/SLTI/MPG 04/2014 related processes
The entire Normative Instruction with an emphasis in the phase of "Plan Contract", in which the instruments necessary to execute the contracts are defined.
Future works: Definition of a common knowledge base for providers that could help promote the lessons learned. This database must be managed by the government in order to make sure that it is maintained.

8.4.2. Structure of IN/SLTI/MPOG/04/2014

This section describes the challenges related to the Structure of IN/SLTI/MPOG 2014. It points out which demands are related to the process definition and activities at each stage for IT/IS solution procurement.

Table 8.3. Challenge 3: Simplifying procurement planning phase

Identification: Simplifying procurement planning phase
Description: The planning phase for IT solutions procurement requires a high effort and cost. One way to simplify this phase is to define what is necessary and/or required in the context of hiring elements. The requirement level from the contracting phase directly affects how the service is performed. Therefore, it is crucial that the hiring planning phase is aligned with best practices that define which items are needed for the service to be delivered according to quality criteria.
Classification: Critical
IN/SLTI/MPG 04/2014 related processes
Processes related to the IT/IS Solutions planning phase defined in IN/SLTI/MPOG 04/2014.
Future works: Designing different process profiles for the Planning Phase based on the contract size, identifying a simpler and focused way to add value to the phase goal, process profile.

Table 8.4. Challenge 4: Setting an approach to IT/IS service delivery considering the size of Brazilian companies

Identification: Setting an approach to IT/IS service delivery considering the size of Brazilian companies
Description: As already mentioned, Brazilian IT/IS companies represent around 94% of the sector. These companies mostly depend, directly or indirectly, on the government to stay in the market in which they operate. On the one hand the Brazilian Federal Government takes steps to improve the growth and strengthening of Micro and Small Organizations, while on the other, the same government requires high maturity and capability process from these companies, which is only found in IT organizations of medium to large size in Brazil. Therefore, there are gaps between industry and government that favor the emergence of conflicts.
Classification: Critical
IN/SLTI/MPG 04/2014 related processes
The entire Normative Instruction, "the tools needed to plan are defined", "execute and terminate contracts".
Future works: Designing different profiles and approaches in order to empower micro and small organizations to provide systems solutions and services for the government.

8.4.3. Implementation of Software Industry, Good Practices and IT/IS Services

This section describes the challenges related to the process definition and implementation based on good practices disseminated in industry as a way to fulfill the processes described in IN / SLTI / MPOG 04/ 2014.

Table 8.5. Challenge 5: Creating process areas for IN/SLTI/ MPOG 04/2014

Identification: Creating process areas for IN/SLTI/ MPOG 04/2014
Description: The IN/SLTI/ MPOG 04/2014 lists processes and activities that meet the various quality model practices such as CMMI model. However, CMMI models are structured in process areas that are associated with development phases. A challenge to overcome this would be the definition of process areas to relate the processes and activities in the IN/SLTI/MPOG 04/2014 to facilitate the implementation of processes in the context of provision of IT/IS services contracts.
Classification: Critical
IN/SLTI/MPG 04/2014 related processes
The entire Normative Instruction, “the tools needed to plan are defined”, “execute and terminate contracts”.
Future works: Defining approaches that facilitate the identification of processes that are present in the IN / SLTI / MPOG 04/2014 and the assignment of these processes to areas of common processes, as in models and norms of maturity and capacity.

Table 8.6. Challenge 6: Restructuring IN/SLTI/MPOG 04/2014 considering the Hiring Process Life Cycle

Identification: Restructuring IN/SLTI/MPOG 04/2014 considering the Hiring Process Life Cycle
Description: IN/SLTI/MOG 04/2014 has activities related to the Acquisition process of IT/IS solutions. However, this process is not oriented to the life cycle of the contract objects, disregarding the acquisition results, which are usually aligned with the strategic needs of the contractor and the service provider. Moreover, as the life cycle only focuses on the hiring process, the results can lead to incompatibility between the contract objects and the activities of the provider.
Classification: Critical
IN/SLTI/MPG 04/2014 Related Processes
The entire Normative Instruction, “the tools needed to plan are defined”, “execute and terminate contracts”.
Future works: Designing project life cycle and solutions that would facilitate the understanding of what should be asked and delivered at each step of the life cycle, also considering the hiring process.

Table 8.7. Challenge 7: Establishing a process standard for IT/IS service delivery focused on Brazilian industry based on maturity levels

Identification: Establishing a process standard for IT/IS service delivery focused on Brazilian industry based on maturity levels
Description: Defining a Process standard for IT/IS service delivery, considering the Brazilian industry context and in accordance with FPA demands. It enables companies of different sizes to gradually increase their capacity in process execution and management, according to maturity levels. The achieved maturity level is an elevated degree for a set of key processes, thus favoring the growth of these companies [SEI 2010].
Classification: Critical
IN/SLTI/MPG 04/2014 Related Processes
The entire Normative Instruction, the tools needed to plan, execute and terminate contracts are defined.
Future works: maturity models proposals, based on knowledge based capacities for delivering IT/IS service.

To accomplish the work, the design of goals and indicators to monitor the number of small and micro organizations providing services for the government is also necessary. Moreover, an indicator should analyze the trends in IT/IS service providers according to the organization's size. In the next section, many initiatives that address research actions to overcome and/or decrease the challenges posed are presented. It is noteworthy that the identified gaps are part of an even bigger set of challenges, prioritized in this work context.

8.5. Progress Evaluation

There has been much discussion among the FPA and TCU regarding the sustainability of actions in the IN/SLTI/MPOG. Among them, its applicability and effectiveness in supporting public procurement. Such discussion suggests a partnership between Industry, Academia and Government, so that the problems identified can be solved or reduced. Even before the creation of norms and regulations to support the effectiveness of public procurement, it is clear that this relationship lacks actions to address not only the processes and regulations of the FPA, but also the capacity of the Brazilian industry to implement the procedures presented by contracting bodies and regulatory agencies.

Although the government attempts to strengthen micro and small companies for greater competitiveness and market performance, their processes and regulations are complex and create barriers and obstacles in the provision of IT/IS services by micro and small businesses. It is important to identify the perceptions, feelings, difficulties and challenges that Brazilian companies face when providing IT/IS services to the FPA. Considering specifically SMEs and their maturity and ability, the contracting processes for IT/IS solutions in Brazil, which affect how these companies work, are a major challenge to be overcome. Therefore, research into the convergence of the IT/IS supplier-consumer relationship between SME and FPA is crucial for the growth and sustainability of the sector in Brazil.

Research carried out by Silva (2013) to map the degree of adherence of IN/SLTI/MPOG 04/2014 and CMMI models showed a strong adherence to Maturity Level 3 (ML3). In ML3, companies need to define standard processes and organizational assets. This reinforces the idea of high complexity required by FPA in the execution of procurement procedures, which is a concern for IT/IS industry. IN/SLTI/MPOG 04/2014 defines processes that are present in so-called "intermediate processes" in CMMI models. Table 8.8 presents mapping results between the IN/SLTI/MPOG/2014 and CMMI models. The mapping depicts the Normative Instruction requirements adherence to the process areas of the CMM-ACQ, CMMI-DEV and CMMI-SVC models. The adherence is expressed in the coverage degree measured in percentage (%).

Table 8.8. Requirements of IN/SLTI/MPOG 04/2014 and CMMI models

Process Areas	(%) CMMI ACQ	(%) CMMI DEV	(%) CMMI SVC
PP	100%	100%	
WP			100%
PMC	100%	100%	
WMC			100%
CM	85.71%	85.71%	85.71%
PPQA	100%	100%	100%
MA	68.75%	68.75/%	68.75/%
SAM		100%	100%
REQM	80%	80%	80%
SD			100%
OPF	11.11%	11.11%	11.11%
OPD	50%	50%	50%
DAR	100%	100%	100%
OT	28.57%	28.57%	28.57
IPM	70%	70%	
IWM			70%
RSKM	85.71%	85.71%	85.71%
ARD	100%		
AM	100%		
AVER	87.50%		
AVAL	100%		
SSAD	100%		
ATM	100%		
RD		100%	
TS		100%	
PI		100%	
VER		87.50	
VAL		100%	
CAM			16.67%
IRP			50%
SSD			91.67%
SCON			75%
SST			60%
STSM			50%

The CMMI models common areas have the same percentage of adherence due to the similarity among the specific practices in each process area.

At Maturity Level 2, the Project Planning Process Areas (PP)/Work Planning (WP), Project Monitoring and Control (PMC)/Monitoring and Control of Work (WMC) and Process and Product Quality Assurance (PPQA) achieved 100% coverage. Therefore, activities and processes in IN/SLTI/MPOG 04/2014 serve 100% of these areas specific practices. Although the Configuration Management (CM) obtained 85.71%, it lacks configuration items identification activities. Besides, the creation of baseline contracts is not defined. The Requirements Management process area (REQM) got 80%. It was not fully met due to the lack of requirement traceability for changing requirement impact analysis. Finally, the Measurement and Analysis (MA) obtained the lowest percentage of coverage, with only 68.75% due to the lack of specification of measures for monitoring and control. In addition, the IN/SLTI/MPOG 04/2014 does not define procedures for collection, storage and analysis of the measurements, which compromises the measurement system.

At Maturity Level 2, Decision Analysis and Resolution (DAR) obtained 100% of coverage. Other Process Areas obtained differentiated percentage, namely: Risk Management (RSKM), with 85.71%; Integrated Project Management (IPM) / Integrated Work Management (IWM), with 70%; Organizational Process Definition (OPD), 50%; Organizational Training (OT) with 28.57%; and Organizational Process Focus (OPF), with 11.11%. The Risk Management Area (RSKM) was not fully met due to the lack of specification of risk sources and risk categories, making it difficult to identify risks in contracts. The Integrated Project Management (IPM) / Integrated Work Management (IWM) present a lack of adaptation to process assets to guide the contribution to process assets of the organizations, which leads to the loss of knowledge generated from experiences and lessons learned from the contracting process.

The Organizational Process Definition Area (OPD) is defective in some points, such as the lack of description to guide the organization in the implementation of the procurement process. Furthermore, there is a lack of definition of an organizational measurement repository containing the organization indicators; and a lack of a standard to define work environments and training teams, in the context of the organization. Organizational Training (OT) process area does not define the strategic training needs. In addition, there are no training records, consequently, there is no evaluation of the effectiveness, which compromises the management of the organization's training area. Finally, Organizational Process Focus (OPF) presents several problems in defining the needs of the processes, identifying improvements, implementation and monitoring processes, as well as the incorporation of lessons learned in the process.

The Specific Areas of CMMI-ACQ: Acquisition Requirements Development (ARD), Acquisition Management (AM), Acquisition Validation (AVAL), Solicitation and Supplier Agreement Development (SSAD) and Acquisition Technical Management (ATM) achieved 100% compliance. The Acquisition Verification Process Area (AVER) obtained 87.50%; since this area does not define a method of peer review for verification and analysis of the acquisition process artifacts.

The Specific Areas of CMMI-DEV: Requirements Development (RD); Technical Solution (TS); Product Integration (PI); and Validation (VAL) were the areas that showed a higher percentage of compliance, with 100% coverage of specific practices. The Verification Process Area (VER) obtained 87.50%, which, as well as verification Area Acquisition of CMMI-ACQ model, does not define a peer review method for artifacts check.

The Specific Areas of CMMI-SVC: Service Delivery (SD) was 100%. Other areas had a percentage of compliance, as follows: Development Service System (SSD) with 91.67%; Service Continuity (SCON), with 75.00%; Transition Service System (TSS), with 60%; Incident Prevention and resolution of incidents (IRP), 50%; Strategy Service Management (STSM), 50%; and Capacity and Availability Management (CAM), with 16.67% coverage.

In the Brazilian context, research has advanced in relation to the procurement processes of IT/IS solutions by FPA. Several studies have led to the MR-MPS-SW, MR-MPS-SV models [SOFTEX 2015], [SOFTEX 2016], as initiatives in process improvement. In addition to the MR-MPS models, CERTICS [CERTICS 2013] was created supported by the Brazilian Federal Government to encourage public procurement of software products developed in Brazil. Despite significant advances, such initiatives address different contexts of the proposed reported challenge in this research. The provision of IT/IS services to the FPA in the context of MSEs is an emerging need, given the representativeness of these companies in the Brazilian scenario and the need for business growth.

Among all the ongoing effort, an approach to Challenges 3, 4 and 7 is being developed as a PHD thesis on CIn (Informatics Center, at the Federal University of Pernambuco).

8.6. Conclusion

The major challenge for research related to public contracts in the Brazilian Federal context involves the creation of mechanisms that both the contractor and the provider are aligned in terms of objectives, goals and direction. This challenge requires a joint effort among stakeholders, especially efforts that require researchers to understand what the processes are that affect the relationships of acquisition and delivery of IT/IS services FPA. As a result, actions can be taken to reduce the increasingly present gaps that favor both sides. Such challenges, once solved, must reduce the difficulties faced by micro and small businesses that depend on the government to remain competitive in the provision of IT/IS services.

Moreover, steps to promote free competition between companies and which are aligned with Brazilian constitutional principles should be taken. In the present scenario, given the legal requirements in services and IT/IS solutions, only large companies which are few in the Brazilian market, namely 7% (ABES 2015), can support the processes that guide the contracts with FPA. As the FPA and the TCU have sought solutions in hybrid processes of contracting services and IT/IS solutions, this effort could also be applied to the context of the definition of hybrid processes in the supply of IT/IS services and products. Such action requires joint efforts, even in the long-term, to support the maturing of micro and small organizations.

The challenges cited in Section 8.3 are critical given the fact that the Brazilian software industry and IT/IS services, as well as the global industry, works in accordance with norms, standards and best practices to develop software, systems, services and IT solutions. However, the FPA processes are based on Brazilian law, specifically Law 8.666/93 which was the basis for the development of IN/SLTI/MPOG 04/2014.

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Challenge 3 - Information Systems Complexity

Chapter

9

Full Interoperability: Challenges and Opportunities for Future Information Systems

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Abstract

This chapter describes full interoperability concept for Information Systems. Some important issues to achieve full interoperability are discussed to better understand the main differences among other levels of interoperability. Although we concentrate on discussing interoperability in three major contexts: cloud computing, the Internet of Things (IoT), and Software Ecosystems, full interoperability is an important non-functional requirement for several other domains. Finally, we discuss some ideas and present our future directions for the full interoperability approach.

9.1. Introduction

Information Systems (IS) are becoming increasingly complex, and this complexity relates mainly to the number of elements comprising the systems, including the amount and diversity of interactions that usually occur, either statically or dynamically, between these elements. IS not only provides business support to a single company, but it also meets the goals of geographically dispersed organizations. Several IS models can be viewed in the current globalized world, for example, an information system that interacts with the Internet of Things (IoT) [IEEE 2015] devices, as a part of an ecosystem platform [Jansen and Cusumano 2012] or sharing published cloud services.

Interoperability is considered as the ability of heterogeneous applications and data sharing procedures to communicate despite being on different pieces of equipment and platforms. Interoperability is usually described as having five main levels: syntactic, semantic, pragmatic, dynamic and organizational (or conceptual) [Asuncion, 2010]. Pragmatic interoperability extends aspects not covered by the syntactic and semantic. It is related to the ability of systems that collaborate to capture the desires of collaboration among those who request and send the results. While several studies have attempted to solve syntactic, semantic and pragmatic interoperability issues, few aim to tackle complex levels, such as the pragmatic, the dynamic, and the organizational. Supporting all interoperability levels for specific domain application can be considered as Full Interoperability support. In a dynamic level, systems are able to understand the changes that occur in both the constraints and the business rules, for example, and treat them properly. In addition, the involved parties expect that the effects caused by the message exchanges are those previously defined. In the organizational level, all previously described treatments are supposed to have been carried out, i.e. assumptions, constraints, and business rules are aligned [Tolk and Muguira 2003].

Considering the needs of interoperating IS, investigating full interoperability support across these systems is a challenge. Specifically, in this new IS usage scenario, we consider interoperability as a major challenge for research in the context of IoT, Software Ecosystem and Cloud Computing. IoT presents interoperability challenges, especially those regarding communication among IS and physical devices whereas cloud computing presents a scenario in which IS must deal with different and heterogeneous platforms. While IoT and cloud computing may host IS from distinct domains (e.g. finance, health, insurance, etc.)

A software ecosystem can be considered as a set of actors who collaborate and interact with a common market by focusing on software and services, along with the relationships between these actors. These relationships are often underpinned by a common technological platform which operates through the exchange of information, resources, and artifacts [Jansen et al. 2009]. In a software ecosystem, in addition to the support of the systems platform, there is a need to consider relationships and interactions between IS providers, organizations that use these systems, research institutes, funding organizations and other stakeholders who are interested in the research results, among other elements. Handling interoperability properly is a key issue in this scenario because different IS will have different requirements for interoperability support. Ecosystems offer a scenario of interoperating different IS however, with similar objectives or properties such as business process, and business rules. Nevertheless, future work must be carried out to explore interoperability issues in other areas, such as systems of systems, smart cities, among others.

This chapter is organized as follows. Section 9.2 presents the state of the art on interoperability, describing work underway on interoperability issues. Some challenges and opportunities on Full Interoperability are described in Section 9.3. Section 9.4 presents Interoperability concerning Cloud environments and its relationship with IS. Section 9.5 describes Ecosystems and Section 9.6 presents IoT both dealing with IS and finally Section 9.7 presents our conclusions.

9.2. State-of-the-Art on Interoperability

Interoperability can be defined as the capacity of heterogeneous and distinct applications to share procedures and data on distinct platforms. It is related to application collaboration regardless of the technologies used (methods, programming languages and, environments) [Bernstein 1996]. In the context of information systems, information exchange and interaction between users frequently occurs across heterogeneous environments. Interoperability is therefore a key requirement to support activities in heterogeneous environments efficiently and effectively. Different interoperability types may be necessary for communication between distributed and heterogeneous applications, for example, (i) syntactic (or technical), (ii) semantic (iii) pragmatic and (iv) organizational [Tolk, Diallo, Turnitsa 2007]. These different types of interoperability are usually related in hierarchy levels where syntactic is the most basic and organizational is the highest.

Syntax deals with the abstract study of signs and their formal relationship to each another without regard to their meaning and use. Syntactic interoperability is associated with the formatting of messages to exchange among different applications that collaborate to accomplish an activity. Syntactic interoperability is concerned with ensuring that data from the exchanged messages are in compatible formats. The message sender encodes data in a message using syntactic rules, specified in some grammar. The message receiver decodes the received message using syntactic rules defined in the same or some other grammar. Syntactic interoperability problems arise when the sender's encoding rules are incompatible with the receiver's decoding rules, which leads to (the construction of) mismatching message parse trees. Web Services standards address syntactic interoperability by providing XML-based standards.

Semantic interoperability concerns the capacity of distinct entities (transmitter and receiver) to comprehend message content meaning. Some problems arise when the message sender and receiver have a different conceptualization or use a different representation of the entity types, properties, and values from their subject domains. Some examples of these semantic differences include: (i) *nomenclature* where there are synonymous and antonyms between data, (ii) *scales and units* when different scales are used to quantify or to evaluate same data, (iii) *divergence of similar concepts*, but of different definitions are exchanged, (iv) *domain* when it involves culture differences and specific knowledge about the domain, and (v) *integrity* when there is disparity between the data integrity of the applications. It is worth noting that to provide semantic interoperability the exchanged information should ensure the same meaning for both the message sender and receiver. Data in both messages have meaning only when interpreted regarding respective subject domain models. However, the message sender does not always know the subject domain model of the message receiver. Depending on their knowledge, the message sender makes assumptions about the subject domain model of the receiver and uses them to construct a message.

Pragmatic interoperability ensures that the message sender and receiver share the same expectation about the effect of the exchanged messages. When a system receives messages, it changes its state, sends a message back to the environment, or both [Asuncion 2010]. In most cases, messages sent to the system change or request the system state, and messages sent from the system change or request the state of the environment. That is, messages are always sent with the intention of achieving some desired effect. In most cases, the effect is realized not only by a single message but also by various messages sent in some order. Pragmatic interoperability problems arise when the intended effect differs from the actual effect. Therefore, this interoperability type is usually associated with the context in which the information is transmitted.

However, we observe that the definition of pragmatic interoperability remains largely unsettled. Unlike syntactic and semantic interoperability definitions, some variations in the definition of pragmatic interoperability are currently used, and there seems to be a lack of canonical understanding.

Other definitions of interoperability can be found in the literature. For example, the definitions are usually grouped into two categories: system and business levels. By system level, we mean that the interaction is mostly between applications through the exchange of messages. By business level, we mean that the collaboration is mostly between organizations, business units, business processes, or even human actors [Legner and Wende 2006].

In this document, we named Organizational Interoperability what some authors call pragmatic interoperability at the business level. Only organizational interoperability deals with compatibility between the business requirements of collaborating parties expressed through their business intentions, business rules, and organizational policies. Collaborating parties should also have a shared understanding of the services they offer and the context in which these services are to be used. Beyond these, they should also establish beforehand and maintain during collaboration trust and reputation-related issues. Some even argue that pragmatic interoperability cannot exist if the willingness of the collaborating parties is not established at the outset [Asuncion 2010]. For smart cities, SOS ubiquitous and autonomous computing, Organizational Interoperability is a desired requirement.

Full Interoperability could be initially defined when a piece of software achieves all desired interoperability levels from the most basic to the highest. Full interoperability means the interoperability support required by a system, a system of system and platforms such as Cloud or IoT. Some scenarios will require syntactic and semantic interoperability, meanwhile others pragmatic and organizational ones. It is the developer's responsibility to define the levels of interoperability requirements to be fulfilled.

