Universität Bremen

Information Technology Standards in eResearch:

A Conceptual Model of the Primary Adoption Process in Higher Education Organizations

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Abstract

Current research on IT standards tends to focus on their lifecycle: from the development and selection, to their implementation and use. This work proposed an interdisciplinary perspective to analyze primary adoption process in the eResearch domain. As organizations are the core entities in the innovation process, the analysis of IT standards adoption was applied to eResearch infrastructures within higher education organizations. The core argument was built on the adopter's viewpoint as it provides the most explanatory process about adoption. Two international case studies probed the suitability of a model to identify the determinant role of factors like external and internal networks, top management support and organization structure. This dissertation delivers new insights that contribute to bring certainty about one relevant context of standards adoption.

Keywords: IT Standards, Adoption, Organizations, eResearch, Higher Education Organizations.

Thank you…

… to my lovely daughter Andrea, who makes my life extraordinary.

… to Héctor, Liz and my little Marifer, for their love.

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CHAPTER ONE

1. Introduction

The last decades have seen rapid advances in the field of Information Technology (IT) and scholarly practices are being clearly impacted by this development. The use of IT to support research process was initially well received by researchers from sciences and engineering, who have taken part on projects to cope with their complex data management process and computing requirements. The emerged movement, called *eScience* in Europe and *cyberinfrastructure* in USA, has consisted of new methods and approaches that aim IT implementations for complex and large scale projects (*big science*). On the other hand, single research organizations are investing considerable financial resources in order to assure that small scale research (*small science*) occurring within their boundaries is supported with adequate IT infrastructures. Current technological frameworks in these organizations aim to integrate their internal requirements with the global networked environment for knowledge production.

The study of IT infrastructures has explored the complexity of IT implementations, their enabling mechanisms as well as their systemic effects. Some of the most important research discussions and analyses about IT infrastructures emerged during the 1990s as an evolvement of Hughes' perspective on Large Technical Systems. Some of these early works pointed out an inherent and core element of the *infrastructuring* process: standards, which were considered infrastructure's core elements. According to this perspective, IT standards (ITS) can be conceived as components with important functionalities that enable infrastructure and influence the value delivered by IT.

So far, little attention has been paid to the relation between these three terms: IT infrastructures, standards adoption and eResearch technology. Although IT adoption in general has been extensively investigated in the last 20 years, there has been little discussion about the process in research organizations, like Higher Education organizations (HEOs). Most efforts have been centered on learning and administration technologies, but little evidence can be found in relation to university's eResearch infrastructure and their standards.

Taking into consideration these gaps, the major objective of this study was to investigate standardization processes of eResearch infrastructures in HEOs. It was intended to apply IS body knowledge on IT adoption, as a way of explaining standards deployment in the eResearch domain. The dissertation focused exclusively on the organizational context and involved factors in the so-called *primary adoption decision*. As interpretative research, this work took the form of multiple case studies and considered one specific eResearch technology: *open access repositories*. The analysis was centered on the adoption of repository systems as *organization standard* and as "container" of specific *de facto* standards in such domain. Two international HEOs were selected as sample and, through the mix of qualitative methods, it was attempted to elucidate the involved factors in every phase of the adoption. One of the main contributions of this work was the use of the process perspective to explore such adoption factors as dynamic elements in each stage.

The rest of this introductory chapter goes deeper into the detailed purpose of the dissertation. It presents concrete research questions and methodological approaches as well as the main contributions to the IS field. At the end, the structure of the document is presented in order to make sense of the contents and their organization.

1.1. Motivation

Paul Erdös claimed that a mathematician is a machine for turning coffee into theorems and for Ian Foster, a scientist "is arguably a machine for turning data into insight" (Foster, 2005). Researchers need data. They collect, categorize, analyze, model and transform them to produce knowledge. Advances in the IT field have been changing the way how they fulfill this role by providing technical infrastructures that modify information related practices and impact global knowledge ecology. In Europe, e-Science has been used as a term that encompasses the efforts of computing related disciplines and researchers to develop solutions for knowledge production processes in intensive information environments. In United States, the term cyberinfrastructure was preferred by the National Science Foundation to refer to the need of networking computing and data resources, particularly focusing on the development of the Grid as well as on the role of data repositories, metadata, collaborative applications, and visualization and simulation tools. In this work, the comprehensive term *eResearch* is used to refer to IT infrastructure for research production that operates under specific contexts and involves users, organizations, technologies and networks.

Within this framework, standards are considered as the technical cornerstones that solve the infrastructural tension among local systems and networks; and at the same time, they allow a series of functions that are continuously *repeated*. A wider notion of standard as a required *solution* is used here in order to include functionalities and their multiple scenarios. Beyond interoperation, ITS enable certain levels of process performance and quality in the provision of IT services and at the same time, they reflect certain assumptions about how a task needs to be supported. This perspective applied to the study of IT standards is significant to establish a link between adoption process, environment and technology domain. Furthermore, such comprehensive approach allows a better understanding of ITS as a factor of IT innovation adoption and their relation to computer supported work processes (i.e. knowledge production in a research environment).

Considering the variety of scenarios in the eResearch domain, HEOs (as research organizations) were analyzed as complex adoption environments. ITS adoption process has been linked to campus infrastructure decisions, taking into account HEO's particular structures (Lynch, 2008). The study of ITS within this specific type of organizations is not new and recent discussions have been focused on the relation between eLearning and instructional technologies. Another focal point has been the study of the functionalities enabled by the implementation of the ITS (e.g. interoperability or compatibility) as a set technical problems. But adoption in organizations implies top level managerial structures and agreements that turn adoption into a complex decision making process that drive the use (or non use) of standards. By analyzing ITS adoption in HEOs' organizational settings, a relation with the result of a large-scale standardization process (intraorganizational, national or even international) can be stablished. For example, to understand the adoption of CERIF as standard for Current Research Information Systems, it is not enough to perform a technical evaluation of the data model for the efficient representation of research data. Current level of adoption in European HEOs can be better understood by considering organizational decisions that are core for the creation of an interoperable European research data network. Hence the definition of ITS management frameworks is necessary to deliver standards' expected benefits and it requires a careful analysis of how adoption processes occur.

This research work deals with the structural peculiarities of organizations as a referent to analyze the conditions that shape the *context of compliance* for the adoption of ITS. The main motivation of this dissertation was to bring insights about:

- the conditions of IT deployment to support research activities (eResearch),
- the main enablers and triggers of ITS adoption,
- decision making processes and decision makers behavior in organizational contexts,
- a process perspective on the adoption (*contextualized* factors), and
- the involvement of relevant stakeholders and their activities.

It was assumed that these aspects contribute to a comprehensive understanding of the ITS adoption and through a model, such knowledge can be instrumentalized to reduce uncertainty in a critical part of the IT implementation process.

1.2. Problem Statement

The general purpose of this research was to explore ITS adoption process in eResearch, considering HEOs' characteristics as adopters. The study was particularly focused on *primary adoption* and inquired about relevant factors that are core for the process within these institutionalized research environments. The central assumptions about the phenomenon were:

- ITS adoption is a *dynamic* process.
- ITS adoption is context dependent.
- ITS adoption is influenced by a variety of organizational factors through every stage of the process.
- ITS adoption is influenced by the particularities of the application domain and the supported processes.

Considering the last statement, it was determined the need of a domain to analyze ITS. In this sense, eResearch[1] integrates a variety of computer supported activities for scientific knowledge production that use standardized IT as part of an infrastructure. Among the variety of ITS developed to support eResearch, this work limited its scope to those *organizational ITS* used for research data preservation in HEOs, concretely open access research repositories.

This work aimed an *holistic* approach to ITS, by establishing the relation between adoption factors and their relevance in the different stages of the adoption process. Based on Rogers' DOI theory and its adoption stages (initiation, decision and implementation), it is proposed a dynamic perspective of the factors through their association with the stages. Hence it was claimed that the placement of the factors within the process elucidates contextual changes in organizational

[1] This term is widely discussed in Chapter 5.

adoptions. Such approach leads to the development of more efficient and systematic strategies to manage ITS adoption.

1.3. Research Questions

The leading questions of this dissertation were:

Main Question

How does the adoption process of IT standards for eResearch services occur in Higher Education Organizations?

Secondary Questions

Q1. How does IT standards adoption process occur at the organizational level?

Q2. How are organizational ITS managed in HEOs?

Q3. How can different ITS adoption factors be identified in each part of the adoption process?

Q4. Which organizational factors enable ITS adoption in research organizations?

1.4. Methodological Approach

To answer the main and secondary research questions of this work, a series of stages were defined. In order to achieve the purpose of this study, the integration of the following aspects was prioritized:

- existent theory about adoption,
- trend research on ITS factors,
- eResearch as specific domain, and
- the particular organizational behavior of HEOs, within a primary adoption process

Figure 1.1 displays the proposed methodological approach (path), designed to bring together all these aspects. It starts with the cdevelopment of an initial theoretical framework to characterize standards, adoption and eResearch practice. Despite the path resembles grounded theory (Glaser & Strauss, 2008), it differs on the role of the initial theory[2] (used as interpretative framework).

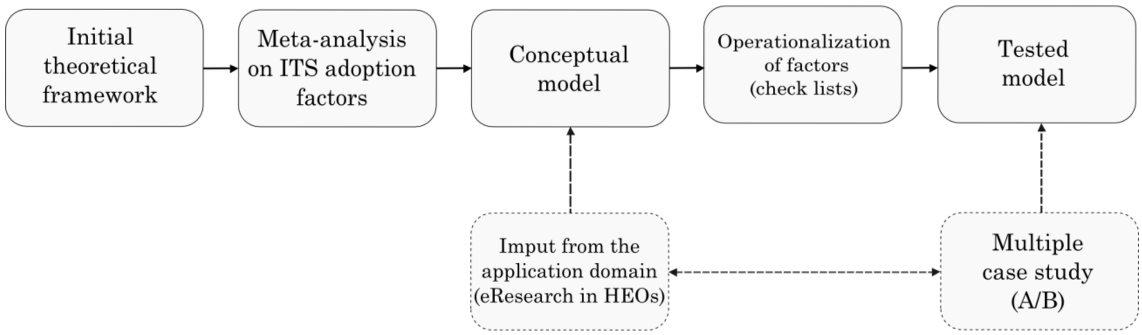

Fig. 1.1 Research path

With the definition of the initial framework, some aspects emerged as core, such as the need of a process perspective and the analysis of primary adoption to make sense of the organizational context. The next step implied carrying out a qualitative meta-analysis on factors in order to learn from current trend research on ITS adoption. As already mentioned in this work, ITS adoption has been slightly researched in IS and such incipient, but solid, production was considered valuable to build a comprehensive *evidence-based* model.

As part of the scope of this work and as necessary condition for the establishment of domain boundaries, the configuration of a conceptual model for factor integration took into account: the particularities of the eResearch technology within HEOs as research organizations and their particular organizational characteristics (i.e. governance and decision making). Once factors were integrated into the model and operationalized with checklists, they were used to drive instrument design as well as data collection and analysis procedures. The multiple

[2] Grounded Theory does not use existent theory to start the research process, but it rather relies fully the empirical data to theorize (Glaser & Strauss, 2008).

case studies[3] included two international HEOs that implemented institutional repositories[4]. ITS primary adoption was analyzed in both HEOs between 2011 and 2012 through qualitative methods, which included interviews and systematic document analysis. In order to make sense of the *process*, the mixed methods approach and an interpretive data analysis were used to identify and place the factors on a timeline. The cases enabled testing and the carachterization of the adoption process in two different organizational environments. As a result, the model probed being a useful tool to analyse the implementation process and allowed an accurate identification of factors (as well as their role in certain stages of the adoption).

1.5. Research Outcomes

This research is based on the perspective of the Information Systems (IS) field. As a computing discipline (Glass, Ramesh, & Vessey, 2004), IS inquiry involves a wider perspective about "the development, operation, use, evolution and impacts on information systems and society" (Iivari, 1991, p. 250). March and Smith (1995) identified two main kinds of contributions in this area: applications for the *information environment* (integrated by people, organization and technology) and additions to the knowledge base (foundations and methods). Thus *constructs, models, methods,* and *instantiations* are outcomes used as input to design, evaluate and theorize about IT in specific environments (March & Smith, 1995). Such perspective emphasizes the study of contexts as a condition for the successful use of IT and therefore, their understanding is core for implementation.

Besides IS, the outcomes of this work can be related to other two computing disciplines as well. In the German tradition, the study can be situated as part of the *Angewandten Informatik* (Applied Informatics) and specifically within a transversal discipline called *Sozio-informatik* (Social Informatics) (Rohde & Wulf, 2011). Traditionally, Informatics have addressed the formalities of Information and Communication Technology (ICT) artifacts and the "quality of informatics design

[3] Sample design is detailed in Chapter 5.

[4] Institutional repositories are considered part of the campus IT infrastructure and eResearch strategy. They are seen as specific IT systems designed to preserve and disseminate research outputs.

achievements" (p. 210), therefore technical criteria are evaluated. However, Social Informatics is mainly concerned about the interaction with users' social practices (Rohde & Wulf, 2011). According to this view, the quality of the change effects in the social system (and in the practices that it structures) is as relevant as formal design criteria. Likewise *Digital Media* is a multidisciplinary field close to Informatics that has a wider perspective on ICT. Through the combination of design, media theory and computing, it conceives *algorithmic* media as a complex research object that is simultaneously: an aesthetic communication tool, a technical channel and social interaction (Faulstich, 2004). Both fields, Social Informatics and Digital Media, point out the need of understanding usage contexts as well as the technical criteria, considering the complex interaction between technology, organizations and people.

The study of IT adoption is consistent with these perspectives and some of their relevant research contributions are systematic analyses of specific implementation conditions. In relation to IT standards, West (2003) identified four main areas of research: technical content, standards creation, standards selection and adoption. The last one has focused on the organizational decisions and processes related to the selection and operation of ITS; as well as standardization at the macro level, characterized by market competition and government regulations (Thomas, 2010).

Based on the presented disciplinary framework and the specific goals of this dissertation, two main outcomes were outlined: an adoption model of ITS and a list of factors involved the process. These deliverables were framed within the eResearch domain and focused on HEOs as organizational adopters. By modeling ITS adoption, it was aimed to offer a systematic representation of the adoption context as a way to analyze it and to assess ITS implementation within organization boundaries. At the same time, the identification of factors was core to offer a granular perspective, allowing the comparison among different organizational environments. In this way, the factors were input elements of the model that provided core information about specific adoption conditions. Together these two outcomes intended to make ITS visible within the IT implementation process and as part of a *dynamic lifecycle*[5].

This research was concerned with exploring ITS and standardization, particularly in eResearch. The outcomes were conceived as part of this domain and covered a set of IT services. The model and its related factors dealt with a series of domain-specific characteristics:

- IT designed and implemented to support research knowledge production.
- HEOs as context and primary adopters.
- Researchers as secondary adopters (target users).

The specific ITS considered to test the model were repository standards and therefore, the adoption factors were consistent with their particular adoption process. The *standardization space*[6] was defined as a mix of o*rganizational* and *technical* ITS, including repository software (as organizational ITS) and harvesting and metadata standards (as technical ITS).

The two proposed outcomes should be considered as analytical instruments and a systematic approach to adoption contexts. Beyond the contribution to the knowledge base in IS, they offer a framework that can be used to drive decision making and evidence-based ITS management.

1.6. Structure

The overall structure of this dissertation takes the form of seven chapters that are grouped in four main sections: research scope, theoretical/conceptual framework, methods and results.

The first section, covered by this chapter, has introduced the scope of the dissertation, its specific purpose and the research questions. Particularly relevant was a statement about the IS perspective to study ITS and the selection of eResearch as domain. Although some initial and general overview about the

[5] See Chapter 3.

[6] The term *standardization* space was proposed as an alternative to traditional typologies of ITS. It is explained in Chapter 2

methods is provided as a first insight, the interpretive focus of this study and the specific methods are detailed in Chapter 5.

The second section goes deeper into the theoretical foundations of this work. Chapter 2 presents a discussion about the term standard, which is followed by an exhaustive description of ITS typologies and the proposed notion of *standardization space*. Two subsequent chapters (3 and 4) develop a structured and solid theoretical framework that incorporates ITS, adoption and eResearch by exploring relevant research in these fields. Central to this work was the qualitative meta-analysis on ITS adoption included in Chapter 4, because this constituted the starting point of the conceptual model and the definition of factors in each category of analysis.

Chapter 5 introduces the research strategy not only as a matter of methods and instruments: it details the research philosophy and nature of the inquiry through a reflection on the interpretive character of the study (research philosophy). The use of the case study strategy is explained in relation to the IS field as well as the pertinence of a mixed methods approach for data collection. This section introduces the Royal Holloway University of London and the Faculty of Philosophy and Literature (at the Autonomous National University of Mexico) as two selected HEOs for the case studies, including the criteria behind this choice and the designed instruments.