The absence of adequate support for full interoperability is a problem for system developers and users as there is a need to use a single environment or the non-automated treatment when distinct tools are adopted. Aspects related to a specific interoperability level are usually implicitly treated in their own application, generating tightly coupled systems hampering application evolution, for example.

9.2.1. Proposals for Interoperability

Interoperability has been a subject of interest in many research works. Semantic interoperability solutions are usually addressed by using ontologies and thesaurus. Pragmatic interoperability is still in its early stages, and the actual solutions are based on discovery, selection and composition of interoperable services in a specific domain and implemented at design time [Neiva et al. 2016], [Tamani and Evripidou 2006]. These solutions are based on human judgment of interoperable pragmatic services, so after human intervention, interoperable pragmatic services can be automatically selected. Currently, with dynamic problems, these solutions are not always feasible, context changes occur at runtime and a pragmatic approach between services implemented at design time does not promote effective collaboration of them.

Information Systems infrastructures are becoming more geographically distributed. This has brought new challenges and increased the need to address interoperability requirements in general. Tamani and Evripidou (2006) propose a method based on search services and user context; however, they do not advance on interoperability issues.

According to Liu et al. (2014), a large number of heterogeneous data sources and their technical factors make interoperability solutions complex. A framework is proposed to assist these complex solutions, but the authors do not explore higher levels of interoperability. Neiva et al. (2016) discuss the pragmatic interoperability solutions in Collaborative Systems domain and in general concluded that there is still a need to conduct further research to support this level of interoperability. Given these results, and what was presented earlier, it is difficult to find straightforward solutions to interoperability.

9.3. Full Interoperable Information Systems: Challenges and Opportunities

The adoption of standards has been used to address aspects of the different levels of interoperability. At the syntactic level patterns have been proposed by organizations (e.g. IEEE, OMG) to ensure the evolution of their systems. At the upper levels (semantic and pragmatic), solutions have been investigated considering specific domains. The evolution of solutions and the integration between the different levels are key issues to the establishment of full interoperability. Setting standards is necessary, but recent research has shown that upper interoperability levels require solutions that go beyond the technical aspects. While some areas opt for open standards, not proprietary, others have adopted specific solutions often based on proprietary standards.

In general, the advance in technology has led to IoT being a paradigm with challenges and opportunities. In the IoT world, multiple devices interact with multiple environments in people's daily lives expanding the possibilities of solutions that can improve their quality of life. Smart devices collect data on the network, process information, make decisions and act considering the interactions carried out. However, the connections between different geographically dispersed devices require advances in research not only regarding the support for different types of interoperability, but also on specific aspects of each domain in the world of things.

Considering the huge use of cloud applications and solutions, interoperability in Cloud Computing might enable solutions or data to move from one provider (public or private) to another cloud. One of the greatest challenges in cloud computing is "lock-in", that is, when consumers of a cloud become dependent on provider services (data or applications) and cannot change or migrate to different providers (horizontal heterogeneity), or in the same cloud (vertical heterogeneity). Establishing interoperability standards[1] has been a feature of certain proposals. The absence of broader support in interoperability can result in the following: (i) restricting the movement of organizations in relation to facilities that cloud computing can offer (ii) reduction in size of the markets of the organizations that develop and use information systems (iii) isolation of organizations in relation to technological advances.

Interoperability in Software Ecosystem (ECOS) is related to the ability of different Information Systems to connect and share services dynamically. The relationships of these systems occur to generate aggregated value for ECOS, which require the opening of its borders where third-party applications can connect and benefit from ecosystem services, creating value for the parties involved. In this scenario, it is crucial that Information Systems and their services are interoperable. Therefore, supporting full interoperability is a key issue.

9.4. Cloud Computing and Information Systems

Enterprise Information Systems users have begun to use a large number of heterogeneous applications to support their business rules. Currently, it is common to find a single company using hundreds of applications designed from different technologies, and running them on different operating systems and databases [Pokraev 2009].

Cloud computing is a paradigm in Information Systems field where computing resources such as hardware, software, development environment and other infrastructure are provided to users as services over the Internet [Shawish and Salama 2014]. The advantages of this paradigm are on-demand self-service, broad network access, resource pooling, rapid elasticity and measured service [NIST 2011].

The National Institute of Standards and US Technology (NIST) classifies cloud computing in three service level models and three deployment models. The three service level models are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS). SaaS involves all applications needed to access the resources of the cloud, PaaS corresponds to operating systems, the development environment such as programming languages and libraries, and IaaS represents all the infrastructure such as servers and storage devices [NIST 2011]. These services are organized in three deployment models according to their type and access policies: private, public and hybrid cloud [Shawish and Salama 2014].

[1] http://cloud-standards.org

Despite the advantages, Zhang, Cheng and Boutaba (2010) claim that cloud computing presents a number of challenges that need to be considered, such as security, autonomy, availability, scalability and standardization. Although a standardization process for cloud providers has been widely analyzed, its actual stage of development is far from what we need for IS. An increasing number of heterogeneous cloud providers (horizontal heterogeneous) and heterogeneous services (vertical heterogeneous) have been emerging as one of the major challenges to provide interoperability support among clouds. All levels of interoperability should be addressed to facilitate exchanges of data and applications. As the device is located on the edge of a cloud, fog computing is also heterogeneous, especially in the scenarios of the IoT, thus increasing the challenge of interoperability levels support [Yi, Li and Li 2015], [Stojmenovic and Wen 2014].

9.5. Software Ecosystem and Information System

Business Workflow [WfMC 1999] is a widely used approach in the IS context. However, the specification of business workflows is not a trivial task. It requires specialized knowledge, often interdisciplinary understanding, and some computing skills from project managers. As a result, it creates some barriers as well as difficulties in developing and reusing workflows when designed by other managers, which often leads to rework. The concept of Software Product Line (SPL) has been used in the IS context [Clements and Northrop 2001]. SPL in information system may help managers in the workflow design. However, an IS business process goes beyond this step. Complex workflows involve interactions between users, and aspects such as the use of large amounts of data and the need for this to be supported by distributed computing resources and services. Besides, they require intense relationship support among resources and services as well as among users. Such issues can be explored in an Information System ecosystem platform.

A Business Workflow specification is a collaborative activity. It goes through a life cycle that begins with the definition of the problem followed by modeling and the execution of the workflow, and finally gets to the results. During this business workflow, information can be lost and reuse opportunities for resources and services can be wasted if the supporting platform does not consider these aspects. This is also because nowadays, business workflows encompass distributed services and users. Therefore, they need to interact across geographically distributed sites. Hence, one of the challenges is the lack of an ecosystem platform to support collaborative business workflow modeling, execution, so that users can act as a unit, can consume services from third parties, and the services must relate to complete a given task.

The specification of a Software EcoSystem (SECO) to support modeling and the execution of business workflows could be a solution to this challenge, applying SECO concepts in the Information System domain, more specifically, in order to support the collaborative development of business workflows. This platform should therefore be flexible so that it can be integrated with external business applications that usually evolve in an independent and constant way. These relationships occur to aggregate value in SECO, which requires an open source code, through which external applications can connect and benefit from its services, creating value for all.

Hence, a SECO platform to support IS must be extensible and flexible. SECO must be both a service provider and a consumer of business software services, requiring the platform to be able to carry out new services integrations without substantial changes. Finally, the platform needs to be scalable, since it supports extensibility and may result in a sudden and unexpected increase in requests for services. With the aim of helping IS users during all stages of a business workflow life cycle, also dealing with high volumes of data, SECO must provide an extensible and integrated platform, supported by a peer-to-peer network. The objective is to achieve a shared environment, which allows the simultaneous presence of IS working in the same business workflow. Furthermore, large volumes of data related to the process can be processed.

Therefore, as contributions, we address two points of view: i) the developer's point of view, where non-functional requirements are evaluated with metrics, and ii) the business workflow´s point of view as an actor using the platform, collaboratively composing workflows and using third-party applications in a real context. As specific contributions, we can mention:

- Developer´s point of view
    - Specification of a distributed repository through which interactions are stored, relevant data is persisted, enabling playback of the workflow.
    - Specification and implementation of a peer-to-peer network, integrated into the platform, enabling the sharing of large volumes of data.
- User´s point of view
    - A SECO platform to support users to carry out collaborative business workflows.
    - Support during the stages of the business workflow life cycle,
    - Sharing of workflow execution data and their assets from the Software Product Line between users and application instances, using the SECO platform, and connected by a peer-to-peer network.

One important component of a SECO platform is the Interoperability Layer. This layer can help IS user collaboration in business workflow development. It focuses on the modeling phase, referring to the moment when collaboration must be intense in order to maximize service reuse, discovery, selection and composition. Thus, we propose a layer that can enhance interoperability through service discovery, selection and composition process by considering syntactic, semantic and pragmatic services aspects. These services can indicate if two or more services/application may interoperate at a certain interoperability level or not. It is worth mentioning that all communication events that occur in SECO must be sent to the interoperability layer. However, different activities performed on the platform require the support of different interoperability types as already mentioned.

9.6. IoT and Information System

The Internet of Things is based on three main pillars, namely, (i) hardware, which includes objects with a unique ID through Radio-Frequency Identification tags (RFID) associated with sensors, (ii) connectivity, which is characterized by the infrastructure that is established between objects and sensors, (iii) services and software that support the intelligence issues so that IoT can operate. The semantic web is one of the technologies that can contribute to this support. Its goal is to process collected data and give meaning to them in specific contexts. In the IoT context, objects can communicate with each other establishing Machine-Machine (M2M) communication. This communication does not necessarily have to have human intervention to be effective [IEEE 2015].

In IoT, devices, such as household appliances, vehicles, cell phones are connected to the Internet. They communicate with each other with a single goal: to improve the quality of life of people. Certainly, this entails other needs and requirements that need to be properly addressed, such as: security, privacy, interoperability and integration, among others. Security and privacy emerge as key requirements because the connected objects manipulate personal and organizational information which is accessed in different application domains. Integration is a key aspect, especially when dealing with data and information associated with geographically distributed organizations. In this chapter, we are mainly interested in interoperability between IoT devices. IoT information can be stored in clouds, thus enabling the use of IoT in any places and at any time. These concepts, associated with a software ecosystem features, contribute to the creation of an IoT ecosystem. Conceptually, IoT can be understood as a set of devices using built-in sensors to gather data. These devices act on that data over a network allowing connectivity of these devices. As a result, they also generate opportunities for users (Song et al. 2010). The use of cloud computing can be integrated into the IoT through the Cloud paradigm of Things (CoT) [Aazam et al. 2015].

Supporting interoperability and establishing standards are key aspects when we talk about the IoT. Therefore, full interoperability should be investigated in depth. There are initiatives in Brazil for research into smart cities and homes, which use IoT concepts, but we still need to advance, especially with regard to supporting different levels of interoperability. Despite the fact that standards have been proposed, adequate interoperability support is necessary due to the risk of non-appliance of standards by organizations. Moreover, the devices involved may have low market acceptance hampering widespread adoption of the IoT. In this context, all devices communicate with each other in different layers. As a result, an IoT ecosystem can be compromised without the support of full interoperability. The adoption of standards is certainly needed, as well as the existence of an Internet infrastructure that supports high quality connections (low cost, high stability and reliability, among other attributes) between objects.

Some market segments in which the IoT can be used are: (i) smart cities (public security, public lighting control, disaster monitoring and traffic) (ii) smart homes (home security, control of home appliances, and control of electricity) (ii) monitoring of diseases and drugs (iii) monitoring of agriculture and farming, and (iii) monitoring and control of vehicles, among others. These are only a few segments that present both opportunities and challenges for research and innovation in Information Systems, particularly regarding interoperability support.

In general, challenges and opportunities for Software Ecosystems (SECO) research are also applied to the IoT ecosystem, such as (i) advance in the SECO monitoring area to ensure their sustainability and longevity (ii) perform knowledge management from the network of SECO actors (iii) analyze ECOS from the perspective of complex networks to enhance strategic decision making involving SI (iii) advance in the studies of the quality of products and services in SECO, considering the advance of the IoT in particular and the importance and market investment in this technology (iv) investigate the management of SECO architecture focusing on its stability, security, among others (v) investigate ways to manage the diversity of licenses (vi) investigate the governance models related to IoT actors, objects, hardware and software.

9.7. Discussion and Future Directions

In this work, the major challenge we consider is to study solutions to support full interoperability requirement for Information Systems, focusing on specific solutions for the IoT, Software Ecosystem and Cloud Computing contexts. In addition, we consider specific application domains such as health, e-government and banking systems, among others. In other words, the challenge is to create, evaluate, modify, write, manage and explore interoperability models related to information systems in such contexts.

The adoption of the aforementioned technologies will be evaluated through the progress of researches, such as, (i) advancing the state of the art of semantic interoperability (ii) advancing in relation to supporting pragmatic interoperability in the IS context (iii) advancing the state of the art in organizational interoperability and other levels (iv) defining and coining the term full interoperability, or synonyms, especially in the IS context (v) suggesting ways to achieve full interoperability (vi) promote the adoption of approaches by industry to adopt the various levels of interoperability.

This proposal aligns with the Grand Challenges in Research defined by SBC (2015). Supporting full interoperability issues can bring significant advances in computer science researches as it can encourage the integration of information systems, considering the software ecosystems, the IoT and Cloud Computing. Moreover, it is not restricted to a single research project, but it can be applied in projects in various fields of IS, such as health, e-government, banking systems (SBC, 2015), among others, that may belong to the IS ecosystem. Moreover, there is a growing demand for interoperable solutions for public and private organizations, involving the areas of the IoT, Software Ecosystem and Cloud Computing. Advances in researches these three areas can be broken down and obtained incrementally, as technological changes occur over time.

Considering the current scenario and the increasing demand for interoperable solutions, a multidisciplinary approach emerges as a key element, especially considering the areas of the IoT, Software Ecosystems and Cloud Computing. For example, health systems require interoperation with electronic government systems and banking systems, among others. Therefore, we believe that there is a need to step up research on interoperability, otherwise we risk paralyzing research in IS which requires full interoperability solutions.

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Chapter 10

Open Perspectives on the Adoption of Cloud Computing: Challenges in the Brazilian Scenario

Glauco de Figueiredo Carneiro, Antonio Carlos Marcelino de Paula

Abstract

Cloud computing is a paradigm shift in computing that has changed the way Information System users deal with and perceive computing. This scenario has created opportunities for companies that have manifested a perceived inclination toward cloud computing and the benefits reaped by them such as low start-up cost, pay only for services used, up-to-date resources/features, and rapid deployment. However, there are challenges in the adoption of Cloud Computing, especially in the Brazilian scenario. Switching to the cloud means giving up incumbent information systems practices and facing the initial perception of losing control of data that previously had been stored in local servers. Moreover, potential adopters of Cloud Computing must face challenges related to identifying the appropriate profile of cloud services that match their needs, considering both the development of a new application or migrating a legacy system to the cloud.

10.1. Introduction

Cloud computing (CC) is a promising technology for software development, changing the way customers interact with data and applications [Di Martino et al. 2015]. Cloud computing has been as disruptive to the technology landscape as Internet was in the 1990's[1]. It has changed the way technology supports companies to deliver their services and how information is consumed. The rapid development of applications, fast response to market changes and possibilities to pay for a service on demand have boosted the adoption of cloud computing where customers only pay for what they consume. The concepts of Capital Expense (CapEx) and Operating Expense (OpEx) are important in explaining this scenario. Capital Expense (CapEx) is

[1]http://www.enterpriseinnovation.net/article/hp-research-enterprises-need-holistic-approach-cloudmanagement

a term used in accounting and means spending money on a physical resource that needs to be amortized, typically 3-5 years. On the other hand, OpEx is an upfront investment that allows a business to make payments on goods or services [2]. Leasing services and resources through OpEx has become an attractive option rather than purchasing physical hardware and database and other types of software, thus preserving important capital reserves for appropriate CapEx. Companies have the option of not buying, storing, and maintaining expensive hardware infrastructure, which can significantly reduce the time and money involved in maintaining, updating, and repairing their own equipment [Di Martino et al. 2015]. This leading to the possible benefits such as low initial cost, paying only for services consumed, up-to-date resources/features, and rapid deployment [Buyya et al. 2009], [Li et al. 2013]. This scenario enables the company to focus on their respective core business. However, there are challenges for companies that plan to adopt the Cloud Computing paradigm, in the Brazilian scenario in particular.

Brazil has the largest computing services market in Latin America followed by Mexico, Chile and Argentina. As such, it has attracted the attention of vendors from across the world and become a very competitive environment. Seizing opportunities, vendors must contend with security concerns, connectivity shortfalls, high costs and a recessive economy recently. These make the Brazilian market a challenging, yet potentially rewarding one for companies with the resources and commitment to manage these issues [3].

According to Frost and Sullivan, Brazil's cloud computing market revenue was $217 million in 2012 and it is expected to reach $1.1 billion by 2017[4]. This represents a five-year compounding annual growth rate of almost 40 percent. By 2017, the firm expects the SaaS market to lead at $584.3 million in spending, while IaaS and PaaS will be worth $489.9 million and $39 million, respectively[5]. A survey conducted in 2014 by Capgemini found that nearly three out of four Brazilian IT decision-makers use a SaaS application for enterprise resource planning or customer relationship management. Smaller but still substantial numbers reported adopting IaaS (55 percent, largely for data backup purposes) and PaaS (39 percent); and the uptake rates of both (but especially IaaS) are expected to pick up in the next few years. Some of the key motivators cited by respondents include the desire to achieve cost savings, enable innovation and raise productivity[6]. Specialists identify unlimited opportunity in Brazil, especially for over one million small and mid-sized businesses. These range from restaurants and ice cream parlors to small farms and language schools. Cloud solutions for such businesses are an affordable way to manage processes, deal with finances, comply with regulations and offer their services to the market as they pay a monthly fee for services without having to invest in infrastructure[7]. This explains why major global cloud providers such as Amazon, IBM, Microsoft, Oracle and Verizon

[2] http://ecsnamagazine.arrow.com/whats-the-difference-between-capex-vs-opex-2/

[3] http://trade.gov/topmarkets/cloud-computing.asp

[4] http://www.slideshare.net/FrostandSullivan/frost-sullivan-analysis-of-the-brazilian-cloud-computingmarket

[5] ibid

[6] www.br.capgemini.com/resource-file-access/resource/pdf/business_cloud_in_brazil_20140827_v15.pdf

[7] http://www.news.sap.com/outpacing-rest-world-latin-american-business-soars-cloud/

maintain or have plans to introduce Brazilian based data centers to support their local cloud operations, while others such as Dell, Google, Rackspace and Salesforce at least market their services in the country [8] [9]. Other foreign providers such as the German cloud heavyweight SAP, the UK's BT Global Services Prominent and Japan's Fujitsu are also present[10].

Brazil also suffers from significant connectivity challenges. The cost of bandwidth is much higher than that in other countries with competitive cloud sectors and there are clear shortfalls in the reliable provision of service and infrastructure, especially regarding the critical last-mile of delivery [11] [12].

Other studies have also mentioned that the decision towards adopting Cloud Computing (CC) takes into account issues such as the range of opportunities for migration, the attractiveness of the cost-benefit relationship and the availability of service providers to offer what best fit their needs [Li et al. 2012a], [Li et al. 2012b]. However, to address these issues, practitioners need to face challenges as described as below.

10.2. Background

CC is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. The cloud model has five essential characteristics, three service models, and four deployment models, as can be seen in Figure 10.1 [Mell and Grance 2011].

- **On-demand Self Service.** A consumer can get services from the service provider without requiring human interaction with each service provider. [Mell and Grance 2011].
- **Broad Network Access.** The resources are available through the network and standard mechanisms that promote use of heterogeneous platforms (e.g. mobile phone, tablet and desktop) [Mell and Grance 2011].
- **Resource Pooling.** The resources of the service providers (e.g. storage, processing, memory and network bandwidth) are pooled to meet multiple consumers in a multi-tenant model with different physical and virtual resources dynamically assigned and reassigned according to demand. There is a sense of geographic location independence due to no control or knowledge of the exact location of the provided resources by the consumer. However, the consumer may be able to specify a location at the highest level of abstraction (e.g. country, state or datacenter) [Mell and Grance 2011].
- **Rapid Elasticity.** Resources can be elastically provisioned and released to increase or decrease according to demand stimulus. From the consumer perspective, the resources available for provisioning will often seem to be unlimited [Mell and Grance 2011].

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[8] http://www.verizonenterprise.com/infrastructure/data-centers/latin-america/

[9] http://www.datacenterknowledge.com/archives/2014/06/05/microsoft-azure-clouds-brazil-southregion-goes-live/

[10] http://www.zdnet.com/article/sap-invests-in-brazil-cloud-facility/

[11] http://techpolis.com/its-taxing-cloud-computing-in-brazil/

[12] http://www.eubrazilcloudconnect.eu/sites/default/files/WhitePaper_Future_EUBrazil.pdf

- **Measured Service.** This refers to the capability to measure and quantify usage of resources. This is required for billing, access control, resource optimization, capacity planning, among other tasks [Mell and Grance 2011].

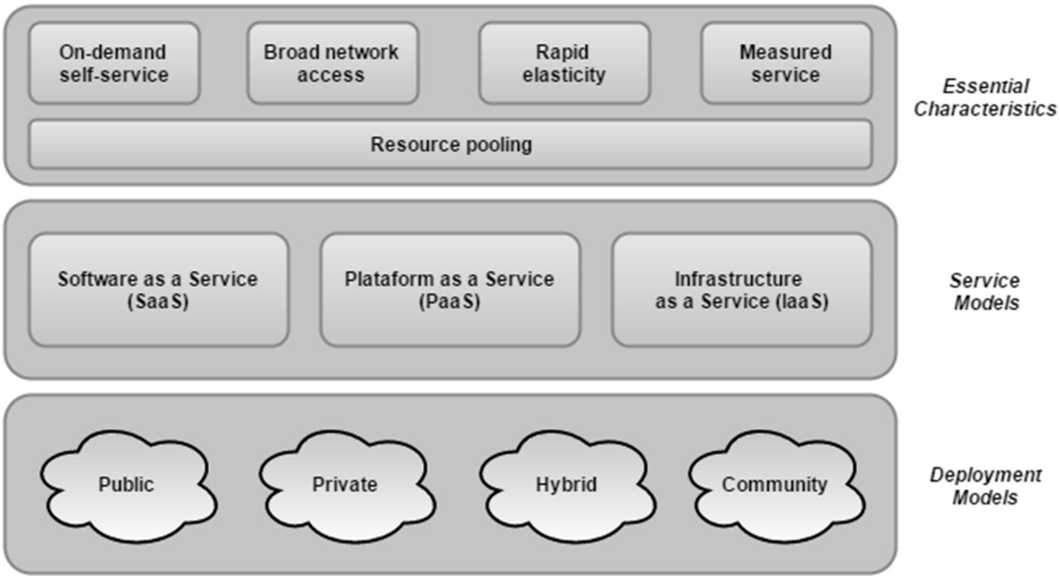

Figure 10.1. NIST Cloud Computing Model [Mell and Grance 2011]

10.2.1. Service Models

Cloud service providers usually offer service models at three levels as described in the following: software/application, platform or infrastructure (Figure 10.2).

- **Software as a Service (SaaS):** The applications running on a cloud infrastructure and can be accessed by various client devices using a web browser. In this model the service provider is responsible for providing the necessary software infrastructure, such as servers, network access and security. The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings [Sadighi 2014], [Mell and Grance 2011].
- **Platform as a Service (PaaS):** Providers of this type of service allow developers to have access to different programming languages and tools without getting involved with hardware environments. PAAS providers provide platforms and operating systems for companies so that they can develop, test and deploy their applications [Sadighi 2014].
- **Infrastructure as a Service (IaaS):** This provides the highest level of user interaction with scalable hardware capabilities (such as storage capacity and servers). The service is usually provided through virtual machines, where the user has complete control of the machine and the software installed in it [Sadighi 2014].

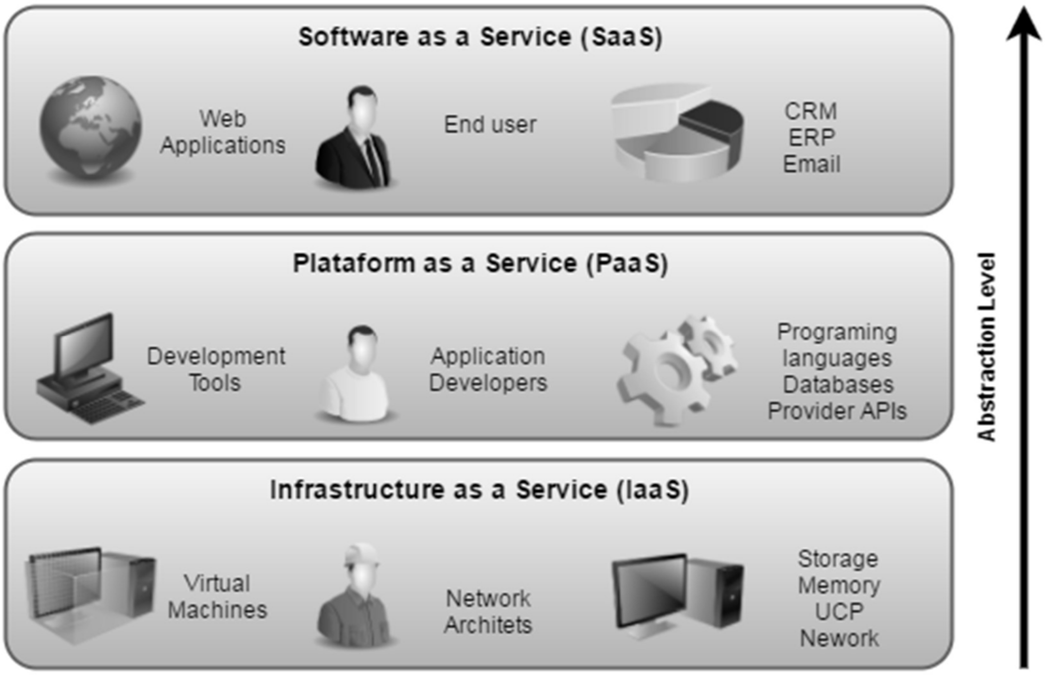

Figure 10.2. Service Model

10.2.2. Deployment Models

The deployment model is comprised of the following:

- **Private:** The cloud infrastructure is dedicated to a single organization. In this case, the infrastructure is maintained by the organization, a third party, or some combination of them. [da Costa and da Cruz 2012].
- **Public:** The cloud infrastructure is used by the general public. It is owned, managed, and operated by a cloud service provider [da Costa and da Cruz 2012].
- **Hybrid:** The hybrid cloud infrastructure is a combination of two or more distinct cloud infrastructures (private, public or community) that are bound together by standardized or proprietary technology. This technology should enable data and application portability (e.g. cloud bursting for load balancing between clouds) [da Costa and da Cruz 2012].
- **Community:** The cloud infrastructure is aimed at a specific community of consumers from organizations or groups with shared concerns. Their ownership, management and operation may be the responsibilities of one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises [da Costa and da Cruz 2012].

10.3. Challenges in the Brazilian Cloud Scenario

In this section, we present and discuss challenges considered relevant and facing practitioners in the Brazilian cloud scenario. The challenges were based on findings reported in a systematic literature review conducted by the authors [Paula and Carneiro 2016]. The authors also included information based on their experience in Cloud Computing activities in Brazil, in small and medium sized businesses in particular. The challenges discussed in this chapter focus on the adoption and migration to the cloud paradigm. **Challenge 1** is by far the most relevant due to its complexity and the need to face the other two challenges discussed in the chapter. For this reason, part 1 of Figure 10.3 points to the other two parts corresponding to **Challenges 1** and **2**. In other words, companies need to identify their business goals that are met by cloud adoption and migration with respective deployment and service models. In **Challenge 2**, we discuss issues required to define the cost-benefit relationship towards the adoption. As can be seen in Figure 1.3, **Challenge 2** is considered a requirement for **Challenge 3**. In other words, this is the suggested order for a company dealing with these challenges.

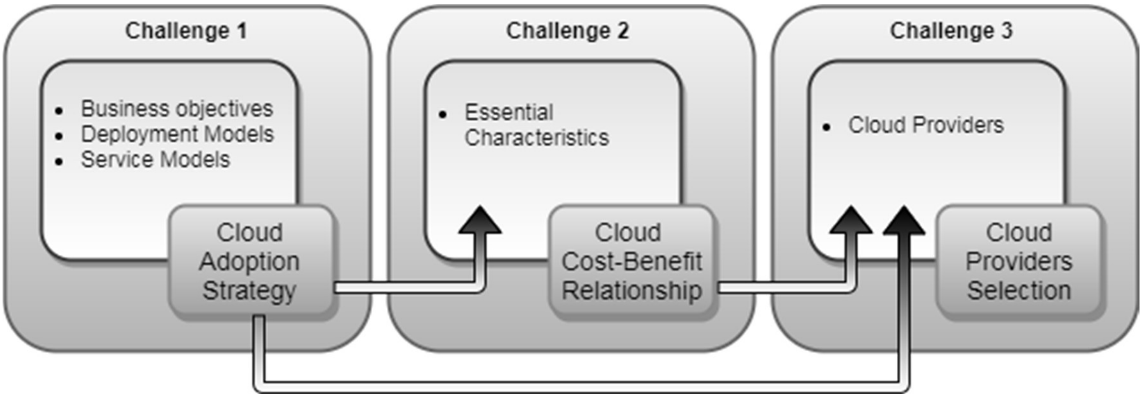

Figure 10.3. Challenges for Information System Practitioners in Brazil

Cloud Computing Challenge 1 for Information System Practitioners in Brazil: *Companies are not yet aware of effective strategies to adopt and migrate to CC.* Having access to strategies that support companies to define their goals in the CC paradigm and respective follow up to achieve them is by far the most important challenge for companies. Without effective guidelines on how to pursue it, the company cannot benefit fully from the advantages and functionalities of CC. We have previously identified a tendency for companies to adopt the IAAS model service [Paula and Carneiro 2016] to migrate their legacy systems to the cloud. In most cases, this happens because the migration process takes less effort required when supported by virtual machines that in this case represent the IAAS directly in the cloud. However, despite the lower estimated required effort, this solution through IAAS is not always the most appropriate for all migration scenarios and does not explore all the potential of the cloud resources. For many cases, PAAS would be a better choice, considering that it offers native cloud resources that can be configured to provide services of the application. On the other hand, studies have reported that the adoption of the PAAS model service poses the challenge of having to adapt the legacy system for the migration. This include the need to rewrite parts of the code, replace libraries and APIs that may not be compatible with the cloud provider environment. All these factors together contribute to greater migration effort and cost. Moreover, according to several companies, there is a lack of technical personnel qualified to perform these activities. Most of them are located in the Southeast Region of Brazil.

Suggested Strategy to Face Cloud Computing Challenge 1 for Information System Practitioners in Brazil. To deal with Challenge 1, we propose the development of an online guideline based on results of a Systematic Literature Review (SLR) focusing on this theme. This on-line guideline should be updated using crowdsourcing resources to obtain feedback from cloud practitioners regarding their experience in planning and performing the migration of their applications to the cloud. Considering the scenario of preference for the IAAS presented before, the guideline can present a set of criteria and evaluation of the cost-benefit relationship of both IAAS and PAAS adoption. Initiatives have already been taken in this direction. An example is the role played by cloud brokers. Cloud users currently face the challenge of defining an strategy to satisfy their specific requirements. Using an intermediate cloud brokering service to this end is a way to meet their requirements [Naha and Othman 2016]. A cloud broker is a third-party individual or business that acts as an intermediary between the purchaser of a cloud computing service and the sellers of that service[13]. Another definition is that a cloud-based service broker entity is a mediator between the cloud consumer and multiple interoperable cloud providers, in order to support the former in selecting the provider, which better meets user requirements [Naha and Othman 2016].

Cloud Computing Challenge 2 for Information System Practitioners in Brazil. *Companies have difficulties assessing the cost-benefit relationship for the adoption and migration to the cloud computing.* The effective evaluation of the costs and benefits of migration to CC can be used as part of its planning and reference for the selection of cloud provider(s) or, depending on the case, a solution with private or hybrid cloud.

In the cost-benefit relationship assessment, the perception of cost reduction due to the reduction of Capital Expense (CapEx) and leasing services and resources through Operational Expenses (OpEx) should be taken into account. This can be explained by the absence of the requirement to tie-up capital, to deal with technological obsolescence, hardware maintenance, as well as purchasing software licenses and depreciation allowances. In the cloud paradigm, these issues are now the responsibility of the provider.

Suggested Strategy to Face Cloud Computing Challenge 2 for Information System Practitioners in Brazil. The same guideline proposed in Challenge 1 has a section dedicated to presenting illustrative scenarios of the cost-benefit relationship assessment and discussing issues that influence the cost-benefit relationship. These scenarios can include the comparison of maintaining a legacy system in traditional infrastructure and maintaining the same application in the cloud. The characteristics that stood out in the selected studies in [Paula and Carneiro 2016] were: cost, performance and security/privacy issues. The cost is by far the most influential characteristic in the adoption of CC. Companies that adopt CC are willing to pay for resources that can be allocated in a pay-as-you-go fashion. This can lead to representative overall cost reduction as a result of several factors including: reduction in maintenance costs, energy consumption, issues related to purchasing software licenses and depreciation allowances now the responsibility of the provider, just to mention a few. For example, performance and security/privacy characteristics are issues prioritized by companies. Considering problems related to security, providers usually update and patch all software regularly to limit possible access points (also known as vulnerability shielding). The use of encryption keys is also recommended to hamper unauthorized access to the company's data. Regarding performance issues, it is possible to allocate resources in the cloud by changing settings in the provider data center and thereby getting a quick response to business needs while increasing performance at times of peak processing. This is an important factor that lead to stability in the services provided by a company.

[13] http://www.gartner.com/it-glossary/cloud-services-brokerage-csb/

Of course, planning the cost of services offered by cloud providers is not a trivial task. For this reason, several providers offer cloud cost calculators (Amazon, Google, Azure, VMware, Ubuntu) to support companies calculating their costs according to services and respective conditions that may be contracted[14] [15] [16] [17] [18]. Moreover, there are also applications on the web that support companies to plan their costs comparing services offered by different providers[19]. The challenge of selecting one or more providers according to the company's need will be discussed below.

Cloud Computing Challenge 3 for Information System Practitioners in Brazil. The selection of service providers by companies according to their needs and profile is not a trivial task. Access to lessons learned and problems raised by inappropriate selection of CC providers provide organizations with more confidence in this task.

The selection of commercial cloud providers is challenging and depends on several factors. Among other reasons, cloud providers continually upgrade their hardware and software infrastructures as well as their commercial plans. This is the result of business competition among major players in the CC scenario [Li et al. 2013]. Studies have shown that successful migration to the cloud is usually driven by a set of criteria to select providers that best fit the company needs [Li et al. 2012b] [Li et al. 2010] [Garg et al. 2013]. For this reason, mapping needs to cloud services and conditions is a good way to select providers. This will be discussed further below.

Suggested Strategy to Face Cloud Computing Challenge 3 for Information System Practitioners in Brazil. The same guideline proposed in Challenge 1 will have a section dedicated to discussing issues related to the selection of CC service providers. The idea is to update this section of the guide continuously based on data collected directly from the site of the most used and relevant providers in order to allow companies and potential users to select services as a result of mapping their needs to service(s).

There are several sets of criteria proposed to select IAAS providers. We present two figures (Figure 10.4 and Figure 10.5) with a set of criteria from two different perspectives. The first was proposed by an independent consultant[20]. The second was proposed by Microsoft Azure in an attempt to support potential clients to move to the cloud. A step in this direction is the selection of providers[21]. The two selection criteria sets are presented below using the mental maps metaphor.

[14] https://calculator.s3.amazonaws.com/index.html

[15] https://azure.microsoft.com/en-us/pricing/calculator/

[16] https://cloud.google.com/products/calculator/

[17] http://vcloud.vmware.com/service-offering/pricing-calculator

[18] https://www.ubuntu.com/cloud/openstack/managed-cloud#calculator-form

[19] http://www.planforcloud.com/

[20] http://www.techrepublic.com/blog/the-enterprise-cloud/11-cloud-iaas-providers-compared/

[21] https://azure.microsoft.com/en-us/overview/choosing-a-cloud-service-provider/

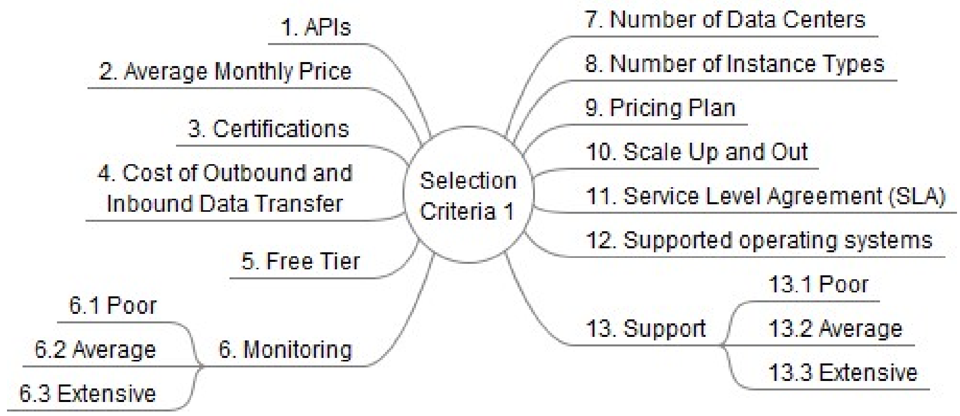

Figure 10.4. IAAS Providers Selection Criteria

The explanation of each criterion is as follows: **1. APIs:** Availability of APIs to interact remotely with the servers. **2. Average Monthly Price:** Estimated cost in US$ for a given server configuration. For example, an average Windows/Linux servers with 1 CPU, 2GB RAM cloud server (or the nearest best option), averaged over data centers for companies with location-based pricing. When available, hourly pricing should be used, based on 730-hour months. Otherwise, monthly pricing could be used. In all scenarios, data transfer costs should not be included. **3. Certifications:** Vendor compliance and security-related certifications. **4. Cost of Outbound and Inbound Data Transfer:** The cost, in US$, for each GB of outbound and inbound data sent from the server. Companies that offer a per second (Mbps) connection for free have costs listed as zero. **5. Free Tier:** Availability of a "free trial" tier for customers to test the service. **6. Monitoring:** This depends on the provider support to let customer monitor contracted services in real time fashion. The following three-level subjective scale can be used to evaluate the monitoring resources: **6.1 Poor:** Providers that have no monitoring/alert solutions integrated, requiring the deployment of third-party tools or that extra services be purchased; **6.2 Average:** Providers with very simple integrated monitoring tools (few indicators or no alerting); **6.3 Extensive:** Providers with very complete integrated monitoring tools offered for no additional cost. **7. Number of Data Centers:** The number of worldwide data centers available to deploy cloud servers. **8. Number of Instance Types:** The number of different server configurations available. Some providers offer fully customizable servers in terms of CPU, these are listed as "configurable". **9. Pricing Plan:** Providers offer pay-as-you-go (usually hourly) plans, monthly pricing plans, "membership" discounts (where the user receives a discount in usage rates in exchange for an extra yearly payment), or any combination thereof. The more options provided, the better, but the pay-as-you-go model is the most interesting stand-alone option as it makes more fine-grained usage possible. **10. Scale Up and Out:** Possibility of scaling up and out individual cloud server instances by adding/removing memory, extra CPUs or storage space or if it is possible to quickly deploy/exclude new/available server instances. **11. Service Level Agreement (SLA):** The uptime SLA offered (regardless of past performance), in percentage points. **12. Supported operating systems:** The number of supported operating systems, regardless of version, available as a pre-configured image. **13. Support:** Depending on the provider support for customer. The following three-level subjective scale can be used to evaluate this item: **13.1 Poor:** Companies that only offer on-line forums for free; any other support must be paid; **13.2 Average:** Companies that offer a single type of 24x7 support for free (either phone-based or on-line chat), in addition to forums; **13.3 Extensive:** Companies with multiple support offerings included in the base price.

There is a tendency for cloud service providers to also suggest criteria for customers to evaluate themselves. For example, Microsoft Azzure has proposed the following criteria[22].

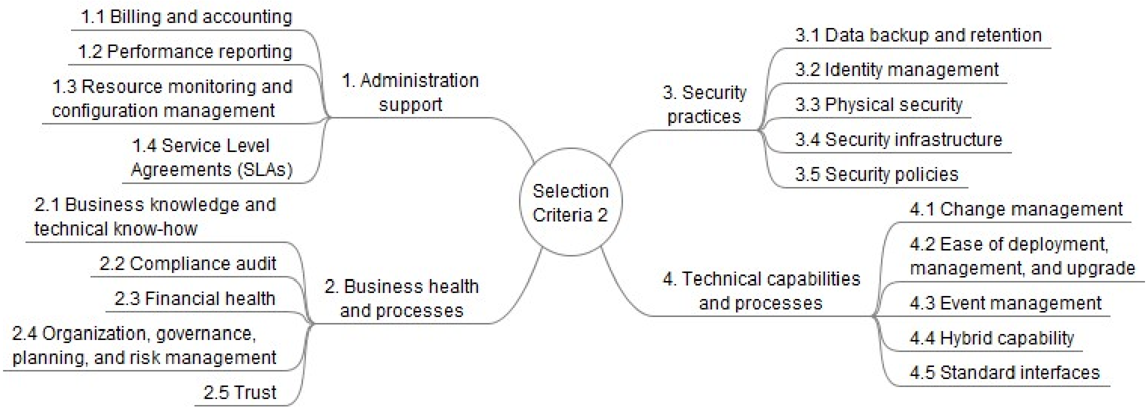

Figure 10.5. Provider Selection Criteria according to Microsoft Azure

The explanation of each criterion is as follows:

1. Administration support. 1.1 Billing and accounting: This should be automated so that customers can monitor resources and the corresponding costs. There should also be support for billing-related issues. **1.2 Performance reporting:** The provider should be able to issue performance reports. **1.3 Resource monitoring and configuration management:** There should be available controls for the provider to track and monitor services provided to customers and any changes made to their systems. **1.4 Service Level Agreements (SLAs):** The uptime SLA offered (regardless of past performance), in percentage points.

2. Business health and processes. 2.1 Business knowledge and technical know-how: The provider should understand the customer business and what the customer is looking for to be able to match it up with their technical expertise. **2.2 Compliance audit:** The provider should be able to validate compliance with customer requirements through a third-party audit. **2.3 Financial health:** The provider should have a track record of stability and be in a healthy financial position with sufficient capital to operate successfully over the long term. **2.4 Organization, governance, planning, and risk management:** The provider should have a formal management structure, established risk management policies, and a formal process for assessing third-party service providers and vendors. **2.5 Trust:** Customer should check the provider's reputation and see who its partners are and also their level of cloud experience.