The fourth and last section is the core part of this work. Chapter 6 focuses on the collected data and presents an exhaustive analysis, driven by a conceptual model. Taking into account organizations' characteristics, their implementations and their adoption processes, the empirical evidence showed the behavior of the factors in each of the different adoption stages. At the end, the conclusions tie up theoretical and empirical strands in order to summarize main findings and to discuss the implications for future research in ITS adoption and eResearch.

CHAPTER OTWO

2. Background

From economics to innovation research and engineering, standards and standardization are terms that refer mainly to a series of procedures and guidelines for service and infrastructure management and development. Since early 80s, standardization research has been an active area that covers a variety of aspects related to these topics and integrates multiple disciplines, including IS. The first aspect that emerges when doing research on ITS is the establishment of a unified characterization of the studied phenomenon, taking into account how it is seen by scholars from a variety of fields.

Then the purpose of this first chapter is to explore the terminology related to the standards and specifically to ITS, as a way of approaching to a rich body of knowledge in this subject and establishing common understandings. Beyond providing a single definition about what a standard means in this work, it is intented to explore the term and its dimensions too. Such approach allows situating the research into context and understanding the object of study as a complex and multifaceted. In order to achieve it, a review on terms and multiple aspects of the standards are presented, including a discussion about their definition and typologies.

2.1. Some History: *"A Life like System"*

Standards have "always been with us" as a way "to control and organize much of mankind activities" (Cargill, 1989, p. 18). They can be dimensioned as a management technique (Cargill, 1989; Cargill & Bolin, 2007) that is used to reduce risk and responds "to changing business requirements and needs" (Cargill & Bolin, 2007, p. 297).

In particular, technology standards are "a cornerstone of the modern information economy", because they "affect firm strategy, market performance and by extension, economic growth" (Greenstein & Stango, 2007, p. 1). Then standardization and standards are considered fundamental for what Krechmer (2000) names a "*life like system*" (p. 70).

Krechmer (2000) affirmed that before the creation of technical standards, tool configuration was transmitted only by instruction and example. He considered that the growing complexity of technology requires standards as a way to "communicate technical information broadly and uniformly" (p. 70). Once these specifications are communicated and implemented, standards get consistently embedded in the technical systems and become inherent to them. All innovations (including information technology), other form of progress and standards follow what Krechmer calls an *evolutionary path*. This author explained the role of standards in the following way:

> *'Each stratum of standards codifies a level of technology for society and requires ways to balance two conflicting objectives: one, incentives for innovation (enabling private gain) and two, the diffusion of new products, services and processes (enabling lower prices and reater (sic) usage - public good). By identifying each stratum of standards, specific issues may be seen that impact society, and new approaches may be developed, to better meet society's needs". (Krechmer, 2000, p. 70)*

By identifying historic periods and the paradigm shift, standards appear "as means to codify technology for a society" (Krechmer, 2000, p. 70) and can be applied to "almost any material, process or action" (p. 70). Furthermore he characterized the evolutionary path by identifying historical periods, technology and some related technical standards (Table 2.1).

Aspects	Historical Periods			
	Agrarian	Industrial	Information	
			Sequential	Adaptive
Communications	Barter and trade routes	Mechanized transport	Electronic (e.g. telephony)	Internet
Technology	Navigation and measuring	Power machines	Linear processes (rail road)	Adaptative processes (computers)
Value system	Private property ownership	Invention ownership	System ownership (public utilities)	Concept ownership (branded IDs)
Strata of standards	Units and reference	Similarity	Compatibility	Etiquette

Table 2.1 Historical periods and standards *stratum* (adapted from Krechmer, 2000)

Unit and reference standards were a factor of development in early civilizations. Krechmer (2000) affirmed that number systems and units of weight and measure were the first attempts to standardize; but later (in 1799), the different standards coalesced into the metric system. Cargill (1989) referred to the Lydian stater, the first coin created and first unit of exchange that was recognized and accepted throughout the Mediterranean. With a common quantifiable denominator, it was easier to do business and therefore it had evident economic advantages.

During the industrial period, the strata of standards focused on similarity, as a way to achieve uniform realizations and "codify the results of repetitive processes" (Krechmer, 2000). Industrial standards were initially centered on specifications, but in the early 19th century, mechanized processes "instigated the powerful concept of interchangeability (the transposition of similar parts)" (p. 70). Cargill (1989) claimed that the Industrial Revolution required more production in less time and nation states had to assure that a degree of commonality existed among them. Hence the era of the interchangeability standards "became based more on functional definition and utility" (p. 15).

After the industrial era, compatibility emerged as a novel concept because new procedures were required for sequential systems, in particular basic services like water, sewage, gas electricity and telephone (Krechmer, 2000). The invention of the railroad was a significant milestone, not only because it was a technical achievement, but for its deep world impact on the world (Cargill, 1989). In United States, railroads began using standards and many considered it "as a major victory for standardization" (Cargill, 1989, p. 16); taking into account that European gauges of rail lines used to change at every country border. The difference between similarity and compatibility strata was discussed by Krechmer (2000), who considered that device standards tend to specify product similarity, while interface standards aim compatibility "by defining the transmitted signals that pass across the interface and using the minimum definition of the receiver functions necessary to ensure compatibility" (p. 70).

The last historical form of standards is the etiquettes, which allow the use of adaptive systems. Etiquettes are *protocols of protocols* (meta-protocol) that "shuttles back and forth between the communicating ends to negotiate which specific protocol(s), data sets and options will be used for compatible operation" (p. 70). The internet is an example of a system based on these standards due to the fact it is build "from a compact series of protocol standards (TCP, IP, UDP, etc.) used to enable end-to-end communications between various programmable computers" (p. 70):

> *'The application layer meta-representation of structured documents such as XML (eXtensible Mark-up Language), along with the optional modules that define sets of tags and attributes, may create a need for other etiquettes (meta-protocols) to negotiate the desired application level data structures between remote systems" (Krechmer, 2000, p. 70).*

This economic-based timeline is one of many perspectives about the joint evolution of technology and standards. It raises questions related to their role and importance, in the past and nowadays. Despite its limitations, Krechmer's work shows that standards can be considered as a *solution* to a variety of technology problems (process and products). Historically they have provided more than "unifying" properties and have turned into complex mechanisms that are necessary for different types of infrastructures.

2.2. Defining IT Standard

The definition of the term standard requires conveying a variety of perspectives in order to include different types of ITS. For this reason, its comprehensive and detailed definition is more complex that just selecting an existing one (de Vries, 2005). The analysis of relevant definitions is not only into an interesting analytic exercise, but a precondition towards a position in this matter.

Standards Development Organizations[7] (SDOs) are bodies that have the main purpose of *creating* standards. One example of a SDO is the well known International Organization for Standardization (ISO), the world's largest developer and publisher of international standards. ISO's main focus is expressed in its widely used definition of standards:

> *"Document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context." (ISO, 2010)*

One distinctive aspect of ISO's definition is the focus on the institutionalization and formalization of the standard by a specialized organization (recognized body). As SDO, its definition points out the core role of the agency as "*legitimizer*". However it is limited because it does not cover non-formal and internal (company) standardization, which tend to be part of agreements or strategic planning in a single or groups of firms.

Another important SDO, but in the Engineering (IT) field, is the Institute of Electrical and Electronics Engineers (IEEE). Its definition does not include the role of the issuing agency and it rather focuses on the materiality and applicability of the standards as well as their purpose: reliability assurance.

> *"Standards are published documents that establish specifications and procedures designed to ensure the reliability of the materials, products, methods, and/ or services people use every day." (IEEE, 2010)*

[7] Also called Standard Settings Organizations (SSO).

Standardization processes and standards setting are also a concern of regions and countries to achieve large-scale levels of technology organization. An example is the European Union, who promotes the establishment of regional standards because they are "very effective policy tools" and contribute to ensure: "inter alia, the interoperability of networks and systems, a proper functioning of the single market, a high level of consumer and environmental protection, and more innovation and social inclusion" (European Commission, 2011, p. 2).

> *'Standards are voluntary documents that define technical or quality requirements with which current or future products, production processes, services or methods may comply."* (European Commission, 2011, p. 1)

The definition of the European Commission points out the nature of the standards as defined requirements that may be complied. Such focus on requirements outlines (technical and quality) needs as the source of the standards and their aim (in the form of products, production, processes, services or methods) is to achieve compliance to their objectives.

Besides the definitions of involved parties on standardization, the research and academic fields have also explored possible directions towards a more comprehensive approach. The seminal work by Cargill (1989) has such wider perspective and it includes a particular element to characterize IT standards and standardization: *acceptance*. In this definition, adopters are agents that participate actively in the process:

> *"A standard is the deliberate acceptance by a group of people having common interests or background of a quantifiable metric that influences their behavior and activities by permitting a common interchange". (Cargill, 1989)*

Nevertheless de Vries (2005) claims that a comprehensive definition of the term standard should include four aspects: it does not restrict the issuing authorities, it matches a variety of problems (covering more than specifications, procedures, rules and requirements) and it refers not only to a public standards and it is not limited to mandatory standards (excluding voluntary). Based on these considerations, de Vries proposed his own definition of standard:

> *"A proved specification of a limited set of solutions to actual o potential matching problems prepared for the benefits of the party or parties involved, balancing their needs and intended and expected to be used repeatedly or continuously during a certain period by a substantial number of the parties for whom they are meant" (de Vries, 1999)*

De Vries (1999) characterized standards as a *proved* and *repeated* (continuous) solution to a problem; thus they are considered problem solvers and adoption is the result of the tension between local needs and the intended benefits. The author claimed that his definition is comprehensive because the proposed are aspects met and therefore, most types of standards can be included (de Vries, 1999).

Authors'		Standards'			
Name	**Field**	**Material**	**Content**	**Purpose**	**Areas of Impact**
ISO	SDO	Document	• Rules • Guidelines	Order	Activities
IEEE	SDO	Document	• Specifications • Procedures	Reliability	• Material • Products • Methods • Services
European Union (2011)	Government (region)	Voluntary document	Requirements	Compliance	• Product • Processes • Services • Methods
Cargill (1989)	Research	Acceptance	Metric	Interchange	• Behavior • Activities
De Vries (1999)	Research	Specification	Solution	Problem solving	• Problems

Table 2.2 Analysis of the definitions

Table 2.2 presents a compilation of the main elements in each definition, including author and their field as well as material (core instrument), content (type), purpose (reason and objective of the standards), and areas of impact (affected parts). From the five definitions discussed above, de Vries' is closer to the perspective of this work and therefore it is used as basis:

> *A specification to be repeated and continuously used for a set of specific problem or problems. Its usage implies a negotiated acceptance by the involved parties as an attempt to solve the recognized problem on a unified way.*

The proposed definition adds two key elements: negotiation and acceptance, because they implicitly address choice and adoption. In the case of the ITS, the spectrum of the problem and the solution is specifically related to Information and Communication Technology (ICT). For De Vries (2005), standards' scope is determined by the entities involved in the standardization (i.e. IT system) not only by certain types of stakeholders or a business sector.

2.3. IT Standards and Infrastructure

In order to understand the phenomena and role of the standards from the Information Systems perspective, it is necessary to explore their implications as well.

The use of standards in IS has been linked to the notion of infrastructure. For Star (1999), infrastructure can be envisioned as an invisible "system of substrates" (e.g. railroad lines, pipes, electrical power plants, etc.). Davenport and Linder (1994) considered not only its *materiality* and conceived it as "the aspects of the physical and human environment that are shared for the public good: streets, bridges, sewers, languages, monetary systems" (p. 885). Some of these ideas have been influenced by the notion of *large technical systems,* introduced by Hughes (1983) and further discussed by Mayntz and Hughes (1988). In relation to the IS field, Edwards (1998) considered that IT is the *infrastructure of infrastructures*, because it operates at the meta-level as internetworks in computer-based infrastructures. Edward's assumption established what can be called as a conceptual difference between IT infrastructure and large technical systems. But in general, the notion of IT infrastructure is problematic (Star, 1999): for engineers it is a topic, for some users is a barrier and for others is an enabler. In her analysis of this specific type of infrastructure, Star (1999) considered a relational concept that becomes real during the practice because they are "part of the human organization and are a problematic as any other" (Star, 1999, p. 380)

In relation to infrastructure's range of impact, Davenport and Linder (1994) considered different types of locations: town or city, state, national and international as well as whole organizations. This differentiation is pertinent when approaching to the ITS phenomena because IS research has already explored the strategic relevance of standards for governments and national IT infrastructures. As elements of the local/regional/national information infrastructures, ITS tend to impact innovation and production at the macro level by establishing solutions considered as strategic (while dismissing other and creating mechanisms to remain active). Individual organizations and their sub-units operate based on external infrastructures and adopt ITS not only as a consequence of action by governments, consortia and SDOs, but as part of a decision making process to follow their own management strategies.

The concept of infrastructure in IS useful because it allows the analysis of computer support and denotes "resources and practices required to help people adequately carry out their work" (Jewett & Kling, 1991). Research in this field have employed a variety of related terms, some of them are: IT infrastructure (Laudon & Laudon, 2005; Laudon, Laudon, & Schoder, 2010; Sirkemaa, 2002, 2009), IS infrastructure (Khosrow-Pour, 2006), IT/IS infrastructure (Grembergen, 2002) and Information Systems Management (ISM) infrastructure (Davenport & Linder, 1994). In spite of using similar or even the same terms, the notion of IT infrastructure can be different.

For Sirkemaa (2002, 2009) IT infrastructure refers to "basic support systems that are shared among users" (p. 202); it is a shared platform for all business applications that can to impact organizations and future decisions in a considerable timeframe. This author conceived IT infrastructure as *inherent* to the *whole organization* structure and operation: resource and capability at the same time (Sirkemaa, 2002).

Reiner and Cegielski (2011) were more specific about the configuration of the IT infrastructure and listed a series of constituents: "physical facilities, IT components, IT services and IT personnel". They considered that IT infrastructure should not be reduced to the technical platform, which consists exclusively of the physical IT components. Thus strategy and the staff should be associated to the IT infrastructure as well. On the other hand, Duncan (1995) studied IT infrastructure as a series of tangible resources like: platform technology, network and telecommunication technologies, key data and core data-processing applications (Duncan, 1995). Sirkemaa (2002) considered IT infrastructure not only as a "combination of different devices and components" (p. 202), because it includes services, management strategies and operation of personnel. Byrd & Turner (2000) incorporated this aspect as well and defined human IT infrastructure as "the choices pertaining to the knowledge and capabilities required to manage effectively the IT resources within the organization" (p. 168). Some other relevant research (Broadbent & Weill, 1999; Rainer & Cegielski, 2011; Sirkemaa, 2002) has envisioned the following components of IT infrastructures and placed them in a pyramid: shared IT services, human IT infrastructure and (technical) IT components. However ITS action is omitted and their role is relegated exclusively to technical or managerial decisions in closed organizational environments.

For this work, a more comprehensive characterization of the IT infrastructure is proposed because it aggregates the notion of information management and the implications of the IT standardization. Figure 2.1 presents a way of visualizing IT infrastructure and standards action, but at the same time, it serves as a basis for:

- bringing together organizational and external IT infrastructures, recognizing the interaction between them while standardizing;
- situating ITS action across the organization; and
- identifying the openness of organization structures (and their processes) to IT standardization;

High level infrastructures are an important referent as well. Therefore the interaction between organizational and public/industry settings should be recognized. It implies not only the process of creating standards, but favoring some of those already available in the market (e.g. Greenstein, 1993). An example of this top/bottom interaction among infrastructures in the eResearch field is grid computing applied to Geographic Information Systems (GIS). In Europe and concretely in Germany, government policy favored the adoption of grid technology to store and process large scale scientific data. Meanwhile, the involved scientific communities have been developing a set of metadata standards to achieve data exchange among GIS (Loudon, 2000). Research centers' adoption necessarily involves external infrastructure and local decisions can be deeply influenced by external trends. But it should be noticed that organizational decisions in the form of market action might also influence macro infrastructures (by generating *critical mass*).

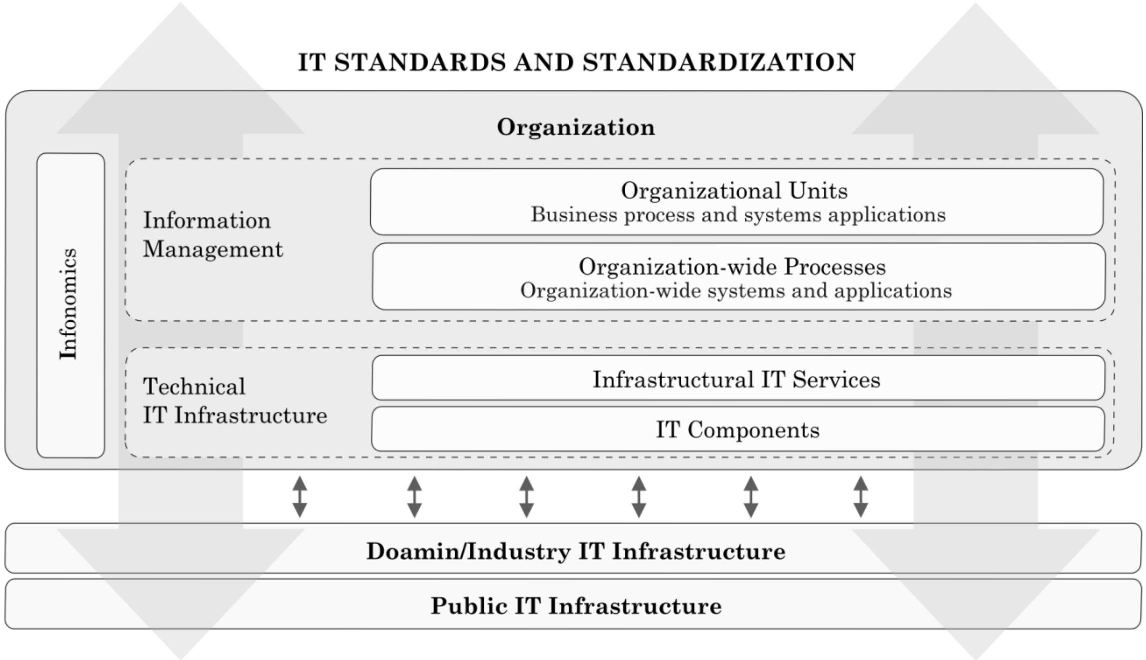

Fig. 2.1 IT standards and infrastructure (adapted from Krcmar, 2005)

Organization's inner structure has been slightly inspired by Krcmar's model of the information management, which separates Infonomics, IS management and ICT technical management (Krcmar, 2005). Figure 2.1 presents information managements integrated by two layers: *information* (content) and *technical IT infrastructure*. At the bottom, the technical IT infrastructure has been conceived to provide storage, processing, communication and technology stack through two main elements: *components* and *services* (Krcmar, 2005). For Broadbent (1996), IT components are commodities that are necessary to provide the material basis for the infrastructure operation. Laudon and Laudon (2005) provided a detailed list of those components that need to be coherently articulated through the IT infrastructure:

- Computer hardware platforms
- Operating systems platforms
- Enterprise software applications

- Networking and telecommunications
- Consultants and systems integrators
- Data management and storage
- Internet platforms

The second element of the technical IT infrastructure is service. Management at this level coordinates the components and available staff in order to ensure innovative, reliable, timely and secure IT technical services (Lientz, 2009). Table 2.3 presents Laudon and Laudon's (2005) list of IT services, which are categorized according to Krcmar's model. But a difference between service management provided at the technical infrastructure level and at the *information management* level needs to be established. Infrastructural IT services are concerned about those shared services that guarantee a physical/technical basis for the application scenario as well as the allocation of information resources (Krcmar, 2005). While at the information level, application software services bring together a series of technical, organizational and subjective elements as a whole into the system (Krcmar, 2005). Thus they consist of *organization-wide capabilities* and system applications for *units' business processes*.

Laudon and Laudon's list (2005) included the establishment of organizational ITS[8] as a service provided by the Information Management. However, these are just one type of standards and they are not the only that interact with the IT infrastructure. ITS are present in all levels as well outside and inside the organization (Fig. 2.1) and therefore a variety of standards exist to match different and specific problems. They are created to satisfy a variety of requirements, imply different actors, are developed by different entities and are product of different processes. The next section presents a variety of ITS types that are referred in the literature and through analyzing these typologies; it is expected to contribute to the wider understanding of standards.

[8] Usually referred as company IT standards (de Vries & Slob, 2006; van Wessel & Ribbers, 2006; van Wessel, Ribbers, & de Vries, 2007)

	IT Services	Description
Information management	IT research and development services	• Research on potential projects and investments that could give added value to the organization strategy and operation
	IT standards services	• Provision of organizational IT policies (e.g. IT to be used, and where, when, how, and by whom)
	IT education services	• User training • Assessment to managers about investments planning and management of IT.
	IT management services	• Infrastructure planning and development • Management of IT financial costs (accounting for expenditures) • Coordination of IT services with the business units • Project management
IS management	Application software services	• Organization-wide capabilities (e.g. resource planning, organization-wide processes and applications as well as shared knowledge management systems) • System applications for organization units' business processes
IT infrastructure technical management	Data management services	• Data storage and management • Data analysis capabilities
	Telecommunications services	• Data, voice, and video connectivity
	Computing platforms	• Computing services for coherent and integrated digital environments (i.e. large mainframes, computers, mobile devices and Internet appliances)
	Physical facilities management services	• Development and management of physical installations required for computing, telecommunications, and data management services.

Table 2.3 IT services and standards (based on Laudon & Laudon, 2005)

2.4. Typologies of IT Standards

In the IT literature, research about several types of standards can be found: from de jure and de facto standards (Burrows, 1999; Hanseth & Monteiro, 1997; Hanseth, Monteiro & Hatling, 1996; West, 2003); to open and closed standards

(Anido et al., 2001; Cargill, 1994; Ginsburg, 2004; Rachuri et al., 2008; West, 2003; Zhu, Kraemer, & Gurbaxani, 2006), data standards (Delhaye & Lobet-Maris, 1995; Münstermann & Eckhardt, 2008; Sherman, 2004; Thomas, Probets, Dawson, & King, 2008a, 2008b), security standards (Fernández-Medina & Yagüe, 2008); interoperability standards (Mykkänen & Tuomainen, 2008); company standards (van Wessel, de Vries & Slob, 2006; 2008; van Wessel et al., 2007); as well as a variety of standards for different application domains like eBusiness (Chen, 2003), eHealth (Braa, Hanseth, Mohammed, & Shaw, 2007; Eichelberg, Aden, & Riesmeier, 2005; Hammond & Cimino, 2006; Jacucci, Shaw, & Braa, 2006) and eLearning (Anido et al., 2001; Varlamis & Apostolakis, 2006) among others. This list is not exhaustive but illustrates a variety of ITS that have been researched by scholars in the IS field.

Bonino and Spring (1991) presented what they called the most cited classification scheme of standards and included three types of standards: *de facto*, *de jure* and *voluntary*. For these authors, *de facto* are those standards accepted in the market as a result of an explicit and implicit agreement of adopters. Regulatory or *de jure* are the standards that have a legal statute or force of law. And *consensus* or *voluntary* standards are publicly developed and are result of exhaustive discussions and intense user and provider dynamics.

Another relevant typology of standards was proposed by Davis (1987), who identified three main types of standards from the economics perspective: *standards for reference and definition, standards for minimal admissible attributes* and *standards for interface compatibility*. Davis (1987) established a major separation into two big categories as well: those that can be applied to the technical design and those to the behavioral performance (e.g. processes).

David and Greenstein (1990) revisited Davis' taxonomy and added the character of the acceptance of a standard as a criterion. They refer to: *unsponsored standards* (not identified originator with a proprietary interest), *sponsored standards* (one or more entities holding an indirect proprietary interest), *standards agreements* (published by a "standards writing organization") and *mandated standards* (set by a "government agencies that have regulatory authority"). The first two types are variations of de facto standards and the last two are "tagged loosely as de jure" (David & Greenstein, 1990, p. 4) .

Another classification was provided by Allen and Sriram (2000), who considered four broad types: *fundamental, prescriptive, performance based* and *interoperability standards*. These standards are respectively for metrics and measures, process, performance and format "to ensure the smooth operation between systems that use the same physical entity or data" (Allen & Sriram, 2000, p. 173). However, the authors warned about their classification (as many others), because the typologies are not mutually exclusive and a standard can fit into more than one categorie.

IT the IT field, Cargill (1989) analyzed specifically some types or categories based on the obligatory nature of the ITS. He stated that research on ITS needs to characterized them as *regulatory* or *consensus* (voluntary). Similar to some of the typologies presented before, regulatory standards are legally mandatory and voluntary are those driven by the market. But Cargill (1989) went beyond in the classification of consensus standards and proposed a series of subcategories presented in Table 2.4.

	Product	**Process**
Implementation	Implementation-product ITS	Implementation-process ITS
Conceptual	Conceptual-product ITS	Conceptual-process ITS

Table 2.4 Cargill's ITS typology of consensus standards (based on Cargill, 1989)

For Cargill (1989), *conceptual* and *implementation* ITS use the notion of standards as problem solvers. Thus ITS can be a solution for a future problem (conceptual) that can change the current configuration of a given system or a current issue to solve, so they are revolutionary and evolutionary (Cargill, 1989), respectively. *Product* ITS describe products as well as services being standardized, which serve as paradigm and are free of external dependencies (assuming certain consistency of the reality). Different to product standards, *process* ITS focuse "on the transformation of a costumer need into a costumer solution, examining a system's inputs and outputs", but they are not concern "with the product that accomplish the transmutation" (p. 35). Cargill (1989) considered that *implementation-product* ITS are the most common and they deal "with an established product or service, with known rules and boundaries" (p. 35), they can be updated and change according to the environment conditions. The *implementation-process* ITS were difficult to categorize for this author, because future (global) implications of an implementation and present (local) orientations of a process tend to have incompatible objectives. However he clarified that implementation-process ITS refer to those that achieve a result (not the product that does it) and gives the example of the telephone system, in which the users care about the user interface and not the communication technology (Cargill, 1989).

Conceptual-product ITS are widespread in the IT industry "which is very dynamic and has a tendency to be product, not process driven" (Cargill, 1989, p. 36). Conceptual-product ITS assure that perceptions about new technologies are valid and the market "reaffirm its own correctness" (p. 37). Then this type of ITS reaffirms the existence of a need and the response to such need, but the standards keep future oriented and marketing driven. Finally, the *conceptual-process* ITS follow the same dynamic of the conceptual-product, but they refer to "a set of expected events that lead to a satisfactory set of outputs based on a specified set of inputs" (p. 39). According to Cargill, one of the characteristics of these standards is being "inherently immutable" (p. 39), because of the possible generation of alternative process and their susceptibility to semantic errors.

2.4.1. Typologies: An Overview

Cargill's ITS typologies are restricted to consensus standards, thus the recognition of other types of ITS is omitted (like open standards, company standards, field oriented standards). De Vries (2005) recognized the variety of perspectives to study ITS, which is understandable in a field that encompasses multiple points of view, processes, products and technologies. In one of the few attempt to analyze ITS typologies and explore the use of ITS types in current research, this author argued that the concepts and terms to describe ITS "are not only diverse but confusing" (de Vries, 2005, p. 2). From the economics point of view, he proposes separating ITS typologies according to three main elements: subject matter (solution/problem), development and use.

a) ITS and subject matter

For de Vries (2005), ITS solve matching problems, which consist of interrelating entities in a way they harmonize or determining features of an entity based on its relation with other. In this way, ITS can be classified according to the entities: a single or group of persons, a thing (e.g. objects, activities, ideas, processes) and a combination of entities (de Vries, 2005). A matching problem is concerned about entities' interrelation: thing to thing (plug-ins and sockets), man to thing (safety and ergonomics) and man to man (management and procedures) (de Vries, 2005).

Figure 2.2 identifies three main categories for subject matter related ITS: *basic, requiring* and *measurement*. According to de Vries (2005), *basic* ITS "provide structured descriptions" (p. 6) in order to facilitate human communication about the entities. Examples of these IT standards are: terminology, units, classifications or codes, ergonomic standards and reference models. Garcia et al. (2006) analyzed this type of standards, like the IEEE Glossary of Software Engineering Terminology (610.12-1992).

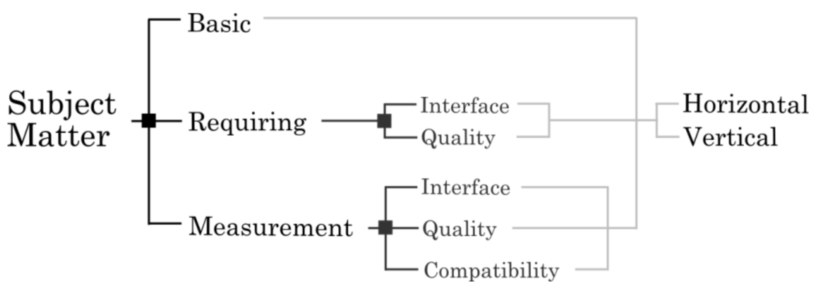

Fig. 2.2 ITS typologies focused on the subject-matter (based on de Vries, 2005)

Requiring ITS are entities' needs or relations between them (de Vries, 2005). This type of ITS has two subcategories: *performance-based* standards and *design-based* standards. The first sets criteria for the solution of a matching problem but the standard do not describe the solution itself. In fact, performance ITS include specifications on extend for deviations from permissible basic requirements and they can be *interference* (requirements concerning the influence of an entity, e.g. safety standards) and *quality* standards (de Vries, 2005). On the other hand, *design-based* ITS portray solutions for matching problems (de Vries, 2005). They can be grouped into three subcategories: *interference*, *compatibility* (fit interrelated entities in order to function together) and *quality*. Particularly, *compatibility* standards have been the focus of a considerable amount of research in the ITS field (Berg, 1989; David & Greenstein, 1990; Egyedi, 2007; Farrell & Saloner, 1985).

M*easurement* ITS are control mechanisms that include assurance methods to check compliance to the requiring ITS. Some examples of software measurement ITS are listed by García et al. (2006), who include those like the ISO/IEC 15939.

De Vries (2005) claimed that each one these typologies can also be matched to *horizontal* and *vertical* standards. Through this second sub-classification, it is recognized the functionalities of hierarchically different (vertical) or correspondent (horizontal) entities (de Vries, 2005). Relevant research on this type of ITS has been produced by Markus, Steinfield and Wigand (2003) in the field of electronic mortgage standards and Kotinurmi, Nurmilaakso and Laesvouri (2003) in eBusiness.

b) ITS and their development

In ITS research, many classifications (Fig. 2.3) are based on the organization that sets the standard and the characteristics of the developing process (de Vries, 2005). Particularly, there is some interest in the structure and operation of Standards Development Organizations (Burrows, 1999; Iversen, Vedel, & Werle, 2004; Lehr, 1992; Rysman & Simcoe, 2007) in several industries and application fields (Hammond, 2005; Zhao, Xia, & Shaw, 2005). Beyond the solely SDO activity, some classifications characterize ITS character and action according to the different organizations that set standards.

The well-known separation between *de jure* and *de facto* standards is precisely based on the setting organization. However, this typology is not free of problems because of the variety of meanings assigned to both terms: as norms (de jure) or public (de facto) (Metcalfe & Miles, 1994); as official, public and voluntary (de jure) or product of extended use (de facto) (Rada, 1993); as emerged from consensus and ratified (de jure) or product of the standards war (de facto) (Stango, 2004); as documented de facto practices (de jure) or product of the practice (de facto) (Burrows, 1999). De Vries (2005) noted the exchangeability of the term de jure to characterize a *government* standard (a standard included in the law) and those set by standardization bodies as ISO. Hanseth, Monteiro and Hatling (1996) proposed a classification that distinguishes *formal, de facto* and *de jure* standards. Thus standardization bodies develop formal standards, de facto are product of market mechanisms and de jure are imposed by law. De Vries (2005) agrees with this perspective and prefers the precise term *government* standards instead to de jure.

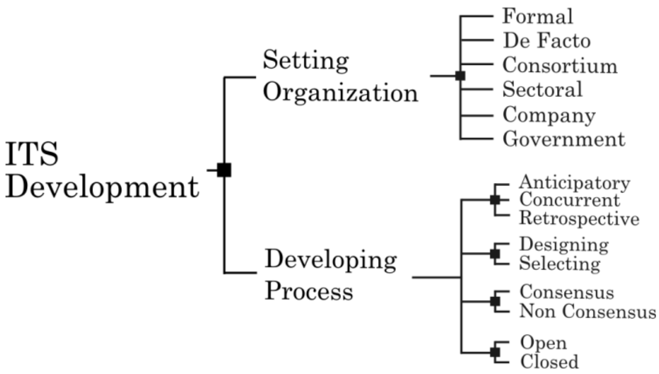

Fig. 2.3 ITS classification related to standards development (based on de Vries, 2005)

In order to avoid confusion about who set a formal standard, de Vries (2005) suggested that *formal* standards are issued by organizations like: ISO, their national members (e.g. the American National Standards Institute and the British Standards Institution), regional SDOs related to these and the International Telecommunication Union (e.g. the European Telecommunication Standards Institute). This author included accredited sector oriented SDOs by national organisms as well.