3. Security practices. 3.1 Data backup and retention: Policies and procedures to ensure integrity of customer data should be in place and operational. **3.2 Identity management:** Changes to any application service or hardware component should be authorized on a personal or group role basis, and authentication should be required for anyone to change an application or data. **3.3 Physical security:** Controls ensuring physical security should be in place, including for access to co-located hardware. Also, data centers should have environmental safeguards to

[22] https://azure.microsoft.com/en-us/overview/choosing-a-cloud-service-provider/

protect equipment and data from disruptive events. There should be redundant networking and power and a documented disaster recovery and business continuity plan. **3.4 Security infrastructure:** There should be a comprehensive security infrastructure for all levels and types of cloud services. **3.5 Security policies:** There should be comprehensive security policies and procedures in place for controlling access to provider and customer systems.

4. Technical capabilities and processes. 4.1 Change management: The provider should have documented and formal processes for requesting, logging, approving, testing, and accepting changes. **4.2 Ease of deployment, management, and upgrade:** Make sure the provider has mechanisms that make it easy for you to deploy, manage, and upgrade your software and applications. **4.3 Event management:** The provider should have a formal system for event management that's integrated with its monitoring/management system. **4.4 Hybrid capability:** Even if the customer does not plan to use a hybrid cloud initially, it is worth making sure the provider can support this model. It has some advantages that the company may wish to exploit at a later time. **4.5 Standard interfaces.** The provider should use standard APIs and data transforms so that the company can easily build connections to the cloud.

10.4. Progress Evaluation

These three main challenges to the adoption of the CC in Brazil, especially for Small and Medium Enterprises (SMEs). These represent an opportunity for the Information System research community and practitioners to discuss issues related to each of them, propose strategies, as well as report and disseminate lessons learnt for companies. There is no doubt that relevant work can be performed to characterize these issues in the Brazilian scenario and therefore support the national software industry in the direction of the CC paradigm. To this end, there is room for a web portal to present and discuss the challenges mentioned in this chapter as well as others. For each challenge corresponding lessons learnt with both successful and unsuccessful scenarios can be described. Companies and providers will have access to the portal to contribute with information following a crowdsourcing model.

The authors will invite researchers from other universities to prepare a project proposal and also request national or international funding for the task. Considering that Brazil is a market with growth potential, cloud providers may be one of the interested players in this portal and be willing to disseminate their services to more SMEs Brazilian companies. Moreover, these providers will be invited to take part in webinars through the portal. The portal will then aggregate a community of stakeholders who play different roles in the cloud paradigm, including researchers, companies, customers and providers.

10.5. Final Remarks

In this chapter we discussed three main challenges faced by Brazilian companies when adopting the CC paradigm and migrating their services to it. Regardless of whether it is public, private or hybrid cloud adoption, companies need to share their experiences so that the community can discuss pros and cons regarding the cloud paradigm. They should therefore have access to the proposed web portal to provide data periodically reporting the way they have used cloud computing resources as well as potential benefits, challenges and business opportunities that this meant for their business. Data provided by these companies will also target performance issues of the services provided in the cloud. The goal is to provide a web portal to the community where data related to experience reports of real scenarios could support the evaluation of CC usage by Brazilian companies. On the other hand, this same portal can be a source of information for researchers in the sense that improvement opportunities identified in the portal can be a reference for research projects to benefit and increase the adoption of CC services and infrastructure in Brazil.

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Challenge 4 - Sociotechnical View of Information Systems

Chapter 11

Strengthening of the Sociotechnical Approach in Information Systems Research

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Abstract

The contemporary world shows evidence that the form of understanding of science and technology strengthened over the modern era has been failing to follow the agile, dynamic and heterogeneous mechanism in which contemporary society establishes its relations and its modes of operation. The rigidity of scientific approaches is strongly supported by pre-set categories and disciplines. When faced with the dynamism of society, this often causes conflict and endangers the effectiveness of research. Hence, we argue in favor of a sociotechnical approach as a mechanism to better understand knowledge construction and to enlarge the possibilities of concretization of the research in all fields of knowledge, and, in particular, in the field of Information Systems.

11.1. Introduction

The sociotechnical approach[1] seeks ways of building knowledge to be able to move in the several configurations that life presents us. This cuts across disciplinary boundaries, and does not suit a fixed language or a pre-established methodology. One must learn to be always reinventing. This is the sociotechnical challenge: learning to be in constant flux to enable productive work at the frontiers of knowledge fields.

While those may seem rather vague words, the field of Information Systems shows us how urgent and concrete this approach is: information systems are spread across our lives; are present in the most unexpected corners and cause profound changes in our way of living and understanding of life. From this diversity of contexts in which a system may act some questions arise and we address them here:

[1] In this paper, the terms "sociotechnical" and "socio-technical" have different meanings, as explained in Section 11.2.

- How to train a professional to build systems capable of operating in the various contexts?
- What skills and knowledge are required to carry out research to provide answers to contemporary requests?

11.2. Context

These issues have already been perceived by the active academic community of Information Systems in Brazil. For example, analyzing the challenges and possibilities of research in this field in Brazil, Cidral et al (2009) pointed out in "Information Systems in Brazil - Challenges and Opportunities" the need to open "the multi/inter/transdisciplinary; the continuous exercise of applied research to industry, government or society problems, in a truly integrated and joint way; and the characterization of the professional profile of a graduate degree in Information Systems, in line with the demands of industry and market". Six years later, researchers working in the implementation of electronic medical records warned (when debating the Grand Challenges in Information Systems): "If it were a matter of technique, the electronic medical record would already be in operation for a long time!" It is not a coincidence that we find two chapters in this book proposing different ways of addressing the same problem: the ineffectiveness of research in the face of life's impediments. What is missing to allow the Brazilian patients to access their health information records? What is missing to allow our research to come effectively into operation?

We argue that it is missing to take into account the sociotechnical network of which we are part. This exposes the many and various reasons that come into play in the execution of our research proposals. It is missing to relate the "technical knowledge" that we claim to have, and the knowledge considered to be "of other types", which includes, among others, the humanities. In order to understand the society, we live in and being able to deal with what we now consider "the most unforeseen issues", we need to improve our skills in relating the most diverse fields of knowledge and operate with them.

The inefficiency of systems that are often designed in isolation from the environments in which they operate and the little resourcefulness of professionals who seek to act on "strictly technical basis" have made us long to overcome the assumption that the technique alone would enable us to build systems that are sufficiently flexible, able to meet the demands of our time. As computing is a field that claims its place among the exact sciences (or at least that is thus classified in the tables of the Brazilian research funding agencies such as CNPq and Capes) we came to believe that looking straight to international technical standards we would invent correct and reliable systems. Adherence and fidelity to such standards captured our minds as much as they closed our eyes to the world we live in.

We soon realized that when we invent and configure the systems, we also invent and configure the users, defining their preferences and ways of acting [Woolgar 1991]. And along with the user, we also invent all the rest: a complex world, the environment that should host the system and enable operation. Therefore, the moment the system is put into operation used to reveal the most disastrous surprises, putting us in front of a user-world that we did not imagine. The world very rarely behaved as our systems expected. For this, the world would have to be committed to the process of co-invention: system-user-environment engaged throughout the whole design process.

Hence, we found ourselves facing the challenge of (re)knowing the world, which implies interacting beyond our expertise. At a first moment, this highlighted our lack of preparation and our refusal to deal with issues that we consider “subjective” or “humanistic”, that is, everything that seems to move away from the technical scope. We reacted and began to consider the presence of different knowledge in training. We comforted ourselves in the certainty that the socio-technical approaches (social knowledge + technical knowledge) would bring the world back, and thus avoid the unexpected conflicts that had encumbered the operation of our systems. New curricula for bachelor degrees in Information Systems have emerged, in which technical and humanistic disciplines co-exist. This is the scenario today, and from this several research proposals have arisen with socio-cultural commitment.

However, a conflict emerged that gave visibility to a deeper cultural issue: the gap between the two cultures, exact and humanistic [Latour 2014]. The disciplinary presence of humanistic knowledge, did not actually lead (or led only tentatively) to the construction of common concepts derived from the dialogue between the parties. It did not enable the invention of the world-system nor favor the construction of productive fields to stimulate the meeting and interaction of technical and humanistic knowledge.

A general scenario of dissatisfaction emerged, revealed in several ways:

- In learning, the enormous difficulties in understanding the contents of disciplines considered technical, which causes failure in alarming rates, and even the dropping out. Along with this, the depreciation of the humanistic part, generally considered “easy and unnecessary”.
- In research, the difficulty in establishing interdisciplinary research programs because of the academic overvaluation of publications centered in the field of computation, and a certain misunderstanding of the differences between *applied* research and *interdisciplinary* research (in the former, an asymmetrical relationship, in which a field provides facilities or services to another, in the latter, co-operation: building a common conceptual apparatus able to solve problems and address issues of both fields). Also concerning research, the persistence of the difficulties of effecting in society the research results.
- Finally, concerning work, the difficulty in training professionals able to respond with ease to dialogue needs and the increasing flexibility of the contemporary world. This is a key to the development of appropriate information systems.

Given this situation, what is our challenge?

Here we propose a quite different approach based on the non-recognition of the division between technical knowledge and humanities. The undermining of this division is supported by the deconstruction of the notions of “essence”, “origin” and “purification” of knowledge. This gives visibility to the evidence that knowledge is socially constructed. It is thus committed with time and place, as well as with the power relations that are configured at this time and place [Shapin 2010]. From this, we reject methods and models that are supported by interferences between a supposed “technical world” and a supposed “social world”. We reject structured, systemic approaches. The sociotechnical approach is supported in the comprehension of the historical paths of construction of knowledge, giving visibility the interweaving of knowledge and things of life and avoiding classifications such as the technical-social and nature-social divisions.

11.3. The Sociotechnical Challenge

Here we propose the challenge of a hybrid approach that can only be identified by a neologism: sociotechnical (without hyphen), a word that means that in addition to recognizing specialties and their interdependencies it is necessary to develop the ability to carry over the differences between them. This is the ability that the Information Systems professional must have to be productive in very different situations: in the dynamics of events this professional must work in the encounter between technical and social. It is a new approach to research: no longer to "make systems *for* the most diverse areas". The sociotechnical proposal is to "make systems *with* the most diverse areas". As proposed by Bernardes, Tavares and Moraes (2004) to "research *with*" society and the labor market.

The starting point for this is to assume a place of speech, that is, to make it clear not only *who* is speaking, but also *when*, *where* and *why* he speaks [Foucault 1972]. The concept of place of speech is important to highlight the inadequacy of disconnecting the subject of the discourse and the event in which the discourse was conceived [Foucault 1996]. Sociotechnical research demands a situated approach [Haraway 1988] regarding the time and place where it is enunciated. Here we see that the prospects of neutrality and universality of the modern conception of science do not meet the demands of the sociotechnical project because it does not promote the direct dialogue with society. Moreover, the sociotechnical proposal goes contrary to the aims of impartiality of modern science. It is strongly committed to its time and place. It is therefore necessary to seek a repositioning of the researcher with respect to the issue it addresses.

Let us return to the major research challenges in computing from the decade 2006-2016 [SBC 2006] to illustrate this repositioning, and see how the sociotechnical approach can contribute to the practice of research, following the dynamics of contemporary society. We will see that, although most of these challenges relate to issues considered technical, almost all proposals are supported by justifications that are considered to belong to the social field. This is not surprising since all knowledge production, even that considered to be exclusively technical, only finds meaning in life and for life, and life is society. José Mujica, former president of Uruguay, expressed this in a few words, during his visit to Brazil to receive the Medal of Inconfidence:

> (...) we are social. No one can live alone. We need a cardiologist, a mechanic, a teacher for our son. We need someone to drive the bus, someone who support us in life, a midwife at birth and a gravedigger when we die. (Part of the speech of José Mujica on April 21, 2016, Minas Gerais)

What is surprising, however, is that as soon as the challenge is recognized as important to society (in the justifications), the researcher turns his/her back to society and focuses strictly on the technique (the goals), and from this point on, there is no place left for the social.

In the decade of 2006-2016, SBC pointed out five major challenges: 1. Information management of distributed multimedia data in large volumes; 2. Computational modeling of complex systems: artificial, natural and sociocultural and human-nature interaction; 3. Impacts caused to the computing area by the transition from the silicon computer to new technologies; 4. Participative and universal access for Brazilian citizens to knowledge and 5. High quality technological development: available, accurate, secure, scalable, persistent and ubiquitous systems.

From these, only the third challenge is not justified on social grounds, relying on technical arguments to convince the reader the need for theoretical and practical researches to support the transition from silicon to modern technologies. Regarding the other four challenges, the social question appears explicitly in the fourth, in the title of the second, and predominates in the examples and justifications of the first and fifth. However, the research efforts presented in the text of each challenge are predominantly technical. This shows a clear division between the social and the technical. Society occupies the role of a beneficiary (passive, just receives the action), but offers little or no collaboration in building its own benefits. This would be a task for the technique. This scene reflects the perspective of “research for”, but not “research with” [Bernardes, Tavares and Moraes, 2004] because it seeks to escape from the encounter between the society and the researcher.

A sociotechnical approach is configured in “research with”, a repositioning: to recognize the place of the other to operate in the meeting of both. This is a hybridity of knowledge throughout the process, deconstructing the idea that the technique is the only way to achieve social progress. This same division between the technical and social is evident in the justifications (social) and goals (technical) of each challenge. The sociotechnical approach helps to harmonize justifications and goals, as it is the dialogue between the technical and social issues. It facilitates co-operation (operating together) of knowledge in its construction process. Therefore, since research has its moment of realization in society, the sociotechnical approach helps to increase the chances of successful enterprises.

Within the ten years envisioned in the Grand Challenge proposal many students in our classrooms will be working as researchers in the information systems field, this is why the fulfillment of a sociotechnical challenge starts in the classroom and continues in the profession. Therefore, we must pay attention to the coherence between the classroom practices and the proposals taught today about the development of systems and professional practices. For example, there is no point in arguing that systems should be made in a dialogic relationship with the user [Beck et al, 2001], [Wells, 1999] if the classroom environment is authoritarian, anti-dialogical, and a place where the teacher is the sole source of knowledge. Similarly, the arguments in favor of a freedom in the exercise of the profession are weakened when they come from an academic community that supports regulatory practices of teaching. In the following, we situate the sociotechnical challenge considering contemporary settings regarding society, education and profession.

11.3.1. Contemporary Society and the Sociotechnical Challenge

Since the start of the twenty-first century, Europe has been shocked by the arrival of refugees from the Middle East, North Africa and south of the Sahara. They are fleeing from the miseries of war and famine. They deterritorialize: go beyond borders. The strength of this exodus terrifies the established powers. They arrive by the thousands daily. It is a movement of deconstruction, where not only territorial borders are questioned, but borders of another kind: limits in access to citizenship. In Brazil, this century has also moved crowds. In 2016, popular carnival blocks such as “Galo da Madrugada”, in Recife, or “Bola Preta”, in Rio, dragged millions. Shortly before, in 2013, the increase in bus fares led no less than 1.25 million people to take to the streets in various parts of Brazil on a single day: June 20th. At that time, the rise in bus fares was given as reason for the demonstration, but a closer look revealed a diverse agenda, overflowing the boundaries of a single and immediate issue, a multiplicity of claims.

From this global phenomenon of questioning borders, we will argue that the scenario of computer systems follows the mechanisms of society. For example, the presence of the crowd, their hybrids and their dynamics, is clear in the field of computing. Hence there is a need for research investment to re-situate the development strategies of systems to better accommodate the contemporary mode of operation.

As in society, in the field of information systems, a crowd is not uniform, but a multiplicity, decentered, which acts to deconstruct borders, to put in check firmly established issues. A clear example is the shift of the control and decision focus in information systems. Previously, this was a prerogative of algorithms, now, it is subject to the becomings of the crowd, thus strengthening a contrast with AI-based solutions that go in the opposite direction of taking decision power and action from people to inferring and deciding for them. These new strategies of control and decision shift the crowd from the position of consumers to that of producers (not only of content) in recent systems of crowdsourcing and human computation [Ahn et al. 2004], [Ahn et al. 2008].

These trends that are now so clearly shown in various contexts followed (and were followed by) modes of thought that arose in the 1970s [Latour, 1994] when postmodern intellectuals presented alternative ways of thought. This means an alternative path to the totalizing, universal, neutral, linear, pure and rational claims of modern thought.

When we say “totalizing” we are referring to the modern scientific view that wants to embrace a whole field of knowledge. The movements of foundations of mathematics of the first decades of the twentieth century are a clear manifestation of this way of thinking, particularly the formalist movement proposed by David Hilbert to ensure consistency, completeness and decidability of the whole mathematics [Cafezeiro, Haeusler, Marques, Cukierman, 2010].

When we say “universal” we are referring to formulations that allegedly could be applied anywhere, independent of the social and cultural settings of each location. By "neutral" we refer to the understanding that the formulations do not carry with them any trace of the place and time where they were conceived and nor personal understanding of who enunciated. By “linear” we mean the concepts that take an evolutionary character, excelling linearly along the timeline, and in this path, disregarding the many redoings and interferences of several factors. By "pure" we refer to the conceptions expressed on disciplinary boundaries. Finally, by the term "rational" we refer to those conceptions that are claimed to be exclusive products of the intellect.

In short, the research in interaction with society puts in check these six qualities of the four precepts of logic of the scientific method of Descartes [Descartes, 2001], a seminal milestone in the modern understanding of science.

11.3.2. The current situation of academic teaching and the sociotechnical challenge

These ideas explored by intellectuals of the 1970s were not only perceived in intellectual and scientific circles, but they were also developed in co-construction with the arts, reaching the media, and infiltrating society. Young people who now sit in our classrooms, were born and grew up after the 1970s, that is, they are the children of this postmodern society. Their way of thinking and operating questions the rigidity of modern categorizations and claims the flow, multiplicities, the decentralization and flexibilization of the borders. Thus, we witness the restlessness to know how to relate curriculum and work, profession and life. Students seek something new, challenging what is established. They are participatory and work well together. Moreover, operating in multiple media at the same time, they do not need to complete a task before starting another and they usually obtain surprising results in what they want to do. This set of characteristics contrasts dramatically with their school grades. Complaints by the teaching staff have become commonplace, usually suggesting that the alleged "failure" of the student is due to the low quality of their high school or admission to university through social programs. However, for some of these students, academic inflexibility and the distance of themes and content regarding social dynamics are often unbearable, often leading to some students dropping out.

The *modus operandi* of academia has not been adapting fast enough for the changes that have been taking place in society. It offers young people an academic education characterized by well-defined borders: the classroom organized around a central figure, the lecturer, physically located in a position from where he/she supposedly emanates knowledge. A curriculum that ignores local identities and subjectivities and is tied on a fixed list of contents; a knowledge categorized in areas, technical and humanistic, which, at the same time reflect and determine the spatial organization of campuses. Academic activities divided into teaching-research-extension categories, which are united only in the text of the Brazilian Constitution, but not in academic practice. The division teaching-research-extension also reflects and determines the bureaucratic structure of the rectories and the division of funds. This is a scene of a university disconnected from the market and industry. Given this conflicting picture, it is not surprising that situations that had already been identified as problematic at the end of the last century have now acquired an untenable dimension. They can be directly measured and visible through dissatisfaction, dropping out, retention and the revolt of both students and teachers.

11.3.3. Regulatory policies of the profession and the sociotechnical challenge

The great adherence of the academic community to disciplinary matters, a conception of teaching that is very focused on a rigid classroom dominated by the authority of the lecturer, and the non-critical obedience to curricular content is reforced by the representative entity, the Brazilian Computer Society (SBC), by the adoption of a reference curricula and minimum content for disciplines based on international models of the ACM (Association for Computing Machinery) and the AIS (Association for Information Systems). Standardization policies for courses to achieve the quality that is envisioned in standards set worldwide are adopted. An alternative way would be to support and encourage the curriculum proposals developed in the localities, and to consider parameters of success and quality with a view to these local initiatives.

However, with regard to the profession, we see within this same community the call for flexibility and dynamic, yet expressed in socio-technical terms, based on the observation of a multidisciplinary approach. For example, the law project 1561/2003, where the SBC stands as community spokesman, ascribes to multidisciplinarity the importance of avoiding the compulsory formal education for the exercise of the profession and rejects the imposition of regulatory boards:

> Unlike other areas of human knowledge, Informatics permeates in a deep and evident way almost all areas of human knowledge. To resolve problems with suitable level of quality, in addition to technical knowledge of Information Technology, the professional must have competence in the areas of specific application, whether engineering, medicine, business, music, etc. If at first the multidisciplinary vocational training was a direct consequence of the lack of higher education courses in Information Technology, it is now a requirement to meet the demand of society for new and increasingly sophisticated applications. And multidisciplinary approach is built on the fertile grounds of freedom of professional practice. (Justifications of the PL 1561/2003, http://www.camara.gov.br/proposicoesWeb/fichadetramitacao?idProposicao=126039)

Here we see that the sociotechnical challenge is still misunderstood. The demand for multiple knowledge is acknowledged, but the separation between the technical knowledge of computers and other forms of knowledge in the various fields is clearly emphasized. Computing is presented here as an area to provide services to other areas through the construction of information systems, and not as an area that is built in the encounter with others. Finally, there is a contradictory separation between the rigidity of the mode of operation in academia and the longed-for freedom to practice the profession.