De facto standards are another type of ITS in Vries' typology (2005). They are issued by three kinds of organizations: *consortiums*, *sectoral* and *companies* (single organizations). Consortium standards are product of alliances of companies and other organizations that develop and agree on them. Sectoral organizations are those that "unit parties in a certain branch of business" (p. 11). And company standards are set by a company or single organization, and according to de Vries (2005) they have five forms (p. 11):

- a reference to one or more external standards officially adopted by a company
- a modification of an external standard
- a subset of an extern standard
- a standard reproduced from (parts of) other external documents
- a self written standard

Finally, *government* standards are those set by a government agency, other than a formal SDO (de Vries, 2005). Their purpose is to solve a matching problem related to internal operation. The role of government standards and standardization policies are deep discussed in research works related to technology growth (Tassey, 1982), for building the national information infrastructure (Radack, 1994) and for technology assessment and social control (Baram, 1973).

The process of ITS development offers more perspectives to analyze and classify. For de Vries (2005), it includes a series of aspects: "when the standards is made, whether or not a new design is made or a existing one is chosen, how decision is done, who is allowed to participate" (p. 11). Considering the development process, some other typologies are listed and briefly discussed in the following sections:

a) *Standardization timing: anticipatory, concurrent and retrospective*
ITS are classified according to the time they are developed. For Sherif (2001), this typology describes timing relationship between ITS and the product lifecycle. If standardization happens before "the expected future matching problem" (de Vries, 2005, p. 11), it is called *anticipatory* or *prospective*. According to Rashba and Gamota (2003), these ITS contribute to the rapid deployment of new IT and have the potential to transform an evolutionary technology into one revolutionary.

If the standard is *concurrent*, it attempts to solve the problem as soon as they happen. In Sherif (2001) and Söderström, Persson and Stirna (2004), these type of standards are called participatory. Considered as *interactive*, they emerged with the possibilities that the internet had brought to collaborative setting process (Sherif, 2001).

Finally, *retrospective* standardization or responsive standard solves current matching problems (de Vries, 2005). Egyedi and Sherif (2010) claimed that these ITS "improve efficiencies or reduce market uncertainties for auxiliary product or services" (p. 167).

b) *Designing and selecting*
De Vries (2005) affirmed that a "regular" standardization process implies the design and approval of the standard; but sometimes a SDO or organization can adopt a solution developed by others. Then *designing* standardization involves the generation of a full new solution, whereas *selecting* standardization is the implementation of preferred solutions already available (de Vries, 2005).

c) *Consensus and non consensus*
Mattli and Buthe (2003) considered that consensus implies that objections are: reconciled, not sustained or considered to be of minor significance, in order to avoid further delays in the decision-making process. De Vries (2005) defined consensus as " an agreement to not disagree any longer" (p. 12). In Hogan and Radack (1997), *consensus* ITS are inherently open because they are *openly* available and "developed openly by consensus standards activities, either formal or informal" (p. 31). The mixed term voluntary consensus standards was used by Zhao, Xia and Shaw (2005) and Guijarro (2005) to refer a standard that is in the middle of de facto and de jure standards (Zhao et al., 2005). In his research on standard selection for eGovernment applications, Guijarro (2005) referred to the US Office of Management and Budget's (OMB) definition of voluntary consensus standard: "owners of relevant intellectual property have agreed to make that intellectual property available on a non-discriminatory, royalty-free or reasonable royalty basis to all interested parties" (Office of Management and Budget, 1998).

On the other hand, *non-consensus* standards are considered to be close to industry, company and de facto standards because they are result of a development process in private settings and not of full consensus (Guijarro, 2005).

d) *Open and closed*
Zhu et al. (2006) considered that *open* standards are those developed "by an open community that uses public communication platforms and software" (p. 517). However, they are not so easy to define as it seems. For Krechmer (2005, 2006) the term open standard has different meanings for developers, implementers and users. This author stated that standards creators consider a standard to be open if the development "follows the tenets of open meeting, consensus and due process" (p. 2). For implementers, an open standard has not costs to them, serves the market, it is not an obstacle to further innovation, and does not favor a competitor (Krechmer, 2006). And for users, open standards are those that allow multiple implementations from different available sources, operate in all needed locations, are compatible con previous implementations and support implementation over the lifecycle (Ken Krechmer, 2005, 2006).

On the other hand, *closed* standards are also referred as synonym of proprietary standards (West & Dedrick, Lea & Hall, 2004; 2001; Zhu et al., 2006) and they can be called sponsored standards (Stango, 2004). For Zhu et al. (2006), a standard is closed when it is set by a group of firms that require private communication platforms. These authors clarified that the ownership of this type of standards "belongs to the developer, thus making it proprietary" (Zhu et al., 2006). For Stango (2004), a key aspect on the adoption of proprietary standards is its dependency on the strategic behavior of the firms owning the standards. So standard's owners have a profit motive to support adoption and can use price and other mechanisms to influence standards' choice (Stango, 2004).

c) ITS and their use

In his analysis of ITs typologies, de Vries (2005) included usage as another criterion to classify standards (Figure 2.4). He considered that within the notion of use, some typologies are based on ITS' *function*, *domain*, *business mode* and *extend of availability* (de Vries, 2005). The category called degree of obligation (initially included by the author) has been omitted here because it has been slightly discussed as part of the de jure and government standards.

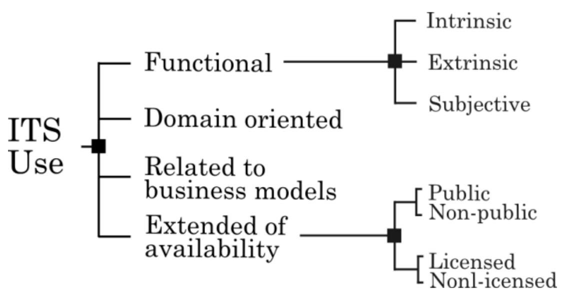

Fig. 2.4 ITS classification related to their use (based on de Vries, 2005)

For the typologies based on functions (or *functional*), de Vries (2005) brought together the notions of *intrinsic-based* on Kienzle's definition (Kienzle, 1943)-, extrinsic –considering Susanto's notion (1988)-, and *subjective* functions. ITS' intrinsic functions imply that standards cause certain consequences depending on their content (de Vries, 2005; Hesser & Inklaar, 1997a). Such intrinsic functions can be describing, recording and freezing solutions during a specific period as well as providing elucidation. Susanto (1988) believed that standards' functions consisted of the relationship between the current situation and the output produced by the standard action in a system. That was taken into account by de Vries (2005), who identified the next ITS typologies based on the extrinsic functions:

- Interchangeability
- Interoperability
- Installed base
- Lifecycle matching
- Controlling assortment
- Transparency
- Data/Information exchange
- Know-how storage
- Repetition
- Dissemination
- Economies of scale enablement
- Benchmark
- Performance assurance

Finally, subjective functions are those related to the interests of specific actors (like external stakeholders, adopting organizations as well as specific departments and individuals) and some of them are (de Vries, 2005):

- IT systems networking and portability
- Facilitate innovation
- Maintainability
- Quality management
- Cost reduction
- Process facilitation
- Contribution to knowledge management

De Vries (2005) identified some subjective functions of external actors, such as: improve cooperation, enable commercialization of IT products, set barriers to competitors, stimulate price competition between suppliers, enable cost effective customization, eliminate or create trade barriers, make product and service supply more transparent, procure safety, avoid extra legal safety requirements, facilitate the compliment of legal requirements, provide reliable testing, enable reuse and improve maintainability. The author warned that this list is not exhaustive because of the variety of stakeholders' interests related to the technical system and management as well as to the application domain, industry or sector.

Typologies related to specific *domain-oriented* standards are commonly used in the literature. In his work, de Vries complained about the ambiguity of using typologies based on business sectors because some disciplines cross with other (e.g. environment) and some ITS can be related to several stakeholders groups and they are used in application domains for which they were not originally developed. However research tends to use these typologies as abstract categories to establish a scope and to identify patterns that can benefit standardization and its study.

The third subcategory is related to specific *business* activities. An example of this typology is the procurement process that can be carried out electronically (e-Procurement) and requires a set of standards to carry out the process with an IT system (e.g. Pushmann & Alt, 2005). De Vries (2005) argued that typologies related to business models can result confusing because they obey to the specific perspective of the target stakeholders. In the e-Procurement example, a firm that sets a system using specific standard for its own procurement process and the suppliers of the same firm will include it as part of its service/product provision.

The fourth and last classification of the list is based on what de Vries (2005) called *extend of availability* standards. He characterized such availability in terms of public access and patent restrictions. *Public* standards are considered to be accessible for all third parties and for public life (de Vries, 2005). Blum (2005) claimed that the use of public standards is part of the expectations of a public standardization process and considered it as a "competitive and socially desirable approach" (p. 2). The last typology establishes the distinction between *licensed* and *non-licensed* standards. According to de Vries (2005), licensed standards are created "when a company (or group of companies or agencies) establishes a new design, gains patent or copyright protection for it, and explicitly sets out to persuade other companies to use the same" (p. 18). Thus the implementer of the standard requires a license to be able to use it (Smoot, 1995). This relation between standards in IT and intellectual property is deeply discussed by Shurmer and Lea (1995), who considered that both have same economic objective: "ensure that society benefits from innovation" but standardization "is much consumer oriented and seeks to encourage common platform whereby users benefit from enhanced competition and trade", while intellectual property rights "reflect the trade-off between the heed to encourage innovation once it has been discovered" (p. 53). Taking this into account, the achievement of "fair, reasonable and non-discriminatory conditions" for licensed standards can be problematic and very complex (p. 53).

2.4.2. The Standardization Space

The last section introduced a detailed and long list of typologies used to characterize standards. However some integration of the typologies seems to be necessary in order to make sense of the current research production, considering the different types of standards. For example Guijarro (2005) studied ITS for interoperability in government but analyzed them at the national and regional level, including open and proprietary-licensed standards, as well as formal and consortium standards. Such diverse characterizations of the standards can drive to the use of a variety of typologies that tend to describe dispersed scenarios and do not address ITS configurations.

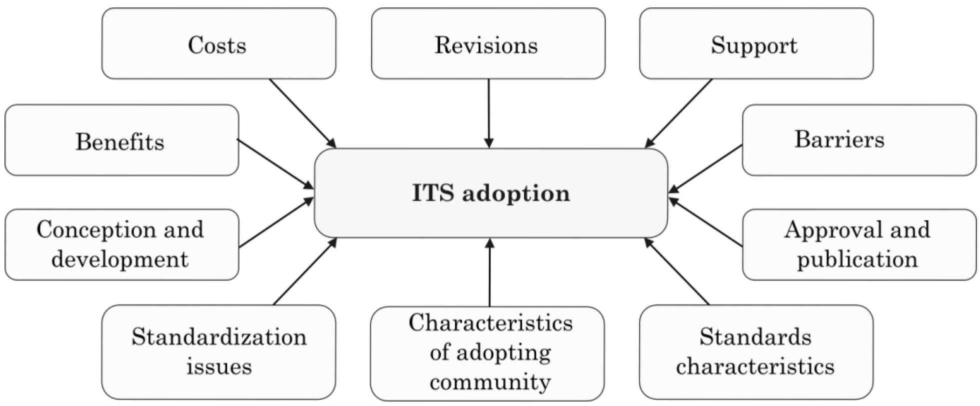

Fig. 2.5 Three dimensional standardization space (adapted from Verman, 1973)

An attempt to understand the convergence of different aspects, levels and subjects that that take part in the standardization was proposed by Verman (1973). These three elements are the axis of what Verman called the *standardization* *space*. Based on this concept, the characterization of a standard is multidimensional, considering the Verman's three dimensions (Fig. 2.5). The author considered that subject in the *x*-axis is the application domain in which standardization is carried out and can be "almost any material, process or action" (Hesser & Inklaar, 1997a, p. 34). Some domains were presented in the last sections, but the list is not exhaustive and its definition can be problematic as already pointed out by de Vries (2005). The *y*-axis represents an *aspect*, which is not clearly defined by the author, but it can be considered as the function of the standard. And the *z*-axis presents the level (range) in which the standard operates (adoption) or it is developed (national, international).

Reconsidering the notion of standardization space, it is proposed to draw it not in a three-dimensional way, but as multidimensional. Therefore a representation with a Venn diagram is introduced, instead of the one presented by Verman. Through a series of circles, the standardization space is defined as the convergence of more than three dimensions that could be customized (by adding those required) for analytical purposes (Fig. 2.6).

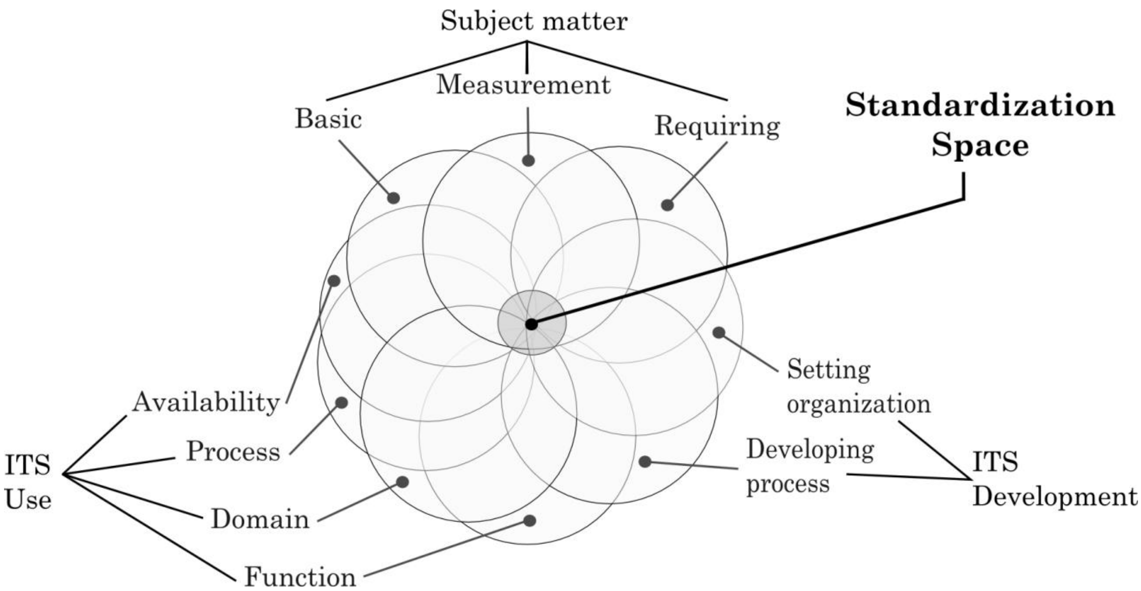

Fig. 2.6 Multidimensional standardization space
(based on de Vries, 2005; Verman, 1973)

The use of this kind of graphic offers a different view of the ITS and the variety of typologies that can be considered to outline research, carry out an engineering process or for management. These of conceiving ITS typologies are not necessarily exclusive and the standardization space can be built with the intersection of several of these categories (not necessarily all).

2.5. Beyond the Foundations

This chapter presented a very general approach to the ITS: considering a historical path as inspiration to introduce this topic and some initial reflections about what is an IT standard. Here, the characterization of ITS as a repeated and continuous solution to a problem with an involved IT entity provided the flexibility and specificity needed to avoid confusion of terms in this work. Later, such concept is used to situate ITS as part of the IT infrastructure.

The second part of this chapter presented a considerable amount of ITS typologies observed in the research production. Based on one of the most comprehensive attempts in this field, a deeper view of main concepts and the research about them was presented. Due to the broadness of this aspect and the variety of perspectives feeding the field, this section aimed to present an overview on the discussions and main terms. The concept of standardization space is an effort to understand how a standard can be included in several classifications at the same time and how to be aware of the variety of the approaches to the same research objects.

CHAPTER THREE

3. IT Standards: Adoption & Adopters

After exploring the basics of standards in the Information Technology field, this chapter focuses on the complexities of their adoption process. Adoption is not a new topic in IS, but the focus on standards still remains underexplored. As a starting point, this work assumes the transferability of the knowledge produced in the IS field and its significance to understand IT standards adoption.

This chapter has been organized in three main parts that focus on the relevant aspects of the ITS adoption process. The first part introduces concepts and analytical frameworks used in IS to explain adoption, which are core to characterize ITS adoption and to outline process' particularities. The second part lays out the role and action of adopters, who are considered agents of change and interact actively with the standards. The last part goes deeper into the ITS adoption process at the organization level, including a categorization of the organizational adoption. The chapter concludes with a discussion about the value of ITS adoption for organizations in order to outline guidelines for the deployment, strategy and management of IT.

3.1. IT Standards and Implementation Research

Over the past three decades IT adoption has been a topic of big interest in IS. It has been tackled from multiple perspectives not only to describe the decisions that drive IT usage, but to understand what contributes to its success in different application contexts. In general, such understanding allows organizations and individuals to profit by using "the intended benefits" of IT (Zmud & Cox, 1979). From the engineering perspective, adoption provides elements to "predict" the success of an IT system and such elements are translated into concrete design conventions to be implemented.

Considering the critical aspects of ITS adoption, this work aimed to integrate the extensive body of research that has been produced on IT implementation. Some outcomes of this research have been applied to understand the adoption of specific ITS, including models, concepts, and methods. Relevant perspectives for the study of ITS adoption are related to the analysis of IT systems, which are characterized by the use of specific standards or the achievement of a specific functionality (e.g. interoperability) or property (e.g. quality or security) enabled through standards.

Precisely, the adoption of open systems, interorganizational IS and data security are some representative examples of indirect research on standards. The next paragraphs show how such research is driven by an ITS perspective and how the issue of adoption is considered a core aspect to study.

The term "open systems" is used to describe a "suite of interface standards (…) whose purpose is to enhance compatibility, scalability, and flexibility of the IT infrastructure" (Chau & Tam, 1997, p. 2). According to Chau and Tam (1997), adoption of ITS in open systems is core because they impact the allocation of IS resources and has "significant ramifications on the IS infrastructure" (p. 1). Open systems were the main focus of a study by Smith, Dedrick and West (2004), whose analysis of the adoption decision leaded to the identification of some implementation barriers (concretely, switching costs and path dependency) to adopt Linux over Unix. In his research on open systems, Krechmer (2008) claimed that ITS are relevant for open systems adoption because of the growing interest on standardization to satisfy technical requirements.

Interorganizational systems (IOS) are a second good example of related ITS adoption research in IS. IOS can be defined as information systems shared by two or more organizations in order to link business processes (Robey, Im, & Wareham, 2008) and they tend to rely on the extensive use of standards. Electronic Data Exchange (EDI) and other XML-based solutions are examples of IOS related standards. For Hart and Saunders (1997), the research on adoption can help to identify critical conditions of "successful use over the time" (p. 39). Premkumar & Ramamurthy (1995) considered that studying standards adoption allows the identification of inhibitors as well as their characterization as technical organizational or interorganizational issues. In their research, they concluded that the low levels of integration EDI information in several internal system applications was caused by specific technical issues and user acceptance of integrated planning and control systems (Premkumar & Ramamurthy, 1995). In their case study of the IOS complying the RosettaNet standard, Chong and Ooi (2008) used factor analysis to identify major adoption issues. They considered trust and type of produced good as the most relevant factors and recommended specific implementation strategies to increase the possibilities of succeed.

The third set of examples is focused on the characterization of information systems based on a property or functionality of the standards. Guijarro (2009) analyzed some aspects related to the adoption of interoperable eGovernment systems, in order to understand maintenance procedures. Another example is the research by Lorence and Churchill (2005), who studied the adoption of information security procedures in American health organizations -which tend do be standards based- in order to identify different types of implementations and the reasons of non compliance to government regulations.

These few examples are just a small sample of articles in IS that are related to ITS adoption research. But some direct work on ITS adoption has beginning to emerge as a way to understand what happen in post-design stages. Good examples of this *direct* production are the works by Thomas, Probets, Dawson, & King (2008b), who address a type of ITS (Exchange of Product Data) as their object of study to explore its development and adoption. West & Dedrick (2006) studied the use of ITS in organizations with similar needs but different software availability, thus adoption was considered necessary to understand the variety of platform implementation situations. Hovav, Patnayakuni and Schuff (2004) considered that the focus on ITS adoption is necessary because "standards differ from the adoption of other technological innovations"(p. 266).

In general, all these papers reinforce the pertinence of studying adoption from the IS perspective, considering the vast available body of knowledge. The IS point of view is also adequate because ITS are implemented as part of the IT artifact and get embedded on it. A comprehensive understanding about IT implementation process can provide some valuable insights. However referring to the process of embracing ITS has been referred using different terms, specifically the word adoption has its roots in the application of the innovation research to IS. But this terminology is discussed in the following section.

3.2. Adoption: Concepts and Theories

Adoption is a word that has been frequently used in IS research in order to tackle aspects related to the choice of a technology innovation. Some studies characterized within the field of "implementation research" (Lucas, Swanson, & Zmud, 2007) used adoption in relation to economics (Jeyaraj, Rottman, & Lacity, 2006) and the spread of the innovations. Precisely one of the seminal works on adoption was Roger's Diffusion of Innovations Theory (DOI), which has deeply influenced the way of understanding this process in IT.

However, the use of the term adoption has not been always consistent with DOI Theory. While some authors refer to *adoption* (Costello & Moreton, 2009; Fichman, 1992; Katz & Shapiro, 1986), others prefer terms such as assimilation (Cohen & Levinthal, 1990), diffusion (Attewell, 1992; Baskerville & Pries-Heje, 2003; Rogers, 2003), acceptance (Davis, 1989; Venkatesh, Morris, Gordon, & Davis, 2003) and use (Boynton, Zmud, & Jacobs, 1994).

For Cooper and Zmud (1990), adoption is a stage of the implementation and a process in which "rational and political negotiations ensure to get organizational backing for implementation of the IT application" (p. 124). The result of such process is a decision "reached to invest resources necessary to accommodate the implementation effort" (p. 124). For these authors, adoption is preceded by an initiation and followed by four stages: adaptation, acceptance, routinization and infusion (Cooper & Zmud, 1990).

A similar perspective was taken by Grover and Goslar (1993), who considered adoption as one stage of the implementation process. Preceded by the initiation stage (pressure to change), adoption is centered on the decision "to commit resources to the innovation" (p. 143). Hence IT innovation process culminates with the actual implementation as the "development and installation activities to ensure that the expected benefits of the innovation are realized" (p. 143).

Despite the variety of usages of the term adoption, this work considers the influential perspective suggested by Rogers (1995), who defined it as:

> *'The process through which an individual or other decision making association passes from first knowledge of innovation, to forming an attitude towards innovation, to a decision to adopt or reject, to implementation of new idea, and to confirmation of this decision' (Rogers, 1995).*

According to this author, adoption implies decision making and choice processes performed by a decision maker (individual or an organization). Then an attitude is assumed towards an IT innovation and the decision making process takes place based on it. A consequence of such decision is the implementation of the IT innovation and its confirmation occurs by embedding it within the supported tasks and the structures in which it takes place.

Taking into account the variety of disciplinary point of views, it is necessary to clarify the similarities and differences between IT innovations (artifacts) and IT standards in order to characterize their specific adoption. This work assumes that adopted ITS have their own action within the implemented IS. Through ITS operation, a solution is attempted to be continuously repeated in a variety of situations. This means that standards drive IT implementation in a specific direction in order to achieve the expected solutions. Some concrete assumptions about the relation between innovations and ITS are:

- ITS generate mechanisms that are by themselves barriers/constrains of IT adoptions. In spite of being embedded in the IT infrastructure as a whole, their specific action has its own consequences, such as lock-ins and network externalities.
- ITS are solutions that outline IS configurations; thus they are one element of an adopted system, not the whole.

An adjusted notion of adoption based on Roger's definition (1995) is applied to ITS. Thus adoption can be defined as a process performed by a decision maker: from the first knowledge about the IT standard to its implemention. This work considers ITS as a solution for an specific problem to be solved within an information system and through the implementation, standards get embedded and are used simultaneously.

A relevant consideration is addressed by Hovav et al. (2004), who criticized the dichotomy of Roger's focus. They claimed that Rogers tends to focus on adoption vs. rejection, but standards adoption can have more modalities: non-adoption of the standard, adoption through replacement, adoption through coexistence and full adoption (Hovav et al., 2004):

- ITS can be adopted as replacement and sometimes, its features are not fully utilized.
- Adoption through coexistence implies the implementation and use of two standards for the same purpose and at the same time. Therefore specific managerial and technical procedures take place to guarantee their simultaneous use.

These authors noticed that adoption modalities are not static and tend to be progressive (Hovav et al., 2004). They can be represented as a matrix that relates a need to adopt a standard and the conditions that enable its operation (Fig. 3.1). This is consistent with what Bayer and Melone (1988) called *differing levels of IT use*.

ITS Need	ITS Conductiveness: Low	ITS Conductiveness: High
Low	Status quo	Replacement
High	Co-existence for best use	Full Adoption

Fig. 3.1 Modalities of ITS adoption (adapted from Hovav et al., 2004)

3.2.1. Analytical Frameworks

In IS research, there is no consensus about an unified theory of implementation and adoption (Lucas et al., 2007). Some significant attempts are based on the outcomes of disciplines like Psychology and Economics, which have contributed with singular point of views about IT adoption. The following are some well known theories applied to understand this phenomenon:

- Diffusion of Innovations[9] (DOI) (Rogers, 1995). Focused on how ideas and technologies spread within a social system. DOI is interested on the decision making process and the context in each stage of the process.
- Davis' Technology Acceptance Model (TAM) (Davis, 1989). Aimed to predict and explain usage based on two fundamental determinants and theoretical constructs: perceived usefulness and perceived ease of use.
- Theory of Planned Behavior (TPB) (Ajzen, 1991). A psychological theory that intended to predict the intentions to perform behavior. TPB's key variables are: attitude toward behavior, subjective norm and perceived behavioral control.
- Absorptive Capacity (Cohen & Levinthal, 1990). Centered on the ability to recognize the value of external information, to assimilate it and to apply it.
- Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975). Emerged from social psychology and conceived (behavioral) intentions as immediate antecedents to behavior. Beliefs about the likelihood of performing a behavior with a specific outcome were divided in two sets: attitudes (behavioral) and subjective norms (normative).

[9] More about DOI is referred in the following sections.

- Organizational Learning (Fichman & Kemerer, 1997). Related innovation adoption to knowledge. It assumed that organizations generate knowledge barriers that inhibit the adoption of technology and learning contributes to override them.
- Network Effects[10] (Katz & Shapiro, 1986). Centered on the positive complementary benefits of adopting a technology.

Some of these frameworks have been successfully applied to IT standards adoption as well. Relevant research has been carried out by authors like Kelly, Feller, & Finnegan (2006) and Chen (2003), who used DOI as a foundation; whereas Chong and Ooi (2008) brought together DOI and the Technology-Organization-Environment (TOE) Framework (Depietro, Wiarda, & Fleischer, 1990) for their studies.

This overview of theories allowed a first identification of research trends and directions. Moreover, some links were established with the IS body of knowledge in order to identify patters in ITS research. The subsequent sections focused on the deeper analysis of these theories, their focus and potential contributions to the ITS field.

a) Normative vs. Factor-based

An early work by Ginzberg (1978) analyzed the incipient research on IS implementation adoption and identified two types of approaches that have remained until today: normative and factor based studies. The normative approach is product of scholars' experience in the field and looks retrospectively into one or more cases with a specific implementation difficulty (Ginzberg, 1978). Ginzberg observed the focus of this research on failure and its tendency to be driven (but not exclusively) by anecdotal data specific to a single case. In ITS, this kind of approach can be compared to the documentation of standards wars, which refer mostly to the adoption path of specific standards in the market. An example is the work of von Burg (2001), who extensively documented the market adoption of the Ethernet as LAN standard.

[10] Also known as Network Externalities (Katz & Shapiro, 1986; Zhao, Mu, & Shaw, 2007).

Ginzberg (1978) considered a second approach based on factors. This type of adoption research begins "by identifying a group of variables potentially relevant to implementation outcomes" (p. 57) and it can be applied to assess "the relative importance of the different variables (or factors) to implementation outcomes" (p. 57). Therefore variables are measured and classified as favorable or unfavorable to implementation success (barriers/enablers). In their analysis, Prescott and Conger (1995) used DOI to analyze adoption and outlined a cross-sectional research design to identify variables "related to particular outcomes, such as successful adoption or extent of implementation" (p. 24). However, some limitations of factor-based approaches were recognized: contradictory results in some cases make difficult to integrate a unified theory, the selection of least controlled variables and a static view of the world since factors are measured in a single point in the time (Ginzberg, 1978).

Some well-known examples of factor-based research in IS are TAM and its extensions (Venkatesh et al., 2003) as well as DOI. In ITS research, factor centered research is a common approach too. Thomas et al. (2008b) discussed Ginzberg's criticisms and considered that in IS and ITS "a single theory of adoption and diffusion is not likely to emerge" (p. 58) because the variety of IT innovations and adoption contexts in which they are applied are too many (Fichman & Kemerer, 1993b). Taking into account these arguments, it is compressible the amount of models have been used to understand ITS adoption and the variety of factors that have been identified through them.

DOI theory tends to be referent of a significant amount of standards-related research because of its comprehensive way of integrating technology, social and contextual factors. But the possibility of adding ITS specific and context specific factors has also been attractive to researchers. Therefore it is common to find ITS adoption models based on DOI, which is adjusted in order to cover specific aspects of the technology and the studied adoption context. Extensions of the DOI have been introduced to explain adoption of a variety of standards and application contexts (Chen, 2003; Hovav et al., 2004; Kelly et al., 2006; Nelson & Shaw, 2003). Table 3.1 presents some examples of research with these extensions, in which the adjustments to fill out ITS orientation and researcher's interests are evident.

Article	Standards	Emphasis	Studied categories	Some related factors
Hovav et al. (2004)	Internet standards	Conduciveness	Environmental Conduciveness	- Network externalities
Kelly et al. (2006)	CNIS standards	Context	Organizational context	- Political Issues - Level of support - Type and scope of decision process
			External context	- Infrastructure investment and Installed base
Nelson and Shaw (2003)	IOS standards	Readiness and participation in a SDO	Organization readiness	- Top management support
			External environment	- Competitive pressure - Participation Level in SDO
			SDO	- Architecture - Governance
Chen (2003)	XML and Web services standards for E-business	Stakeholders, organization and decision making	Stakeholders	
			Organizational factors	- Organizational culture - IT infrastructure - IT skill set
			Decision criteria Decision maker	

Table 3.1 Examples of factor-based research with DOI extensions

Factor-based research has been able to provide the flexibility necessary to explore the variables related to the specific action of specific standards. This is clear in Table 3.1 because it shows the relevance of a variety of aspects to adopt specific standards. Hovav et al. (2004) explained that "high interoperability makes the influence of the community over the adoption decision especially important" (p. 274) and therefore pertinent factors were considered. In their study, Nelson and Shaw (2003) added some categories of factors that are relevant for IOS standards like organization readiness. They claimed that "IOS are an outward manifestation of an organization's ability to plan, commit and execute according to requirements established with external trading partners"(p. 267) and therefore, they included the factor called "top management support" . These few examples point out how theories as DOI with a factor orientation have been modified in ITS research.

b) ITS-centric vs. adopter-centric

West (1999) proposed to separate ITS theory and research according to their focus as adoption or innovation centric. The innovation-centric "focuses on a single innovation and who adopts that innovation", whereas the adopter-centric "examines a single adopter and the innovations it adopts". Thomas (2010) argued that the main difference between both approaches is the research level and considered that the adopter centric approach takes place on organizations from a "decision making perspective" (p. 40). However, a broader view of the production in this field suggests that the adopter-centric perspective cannot be limited only to the organization level and it should consider networks as well as industry sectors.

One of the main characteristics of the innovation-centric research is its tendency to have "a pro-adoption bias, with late adopters labeled *laggards*" (West, 1999, p. 2). In her analysis of the research production, Thomas (2010) proposed a framework to systematize the concepts emerged from the innovation-centric research and outlined a set of possible research directions. Figure 3.2 presents such framework, which compiles elements of DOI (Rogers, 1995) such as standards characteristics, characteristics of the adopting community as well as standards conception and development (Egyedi & Dahanayake, 2003; Gerst, Bunduchi, & Williams, 2005), approval and publication (Egyedi & Dahanayake, 2003), revisions (Egyedi & Loeffen, 2001), standardization issues, costs, benefits, barriers and support (Themistocleous, 2002).

Thomas (2010) identified significant differences considering the aggregation of both perspectives. The innovation centric perspective is centered on the aggregation of the adoption and implementation of each adopter "within an innovation targeted social system over time" (p. 40). On the other hand, the adopter centric "would be an aggregation of the adoption and implementation decisions" within specific networks, organizations and sectors over time (p. 40).