11.3.4. The research in computing and the sociotechnical challenge

In the field of research, the history of the construction of the Information Systems field Cafezeiro, Costa, Kubrusly [2016a] shows the demand for a sociotechnical approach.

At the end of World War II, the Cold War made it clear that the techniques by themselves would not meet the demand of sudden changes and quick responses required by the scenario of this new war. There arose the need for a science which would not be accomplished in the field of exact knowledge and not even in the humanities, but in the meeting of both. The mathematician Norbert Wiener coined the term "cybernetics" to refer to the sciences of border areas, a new field that would treat information in multiple views [Wiener 1985].

Later, mainly due to the discussions in conferences promoted by NATO in 1968 and 1969 [Nato 1968], [Nato, 1969], Computer Science was configured on the choice of a disciplinary science within a mathematical base. At that time, the voices against this choice were not strong enough to counteract the mathematization of Computer Science. Their understanding of computation based on “information” was a clear demand for hybrid knowledge. Only a few decades later, the diversity of fields with which the computer systems would interact again brought into the foreground the need for interaction with various areas. This showed the impossibility of fulfillment of the demands from a knowledge confined to the field of Computer Science. The curricula of Information Systems emerged, differing from the Computer Science curricula by a socio-technical perspective. The adherence to Computer Science explains why the practice in research in Information Systems is still predominantly disciplinary often disregarding the sociotechnical approach.

Today the field of Information Systems is receptive to interdisciplinary conceptions. The main reason is that information systems incorporate and give visibility to these issues of contemporary society, and therefore there is a need to understand the social dynamics and cooperate (operating together) with it. Moreover, it is a recent science whose institutionalization has occurred in a hybrid form. It is a young field, which, like the students who attend our classes, was born and raised in the wake of a dynamic, agile, flow and hybrid society. Therefore, the achievement of the sociotechnical approach is a challenge for the next decade. This means creating possibilities to operate on the border of the categories which are still shown dichotomous and isolated. Information systems can capture and respond to demands flow, dynamism and diversity of the society. Surpassing the very borders of the field of Information Systems, this learning may contribute to propose new teaching and learning concepts, new ways to accomplish the construction of interdisciplinary knowledge, spread by the various fields of knowledge [Cafezeiro, Costa & Kubrusly 2016b].

11.4. Background

As for research in Information Systems in Brazil, the sociotechnical challenge relates to the evolution of the understanding of sociotechnical studies that have arisen in the field of Software Engineering [Cukierman 2007]. This has a start point in the socio--technical approach that is based on the demarcation between the technical and the non-technical (this latter, would be the social) and proceeds in arguments based on the overlapping of these areas.

These discussions are supported by the Actor-Network Theory (ANT), which is a widespread practice in Rio de Janeiro [Araujo and Valente 2014]. The concept of 'translation' [Law 1977] provides a way to make the methods that are supposed to be strictly followed more flexible. It argues for the possibility of re-signifying knowledge according to the demands of its use. The same author also proposes the term "ontological politics" that help (re)building (re)frameworks, demonstrating that reality does not precede the mundane practices, on the contrary, it is performed from them [Mol 1999].

The Actor-Network Theory places us in the position to challenge established practices and the imposition of the hegemonic approaches, to eventually propose new ways that best suit Brazilian research needs. The reference [Bijker and Law 1992], Bijker 1995] deals directly with the sociotechnical approach, and Woolgar (1991) brings the issue into the field of users and usability. Other concepts already mentioned in this text contribute to the sociotechnical proposal to the extent that they claim adherence to time, space, event, subject, and avoid the universal approaches (those that are presented as if they were "of nowhere", or what has the same effect, "of everywhere"). The concept of "place of speech" that can be found in Foucault (1972), Foucault (1996), and the proposal of situated approach of [Haraway 1988] are in tune with ANT.

Regarding contemporary practice in the classroom and contemporary approaches to the profession, we refer to the proposal of Gary Downey for engineering studies in the US, called "critical participation" [Downey 2009]. Downey's proposal is inspired by the work of Gramsci (1999).

In Brazil, the approach presented here has its foundation and inspiration in the educational proposals of Paulo Freire [1985,1987]. Issues related to the sociotechnical approach in exact sciences are discussed in [Cafezeiro, Costa, Kubrusly 2016a].

At the Federal Fluminense University, the sociotechnical challenge is also adopted in the field of psychology in the proposal “research with” [Bernardes, Tavares, Moraes 2004]. These studies argue for a change in the researcher's stance with respect to the group related to the research seeking rapprochement, dialogue and co-construction, in the same way as the current trends in systems development argue for a constant rapprochement between user and designer.

11.5. Progress Evaluation

We list below some parameters that may indicate the evolution of the sociotechnical approach, reducing the gap between categories that today are firmly grounded in academic practice. We take as example the trajectory of the course of Information Systems of the Federal Fluminense University:

- Shortening the distance between technical and humanistic disciplines, making the dialog between them effective
- Promoting this dialogue also within disciplines considered of the technical scope.
- Basing the teaching in the flow of dialogue and debate, as opposed to supporting the teaching on the presentation of program content
- Approximating academia and the labor market by encouraging the operation of junior companies and the participation of entrepreneurs from the information technology field in the classroom, discussing the profession and market practices together with students
- Making the dialogue between teacher and student effective seeking a more participatory classroom
- Encouraging research and creation at all levels, increasing the participation of graduate students in research projects
- Working on the demand of local problems as opposed to prioritizing fixed issues, universally attributed to the area of Information Systems.

In terms of the progress evaluation of this proposal, we have seen that the most recent disciplines of Information Systems courses tend to incorporate the sociotechnical approach more easily. The greatest difficulties are in the disciplines of early training such as introduction to programming, data structures, mathematics, and some inherited disciplines of Computer Science which adopt standards considered universal or unquestionable, or that are too submissive to the models of success of the developed world. The adoption of a sociotechnical approach in these contexts involves considering the construction process of each subject, topic, result or method, to make visible the participation of the society in the formation of concepts, formulas or methods. This means leaving apparent that the process of construction of sciences is situated, that is, related to a time and place [Sawyer and Jarrahi 2014]. In addition, it is important to bear in mind that the process of construction of sciences is always committed to certain interests. Therefore, the effectiveness of the research is facilitated when the links between the addressed topic and its environment of enunciation (who-when-how-where) are explicitly addressed.

It should be emphasized that, from its beginning, the field of Information Systems shows a clear demand for the sociotechnical approach. This can be perceived by the presence of sociotechnical actors (people, society, organizations, other sources of knowledge) in the relevant problems of the field. Hence, the progress evaluation of this approach can be observed by the ease with which the sociotechnical challenge is received in its intended environments.

- Computer systems directly show the demand for a sociotechnical approach when computers require human processing to carry out their tasks (the field of human computation).
- Computer systems already incorporate culture as a key element in the construction of their interfaces, and more, today we realize that culture is reflected in the very architectural arrangement of computer systems.
- Ubiquitous systems that spread imperceptibly in our daily life only achieve success when they can capture the environment of social dynamics where they intend to operate.
- The organization of large data volumes (mining) and the organization of large volumes of work (outsourcing) require the behavioral and cultural understanding of the place where it will be supplied or used.
- Organizations now recognize the importance of other skills in addition to technical ones. This can be noted in the current forms of the dynamics of recruitment and selection of human resources, as well as in efforts and investment in work strategies in collaborative groups.
- The proliferation of social networking in specific areas, at work, at school, in family or for fun, makes the importance of interaction and collaboration clear in different situations of life.
- The need to expand participatory access to Brazilian citizens, as well as the construction of public policies for science, technology, society and innovation, and the deployment of applications to support public policies (e-learning, e-government, electronic support scientific research, medical electronics) require the observation of cultural and social issues to the same degree as technical requirements.
- The transition from competitive social paradigm for collaborative is performed in the relationship between the different areas, and therefore dialogue between these areas. Hence, the need to undo the gap between the two cultures: the world of technology and the social world.

11.6. Final Remarks

In very general terms, the sociotechnical challenge lies in destabilizing borders that today are still very rigidly established because it is in this hybrid space between the usual categories that one can realize the dynamics of the contemporary society operating in constant changes, permanently remaking itself. The sociotechnical challenge in Information Systems is to follow the flow in society, perceiving that solutions to the demands of society never exclusively belong to a single domain or discipline.

What should be done in the field of research? Researchers should be aware that without establishing in fact a constant dialogue with our society, their research will tend not to produce the desired effect. This is because, for several reasons that are not in the scope of technique, these researches are prevented from going into operation. The way to establish this dialogue is to understand the *modus operandi* of contemporary society to make it possible to negotiate with it. This requires adopting a situated practice [Haraway 1988] of research, where society is present and participating in the entire process, and not only in the justifications.

This is an issue that is becoming increasingly clear for system developers. They now realize that involving the users only at the initial and final phases of the development process increases the chances of impediments and inadequacies in the implementation of systems. Similarly, the Information Systems community is realizing that keeping society isolated in justifications of research makes it difficult, or even impossible to achieve the desired results.

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Chapter 12

Systemic and Socially Aware Perspective for Information Systems

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Abstract

Information and Communication Technology triggers changes affecting the environment in which it operates and the people who live in this environment — even those who do not use it. Information Systems are available worldwide, shaping organizations, business, governments and societies. Therefore, designing and using information systems has assumed new dimensions in terms of complexity and has required a wider and deeper understanding of the ethical and social responsibilities of those who design them. In this Grand Challenge, we argue that technical, social, legal and ethical problems in the development and use of information systems arise from a narrow understanding of information systems that does not favor the social world in which they exist and are used. Instead, we must develop and adopt a systemic view for Information Systems that considers a technical solution as part of a more complex social system in which people live and interact; a socially aware view able to understand and anticipate the demands, challenges, problems and opportunities of a society increasingly connected and mediated by interactive technologies.

12.1. Introduction

"(…) science and technology is not given. It was made by people like us. If it's not doing for us what we want, we have a right and a responsibility to change it." (Mike Cooley[1]. December 9th, 1981)

The call for papers for the Grand Challenges in Information Systems in Brazil (GranDSI-BR) highlights that "*Information Systems (IS) have been one of the main agents of economic growth and social transformations in Brazil and the world in recent decades, and the perspective is clear that they will remain so in the next years*". In recent years, the changes computing systems have triggered in economic, ethical, political issues, as well as in organized societies, have become more evident and critical [Pereira et al. 2015]. IS have caused profound changes in the way

[1] http://www.rightlivelihoodaward.org/laureates/mike-cooley/ Last access on 02 February 2017.

organizations function, businesses are defined, carried out, and regulated, and life in society is organized. Although IS is both a well-established and recognized discipline and area of computing technology, it is constantly changing, requiring permanent (re)positioning to remain useful and responsive to the demands of an increasingly technology-mediated society.

In 2015, the Brazilian government launched the eSocial® platform[2], designed to manage and facilitate the payment of taxes for domestic workers. Imposed by the federal government as a substitute for existing methods (e.g., manual payments, automatic debit), the system was launched in November 2015 and, due to technical problems, its poor user interface, a lack of understanding of the formal and informal aspects of the problem domain etc., about 1/3 of its registered employers were not able to pay their taxes and late payments were subject to fines. An article published in "O Globo" newspaper (in Portuguese) highlighted "gross errors" as the result of a poor system design, such as not considering particularities of the Brazilian zip code address, ignoring different e-mail address format, and not even paying attention to the level of knowledge and experience in the use of computer systems by the potential users, namely, the diversity of the Brazilian population. In this case, people were forced to use a system that did not allow them to comply with the imposed norms. In practice, people were fined for being prevented from complying with their obligations, not to mention the emotional and social impact on the ones who used to pay their taxes at a bank branch, and do not have access to computer technology (e.g., elderly people). The system which was originally designed to make tax payers' lives easier and to favor formal registration of the domestic work class, became an example of how an interactive computing system can be imposed and create barriers and complicate a task people had few problems performing in the past.

In September 2015, Volkswagen®, one of the largest companies in the automotive industry, admitted that it had developed a software system to manipulate pollutant emissions rates for some of its vehicles[3]. Installed in 11 million diesel vehicles around the world, the software identifies when vehicles are being tested, manipulating pollutant emission data in order to meet the standards and laws required in specific countries, such as the USA. However, when the car is in its normal usage mode, i.e., on the streets and highways, the device is turned off and gas emissions may be 10 to 40 times greater than those identified in laboratory tests. This case raised concerns and discussions on the critical importance of considering ethical issues and responsibilities in Information Communication Technology (ICT) design, an example of how a software system can (be designed to) cheat technical and legal norms.

In March 2016, Microsoft® had to deactivate Tay (acronym of "thinking about you"), its chatbot, as it became racist, cited Hitler and started supporting Donald Trump's immigration plans a few hours after it had been launched online. The chatbot was targeted at 18 to 24-year-old people in the US as part of research on conversational understanding, designed to engage in conversations via twitter and to learn from these interactions. According to Microsoft[4], it planned and implemented several filtering features and conducted extensive user studies with diverse user groups when designing Tay. However, Twitter® users were able to explore

[2] http://www.esocial.gov.br/

[3] http://www.bbc.com/news/business-34324772

[4] http://blogs.microsoft.com/blog/2016/03/25/learning-tays-introduction/#PmLozZ6PuFpz4ZY5.99

vulnerabilities in Tay, "teaching" the chatbot in a way Microsoft was not able to anticipate. Microsoft took "*full responsibility for not seeing this possibility ahead of time*", claiming that Artificial Intelligent systems feed off of both positive and negative interactions with people, making the challenges as much social as technical. Microsoft admitted: "*Tay is now offline, and we'll look to bring Tay back only when we are confident we can better anticipate malicious intent that conflicts with our principles and values*". However, Microsoft alerts: "*we will do everything possible to limit technical exploits but also know we cannot fully predict all possible human interactive misuses without learning from mistakes*".

Decades ago, Papanek (1971) drew attention to the field of industrial design, arguing that designers are not free of responsibility for the products they create and deliver to the world. Criticizing a culture centered on economic and technical issues, the author pointed out to the impacts caused by the design of products that promote bad and harmful behaviors, or even mutilate and kill people, neglecting the social context of design, the target audience and society in general. For Papanek, it was mandatory to start thinking about a socially and environmentally responsible design of products, tools and infrastructure, and to recognize designers' social and moral responsibility in this process.

The examples cited above indicate that we still live at a time analogous to that criticized by Papanek (1971), but on an ever-increasing scale. Technology triggers changes affecting the environment in which it is inserted and the people who live in this environment — even the ones who do not use it. Ubiquitous Computing, Wearable Computing, Social Applications, Ambient Assisted Living, and the Internet of Things are some examples of how computing information systems have permeated all aspects of personal and collective life in more complex and connected ways. The challenges and problems of an ICT-mediated society can neither be solved from a technically-centered perspective — ignoring the social world in which solutions are used and people live, nor be addressed with specific approaches in an isolated and fragmented way.

A technical-centered perspective has been a standard practice in the domain of Information Systems, as well as in Computer Science, partly due to a lack of knowledge and support tools to adopt (and practice) a systemic and socially aware perspective. Consequently, it is difficult to design solutions and obtain results that make sense to the different stakeholders interested in the problem domain and then produce the expected benefits for the social, technological and scientific development of a society.

Ethics, human values, and culture are intertwined with each other [Pereira and Baranauskas 2015], and seem to be critical issues for a socially aware understanding of Information Systems. Areas such as architecture, medicine, engineering and law are concerned about investigating how to build better physical spaces, provide better quality of life, developing more efficient technologies, and ensuring better organization and conditions for human life. Information Systems, as both a powerful tool and an area in itself, must take such issues seriously, encouraging its professionals — in their different roles — to be aware and concerned about how to use knowledge and solutions to improve the lives of people in their environments in a way that makes sense to them and not trigger adverse effects on the lives of individuals and communities.

In the field of Human-Computer Interaction (HCI), different initiatives have been made to identify and inspire directions in HCI for the near future. Bannon (2011), for instance, argues for a reformulation (reimagination) of the HCI discipline, exploring new forms of living with/through technologies. Bødker (2006) talks about a third wave in HCI in which new elements of human life are included, such as culture, emotion, and experience, which require new forms of understanding design of computing technology able to account for such elements. In 2007, researchers from academia and industry, from several countries and with different backgrounds, joined efforts to understand and idealize HCI in 2020 (2009); and in 2012, the Brazilian HCI research community prospected grand research challenges for HCI in Brazil for the next 10 years [Baranauskas et al. 2015]. These initiatives suggest that considering human values and understanding the cultural context of design are challenges for the area itself and for all those involved with the design, evaluation and use of interactive computing technology. Such concerns are naturally extended to the IS domain.

Particularly in the field of IS, several initiatives have been made over the last four decades to discuss and inspire the development of this field. Becker et al. (2015) presented an overview of such initiatives and presented a study with 143 IS academics to prospect grand challenges for the IS field and discipline. The authors argued that the IS field is characterized by its social context, and identified 21 possible Grand Challenges they grouped into 4 main categories: i) socio-technical challenges, ii) IS infrastructure challenges, iii) societal and ecological challenges, and iv) social and affective challenges. For Becker et al. (2015), the results suggested that the old debate on the identity of IS had not yet been overcome, as results highlight a strong concern of IS with itself (i.e., its identity, relevance, foundational theory, methodological pluralism). These results suggest the identification of challenges, but not necessarily of Grand Challenges. Nevertheless, they highlight IS as a practical discipline that needs to serve the goals of society, requiring a deep, critical and socially responsible understanding of what society requires.

In fact, when discussing a future agenda for the IS field, Walsham (2012) questions whether we, as a community, "*are making a better world with ICTs*". The author highlights that dramatic changes have occurred over the last decades, with ICTs being spread over almost all countries and becoming pervasive in many areas of human activity. Such changes raised concerns that the research contribution of the field could have got lost and that the field itself could be in decline, and the author suggested that an agenda focused on ethical goals should be mandatory for the field to remain relevant and offer a unique contribution.

In this chapter, we highlight as a Grand Challenge the concept and adoption of a Systemic and Socially Aware Perspective for Information Systems, focusing on ethical goals and considering a technical solution as being part of a more complex social system in which people live and interact. Such a perspective could serve not only as a theoretical and methodological framework, but also as goal to pursue, helping to characterize the area's unique contribution to science and technology for a better world.

12.2. Background

In 1959, Hall had already found that introducing or changing a technology is the most powerful way to promote changes in a culture and to redefine a society. In different ways, contexts, and dimensions, technology has affected our lives: the ways we work, study, eat, interact with each other, understand time and space, and live. More and more life is being mediated and influenced by ICTs.

When studying and discussing culture as a form of nonverbal communication, Hall (1959) introduced the notions of informal, formal, and technical levels in which humans operate and understand the world. The informal represents the culture, values, habits, beliefs, behavioral patterns of people and other aspects that are usually difficult to describe and even identify. The formal represents aspects that are well established and accepted, becoming social conventions, norms, or laws. The technical level represents aspects that are so formalized that they can be automated or approached in a technical way. According to Hall, each level is present in any situation, but one always dominates at a given instant of time and we deal with them separately — i.e., when we focus our attention on one level, the other two levels are in the background, intertwined with the one in focus. The author explains that, sometimes, the shifts (and boundaries) between these levels are subtle and rapid, but such shifts are the basic requirement to understand the process of change in a society.

Organizational Semiotics theory proposes a structure named Organizational Onion [Stamper, 2000], also called "Semiotic Onion", to explain how the informal, formal and technical levels coexist in the context of organizations and information systems — see Figure 12.1. The central idea is that any technical artifact is embedded in a formal system that, in turn, is embedded in an informal one. It means that a technical information system, for example, is capable of automating or implementing only part of a formal information system that exists in society and is composed of norms, rules, laws and regular patterns of behavior, which in turn, exist in an informal information system that is part of the social world where people live, interact with each other, develop their values, have their needs, expectations, dreams, intentions, etc.

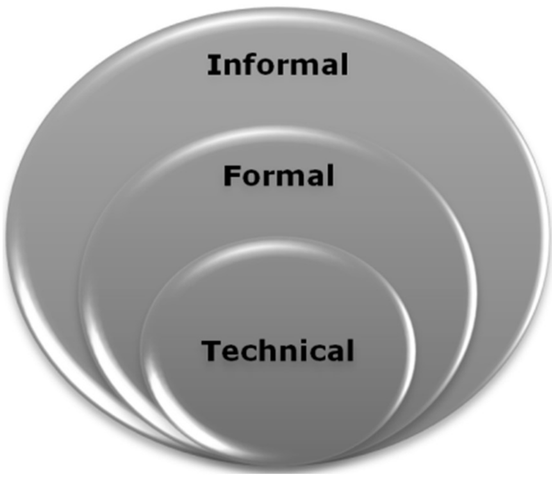

Figure 22.1. The Semiotic Onion

Organizational Semiotics [Liu 2000], [Liu and Li 2014] considers an organization and its information system as a social system in which human behaviors are organized according to a system of norms. For Stamper et al. (2000), these norms govern how the members of a community think, behave, make judgments, and perceive the world, and are directly influenced by their social context. Organizational Semiotics explores the use of signs and their effects on social practices, providing a set of methods (e.g., Problem Articulation Method, Norm Analysis Method) and artifacts (e.g., Stakeholders Identification Diagram, Semiotic Ladder, Ontology

Charts) to deal with information and information systems in a balanced way, considering technological issues as well as human aspects of information resources, products, and functions.