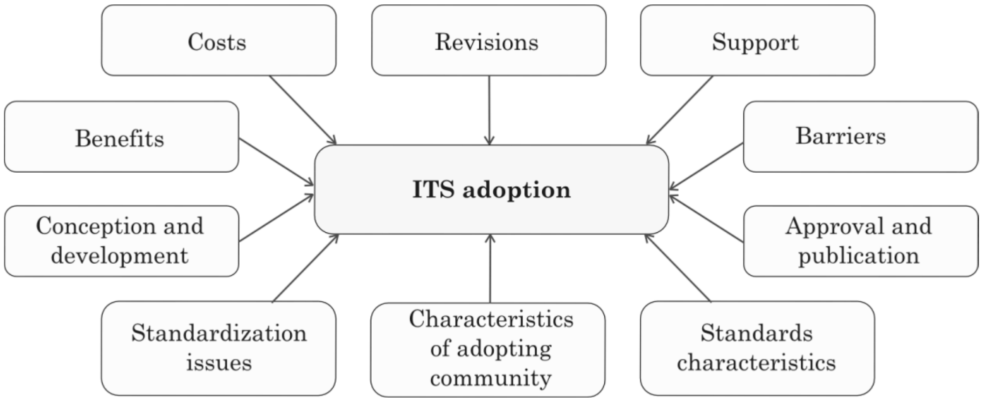

Fig. 3.2 ITS innovation-centric adoption (based on Thomas, 2010)

c) Adoption unit based

In DOI, Rogers (1995) differentiated a type of adoption process that occurs within organizations. Through this distinction, Rogers suggested that the level of adoption is relevant to understand the process. The adopter's role in research was analyzed by West (1999), who referred to an adopter-centric focus and situated organizations as adoption's elemental unit. These studies based on units have also been referred by Thomas (2010), who claimed that this conceptual separation is an instrument to establish limitations to the current analytical frameworks.

Explaining adoption in terms of units of adoption is not new for in IS. Díez and McIntosh (2009) argued that implementation theories in this field have referred to certain units, who perform the process: individuals or organizations. These authors considered that theories like TPB or TAM focus on individual behavioral intentions to adopt IT (Díez & McIntosh, 2009). For example, the TAM model considers subjective indicators like perceived usefulness and perceived ease of use as main predictors of individual adoption (Davis, 1989); and later, Venkatesh et al. (2003) added to the TAM variables such as social influence (related to the behavioral intention) and facilitating conditions (related to the use behavior) in order to propose a *unified theory*. Another example is TPB, which situates adoption decision as product of individual intention, determined by the attitude towards the behavior, subjective norms and perceived behavioral control (Ajzen, 1991).

Besides these theories oriented to individual adoption, there are some concerned with explaining the process in organizations. Díez and McIntosh (2009) referred to two of them: DOI and absorptive capacity. As it is showed in Table 3.2, DOI is a particular case that covers individual and organizational adoption including variables related to innovation attributes and characteristics of the process in organizational environments (explained later in this chapter).

Theory	Adoption Unit	
	Individual	Organizations
Absorptive capacity		•
DOI	•	•
Planned behavior	•	
TAM	•	

Table 3.2 Classification of IS implementation theories according to the adoption unit (based on Díez & McIntosh, 2009)

All these frameworks suggest a variety of research directions in the analysis of adoption. In spite of their substantial differences, they emphasize the importance of assuming a specific position to understand adoption and the impact of such decisions. Taking into account the last part of this section, the focus on adopters was found to be pertinent for the study of IT standards. Precisely, addressing the adoption context (Egyedi, 2007; Egyedi & Dahanayake, 2003; Egyedi & Hudson, 2005) raises the importance of distinguishing between levels of adoption. Thus it is required to inquire about standards' path to deliver the expected benefits, by characterizing the variety of circumstances that an ITS need to face.

3.2.2. Towards an Integrated Perspective

In his study of IT innovations adoption, Gallivan (2001) proposed an hybrid framework that combined different levels of adoption and followed an approach based on the theory called Contingent and Authority Innovation Adoption (Zaltman, Duncan, & Holbeck, 1973). Zaltman et al. (1973) found out that authoritarian adoption occurs in stages and classified them in two processes:

primary and secondary. According to them, primary adoption process is influenced by management objectives, interactions for change and availability of the innovation. Once that primary adoption has occurred, one of the next three directions can be followed by managers to assure that the secondary adoption occurs (Zaltman et al., 1973):

- they mandate adoption within an organization,
- they provide infrastructure and support for voluntary adoption, or
- they target a specific pilot project within the firm and decide later on a broadly adoption.

Both studies (Gallivan, 2001; Zaltman et al., 1973) addressed the need of integrating analytic frameworks to situate adoption at different levels. In this research work, such integration is considered relevant too because it enables the establishment of a relation between units of adoption and the standardization process. Moreover it was assumed that the decision made by different adoption units can have a particular impact and the conditions of the process might be very specific. For example, the analysis of individual adoption of a new process standard relies on the analysis of subjects, their motivations and contexts; whereas an organizational adoption requires a different set of indicators that might include strategic and policy aspects.

Figure 3.3 presents four adoption levels, which were slightly outlined in the last chapter when referring to the IT infrastructure. These four levels bring together a wider understanding of infrastructure (inside and outside organizations) and the ultimate participation of end users (secondary adoption). In summary, IT standardization can occur at macro, meso, micro and individual levels.

The macro level can be described as a large amount of users (corporate or individual customers, as well as policy makers considered region's representatives) who adopt a standard. The adoption decision at this level tends to produce infrastructure and market effects. This means that significant conditions (policies, regulations, enablers) can be generated to match a specific view of the problem and that market conditions tend to favor the critical mass of a standard, causing network externalities effects. An example of research at this level is given by Blum (2005), who compared the diffusion of open standards in United States and Europe.

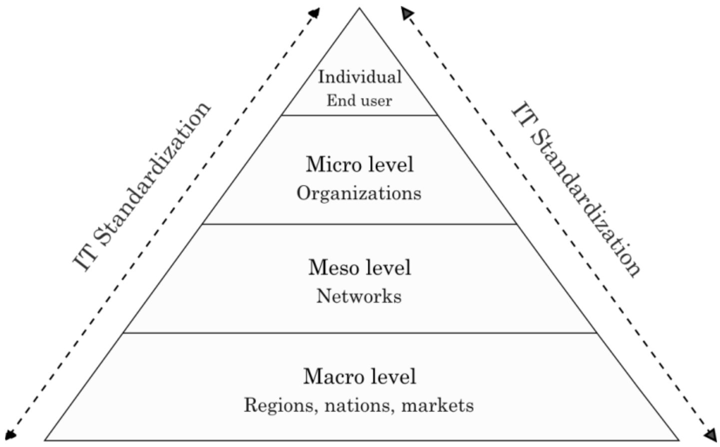

Fig. 3.3 Levels of IT of adoption

The network has been conceived as meso level and covers the adoption within communities and intra-organizational. This level of analysis is employed to study the influence of the networks in standards adoption and standardization efforts in specific groups. Its separation from the market level implies that community-oriented choice on standards is based on central agreements shared by the members. Here ITS management can follow distinctive characteristics because administrative strategies might be centralized. At this level, Weitzel et al. (2003) as well as Stockheim, Schwind and Weiss (2006) have studied the notion of network externalities and its influence on ITS selection.

The micro level rests on organization adoption. Organizational local adoption has become in a topic of interest for standards research because it is there, where decisions are taken to embody standards in structured systems and procedures. In organizations, ITS take part of the every-day practices.

Finally, the subject (end-user) level is concerned about individual and subjective aspects of the standards adoption. End-users, as those who perform everyday tasks, have their own perceptions about the systems they use and the embedded ITS. Ellingsen (2004) recognized the possibility of linking organization and end-users analysis because their work practice gets impacted by the standards but at the same time, they customize the use of the ITS.

The levels listed before point out that adoption can be contextualized considering the adoption unit and the possible interrelation among the levels. As it was mentioned before, the succession of decision among the levels can be understood in the way Gallivan (2001) and Zaltman et al. (1973) suggested, implying that adoption strategies in the different levels influence some other contexts of adoption. Such relation among levels implies that in spite the regulatory essence of the standards, adopters actions, decisions and contexts affect standardization and vice versa. These implications about the role and influence of adopters within the process are outlined in the next section. Here, adoption is characterized as a non deterministic process and adopters shape ITS standardization for adoption change.

3.3. IT Standards Adoption and Adopters Action[11]

The relation between adopters and ITS can be conceived on different ways and its comprehension is essential to characterize the adoption process. Unit of adoption oriented or adopter studies take different positions about the role of diverse actors and the impact of their practices within the standards lifecycle. Such assumptions are fundamental not only to establish common terminologies, but to situate the scope of action of the standards and the adopters. Theoretical and disciplinary perspectives oscillate between technological determinism and social shaping of technologies (Heap, Thomas, Einon, Mason, & Mackay, 1995; Mackenzie & Wajcman, 1999; Smith & Marx, 1996a), authoritarian and democratic (Winner, 1999), as well as completed and unfinished design of technologies.

3.3.1. Adopters: Between Technological Determinism and Social Shaping

Standards can be regarded as universalities with a deterministic purpose (Johnson, 2008). For Millerand and Bowker (2009), standards have the capability to create new social orders by modifying certain practices around the technology and legitimatizing them. In a strict sense, pure or hard determinism "portrays technology as a exogenous and autonomous force which coerces and determines

[11] Part of this section was published in (Castro & Breiter, 2010a, 2010b).

social and economic organizations and relationships" (Keith & Woolgar, 1997, p. 11). In their criticism to this approach, Keith and Woolgar (1997) claimed that determinism resembles Darwinian survival, in which technology follows efficiency as rule for survival and prosperity is achievable only for those who stick to it. Heilbroner (1996) opted for a soft version of determinism regarding the influence of technology in society but also as product of socioeconomic forces on its development. In 2002, the Report for the National Institute for Standards and Technology, the National Research Council in United States (NRCC, 2002) stated that technological development and adoption are interactive processes, which they defined as soft determinism (Smith & Marx, 1996b). It is claimed that hard determinism fails to explain the diversity of results when implementing a technology in different contexts. And precisely, the identification of the conditions that cause these variations can only be studied under a different understanding of the relation between technology and adopters.

On the other hand, social constructivist theories have been conceived as a direct challenge and response to the hard determinism (Bijker, Thomas, & Pinch, 1986; Johnson, 2008; Mackenzie & Wajcman, 1999). Basically they rejected the technological development based on the laws of nature and sustain that "society" (through interest groups, laws, the economy, political decisions, power games etc.) shapes and directs technology in every phase of its development" (Johnson, 2008, p. 93). Considering this perspective, adopters are able to decide "where, when and how the technology can be used" (Johnson, 2008, p. 94) and the adoption is a multidirectional flexible process that "always rests on real-time work" (p. 275). Hence, the use and adoption shapes they way technologies are implemented. "The model will not be a set of narrowly defined concepts to be employed indiscriminately in empirical research. Rather, it will be a heuristic device, a set of sensitizing concepts that will allow us to scope out relevant points, but one that will require adaptation and reformulation for use in new instances" (Bijker et al., 1986, p. 17). For Bijker (1995), there is a "pluralism of artifacts", i.e. if there are more than one interpretation for an artifact, which determine if the artifact functions, we have to regard instead several artifacts. There is always a degree of interpretative flexibility associated with each new tool (Bijker et al., 1986). The implementation of a new initiative meant a change or replacement of existing practices. In the case of ITS as artifacts, specification can be only one part of the implementation and might result into a deviated result out of the standard (Egyedi & Blind, 2008).

The implementation change (Egyedi & Blind, 2008) is a problem for standards integrity and support the notion of multiple forces driving their path (Egyedi & Hudson, 2005). This dynamic aspect of the ITS shows the unpredictable character of the adoption and the need of adopter studies on different levels to understand it. According to this perspective, it is recognized that ITS are shaped during adoption by markets, networks, organizations and persons. Recently, some studies have been concerned about the adoption process and the factors that affect it. Gerst, Bunduchi and Williams (2005) made an analysis of an electronic portal implementation based on the concept of social shaping of technology. Thomas et al. (2008a) presented three cases of the adoption of the Standard for the Exchange of Product Data (STEP), basing their approach on the use of the DOI theory and the economics of the standards by Fichman and Kemerer (1993a). Also West (1999) investigated the relevance of human capital, external coupling and ideology for ITS selection. The last two studies follow the idea that adopters are agents of technological change (Kline & Pinch, 1999) and therefore, standards lifecycle gets extended.

3.3.2. Adopters as Change Agents

The influence of adopter's actions has been already established, but the insertion of change within the lifecycle is necessary as contextualization: from the development -through the cycles of maintenance- to the succession. Considering the social shaping of technology, the appropriation (i.e. adoption) of any technology (including ITS) "cannot be entirely separated from its design and development" (Heap et al., 1995, p. 44). From the developer's perspective, adoption should be included as part of the design work and successive re-engineering. This idea is also supported by Edge (1995), who affirmed that technology adoption often influences future technical decisions. In the particular case of standards, Timmermans & Berg (1997) considered necessary to look at the processes of incorporation and transformation in order to understand the universalization of a standard.

Fig. 3.4 has been adapted from Egyedi and Blind (2008) to show an adapted ITS lifecycle model that focuses on change and adoption (originally referred as implementation). In the graphic, the lifecycle starts with the specification and development, continuing with the maintenance cycle. Then, adopter's feedback is a reason to revise the standard, and when a new one is required, the succession includes extensions or replacements (Hovav et al., 2004).

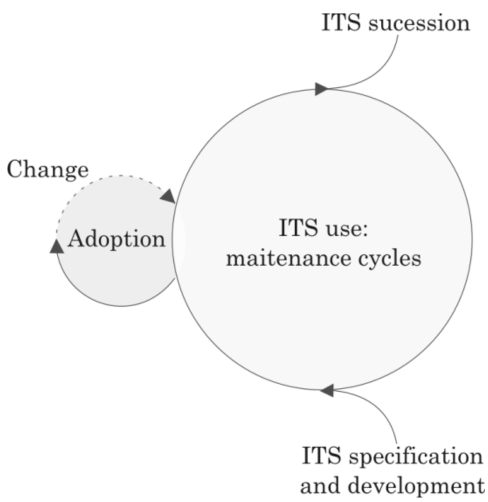

Fig. 3.4 Adoption change cycle (adapted from Egyedi & Blind, 2008)

In this work, we prefer the notion of adoption change instead of implementation change used by Egyedi and Blind (2008) and as it is consistent with Rogers' terminology (Rogers, 1995). Through this conceptual separation of the process, analytical stages are identified and concrete information about the status of the standardization can also be inferred.

Within this lifecycle, the notion of change is operationalized in the general standard's path and the effect of adopters' actions is seen as part of the chain. Egyedi and Blind (2008) pointed out this aspect by using two different arrow styles to draw change in the graphic: standards are tacitly defined at the beginning of the adoption process, but when change happens, standard's path gets "irregular". If such change is operated during the adoption, this means that adopters and their environments are the responsible agents.

3.4. Organizations as Adopters[12]

This work addresses specifically the adoption at the organization level. The relation between IT and organizations has been widely studied in computing related disciplines (Attewell, 1992; Attewell & Rule, 1984; Gurbaxani & Whang, 1991; Orlikowski, 1991; Orlikowski & Barley, 2001). Orlikowski explored the relation between organization studies and IT research (Orlikowski, 1992; Orlikowski & Barley, 2001) and affirmed that through understanding organizational phenomena, it is possible to explain how the development and use of information technology occur. She recognized the influence of organization settings to address the role of the human agency embedded in institutional contexts and technologies as material systems (Orlikowski & Barley, 2001). Furthermore, other perspectives conceive organizations not only as environments of IT implementation and use, but as important part of the innovation system because they are "the main vehicles for technological change in that they carry through innovations" (Edquist & Johnson, 1997, p. 58). It should be noticed that besides research and development activities, "the processes of diffusion of product and process innovations" occurs mainly through organizations (p. 58).

Organizations as object of analysis offer a comprehensive perspective to understand standards adoption. Once that the decision on ITS adoption in organizations is made, standards get embedded during the implementation into the entire organizational system and information about their performance can be gathered for later technical re-engineering and management decisions. Then, they are source of rich information about ITS efficiency and not only at the technical level, but about the implications for the adopters who decide on a standard. Due to its complexity and character as microcosms, organizations can be studied on a comprehensive way and covering the entire adoption process: from the decision, to the implementation and use.