In a social responsible perspective, Baranauskas (2009, 2014) articulates ideas inspired by Organizational Semiotics [Liu 2000] and Participatory Design [Schuler and Namioka 1993] to propose a framework that considers a dialogue with design materials and mainly among individuals in their different roles (e.g., designer, developer, user, other stakeholders) to conduct participatory work in interactive system design. For this author, the technical aspects of system design depend on and impact the formal and informal aspects of organizations and society. A technically centered perspective (i.e., focused on the onion's core) prevents those involved in a design context from a wider sense-making of the problem being handled and the solution being proposed.

Instead, Baranauskas (2009, 2014) argues that any design process must be understood as a movement from the outside to the inside of the Semiotic Onion: a social process that starts in society, crossing the informal and formal layers of signs towards the construction of the technical system — see the arrows in Figure 12.2, returning from the technical layer and impacting the formal and informal layers, and society. When moving from outside to inside the onion, the movement favors the identification, articulation, and formalization of relevant aspects of the social world (e.g., stakeholders' values, culture, expectations, tensions), generating new knowledge and awareness of the social context. Therefore, when returning, moving from inside to outside the onion, the movement occurs in an informed way, reflecting an understanding of the social world, making sense to stakeholders and, potentially, promoting acceptance and adoption.

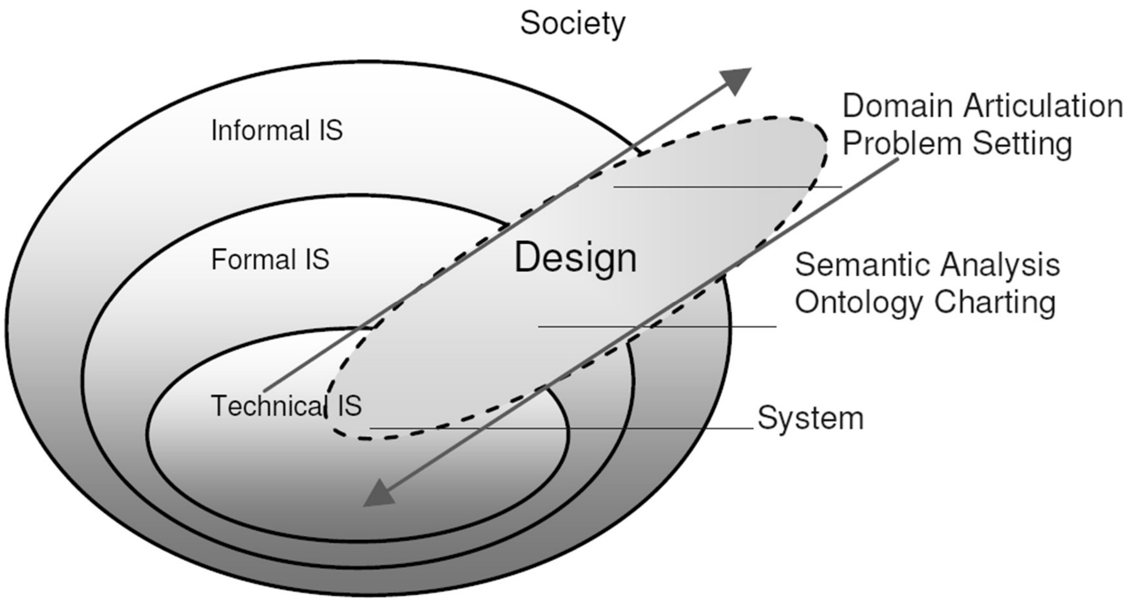

Figure 12.3. Baranauskas' (2009) Social Responsible Perspective for Design

The dashed ellipse in Figure 12.2 represents the design process of a technical information system in action: the process starts in society, i.e., it is triggered by the social world (to solve a real-world problem, to advance an existing solution, to provide a new service, etc.), it crosses the informal layer where activities are carried out to understand the problem (e.g., identify the stakeholders, their cultural differences, needs, interests, and expectations). Then, design progresses from the informal to formal layer where design activities support the identification and organization of requirements, the decision-making informed by the knowledge constructed during problem understanding, and the solution modeling. The process continues towards the construction of a technical system through activities that support interactive prototyping, the codification, experimentation of design alternatives, and their evaluation.

The dashed ellipse indicates that the process does not finish at the technical level, but continues crossing back to the formal and informal layers and returning to society. This means the design product will potentially trigger changes that may require updating the system model, reviewing agreements, justifying design decisions, as well as impacting established processes, formal norms and laws, and people's daily practices. Therefore, the design product also impacts the shared understanding about the problem and solution, its importance to the different stakeholders, the way activities are performed, valued or needed, and so on. The design process progresses iteratively and incrementally as much as necessary. It starts before the problem is understood and a solution is proposed, and lasts while the technical system is triggering impact — the disposal or replacement of the designed technical system is also part of the movement. Once a technical system is designed and delivered, it changes society irreversibly. Therefore, systems must be designed from a systemic and socially aware perspective, not as a mere technical component.

12.3. The Grand Challenge

The "Systemic and Socially Aware Perspective for Information Systems" Grand Challenge urges us to move from a technical centered perspective of information systems to one that recognizes and considers a technical solution as being part of a more complex social system in which people live, interact, develop their cultures and values, and organize their societies. Such a perspective must be informed and enriched by ethical goals, such as favoring the participative and universal access of people to knowledge [Medeiros 2008], promoting quality of life [Bannon 2011], reinforcing democracy and social participation, etc.

As we discussed previously, a technical centered perspective to IS narrows our understanding of the social context in which it is/will be delivered and operate, making it difficult to anticipate the impact and consequences of its introduction as well as obtain results that make sense to the different stakeholders directly or indirectly involved in the problem domain. It easily results in systems that violate legal norms and ethical issues — such as the case of *Volkswagen*®, that behaved quite differently from the expected or desired when the system was designed — such as the case of *Microsoft's*® *Tay*, and that generated difficulties for people, changing their tasks and environments in a way that did not make sense to them, triggering negative psychological, economic and social effects — as the case of the *eSocial* platform. Therefore, when we talk about a "systemic perspective", we talk about considering the technical system as part of the formal system, which is part of an informal system built by people in their social world.

However, a systemic perspective is not enough, as it can be "cold" disregarding its social responsibility and insensitive to the real needs of a society and its ethical concerns. When talking about Ambient Assisted Living, Bannon (2011) mentions how often designers and researchers develop products and carry out research hoping they will support elderly people to have a better quality of life at home instead of in an institution. However, looking more carefully, their research outcomes end up providing fulltime remote monitoring of these people instead of adding to their dignity or empowering them to remain autonomous, managing their privacy, keeping in touch with their friends. This is what usually happens when we think of technology before people, and when the concern with the key people (e.g., the elderly), their real needs, concerns and values are not actually primary, but secondary.

The design of educational technologies, especially for disabled students, usually suffers from the same “good will but narrow view” problem: designers, researchers and teachers are often interested in promoting students learning, developing their abilities, capacitating them to use technology, etc. However, although these studies usually strive for user-centered design and defend the idea of universal access and social inclusion, on looking more closely, their outcomes end up automating activities and procedures already conducted in the classroom. They expect students to achieve a “normal performance”, and evaluate students based on pre-defined parameters instead of it naturally making sense to them, adding to their quality of life and promoting their welfare. Such a technical centered perspective very often blinds us to the understanding and to the design of new solutions and strategies that consider students and their particularities, so that students can develop the abilities necessary for their context of life, promoting their own progress.

As Lee (1989) argued, “*neither a computer nor the teaching of computer science has any value or meaning outside of its impact on people*”. We think that the IS community in Brazil has a role to play and a responsibility to face: designing systems that improve the lives of people in their environments, in a way that makes sense to them and not trigger adverse effects on individuals and their communities. This naturally includes the concern for universal and participative access, designing systems that can be accessed by everyone, to the greatest possible extent, without discriminating [Baranauskas and Souza 2006]. Therefore, when we talk about a “socially aware perspective”, we talk about a socially responsible, participatory and universal design of IS, both as process and product. If we want the Information Systems community to contribute to the scientific, economic and cultural development of Brazil, then we must adopt a socially aware perspective to our research, development and teaching practices.

The Brazilian context is intrinsically complicated: the country has continental dimensions, a population of more than 200 million people, a diversified culture, and is traditionally marked by social inequality. Although Brazil experienced rapid and profound transformation in the last decade, its limitations and inabilities in critical areas have become more evident (e.g. education, science and technology, healthcare, infrastructure and security, etc.). Scientific and technological development is a crucial factor in overcoming these limitations, but the benefits of development are only achieved and felt dimensions if it occurs in a socially responsible way.

Recognizing the complex and challenging context of Brazil, the Information Systems community has an important role and the unique responsibility to direct efforts towards producing studies and results that help to overcome the challenges of designing better solutions for our society. The Grand Challenge presented in this chapter requires a change in posture and organized work from the Information Systems community with implications and requiring effort in several dimensions, such as:

- Conceptual: there is a need for theories formalizing systemic approaches to the design of information systems, especially considering applications for all in the mobile and web domains. The explicit involvement and consideration of ethical issues require explicit articulation of different areas and fields, and must be part of such approaches. The background presented in this chapter can serve as a starting point.
- Methodological: there is a need for new process models for IS development that see IS under a systemic and socially-aware lens. New artifacts, methods and tools in line with that lens are needed to support such processes. New practices are also mandatory as social participation and engagement are key for a systemic perspective. Participatory [Schuler and Namioka 1993] and Universal Design [Preiser and Ostroff 2001] can serve as a basis to rethink current practices and inform new ones.
- Educational: the conceptual and methodological dimensions require us to rethink our IS curricula, especially for computer science, engineering and related fields, to enable our professionals not only to have a wider understanding of the products of technology they are building — sensitive to the different needs, competencies, and social values of systems — but also to an ethical understanding of the problems they are trying to solve, the methods they are using, the practices they are planning and conducting, the impacts they are triggering, and the social responsibility they have.
- Cultural: the previous dimensions demand a shift in our position while researchers, scientists, teachers, and practitioners. It demands us seeing the people prior to the problem to be solved, the social impact prior to the technology to be designed, and the actual needs of stakeholders ahead of automating tasks. Such a shift must be reflected in our research projects, methods, curricula, academic forums, debates, etc. The challenge presented in this chapter requires the IS community to embrace multi-disciplinarity and actually to conduct multidisciplinary work — with other fields of Computer Science (e.g., Human Computer Interaction, Software Engineering, Computing Architecture) and other areas of knowledge (e.g., Sociology, Psychology, Linguistics). It is necessary for the community to rethink its own practices, theories and methods, which clearly have contributed to the field, but that seems not to account for the complexity of a scenario where IS is not only used, but is already part of our lives.

12.4. Progress and Evaluation

Concrete examples that could benefit from the results in this challenge encompass any kind of technical information systems, especially those dealing with critical or dependable information (e.g., healthcare, education, financial, security, logistic domains), easily reaching society via better services and solutions, reducing costs, improving performance, favoring access to knowledge, and so on.

Research benefits involve all society, and the Information Systems community will profit from the advances in this challenge, with new concepts, artifacts, methods, practices and tools, as well as the socialization of practical experiences and case studies. Such benefits will naturally extend to other disciplines of Computing Science concerned with the design of interactive computer technology, such as Software Engineering, Informatics in Education, and Human-Computer Interaction. Other scientific domains related to this challenge may also benefit from its advance, such as Business strategy, Economics, Sociology, Design, Education, etc.

As suggested in the previous section, a Grand Challenge requires investigation and advances in different dimensions that are equally challenging, such as the conceptual, methodological, educational and cultural ones. The progress in this challenge's different dimensions can be promoted via public forums in local, national and international conferences dedicated to debating new concepts, theories, methods and practices for systemic and socially aware approaches — the Grand Challenges initiative conducted by the Brazilian Information Systems community is an example itself. Short courses, workshops and online communities can support discussing challenging problems, sharing and socializing new experiences and their results, generating and evaluating new knowledge, and so on. The curricula must be revisited to reinforce ethical issues, social and participatory practices, as well as to provide practical experience for the students, developing their critical thinking instead of only specialized abilities — as Einstein defended several decades ago [Fine 1952]. Experiences in real scenarios, with multidisciplinary teams and in participatory ways, are very interesting and important contexts to develop, study, analyze, apply and evaluate new concepts and methods with the potential to produce technical results in terms of the designed solutions.

Direct and indirect indicators can evaluate the progress in these dimensions, also serving as a possible list of actions to support such progress, such as:

- Number of initiatives to promote the discussion on this challenge and the dissemination of results and advances (e.g., workshops, tutorials, keynotes, panels);
- Appearance/inclusion of the challenge and related themes as topics in the call for papers of IS conferences and journals;
- Number and type of publications (books, journal and conference papers, abstracts, posters, social media contents) citing the challenge, contributing to its advance, using it as a context, criticizing it, promoting its discussion, etc.;
- Inclusion of topics related to the challenge in the curricula of information systems disciplines and courses;
- Volume of call for research projects, in terms of number and funding, that support research in the context of the Grand Challenge;
- Number and examples of technical information systems designed from the perspective proposed by the challenge;
- Initiatives that explicitly align information system development with social practices with stakeholders;
- Consideration of the challenge, and its related topics, as explicit research lines/projects of research groups;
- Number of PhDs and Masters carrying out research to advance the challenge;
- Formation of partnerships and networks between different research groups, institutions, and public and private sectors to develop research and applied work on related subjects;
- Public surveys on the nature of research projects being conducted, the kind of approaches and methods used, the background theories adopted, and so on.

Advancing a Grand Challenge requires a coordinated effort from the entire community, with periodic reviews of goals and directions, and monitoring the progress being made. It is essential for the community to keep the challenges in mind and explicit in their calls, events, discussions, teaching practices, etc., looking for partnerships with the public and private sectors in order to obtain results that benefit society.

12.5. Final Remarks

In this chapter, we presented the conception and adoption of a Systemic and Socially Aware Perspective as a Grand Research Challenge for Information Systems in Brazil. We argue that we must revisit and rethink our practices in order to remain relevant and to produce effective contributions for a society which is increasingly mediated by ICTs in a country marked by social inequalities and chronic problems.

We argued and presented different examples demonstrating that a technology cannot be detached from the social context in which it was designed and delivered. Computing Information Systems, and computing artifacts in general, are produced through intentional and rational processes influenced by the background of different stakeholders, and are delivered in environments where several different stakeholders exist, who have different interests and both cause and suffer direct or indirect effects from its introduction. Computing artifacts permeate all the aspects of people's lives, not only solving problems and automating tasks, but also connecting people, mediating complex social interactions, allowing the expression of creativity, play, learning, etc. Therefore, the concern with computing artifacts cannot be restricted to their designed functions and quality attributes, but they should include a concern for the environment in which they are inserted, the people that live in that environment, the possible uses they can serve, and effects they may trigger.

In this sense, we argue that it is not possible to design computing information systems that make sense to people and their organizations, and that reflect an understanding of — and respect for — stakeholders' social world if designers pay attention solely to technical issues. It is important to begin by understanding the informal and formal aspects of the design context as profoundly and broadly as possible. Like the movement started by Papanek (1972), it is critical to challenge the way information systems are designed, moving from a technically-centered perspective to a socially and ecologically responsible design of systems, their infrastructures, and the tools used to build them. Information Systems, as a community and a discipline, can achieve its potential to contribute to society only if stakeholders are identified, understood, and involved accordingly, and if professionals are able to pay attention to the genuine needs of these stakeholders, considering the dynamics of their social context in a responsible way.

The idea of formulating Grand Research Challenges has been adopted in several countries and in different areas of knowledge. For ICT and Computing in Brazil, the Brazilian Computer Society had a pioneer initiative in 2006 [Medeiros 2006], and the Human-Computer Interaction community conducted a similar initiative specifically for its field in 2012 [Baranauskas et al. 2015]. Both the initiatives seem to have helped in the formulation of a long-term research agenda, influencing researchers, practices, conferences, and even public policies on research funding, as happened with 2006's Grand Challenges. We hope this initiative is the first one in a series of events and publications. We believe it can contribute to significant changes and advances not only in the domain of Information Systems, but also in Computer Science and its applications, mainly with regard to producing interactive technology for the scientific, economic and social development of the country, in a participatory and universal way.

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Chapter 13

Technological and Human Challenges to Addressing Death in Information Systems

Cristiano Maciel, Vinícius Carvalho Pereira

Abstract

The area of Information Systems is being challenged by new cultural and technological scenarios to address the phenomenon of death in the light of technical, cultural, legal, ethical and affective principles. Besides, there is an urgent demand for project solutions to digital legacy bequeathed by deceased users.

13.1. Introduction

Death is part of life; therefore, it should be properly addressed in computational environments. As technology develops, information systems that used to store data in a desktop computer (with a single user logged in) have undergone drastic changes. Nowadays the number of multiuser and distributed systems are growing with the result that data are stored at different locations and in different manners to be accessed individually or collectively. However, what happens to the data when their owner dies?

As we know, humans are essentially social creatures. Therefore, their presence in web environments and the complexity of modeling systems that represent human relations in the real world are challenging tasks [MACIEL 2011]. These involve addressing their post-mortem digital legacy, a promising new area in which Brazilian researchers have made major contributions. The end of life is an interesting research domain for many reasons – multidisciplinary, social and cultural ones –, especially due to the technological challenges to addressing this issue.

When it comes to the fate of someone's digital legacy, control mechanisms may be created so the user can: a) name a person who will be responsible for the contents in that system; b) opt for the immortality of his/her digital life; or c) program the account to be deleted if a definite set of actions are no longer performed. However, modeling such mechanisms, especially within the social web and all its social network applications, is a complex task, which must be carried out considering users' needs (functional requirements) and the characteristics of the product (nonfunctional requirements). Despite these challenges, the great number of social applications on the web entails the creation of digital spaces where cultural practices regarding death are performed. See for instance, digital memorials, i.e. web environments that allow users to pay homage to the dead [LOPES, MACIEL, PEREIRA 2014].

Considering different goals for the creation of Digital Heritage Management Platforms (DHMP), based on literature review and on an analysis of related systems, Oliveira *et al*. (2016) propose four sets of functionalities: a) messages – functionalities to send previously configured messages; b) memorial – functionalities to create online memorials; c) management of digital heritage; and d) digital immortality – functionalities to create a bot/avatar that simulates the user's behavior. According to the authors, those functionalities are aimed at creating a cloud-computing platform.

Given this background, issues related to users' death are presented here as challenges to the development of information systems. The great challenge for the Information Systems community is to investigate how to address death and design solutions for digital legacy systems in light of technical, cultural, legal, ethical and affective principles. This article is based on a literature review, on previous studies we have conducted [MACIEL 2011], [MACIEL; PEREIRA 2013], [MACIEL; PEREIRA 2015], and on the analysis of websites and social web systems.

13. The theme in different communities

In 2009, for the Brazilian Internet Steering Committee (CGI.br) to base and guide its decisions according to fundamental propositions, ten principles for the use of Internet in Brazil (CGI.Br 2009) were established. Among others, these principles include freedom; privacy and human rights; innovation; functionality; security and stability; and a legal and regulatory environment. These principles meet the goals of this article, and results from research in this area can help address death within the realm of information systems.

The Brazilian Computer Society established the Grand Research Challenges in Brazil from 2006 to 2016 [MEDEIROS 2008]. Among the five research challenges, four are related to the issue discussed here: Management of information over massive volumes of distributed multimedia data; computational modeling of complex systems: artificial, natural, socio-cultural, and human-nature interactions; participative and universal access to knowledge for the Brazilian citizen and Technological development of quality: dependable, scalable and ubiquitous systems.

In 2012, the Human-Computer Interaction Special Committee (CEIHC), from the Brazilian Computer Society (SBC), launched a call for "GranDIHC-BR: Grand Research Challenges for Human-Computer Interaction in Brazil", within IHC'12. At the time, researchers from the area identified great challenges, detailed in [BARANAUSKAS, de SOUZA, PEREIRA 2014]. Among these challenges, the ones related to human values stand out: privacy in the connected world and posthumous interaction and post-mortem digital legacy. In turn, these aspects entail a subsequent challenge: professional development for HCI and the market because systems related to post-mortem issues have been developed by companies that discovered this novel and promising market niche. From then on, there has been growing interest in themes related to death and digital legacy and research within the HCI community has been fostered.

At the international level, the association between technology and death has attracted the attention of the academic community too, resulting in conferences, papers and books. For instance, members of the Brazilian community organized the book *Digital Legacy and Interaction: Post-Mortem Issues* [MACIEL, PEREIRA 2013] in 2013, at the invitation of Springer. This invitation was made considering the impact of the first papers by the authors [MACIEL 2011], [MACIEL, PEREIRA 2012], [MACIEL, PEREIRA 2013) about death and HCI. The book is an international and interdisciplinary work as it contains chapters by researchers from different countries and fields, such as Computer Science, Design, Languages, Arts and Law. In 2015 a paper presenting the challenges posed by death and mortality to human-computer interaction was presented to the international community [MACIEL, PEREIRA, 2015]. These studies, as well as others from related issues should be shared among different communities, especially the Information Systems one, where such discussions are still incipient.

14. Some studies in the area

Before we discuss some studies in the area and the challenges researchers have been faced with, it is important to understand the main concepts related to death, mortality and legacy regarding technology. Carroll and Romano (2010) define that "a digital legacy is a summation of the digital assets you leave behind to others. As the shift to digital continues, the digital legacy left behind will become a greater part of your overall legacy".

In turn, there is the definition of digital assets by Oliveira *et al*. (2016) (*apud* Carrol and Romano, 2010). For them, digital assets are all the e-mails, files in digital formats, images, audio, videos or similar digital files which are stored in digital devices, desktops, laptops, tablets, peripherals, storage devices, telephones, cellphones, smartphones or any similar digital device available now or in the future, irrespective of their physical properties. In turn, digital accounts are email accounts, software licenses, social network and social media accounts, financial management accounts, domain names, web hosting accounts, online stores, affiliate programs and any other existing or future digital accounts.

Bellamy *et al*. (2014) use the term "digital property" to refer to all digital assets. For Brubaker *et al*. (2014), digital heritage consists in the full set of digital properties a user leaves behind to an heir. According to the authors, digital legacy can represent identity, social interaction, intellectual property and other activities that might identify the user. The challenge posed by this heritage, according to each country's legal system, is to define who the heirs are.

In a research carried out in Portugal, de Oliveira *et al*. (2016) discovered that most interviewees do not think about the fate of their digital heritage, and do not even know the policies imposed by the online services they use. Their research also shows that, the more technologically mature users are, the more likely they are to become users of digital heritage management platforms.

Massimi and Charise (2009) have coined the term *thanatosensitivity* to describe an approach that actively seeks to integrate the facts of mortality, dying, and death into design and research in the area of Human-Computer Interaction. The group led by these scholars has carried out many studies in the area, both through workshops and scientific research. In 2011, Massimi *et al*. (2011) argued that research in HCI should address death in a lifespan-oriented approach. According to them, there are four main groups of stakeholders in this area: the living, the dead, the dying and the bereaved; besides, there are four main thematic areas that map out what research on the end of life might include: materiality, identity, temporality and research ethics/methods.

In 2011, Maciel carried out a preliminary study in Brazil with software engineers to investigate the possibilities for users to previously configure their post-mortem intentions within the system. The answers collected from the developers encompassed the following solutions for the fate of digital legacy: a) attributing password power to third parties, while alive or in a will, attesting the wish for posthumous interaction; b) having a registration number of the digital legacy in the equipment or in the network, so that a login is not necessary for access; c) keeping a link with real world institutions and documents to confirm a passing away in the Social Web context; and d) providing resources in the Social Web applications to register users' volition. The latter entails software programs providing settings for users to determine what their wishes are towards the fate of their digital legacy. That means users would have decision power on their legacy after this inescapable phenomenon: death. All the aforementioned solutions permit us to investigate the needs of users and applications from the developers' perspective, permeated by beliefs and taboos, so as to foster this discussion within the Information Systems community.

For Maciel and Pereira (2012), the idea that people may record their post-mortem desires in software is also to ponder the way taboos on death have been recodified in different societies in modern times, especially after the Internet. Here recodifying means rethinking, changing symbolisms and facing one's own mortality. As a philosophical activity, this kind of research involves understanding modern human taboos towards death and digital legacy on the Internet. Thus, the authors ask: to what extent are software engineers influenced by their own taboos and beliefs on death when they have to think of solutions for user digital legacy by means of software settings? This question arose from the aforementioned research [MACIEL 2011], especially regarding how users express their volition through software.

From the answers research participants gave to the survey, it is clear that their discourse was permeated by taboos and beliefs regarding death, which influenced the digital legacy solutions they could propose. Given the need to understand how those cultural aspects could influence the design of *thanatosensitive* solutions [MASSIMI, BAECKER 2010], the implicit and explicit taboos and beliefs identified in the respondents' answers were put into seven groups. Table 13.1 shows these groups, the number of respondents who expressed these ideas in their answers and the corresponding percentage among the 83 interviewees.

Categories	**Respondents**	**%**
Non-profanable legacy	14	16.86
Funeral rites	13	15.66
The immaterial beyond death	27	32.53
Death as an end	30	36.14
Death as adversity	12	14.45
Death as an interdiction	8	9.63
The space required by death	7	8.43

Table 13.1. Categories of taboos and beliefs regarding death

The analysis of the software developers' answers suggests that their expectations for post-mortem digital legacy are permeated by beliefs, and moral, religious and ideological values, which can influence the design of *thanatosensitive* solutions. These cultural values must be further studied to support the development of information systems in the area.

It is also necessary to study what is more tangible in post-mortem digital legacy: posthumous interaction [MACIEL, PEREIRA 2012], which can be represented by online mourning (for instance, by creating specific groups for a deceased person, visiting dead users' profiles, or changing one's photos in a web profile, so as to add an image that conveys the user's grief). The concept of posthumous interaction refers to the interaction between systems and the dead users' data, or between living users and deceased ones via the system. For the authors, it is a surprise that, among the research subjects, 59% had already interacted in their social networks with dead users' profiles. Although this issue is more directly related to the area of Human-Computer Interaction, the Information Systems community should also have this discussion, owing to the need to design systems that are sensitive to posthumous interaction.

Researchers have been working on different fields concerning digital legacy and posthumous interaction. These studies address technical, legal, cultural and affective aspects of the relationship between death and technology. In the market, some systems and functionalities have been created to meet this growing demand, and this has fostered new academic studies in this area.

In Brazil, Google launched *Google Inactive Accounts*, which enables users to manage data in their accounts [MACIEL, PEREIRA 2013], [PRATES, ROSSON, de SOUZA 2015], (BAHRI, CARMINATI, FERRARI 2015] and to write a digital will, so as to define the fate of their digital legacy. From the perspective of the Brazilian law, the solutions the market has proposed so far must be improved [MACIEL, PEREIRA, SZTERN 2015], as they have technical and cultural limits and are not aligned with the national legal system. The latter study involved an interpretative analysis of Brazilian law so as to ground the discussion of surveys answered by software engineers about Google Inactive Accounts. Issues such as inheritance rights, the right to be forgotten, temporality of contact information and technical limits of the tool came up in the respondents' answers.

Bertasso (2015) has recently investigated Brazilian law regarding the inheritance of digital assets stored in cloud computing services. The results show that, despite the great number of deceased users, the estimated economic value those assets have and the significant number of people who access cloud-stored services, Brazilian law does not have an objective approach to the right to digital heritage. The author analyzed the terms of use for the cloud storage services of Dropbox[1], Mediafire[2], JustCloud[3], Syncplicity[4] and Wuala[5], focusing on: files and permissions; sharing files; responsibility; copyright; changes in terms of use. The author concluded that the terms of use of all these systems have clauses that exempt them from any legal responsibilities. Besides, they do not cover all situations that may arise in the context of data storage, such as access to a deceased user's data or naming a digital heir.

Developing the aforementioned research, Meireles and Batalha (2016) discuss solutions for the proper handling of a user's digital legacy. To do so, they present prototypes of pieces of software whose main functionalities are identified in the following tools: Morte Digital[6], Se Eu Morrer Primeiro[7], Safe and Beyond[8], Password Box (Legacy Locker)[9], Addio[10], and Google Inactive Account Manager[11]. Based on an analysis of these tools, the authors sum up the main difficulties they faced in the design of such systems:

[1] https://www.dropbox.com/privacy#terms (Accessed in July 2017)

[2] https://www.mediafire.com/policies/terms_of_service.php (Accessed in July 2017)

[3] http://www.justcloud.com/terms#terms (Accessed in July 2017)

[4] https://www.syncplicity.com/legal/terms-of-service/ (Accessed in July 2017)

[5] https://www.wuala.com/en/about/terms (Accessed in July 2017)

[6] http://www.mortedigital.com.br/ (Accessed in May 2017)

[7] http://seeumorrerprimeiro.com.br/planos (Accessed in May 2017)

[8] https://www.safebeyond.com/ (Accessed in May 2017)

[9] Legacy Locker. http://legacylocker.com/ (Accessed in May 2017)

[10] http://www.addio.com.br/(Accessed in May 2017)

[11] https://www.google.com/settings/account/inactive (Accessed in May 2016)

- taboos about death;
- detecting the death of a user;
- determining who the heirs are;
- data security;
- sharing different sorts of file;
- determining an heir's different kinds of access;
- transfer of passwords;
- storage of posthumous messages.

Considering such difficulties and the functionalities that were identified as necessary to address digital legacy, the prototype of the system "Meu Legado" was built. The authors carried out a usability evaluation of the prototype according to Nielsen's heuristics. They concluded that the system "Meu Legado" presents valid solutions to the problems posed by digital legacy and therefore can be used to help make users aware of the importance of planning the fate of one's digital assets after death.

From a similar perspective, Oliveira *et al*. (2016) discuss the need to create Digital Heritage Management Platforms (DHMP), which are information services based on the SaaS (*Software as a Service*) architecture. The main functions of a DHMP are storing information or data related to digital legacy and allowing users to manage the data, which, in most cases, involves planning what will happen when the user dies. Such services instruct the user on how to gather and organize their digital legacy. Users are instructed on how to store information and organize detailed plans for what they would like to happen to their legacy. These plans allow the user to decide on what information from the account can be shared, and who with; or how they want to get rid of any legacy.

For the authors, the main goals of these platforms are:

- Storing digital legacy
- Managing digital legacy (gathering, planning)
- Preventing information loss
- Preventing identity theft
- Supporting online accounts management
- Creating online memorials
- Storing information to build a bot or an avatar of the user
- Helping in the grief process

By means of a preliminary analysis of these platforms, Oliveira *et al*. (2016) identified some standard functionalities, described below in stages:

1. The user creates an account, inserts an inventory of his or her digital heritage and saves his or her data and information;
2. The DHMP delivers a unique code;
3. The user defines a digital executor and delivers the unique code to him or her;
4. The digital executor informs the app about the user's death;
5. The DHMP app tries to communicate with the user within the previously set deadline;
6. Should that communication attempt not be successful, the DHMP triggers the actions previously defined by the user.

For Bahri, Carminati and Ferrari (2015), because privacy preferences vary widely among users according to their cultural and personal values, digital legacy planning must be considered as highly dependent on circumstances to be effective. There are many types of data, and their value is entirely subjective for each user.

That makes it more complex to develop digital legacy solutions, because in a single application, different kinds of data might be destined to different heirs. Take, for instance, the Google platform, where a single password gives access to emails (Gmail), photos (Google Photos), social network (Google Plus), among others.

In a collaborative workshop with elderly people, Thomas and Briggs (2014) studied the participants' values regarding digital heritage. By adopting the *Value Sensitive Design approach*, the researchers realized that there was a clear difference in the value systems when they were applied within or without the scope of the family. Participants emphasized the importance of digital legacy within the scope of the family, so that new generations could know some of the history of their ancestors and family bonds were strengthened. However, most respondents did not feel comfortable with the idea of sharing information about deceased relatives with strangers. In turn, as to beyond the scope of family, participants said that information about legacy could benefit people in a wide range of contexts, but less emotionally.

Related to this, Brubaker *et al*. (2014) point out that many different kinds of data are generated in social networks, and they recommend a framework of solutions to manage them. This framework is divided into two stages: support and assistance for users to plan their digital legacy; and carry out the plan after the death is confirmed. In the first stage, users categorize their data into "for donation", "digital legacy", "intellectual property" or "destructible data". Next, the user must choose to whom (and with what privilege level) each category of data is to be bequeathed. In the second stage of the framework, the user's plan for his or her digital legacy must be carried out as soon as his or her death is confirmed. The first measure to be taken is the deletion of destructible data.

The authors believe there are two main challenges in the second step: a) the time for execution, that is, the system must have a mechanism to identify whether the user is dead (which can be done based on an inactivity period or on a warning from a third party) and only then carry out the plan for his or her digital legacy; and b) handling data in secrecy, so as to respect the wishes previously defined by the user before death. Brubaker *et al*. (2014) also highlight that handling digital legacy is a great challenge in case of the passing away of whole families or communities, such as in natural disasters.

Another systemic perspective is the development or transformation of digital profiles into digital or online memorials. The concept of a digital memorial is derived from the concept of memorials in the physical world, where concrete monuments are made to symbolize and honor the memory of a person or an event. According to Riechers (2013), all personal memorials come from a common human need: honoring death in a context that evokes memories of pain and happiness, and comforting the bereaved. In digital memorials, those practices are transferred to the web, thus allowing users to pay homage to dead people through virtual candles and flowers, or even through verbal messages. Some systems include also options to "pray" for the deceased. For Carrol and Romano (2010), online memorials are particularly unique because they transcend space and time. For example, one can attend a virtual memorial or visit a tomb or any other memorial through the web anywhere, at any time.

In a study about digital memorials, Lopes, Maciel and Pereira (2014|) analyzed the systems iHeaven[12] and Saudade Eterna[13], which are no longer online. Based on the inspection of these platforms and on a qualitative analysis in the light of social network features, together with results from tests with uses, the authors created some practical recommendations for the design of digital memorial software. These recommendations and the related prototypes provide guidelines that designers of solutions for this area should follow so as to meet users' expectations upon navigating that kind of social software, preserve deceased users' reputation and the respect for them, and safeguard multiculturalism in these applications.

Another system in this area is *Digital Memorial*[14]. According to its website, "*Digital Memorial create and implement digital memorial solutions to improve family and friends usage and experience in memorializing a 'loved one'. We are a memorialization technology company located in the UK but working throughout Europe, North America, South East Asia… Digital Memorial is committed to giving excellent customer service*". *Digital Memorial* services include QR code products and solutions; NFC (*Near Field Communication*) software and tags; the campaign "Keep their memory alive"; GPS solutions; sites and gift boxes to show sympathy. The great market behind this solution is therefore clear.

Facebook has the option to change a common profile into a digital memorial after a form is filled in, proving the user's death. According to Facebook[15], "*Memorialized accounts are a place for friends and family to gather and share memories after a person has passed away. Memorializing an account also helps keep it secure by preventing anyone from logging into it. If Facebook is made aware that a person has passed away, it's our policy to memorialize the account*". Below (Figure 13.1) we can see the interface with the memorialization request form[16].

Also in Facebook, it is possible to determine an heir contact for your account. This option is available in the security settings of the user's account. According to Facebook,[17] "*A legacy contact is someone you choose to look after your account if it's memorialized. Once your account is memorialized, your legacy contact will have the option to do things like:*

- *Write a pinned post for your profile (ex: to share a final message on your behalf or provide information about a memorial service)*
- *Respond to new friend requests (ex: old friends or family members who weren't yet on Facebook)*
- *Update your profile picture and cover photo*".

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[12] http://www.iheaven.me/ (Accessed in May 2014)

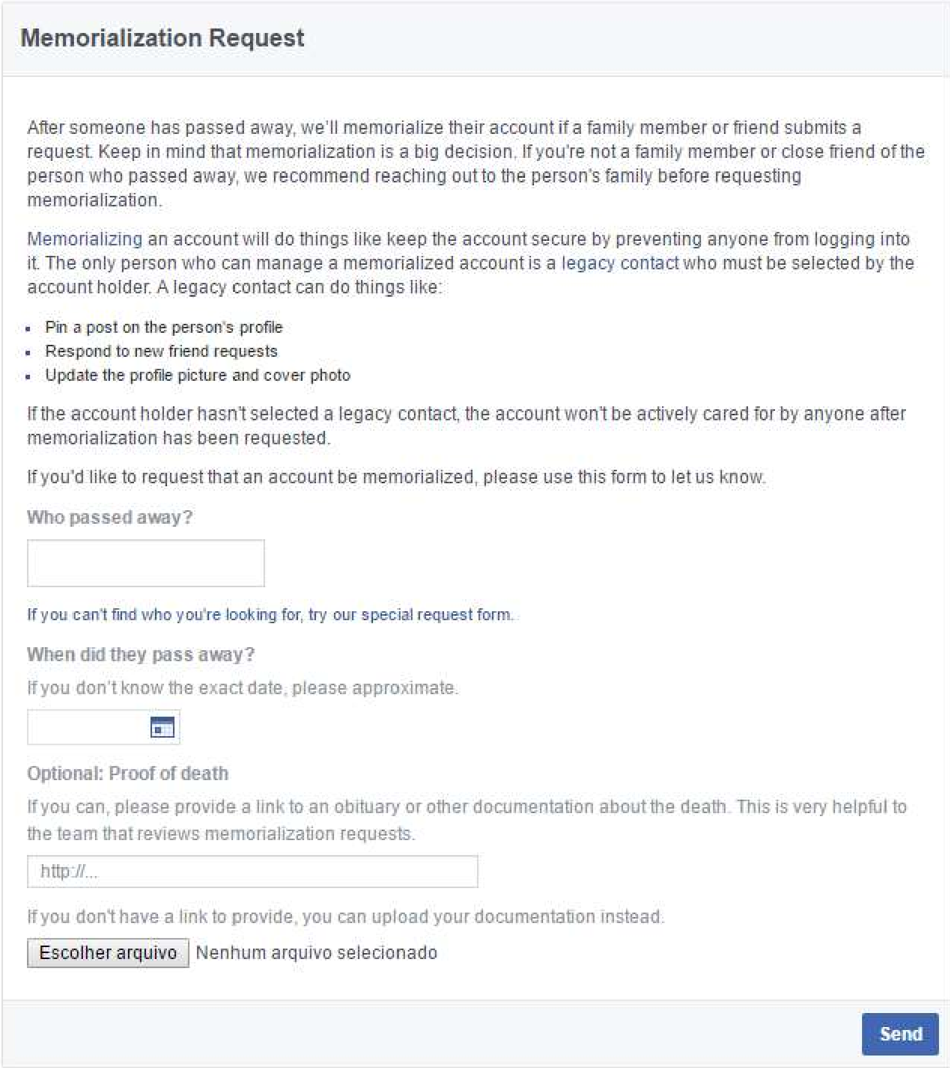
[13] http://www.saudadeeterna.com.br/ (Accessed in May 2014)

[14] http://www.digital-memorial.com/ (Accessed in October 2016)

[15] https://www.facebook.com/help/150486848354038?helpref=faq_content (Accessed in October 2016)

[16] Form accessed in October 2016.

[17]https://www.facebook.com/help/1568013990080948?helpref=search&sr=21&query=memorial Accessed in October 2016.



Memorialization Request

After someone has passed away, we'll memorialize their account if a family member or friend submits a request. Keep in mind that memorialization is a big decision. If you're not a family member or close friend of the person who passed away, we recommend reaching out to the person's family before requesting memorialization.

Memorializing an account will do things like keep the account secure by preventing anyone from logging into it. The only person who can manage a memorialized account is a legacy contact who must be selected by the account holder. A legacy contact can do things like:

- Pin a post on the person's profile
- Respond to new friend requests
- Update the profile picture and cover photo

If the account holder hasn't selected a legacy contact, the account won't be actively cared for by anyone after memorialization has been requested.

If you'd like to request that an account be memorialized, please use this form to let us know.

Who passed away?

If you can't find who you're looking for, try our special request form.

When did they pass away?

If you don't know the exact date, please approximate.

Optional: Proof of death

If you can, please provide a link to an obituary or other documentation about the death. This is very helpful to the team that reviews memorialization requests.

http://...

If you don't have a link to provide, you can upload your documentation instead.

Escolher arquivo Nenhum arquivo selecionado

Send

Figure 13.1. Request to change a profile into a memorial in Facebook

The system allows the heir contact to download a copy of everything that was shared in Facebook. In this help page, there is also the message: "*You also have the option to allow your legacy contact to download a copy of what you've shared on Facebook, and we may add additional capabilities for legacy contacts in the future*". This strengthens the ideas in this challenge, as other options can be considered for deceased users' profiles in social networks such as Facebook.

Pereira, Maciel and Leitão (2016) have carried out semiotic studies of design elements in real-world artifacts such as tombs, tombstones and physical memorials. Their analysis considered cultural elements from different societies and was based on a previously selected sample. By investigating the real-world domain, the authors elicited design requirements and built theoretical and speculative knowledge in the domain. Their main contributions are: a) a description of the design space of digital memorials, in terms of the actors involved and their objectives upon interacting with the application; and b) scaffolds to reflect upon the design process of digital memorials.

Bahri, Carminati and Ferrari (2015) warn that: a) in Facebook, a memorial can be seen by friends according to the privacy preferences of the deceased user's account, which were determined by the user before his or her death; b) a memorial cannot be found by unknown people through searches; and c) it is not possible to add a deceased user's profile as a friend. The authors also highlight that, as there are interactions in social networks that persist longer than a user's lifetime, it is necessary to design a system with a platform for social activities among circles and groups previously established by the deceased user. In this case, the authors suggest that the heirs act as stewards or mediators, who execute the deceased user's wishes although they do not have access to his or her accounts or data. That would enable the management of sensitive data, such as material that might damage the deceased user's image or be considered as SPAM.

Another functionality that has been offered to users is the possibility of sending posthumous messages. Pereira *et al*. (2016) analyzed the future impact of settings in the domain of posthumous communication. The authors called posthumous communication the process of sending, after a user's death, a message previously written by him or her. Their analysis explores two different perspectives. The first one is related to how designers help users understand the future impacts of settings they choose. According to Prates *et al*. (2015), there is a challenge in the design of system settings when the effects of those settings are not in the short term, demanding an anticipation of interaction. The second perspective has to do with recommendations for designers to define requirements related to volitional aspects in the context of digital legacy (MACIEL, 2011). The authors' goal was to come up with indicators for what each perspective can inform about posthumous communication, and what the gains are from combining them. To do so, the authors analyzed two tools that send posthumous messages to family and friends: *"If I Die"*[18] and *"Se Eu Morrer Primeiro"*[19]. Each system was analyzed through the Semiotic Inspection Method (SIM) [de Souza *et al*. 2006] and then from the perspectives of settings with future impacts [PRATES et al. 2015] and volitional elements regarding post-mortem digital legacy [MACIEL 2011]. As results, the authors present a thorough analysis of these two tools and the specific functionalities designers provide users with. Furthermore, there is a discussion about the particularities of systems that focus on posthumous communication, so they broaden the discussion on concepts related to the management of posthumous messages.