Determining the characteristics of organizations require considering the big amount of research that has been produced in organization theory and that have

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[12] Part of this section was published in (Castro & Breiter, 2010a, 2010b).

influenced the research of the IT field when using organizations as units of analysis. From the classical theories to the dominant approaches to the postmodern theories, organizations have been considered as organisms, brains, cultures, political systems, agents of flux and transformation, and as instruments of domination (Morgan, 1998). An example of this is Nilakanta and Scamell's work (1990), which investigated the relationship between the communication flows in companies and the diffusion of database design tools. In this work, it is assumed that organizations have communications structures that influence the path of the innovation within their boundaries. Atewell (1992) researched on innovations in organizations as knowledge and learning systems, particularly in regard to the barriers for business computing. This author considered that the adoption process relies on organizations' knowledge capabilities. In the same way, Cook and Yanow (2005) outlined a theoretical approach about the organizational learning and knowledge production from a cultural perspective. The influential research by Aiken and Hage (1971) explored the variables that characterized organic organizations and their influence on the rates of innovations. In the early 70's, they concluded that defined characteristics of organics organizations such as diversity of occupations, high involvement in professional association, intensity of scheduled communications and intensity of unscheduled communications influence in the degree of innovation.

From a (modern) structuralist perspective (Shafritz, Ott, & Jang, 2005), Rogers (1995) characterized organizations "stable system of individuals who work together to achieve common goals through a hierarchy or ranks and a division of labor" (p. 375). It is suggested the formality of the organizational goals and structure are determinant together with the tension between subjectivity and the existence of rules, authority and norms (Shafritz et al., 2005). Then a "predictable organization structure" can be obtained through: predetermined goals, prescribed roles, authority structure, rules and regulations, and informal patterns (Rogers, 1995, p. 375).

This initial overview about organizations has indicated some arguments to consider them as core entities and it has highlighted a series of characteristics to be taken into account. The selection of a structuralist perspective on organizations situates standardization close to formal organization structures, regulations and managerial decision (authority) but at the same time in tension with subjectivities and informal patterns that impact operation.

From all theoretical approaches related to adoption, Roger's DOI (1995) is concerned not only with the diffusion of innovations among individuals and it addresses also the significance of organizations as adopters. Precisely, Rogers pointed out the relevance of this theory because "in many cases an individual cannot adopt a new idea until an organization has previously adopted" (p. 371).

Organizations constitute a type of adopter that relies on collective and authority based decisions (Gallivan, 2001; Rogers, 1995; Zaltman et al., 1973). Organizational adoption process tends to be more complex than individual's because it involves subjects that play different roles in the decision making process (Rogers, 1995). DOI model sets decision as a core part of the adoption and classifies such decisions in three categories that resemble the categorization by Zaltman et al. (1973). Both classifications of adoption decision carried out in organizations are presented in Table 3.3.

Zaltman, Duncan, & Holbeck's types of adoption decisions (managerial)	Rogers' types of organization adoption-decision
• Managers mandate adoption within an organization, • Managers provide infrastructure and support for voluntary adoption, or • Managers target a specific pilot project within the firm and decide later on a broadly adoption.	• Authority innovation-decisions • Collective innovation-decisions • Optional innovation-decisions

Table 3.3 Comparison of two classifications of organization/authority adoption (based on Rogers, 1995; Zaltman et al., 1973)

Zaltman at al. (1973) considered that after a formal decision is made, organizational management structure operates to ensure that adoption occurs (standardization planning, operation and controlling): voluntary or obligatory. The first classification focuses on a *rational* decision about adoption and therefore, strategic-oriented categories are listed. On the other hand, Rogers (1995) considered adoption is not always a managed process and identifies a variety of adoption decision processes; thereby voluntary adoption decision in organizations can be contingent as well. This means that individuals might adopt or not certain standards even though the organization formalizes it or individuals can make their own decisions because the organization did not assume formalize a position about this matter. But this last type of adoption occurs arguable at the individual level not the organizational.

3.4.1. Rogers' Model of Adoption in Organizations

The Diffusion of Innovations is a theory proposed by Rogers (1995) that emerged in the 1960s to explain the process in which an "innovation is communicated through certain channels over time among the members of a social system" (p. 5). As part of his theory, the author proposed a series of mechanisms and variables that could affect the diffusion process in several settings, like decision making. Roger's theory is a full approach that integrates individual and organizational adoption decisions (Rogers, 1995) . For the first, five set of factors were referred as core to influence decision: relative advantage (improved innovation), compatibility, complexity (*perceived simplicity*), trialability (the individual can test the innovation) and observability (the innovation is visible to other stakeholders). Around the decision process in organizations, Rogers (1995) built an adoption model (Fig. 3.5) that consists of three main phases: initiation (all the information gathering, conceptualization and planning that lead up to the adoption decisions), decision and implementation ("events, actions and decisions involved in putting an innovation into use" (p. 392)).

Rogers' adoption process is consistent with the definition of ITS provided in the last chapter. If a standard consist of a solution of an IT problem to be consistently and repeatedly used, then the model is adequate because the agenda-setting covers problems that create a perceived need. The identified problem is fitted with an ITS (matching) and adoption takes place as a decision making process. Later, implementation consists of three sub-phases: redefining/restructuring (mutual shaping, the standard is reinvented and organization structures are adjusted), clarifying (the relation between ITS and organization becomes clearer) and routinizing (ITS turn into an ongoing element of organization activities) (Rogers, 1995). Thus it is claimed that Roger's adoption process in organizations can be successfully applied to IT standardization and each of the subphases.

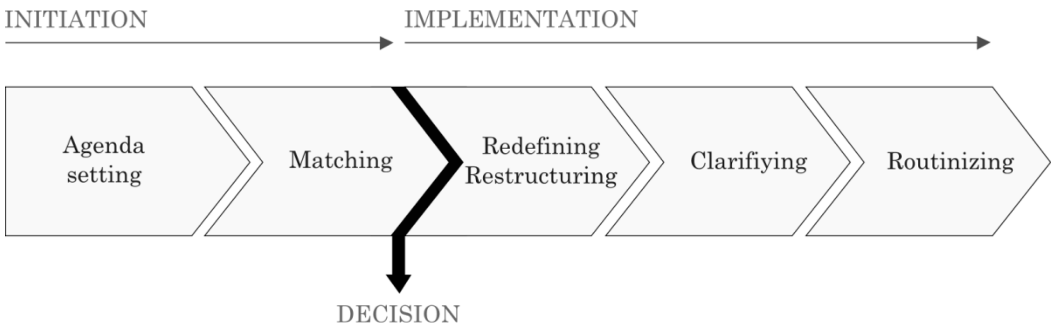

Fig. 3.5 Rogers' model of the adoption process in organizations (adapted from Rogers, 1995)

a) Agenda-Setting

It occurs when an organizational problem is defined as a perceived need that can be satisfied with the standard. For Rogers (1995), agenda setting is the way in which "needs, problems and issues bubble up through a system and prioritized in a hierarchy of attention" (p. 393). Three main activities can take place in this subphase: identifying (knowing about the problem), prioritizing (assigning an importance) and searching. This stage focuses on organization's searching those standards in the environment that can be potentially useful to meet organization problems and goals.

b) Matching

Matching consists of the process of fitting an innovation or standard to a perceived problem. The match is conceptually planned and designed as an "attempt to determine the feasibility of the innovation solving the organization's problem" (Rogers, 1995, p. 394).

Together agenda setting and matching are Rogers' *initiation* or *pre-implementation* phases of the adoption process. Initiation in this model can be defined "as all the information gathering, conceptualizing and planning for the adoption" that leads up to the decision to adopt (Rogers, 1995, p. 394). The adoption decision stands between initiation and implementation, integrated by the following post-adoption phases:

c) Redefining/Restructuring

This phase is consistent with the adoption change referred in the section 3.3.2. Rogers considered that innovations are "re-invented to accommodate to the organization's needs and structure" and "when the organization's structure is modified to fit with the innovation" (Rogers, 1995, p. 394). Both organizations and standards are expected to change at least in certain degree, this change is called mutual adaptation (Rogers, 1995). Such phase can be linked to the social constructionism and it occurs because "innovations never fit perfectly in the organization which it is to become embedded" (p. 395).

In the specific case of the ITS, redefining/restructuring can imply the encounter of standards with other pre-adopted ITS, which might be replaced or might coexist with it. This preexistence of a standard supposes not only a redefinition for the organization members, but of the IT technical infrastructure too.

d) Clarifying

This phase can be linked to the organizational learning process, which is a way of making sense about the standard's usage to extend its benefits. Rogers (1995) considered that this stage encompasses the processes of clarifying the meaning of a new idea to all organization's members. Management action can take place to avoid misunderstandings or unwanted side-effects considering that innovations are surrounded by uncertainty (Rogers, 1995). Some usual questions that are answered during the clarification phase are: *"how does it work? what does it do? who in the organization will be affected by? will it affect me?"* (p. 399). The construction of meaning of the innovation occurs over time through human interaction and uncertainty is solved through such interaction (Rogers, 1995).

e) Routinizing

Routinization happens once that an innovation has been incorporated to the structure and regular activities of the organization, then "the innovation loses its separate identity" (Rogers, 1995, p. 399). At this point, organizational members do not consider an innovation as new anymore.

These five phases provide an overview of the technology adoption process from Rogers' perspective. Some aspects have been highlighted out about their relation to the concrete adoption of ITS; however it is considered that this process requires some adjustments to describe the specific aspects of their adoption. In this work, the adoption in organizations is strongly linked to De Vries' notion of *company standards* (de Vries, 1999; de Vries & Slob, 2006). As already mentioned, this type of standards refers to that adopted by an organization for its own needs (DIN 820), thus ITS are the solution "to its own requirements and its position to do so" (Hesser & Inklaar, 1997b, p. 107).

3.4.2. Characteristics of the Organizational Adoption

Company standards offer the required analytic framework to explain IT standardization at the organization level. However, in order to avoid the restrictions of the word *company* (considered profit corporate entities) and the reduction to a typology, the term *organization standard* is preferred. The next figure (3.6) reproduces the forms of adoption in organizations (briefly mentioned in the last chapter), but they are adapted to fit in the ITS perspective:

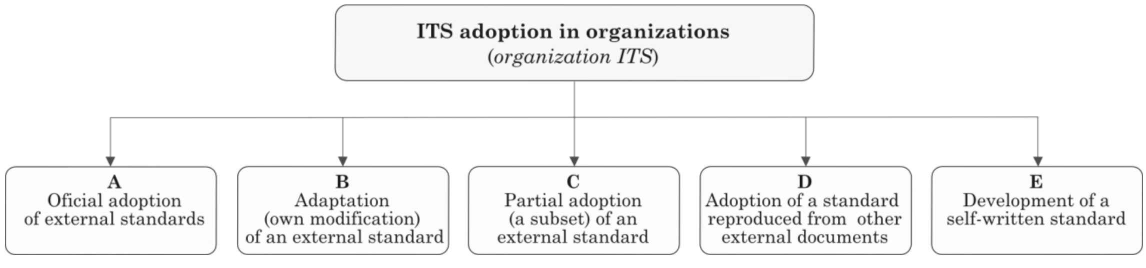

Fig. 3.6 Forms of ITS adopted in organizations
(adapted from de Vries, 1999; de Vries & Slob, 2006)

Organizations adopt ITS in five different forms, which are influenced by the initiation stages and impact the implementation. They tend to share the initiation phases (agenda setting and matching) that produce specific requirements. The derived decision to adopt a standard requires its formalization, which implies setting off a form of adoption and a standardization strategy to achieve the benefits of the ITS. Once all those aspects are defined, a variety of paths for the implementation can be followed:

a) When an external standard is fully implemented, its *adjustment* is necessary to bring to a satisfactory state that meets the organizational context (form A). In this context, the ITS reaches such state when it changes to be locally functional.

b) When an external standard is modified to be implemented, an *adaptation* process is required to modify the standard and fit into the organization (form B). The standards of this form of adoption are developed outside the organization but they change to meet the specific problem to be solved.

c) When a standard is partially adopted, a meaningful *extraction* is required to be later adjusted or adapted (form C). This means that the organization adopts the part of the standard that it needs, thus the standard change to be locally functional or to tackle the referred problem.

d) When a standard is reproduced based on external documents, it gets *adapted* (form D). This form is similar to B, but the source of the standard had originally another purpose.

e) When a standard is self-written, the standard is fully *developed* by the organization (form E). In this way, development implies an in-house knowledge of the problem and the use of internal resources to define the standard. This form is based on the organizations' available resources for subsequent technical implementation as well as on the expert knowledge about the application context.

It should be noticed that in the original process proposed by Rogers (1995), the development was not included as the first step of the implementation because it tends to refer to external innovations. But in this work, the design of a new standard should occur as a consequence of the decision and the technical implementation takes place when it becomes part of the infrastructure. In the case of IT, the technical development of the IT artifact (and the embedded ITS) occurs as a restructuring process of the decision and the adjustment of local conditions. From the technical perspective, restructuring implies dealing with:

- the IT strategy and management in the organization,
- the technical implementation of the ITS within the IS,

- the specific understandings about the ITS by the managerial and IT staff, and
- the current IT infrastructure (installed base) to support operation.

From the organizational and end-user perspective, restructuring implies struggling with change in task performance and eventually, in the organization structure. After the core restructuring activities, the clarifying phase involves a learning process and then, secondary adoption takes place. It implies that a series of decisions are made at the end user level for the adoption of individuals and therefore, the organization sets a series of enabling conditions. Some of such conditions are the information system that embeds the ITS and the required training for its usage. The clarifying stage involves management action to deal with the assimilation gap (Fichman & Kemerer, 1993b), which assumes that organizational adoption does not guarantee that an innovation (i.e. standard) will be actually used by the target users (Gallivan, 2001). For Fichman and Kemerer (1993b), the assimilation gap can be defined the "as the difference between the pattern of cumulative acquisitions and cumulative deployments of an innovation across a population of potential adopters" (p. 5). For Leonard-Barton (1988), mutual adaptation is the encounter between technology and user environment. Such concept allows understanding better the dynamics of the implementation and why technology "almost never fits perfectly into the user environment", although "developers reduce the uncertainty inherent in the innovation process by technical iterations and prototyping" (p. 251).

In Gallivan (2001), managerial intervention takes place as a way to ensure deployment that can be situated in the clarifying phase. He referred mainly to training and support as core activities that can be critical to achieve it. Usually called top management support in implementation research, management action tends to be considered a critical factor to assure efficient implementations (Dong, Neufeld, & Higgins, 2009; Lin, 2010; Nandhakumar & Baskerville, 2011; Thong, Yap, & Raman, 1996). These managerial interventions "describe the actions taken and resources made available by managers to expedite secondary adoption, including mandating usage" as well as "company-sponsored training, resource support, hiring new employees or hiring consultants experienced with the technology to serve as mentors" (Gallivan, 2001, p. 61). All these activities have significant implications for the adoption of end-users within an organizations (Gallivan, 2001).

Finally, in the routinization process happens when the ITS successes and it "is used in practice" (de Vries & Slob, 2006, p. 65). For de Vries and Slob (2006), a standard should be used to produce value and to solve the problem that motivates the adoption. So when this happen, an evaluation of the usage is the basis "for withdrawing, maintaining, or changing the standard" (p. 65). These authors pointed out the relevance of the end users feedback and the managerial staff responsible of adopting a standard as solution. The quality management of the standard controls (through user feedback) if the standard answers the essential question: "are the (potential) users of the standard satisfied?" (p. 65). Hence routinization can be used as input for further standard reengineering and succession, linking ITS usage to IT performance and in general, to the organization operation. Then the study of adoption needs to be necessary linked to the generation of value through IT and its standards.

3.4.3. IT Standards and their Value for Organizations

In the last section, the exploration of ITS typologies elucidated a variety of possible IT problems that standards can solve, including their functions and purpose. But de Vries and Slob (2006) went beyond of mere functions and aimed to establish a direct relation between the value produced by the ITS and their target organizations. Precisely, Wuellenweber, Koenig, Beimborn, & Weitzel (2009) have considered that "in standardization research determining the value of a standard has remained an open issue for decades" (p. 539).

In general, IS research has been concern about how IT impacts organization performance. An example is the work of Melville, Kraemer and Gurbaxani (2004), who carried out an exhaustive literature review to explore trends on what they called IT business value and included references to "productivity enactment, profitability improvement, cost reduction, competitive advantage, inventory reduction and other measures of performance" (p. 287). According to them, the

Resource Based Theory (RBT[13]) (Barney, 2001) is a theoretical framework that could adequately integrate a variety of aspects and they proposed its application to model IT business value because of the following reasons (Melville et al., 2004):

- IT tends to impact organizational performance through business processes.
- Other resources in the organization (e.g. workplace practices) interact with IT, weather as mediator or moderator.
- The external environment plays a role in value generation.