Among their research findings, Pereira *et al*. (2016) discuss how posthumous communication systems permit the sending of messages with various contents. For example, instructions on how to proceed after the user's death, instructions on access to some physical or digital asset left behind by the deceased user, or even sentimental messages. Therefore, users must understand not only what messages they can send, but also the implications of the decisions they make and express in the system settings regarding the sending of the messages (what will trigger the sending, who will receive them etc.). To do so, the designers must allow the user to anticipate the interactions that will be made available in the system, and what is more, they must make it very clear how that must be done.

Another example of a system for posthumous communication is Perpetum[20], an application that provides the user with a number of choices of actions he or she may want to be performed after death. For example, the user may choose to have a post in his Facebook

[18] https://ifidie.org/. (Accessed: September 2016).

[19] http://www.seeumorrerprimeiro.com.br/ (Accessed: September 2016).

[20] https://perpetu.co/ (Accessed: October 2016)

timeline informing all his or her friends about his or her death or the automatic forwarding of emails from the dead user's account to someone else etc.

The aforementioned studies show that research in the area has addressed death in information systems in different and interdisciplinary ways. Many companies have also been producing systems related to death, mortality and heritage; those solutions must be critically analyzed through research approaches.

15. Challenge Proposal

Given what we have seen, the great challenge to the Information Systems community is to investigate how to address death and design solutions for digital legacy systems in the light of technical, cultural, legal, ethical and affective principles.

The study of those issues will enable us to draw up guidelines to conceive systems that consider the fate of digital legacy embedded in software and to inform normative institutions on the discussion of those issues, from an interdisciplinary perspective. Further investigation is required into how web systems, such as cloud computing applications, social networks and digital memorials, have been used and developed when it comes to death-related phenomena.

The design of solutions has been addressed in different ways in the area of Information Systems, some of which have been briefly presented in this chapter. As many of these elements are modeled in sets of systems, the development complexity is enhanced. For example, it is possible to tag different people (identities) in a photo and share it in different places, allowing varied social interactions. However, if this photo is deleted, how should we handle the persistence of data should a deceased user want that photo to be erased from his or her account in a social network?

With the popularization of digital assets and digital contents produced by users, the management of such data gets increasingly complex. Therefore, handling it as future legacy becomes a challenge. First of all, it is usually scattered in multiple spaces: there are not only data available online, but also stored in personal computers and mobile devices, for instance. Besides, data (such as documents and photos) must be classified into inheritable or non-inheritable items by the user. However, each user stores and organizes different sorts and amounts of information, thus adopting distinct classification patterns. As that (dis)organization of data threatens memory preservation, digital content curatorship is a growing concern for archivists. If it is hard to identify what is valuable in a great mass of digital contents, there is a risk something important may get lost. Besides, if data are locked in password protected accounts, they cannot be accessed anymore. On one hand there is the concern with memory preservation; on the other, there are the ethical aspects of accessing data, such as users' privacy or even the reuse of data to recreate life through artificial intelligence. Therefore, it is fundamental to make users, software engineers and analysts aware of these ethical aspects.

Among the challenging research questions for this area, we can highlight the following:

- handling bereavement in systems where posthumous interaction takes place, considering the users' emotional workload
- discussing, from the perspective of each country's legal system, to what extent companies should be exempt from legal responsibilities regarding the user's digital legacy, which has consequences for the terms of use
- the systemic complexity regarding the diversity of data and their use, as well as the variety of technological devices and storage resources, such as clouds

- respecting users' privacy, which heavily depends on the way data are forwarded to the heirs
- constantly debating this theme, so as to overcome taboos on death that might influence the design of solutions
- carefully detecting death, handling heritage, and making sure the heir meets his/her responsibilities properly.
- managing the conflict caused by settings in different systems, or even by the different decisions configured in the systems and in a formal will in the physical world
- defining the limits and possibilities for posthumous communication systems
- defining the limits and possibilities for immortality within software programs, considering artificial intelligence tools

From a methodological point of view, we have the following challenges:

- interdisciplinary research, as designing sociotechnical systems demands a multicultural and multiperspective understanding of different epistemological fields
- the bond between academy and market, so as to develop solutions that properly address the impact of death and digital legacy on users and society as a whole
- the use of varied techniques, methods, procedures and tools in system analysis. Techniques from the Information Systems area, such as Business Process Modeling, can be especially useful in that context
- the analysis of objects and phenomena in the real world, so as to bring elements to system projects in digital environments
- studying the profile of each user generation, as they may have different actions and reactions towards these systemic possibilities
- studying new computational solutions as well as the existing ones.

The advances in this challenge can be assessed based on the amount of research carried out in different communities, on the quantity of projects in the area, and on the advances in terms of functionalities implemented in existing information systems and in new ones.

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Chapter 14

Research and Education in Data Science: Challenges for the Area of Information Systems

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Abstract

Data Science (DS) is an interdisciplinary research area that uses concepts based on Big Data Analytics, Programming Languages and Mathematical fundamentals to develop research into insight discovery from datasets. The data-driven decision-making approach has become a challenge for researchers and lecturers in the Information Systems area. This is because the skills and theoretical issues require a heavy course workload and high number of class hours. This work introduces a discussion of the insertion of the DS subject in Information Systems courses, and researchers' efforts to establish goals for professionals and lecturers involved in DS.

14.1. Introduction

The proliferation of computational systems in the industry has caused significant changes in the way data are collected, transmitted and analyzed [Turban et al. 2010]. In addition, there is considerable progress in the management of persistent systems and Data Base Management System (DBMS). The advance started with Peter Chen [Chen 1976] who proposed the E-R diagram to aid the design of databases and defined the requirements of problems, entities, attributes and relationships in a graphical way. Complementarily, DBMS has been consolidated as the main database approach, ensuring the properties such as Atomicity, Consistency, Isolation and Durability, called ACID [Silberschatz et al. 2006].

Relational DBMS was the major resource to store data, facts or transactions, and it became a valuable tool for data analysis using tables, reports, maps or graphs, allowing approaches to manage or to monitor business in most areas of knowledge.

Data generation has been growing exponentially and, which demands collecting, organizing, analyzing and extracting insights from data warehouses systematically, in heterogeneous environments, geographically distributed and, in distinct contexts of applications.

Thus, for a professional to be up-to-date with the stack of technology to collect, process, analyze and data visualization is a humanly impossible task. However, at the same time, it can become as a new job.

In the Brazilian context, Information Systems graduates are looking for these opportunities and, the courses coordination often input new contents as part of traditional syllabuses of computing courses.

Considering the need for an interdisciplinary approach to innovation in this area, as well as the approach of an applied science, positioning computer technology as the driving force for innovation, we have identified a major gap in the information systems curricula. There is a lack of focus to perform special skills to meet Data Analysis effectively. For example, the contents of the database syllabus are presented theoretically and systematically. Instead of this, a practical approach can tackle database but emphasize data analysis as well as relationships with other programs. These aspects may be more or less evident depending on how the lecturer deals with the subject. The discussion of different ways of data collection or manipulation of data for using in data mining is usually defined by the scope of the subject used as a case study.

14.2. Background

In recent decades, data storage technologies have undergone progressive advances that have transformed the data collection concept and as a result the ability to generate digital data exceeds the human capacity of analysis.

Before discussing Big Data, it is important to discuss what kind of data this is. We can expand on this point, starting by defining data (from Latin - Datum), which means details. These details represent events observed, which occurred at a certain time and space. They can be collected, organized, classified and analyzed. In the same way, they can be shown in numeric or alphanumeric form, as a symbol, image, etc. The data can be collected from nature or from details about business processes.

Details that can be created day-by-day, as discussed in Simon (1996). The author used the term "artificial" as opposed to "natural" and addressed the world created by human beings, with laws and contexts connected by our collectivity. At this point, we devote especial attention to the dichotomy between natural and artificial.

From nature, there are infinite details to be collected. For example, a bird’s movement can provide data such as velocity, altitude, direction, fly time etc. In the same line, there are details of a job process such as a start date, stakeholders, incomes, descriptions etc., aggregating a set of data that can be the input for analytical studies that will support decisions about specific contexts.

Knowledge is generated from the relationship between the observed object and the human being. In the database context, the data of a referred object, when manipulated in the right way, can produce value judgment and become information. Information used in a context becomes knowledge.

This set of available data, objects attributes, events and processes will compose a large collection, and provide better knowledge about our reality, our context. However, the data desired is not always collected, and the inverse is also true. We do not always have what we need. With or without available data, discovering patterns hidden inside the data in a chaotic universe is a challenge for Computing Science.

There are currently huge volumes of data; so high that it has been necessary to develop techniques to suppress data that does not interfere with a specific analysis, and build models with only essential data for specific purposes. The term Big Data (BD) is used to define a set of technological tools which allows a new approach to treating and exploiting large sets of data from different sources and formats, for decision making purposes (Breternitz et al. 2015). These authors claim that the volume of data has grown exponentially, which has stimulated improvements in tools to treat them and to exploit them.

Big Data is the term currently used to refer to the volume of data we collect from various sources for further mining and for searching non-trivial patterns in a given context. The search for patterns or the deeper understanding of the data collected is usually called Analytics. This is done with the use of different tools, able to process predictive analytics, data mining, statistics, artificial intelligence etc. Certain authors use expressions such as Advanced, Discovery and Exploratory Analytics; from this point on, we use the expression BDA (Big Data Analytics).

According to Vaisman and Zimányi (2014), Analytics can be defined as the discovery and communication of meaningful patterns in data collections. Such patterns become evident through the application of prescriptive and predictive models derived from statistics and artificial intelligence. Identifying patterns helps us take better decisions. However, this is a probabilistic world, and nothing is 100% certain.

We cannot define Big Data as one tool or one product. It is a process with several iterations and requires different skills to perform in a value chain. Figure 14.1 shows the macro process of a Data Value Chain.

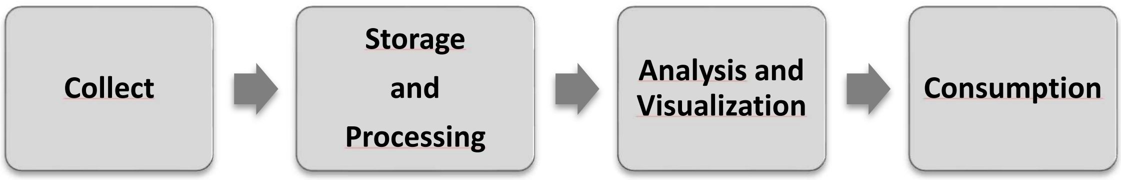

Figure 14.1. Data Value Chain

Building this value chain is not trivial. Big Data analysts are estimated to spend between 50% and 80% of their working time collecting, cleaning and churning data from different sources and formats, in other words, preparing the data to make sophisticated analysis. This has been the focal attention of many startups to build tools based on refined data.

As regards storage and processing, over the years, researchers and computer professionals were observed to lead excellence in the use of DBMSs (Database Management Systems), as well as operating systems with parallel processing capability in high impact performance and scale cluster. This has contributed to consolidating essential transactional systems technologies in several areas such as Economics, Education, Health and Safety.

Data analysis is an interesting topic that generates interest in various contexts. There are different techniques, tools and algorithms for performing analysis and subsequent data visualization. In 1914, William Brinton published a book about graphical methods to show data. We still have the need to find the best way to visualize aggregations and other analytical results.

Finally, data consumption addresses several issues deserving attention. We already have business processes with BDA support in near real-time. It is an advanced stage, but it requires joint efforts from different backgrounds.

Some authors, such as Zikopoulos et al (2012), say that Big Data is characterized by four aspects: Volume, Velocity, Variety and Veracity.

The feature "volume" refers to volumes of data digital form growing exponentially, from not only conventional systems, but also from sources such as Facebook, Tweeter, YouTube, RFID, embedded electronics, cell phones and similar, sensors of various types, etc. To illustrate this feature, McAfee and Brynjolfsson (2012) reported that in 2012, every second, there are more data transiting over the Internet than the total stored in it 20 years ago, and that Walmart alone collected more than 2.5 Petabytes each hour, in order to store transactions made by their clients.

Another important aspect of Big Data is the "velocity" at which data can be captured and processed in nearly real time and this can give a competitive advantage to organizations. This can be exemplified by the experiment conducted by Prof. Alex Pentland’s Research Group of MIT Media Lab: the group captured location data of mobiles in order to find out how many people put their cars in the parking lot of the American Macy's group stores on the 2011 Black Friday (which marks the start of the Christmas shopping season in the United States). These sales could be estimated accurately even before they occurred, generating competitive advantages for commercial and marketing areas and third parties, such as investors in stock markets. This case and similar ones are also reported by Clifford (2012).

Regarding "variety", it should be noted that in addition to different sources, the data collected often have different characteristics from those processed by conventional systems, which are not structured and refer to things such as sound, image, movement, temperature, humidity and even variations in the chemical composition of air [Lohr 2012]. Davenport (2014) notes that although the volume of data is what demands the most attention, the lack of structure is the most difficult aspect to work with data storage.

The aspect "veracity" refers to data that cannot be "perfect"; e.g. we must consider how good the data should be to generate useful information and also the cost of making them good.

There have been advances in hardware and software to face demands of performance and availability. It has been a long way to arrive in the Hadoop Platform, which is able to cluster management and parallel processing to leverage BDA. Today, Hadoop is the most widely adopted platform, considering the options available on the market. It is a hybrid model with free and paid associated products, approved by different players in this segment.

New business applications will be using the IoT - Internet of Things. This depends on a universe of data to be collected, processed and stored. At this point, it is important to note that the technologies will be favored by Cloud Computing technologies, in which hardware and software are available to the market as services. The IT business mode is known as XaaS, an acronym, replacing X with P will make "Platform as a Service" or use the I for "Infrastructure as Service."

The issue to be observed is the variety of data that we are dealing with. Different formats are generated and managed in computational applications. Texts, movies, audio, maps, among others, are in the agenda of database administrators. How should such varied content be stored, processed and analyzed?

In order to extend the persistence options, new paradigms have been adopted in new databases called NoSQL (Not Only SQL). Tools such as Cassandra and Mongo-DB have been presented as solutions that address huge volumes of data with speed. distributed and low latency manner were used in social networking and other applications that require high levels of scale and availability. These tools generally apply to platforms such as Hadoop, which orchestrates the distributed file system and parallel processing to guarantee the performance of the implemented applications. Combining hardware and software specific appliances are processing systems in memory to provide performance in analytic queries. Vendors such as IBM, Oracle and SAP, are already available, allowing accelerating these transactions processing.

The discovery of unsuspected associations and summarization of data and visualization dashboards are on the agenda of organizations that aspire to become data driven. For this reason, software companies and the academic community are undertaking ongoing efforts in the search for models and more efficient and effective tools.

Organizations keep their data in silos or in isolation. Just as the systems of a city, the data produced in one application must be integrated with other, providing new perspectives in the context in which they were generated. However, new efforts are developed to add value from the data-driven, providing interaction between systems, to reduce the characterization of data silos in a Big Data Platform.

The integration of systems has been a trend, considering that the data can be enriched with new data to provide extra capacity for analysis and a better understanding of the processes of a company. However, to ensure systems integration, it is necessary to further studies on standards and reference models to ensure interoperability in distributed and open environments.

Another point is interoperability. This is the ability of a system to communicate or share data with other systems via interfaces or brokers without expending additional efforts for this activity. Contemporary organizations need interconnected information systems to encompass broader organizational contexts, and to reduce the technological limits. These demands are moving to more open, integrated, flexible, modular, federated, secure and transparent systems specifications. Models such as the RM-ODP (Reference Model - Open Distributed Processing) have been instantiated in projects to reach the needed solutions.

The opportunities to apply these concepts are numerous in finance, health, safety, manufacturing etc. McAfee and Brynjolfsson (2012) conducted studies and concluded that companies where BDA is effectively used are 5% more productive and 6% more profitable than their competitors - those numbers are a powerful argument for using this approach. In the current scenario, there are several examples of BDA available. Applications for Marketing, e-Commerce, e-Health, among others. In addition, there are barriers to the deployment of BDA, such as the costs involved, lack of C-level sponsorship, issues about hardware scalability and availability of software inside the organization. However, the greatest barrier is the lack of qualified human resources.

Nevertheless, to create value from the data requires a number of steps. Understanding each step is important to establish the organizational data architecture able to address problems in an agile and scalable way. These issues are embedded in the digital transformation. Cloud Computing, Mobile Systems, Analytics and Social Media are the objects of study on the business agenda.

These issues are interconnected and produce unlimited possibilities for innovative products with a direct impact on the quality of life. In an interdisciplinary way, we are creating products to monitor aspects of our health, what we do, what we eat etc. Data are collected on smart phones to be processed in the cloud environment.

The 4.0 Industry has attracted attention from researchers and generated advances with the Internet of Things and Analytics areas; systems called MES (Manufacture Execution System) and RPA (Robotic Processing Automation) are in the current agenda of CIOs and CEOs looking to position themselves as managers of Data-Driven organizations.

In conclusion, there is an emerging demand for professionals with a holistic vision, capable of using an interdisciplinary approach, to be able to apply analytical tools to the various contexts and scenarios of human activity. We believe that these skills are inherent to information systems professionals. Developing these constructs through academic research and by offering more effective curricula represent an important challenge for the information systems area.

14.3. The Challenge

Considering higher education in Brazil, professionals looking for skills and competencies to work in analytical systems can study Computer Science, Computer Engineering or Information Systems. Students should be able to act on issues such as requirements engineering, database modeling, management and monitoring of DBMS, following a closer approach to the analytical needs of organizations.

We understand that updating the academic curriculum is not trivial; the contents must be aligned with different stakeholders (the market, governments and schools) to build robust pedagogical projects that enable the proper training of undergraduate students.

Among the instruments that guide a Higher Education Institution in defining the contents for a computing curriculum is the National Curricular Guidelines (DCN), approved by the Ministry of Education in 2016 [MEC, 2016]. This defined as part of information systems skills: responsibility for collecting, storing and managing data to use in different areas, the creation of applications, systems and interfaces with programming and software engineering.

What has been observed over the years in this sub-area of computing is the movement of researchers and database professionals towards generating excellence in the use of database management systems and this has contributed to promoting essential technology in sensitive areas of Economy, Education, Health and Safety. However, as computer prices and sizes have fallen, new usage demands have been created, besides sophisticated collection needs, storage and processing in terms of speed, volume and high variety usage in the framework of Big Data.

Activities such as genetic analysis, sensor measurements and social networks rely on massive data storage to Exabytes with volumes of collection in Terabytes daily. This has led to a significant change in the database area. Traditional Relational DBMSs have difficulty archiving new levels of availability and scalability, maintaining the ACID properties. In response to this, industries and open user communities are creating new persistence mechanisms to support the new demands. Consequently, new paradigms, architectures, models and tools have been developed and now share space in the current market database, often coexisting in polyglot persistence applications. Moreover, IoT projects, another increasingly relevant topic, transversely involves hardware issues, network, database and computer architecture (IOTA, 2012).

These issues have amplified the difficulty in updating pedagogical projects regarding persistence issues. As previously mentioned, the DCNs for computing were proposed in 2012, and approved in 2016. This time lag impacts changes in the educational structure. Within the area of computing, a number of applications have since appeared, for example Waze which was unknown in Brazil before this time.

Therefore, defining key concepts to be taught on computing courses is a complex task. A change in menu goes through various approval bodies at the university. It must also be aligned with DCN, ENADE (National Examination of Students' Performance), SBC (Brazilian Computer Society) etc. besides meeting market needs and this all requires time.

Regarding Information Systems courses, the basic skills in database courses currently are: DBMS architecture, database design and Structure Query Language for manipulating datasets. This is not enough to meet current demands. Some IESs also include courses for programming database and/or trying to optimize the workload of courses, offering Business Intelligence disciplines and Multidimensional Modeling, Online Analytical Processing (OLAP) and Data Warehouse (DW).

A suggestion could be the treatment of these constructs as the basis for information system courses, building a deeper formation in order to generate skills, knowledge and professional attitudes. In the context of Bloom's taxonomy, this would include the adoption of verbs such as implement, develop, analyze, among others, to the contents of related disciplines.

Another challenge proposed in this text is the role of researchers to further the discussion about vocational training of Data Scientists, with regard to the basic concepts necessary to support projects in the Big Data Analytics platform [Breternitz et al. 2015]. Updates would be offered to Information Systems Pedagogic Projects or others, without extrapolating the course hours or affecting other contents.

This challenge can be addressed by the following:

- Discussion of initiatives to be proposed by researchers and that transcend the issue of including new issues into the pedagogical projects, such as the need to prepare lecturers to teach topics related to Big Data and Data Science, production of specialized papers and books and setting up Forums for constant discussion of the subject. This should generate inputs that can be quantified and thus used to assess the evolution of the challenge presented here.
- Definition of systematic research on the subject, to be held periodically, as a strategy to follow what has been researched in the area and relating this research focused on training people with skills in teaching subjects regarding Big Data and Data Science.
- Collective elaboration of a reference-syllabus necessary for working with data science, involving course coordinators, allowing, among other things, the mobilization of managers and the engagement of stakeholders.

14.4. Progress Evaluation

We believe that these topics can generate key performance indicators to follow the progress. Employment indicators and participation in forums can be measured, as well as the number of related publications.

14.5. Final remarks

Data science provides many opportunities as well as having positive and negative impacts on society. In a disruptive way, this wave has grown to allow us facilities to improve our quality of life. We have been innovating and reinventing how we live, at high speed. Hence, the field of Information Systems has a great role to play, as a part of an interdisciplinary world, with innumerable challenges, many of them still unknown.

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