Taking into account all those aspects, Melville et al. (2004) proposed a model that included: a) an organization that invests and deploys IT resources; b) external factors that shape the extend in which IT value can be generated and captured; c) a competitive environment, including industry characteristics and partners; and d) the macro environment, e.g. country and regional contexts. The adapted model (Fig. 3.7) presents the organization as managing and deploying IT (Melville et al., 2004) while using a variety of available resources (IT, incl. ITS, and "complementary") to perform "activities underlying value generating processes" (p. 295). Then performance includes that of (specific) operational business process and of the (overall) organization. For Melville, Kraemer and Gurbaxani (2004), domain/industry characteristics include: regulation, technological change, specific ITS, competitiveness and so forth; which together with the resources and processes of partners tend to impact performance. And finally, the macro level (public infrastructure) denotes what the authors call country- and meta-country factors that shape IT application.

In spite of its limitations, this general model addresses how to conceive ITS value in organizations: as internal resource of the organization related to IT but also as external characteristic. Then adoption turns into a multidimensional and multilevel process that generates an ultimate impact in the organization as well as in the internal and external ITS development and setting. The model draws a transparent connection between ITS, adoption and organizational performance, turning ITS into one of the enablers that can boost performance.

[13] For a discussion about the limitations and pertinence of RBT, see (Priem & Butler, 2001).

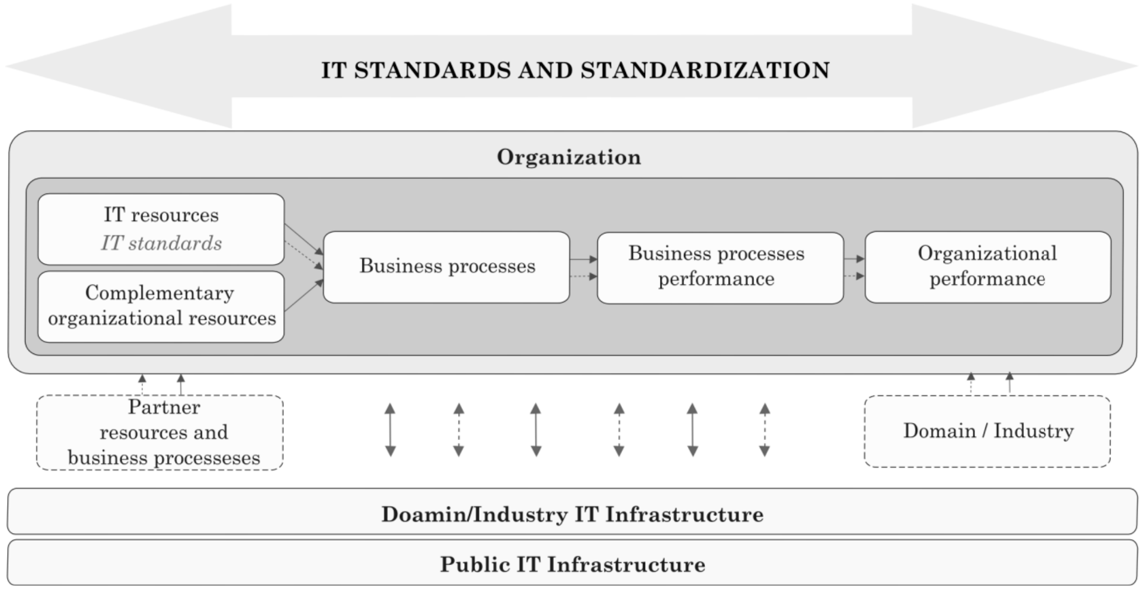

Fig. 3.7 ITS in the IT business value model
(adopted from Melville et al., 2004)

Another approach to ITS value is proposed by Kayworth & Sambamurthy (2000), who considered that ITS value can be addressed because of their relation with IT infrastructure. In spite they did not address a specific model for value measurement; the authors provided arguments to link adoption to IM and organizational performance. In the study by Kayworth & Sambamurthy (2000), ITS adoption is valuable for organizations because it tends to define the acquisition, management and use of IT infrastructure assets. Such study lists three main aspects related to the value of ITS:

- They are the basis to sustain IT-based innovations.
- They facilitate effective use of substantial investments in IT infrastructures.
- They protect the integrity of the IT infrastructures, communicating its capabilities and guidelines for its effective use.

For Ross (2003), the value of the ITS is better understood when linked to the notion of IT architecture. This author noticed that IT architecture and IT infrastructure tend to be used interchangeably or as *a list of organizational ITS*. But the term enterprise IT architecture is a concept that brings together ITS and business requirements as "the organizing logic for applications, data, and infrastructure technologies, as captured in a set of policies and technical choices, intended to enable the firm's business strategy" (Ross, 2003, p. 32). ITS can be considered enablers of organization's objectives that add value in different stages of the IT architecture competency, therefore their strategic adoption is critical to support overall performance (Ross, 2003). Based on her experience in firms, she (2003) identified four stages in the organizational evolving of IT architecture to increase their IT architecture competences. Each stage is presented in Figure 3.8, which also situates ITS adoption according to different strategic purposes.

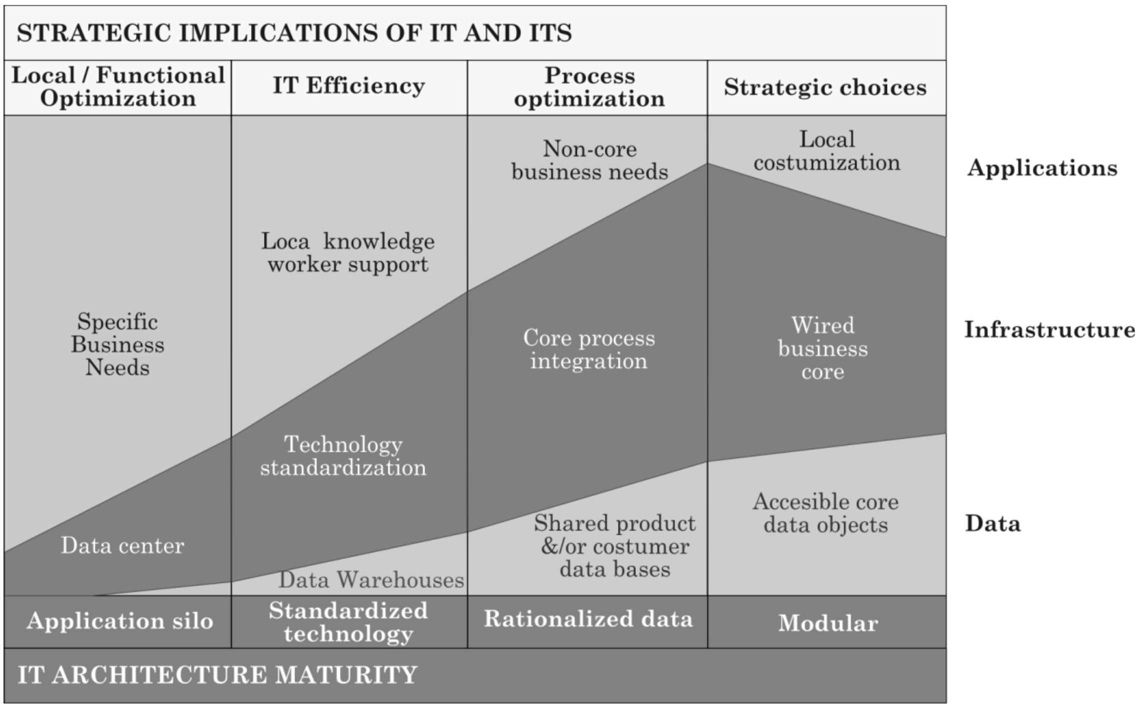

Fig. 3.8 ITS and resource allocations across IT architecture stages (Ross, 2003)

In Ross' model, the main distinguishing elements are: "logical design of their applications, data, and infrastructure; the IT capabilities they provide; the strategic opportunities they present; and the IT management and governance processes they demand"(p. 34). The first stage named *application silo* focuses on local optimization through delivering individual applications (usually limited geographically or to a single function) (Ross, 2003). Here, organizations have few shared IT infrastructure and each system manages its own data, thus ITS tend to be mostly technical decisions to assure basic component's functionalities. The second stage implies an enterprise-wide IT architecture and delivers value through IT standardization (Ross, 2003; Ross, Weill, & Robertson, 2006). ITS operate to limit the technology choice while reducing costs through increasing IT maintainability, reliability, and security. This second stage (*technology standardization*) focuses on IT efficiency and data warehouses tend to be introduced, but the transaction data remain in the individual application (Ross, 2003). The third stage (*rationalized data*) extends standardization to include data and processes. Its main purpose is optimization through organization-wide standards. Ross (2003) considered that ITS value can be expanded to the performance of more stakeholders (e.g. suppliers, costumers).

Finally in the fourth stage (*strategic choices*), IT architecture is established "based on the organization-wide but with loosely coupled applications, data, and technology components to preserve the global standards while enabling local differences" (Ross, 2003, p. 39). Then the organization introduces new governance mechanisms to encourage and manage component reuse (Ross, 2003; Ross et al., 2006). ITS are managed in this phase to allow flexibility, while producing benefits from their performance. The issue of flexibility and standards in ITS has been widely discussed (Byrd & Turner, 2000; Duncan, 1995) because of the risks to performance, but Ross proposed a strategic balance to cope with local customization in an standardized environment, maximizing ITS revenue.

This slight overview of the IT architecture categorization by Ross (2003) points out that the value delivered by the standard depends on the role they play in the target organization and its IS. This framework suggests that adoption results critical to achieve the full benefits in each stage and the value of the ITS varies according to their contribution to IT capability along the time. In the model ITS are turned into an asset that delivers value as part of a strategy. Another relevant aspect that have emerged was the scope of the ITS and its implication for adoption: technical infrastructure standards can face managerial resistance during the implementation, while process standards (optimization-oriented) have a direct implication in end-user tasks. The last aspect that should be mentioned is the direct relation between management action and adoption. In this work it is assumed that research on adoption can be source of relevant input to develop management strategies that increase the success in IT implementation and that, ITS achieve the expected value. For this reason the purpose of this dissertation results particularly pertinent. Because it offers insights about how adoption happens and how this is relevant to deliver ITS value in organizations.

3.5. Rethinking Adoption

This chapter aimed to offer a deeper view on the ITS adoption process and have centered the scope of this work towards organizational adoption. The first aspect situates adoption as a complex process of decision making and the influential perspective by Rogers has been used to go deeper and explore the dynamics of ITS within the organizational settings. The second aspect considers organizations as relevant agents in the adoption that establish multiple conditions that drive and influence the actual use of standards.

The last part of this chapter offered some insights about the management of ITS and how they deliver value within specific strategic phases of the IT architecture maturity (Ross, 2003). Through this search of ITS value, standards adoption is related to:

- the satisfaction of technical and organizational requirements,
- technical and strategic solutions in IT,
- management strategies for the implementation of information systems,
- ITS impact on IT deployment and user acceptance, and
- the delivery of value, linked to organization's performance.

In order to go deeper into this topic, this work focuses now on a domain. Considering that adoption is complex because of all the conditions that take part in the process, this work situates the analysis of the adoption process in a specific type of organization that performs specific activities: research.

CHAPTER FOUR

4. IT Standards for eResearch: Adoption in Higher Education Organizations

After exploring the basics of standards in the IT field, this chapter focuses on the complexities of the adoption process. Referring to adoption is not new in IS related disciplines, whereas the focus on standards still remains under-explored. As a pertinent starting point, this work assumed the transferability of the knowledge produced in the IS field and its significance to understand ITS adoption. A large tradition in IT innovation research has explored the complexities of the adoption process and its importance is out of discussion: the understanding of what enables IT use is core to guarantee its expected benefits. This chapter considers the experience in IS and explores the concrete adoption of ITS at the organization level as well as an overview of the eResearch field -from definitions to its complex landscape- and a concrete focus on HEOs as relevant context. Besides the theoretical perspective about eResearch and HEOs, a qualitative meta-analysis is presented as the basis of a conceptual model of adoption in this context.

4.1. First Reflections

The current scenario for the production of knowledge represents huge challenges for the individuals and institutions that focus on research (Office of Special Projects, 2001). The use of IT for the scientific endeavor has increased dramatically, impacting the way how research practice is carried out. For Hine (2008), IT in science has been introduced "with the hope that it will improve the work that researchers do or make it more efficient" (p. 4). This author considered that besides time and resources, digital technology is relevant because it increases accuracy, one core value in science (Hine, 2008). Through the automation of certain tasks, it is expected that errors get reduced and in this way, reliability and reproducibility can be enhanced and fit "well with values that science holds dear" (p. 4). Beyond the idea of efficiency, the impact of IT in academic research cultures and practices is evident in a variety of aspects like: spatial organization, distribution of roles, knowledge representation, quality control as well as economic and legal aspects of publishing (Nentwich, 1999). With a particular focus on communication patterns, Nentwich (1999) recognized that IT can potentially change all dimensions of research activity, from the organizational aspects to the knowledge production process (provision, preparation, administration, processing and presentation of information). Beaulieu (2001) considered that IT provides not only technical support for existing processes and claimed that it represents "a particular configuration of goals and practices , pointing out a new approach to scientific work" (pp. 635-636). In the same way, Pearce (2010) referred to the use of IT as a process of enhancement: the enhanced researcher "will use a variety of technological tools to carry out their research" (p. 1194).

Borgman (2007) took into account a wider approach to the support of scientific research and linked it to the concept of infrastructure "as a collective term for the technical, social, and political framework that encompasses the people, technology, tools, and services" (p. 19). This author identified the use of a variety of terms that refer to aspects of the scholarly information infrastructure, such as those with the "e-" prefix (e.g. e-Research and e-Science) and the "cyber-" prefix (e.g. cyberinfrastructure) (Borgman, 2007). These prefixes can imply different assumptions about the IT support to scientific research, in spite of the interchangeable use in the literature (Gold, 2007a). For Borgman (2007), "*e-*" can been understood as "*enhanced*", "*enabled*" or "*electronic*", while "*cyber-*" tends to be linked to Wiener's approach of Cybernetics (1965).

This initial reflection points out the need of an adequate term includes all fields of knowledge (scientific disciplines) as well as the digital applications in which IT standards are implemented. This aspect is further discussed in the following section.

4.2. What is eResearch?

When referring to the technology, tools, services and practices around digital technology to support scientific research, the term eResearch is preferred in this work. Besides the discussions about the prefix, previous studies (Beaulieu & Wouters, 2009; Borgman, 2007; Hey & Trefethen, 2008; Lynch, 2008; Nentwich, 1999) have discussed the implications of using the words science, research or infrastructure to describe this phenomenon.

a) Research or science: encompasing disciplines

For Nentwich (2003), the problematic use of the words research and science is linked to the English language. He considered that the German word *Wissenschaft* is more integrative because it is used to encompass all scientific disciplines. Hey & Trefethen (2008) agreed with Nentwich and considered eScience as a restrictive term because it has been exclusively linked to the physical sciences. For Beaulieu & Wouter (2009), the use of the term eResearch is a critique to eScience, because it emerged as an integrated approach that covers "a broader range of academic activity", including different research modes and disciplinary practices (Hey & Trefethen, 2008, p. 28). Precisely eResearch is preferred in this work and applied to all the digital technology implemented to support scientific research in all disciplines, without distinguishing between physical, and social sciences and humanities.

b) Cyberinfrastructure[14]: grids and clouds for big science

In United States, the term cyberinfrastructure emerged as an umbrella concept (Wright, Sumner, Moore, & Koch, 2007) in a similar context to eScience . In their influential report, Atkins et al. (2003) defined infrastructure as "public works that are required for an industrial economy to function" (p. 5) and considered pertinent the use of the word cyberinfrastructure as a type of infrastructure specifically "required for a knowledge economy" (p. 5). Jankowski (2007) considered that cyberinfrastructures have a similar role to other existent public infrastructures (e.g. roads, railways and networks for water and gas); thus cyber-infrastructure tends to emphasize the instrumental role of the technology and its potential to be a factor of transformation of the scientific practice (EDUCAUSE & CASC, 2009). Usually linked to initiatives that tend to promote big science (Lee, Dourish, & Mark, 2006), the term suggests large scale research with requirements like distributed storage, processing and collaboration. But as Lynch (2008) points out, IT for science includes not only these large scale infrastructures, it requires the development of campus cyberinfrastructure capabilities (in the case of academic research in higher education) and basic support for small science.

The Atkins Report (2003) included an integrated view of cyberinfrastructure services that are organized according to specific layers (Fig. 4.1) and "enable new knowledge environments for research and education" (p. 13). This situates the IT technical infrastructure with the base technology for computing, storage and processing. Cyberinfrastructure's core consists of a middleware layer and related services for scientific work such as: high performance computation services; data, information, knowledge management services; observation, measurement, fabrication services; interfaces, visualization services; and collaboration services. Finally, the upper part of this model refers to community-specific knowledge environments that enable access to content. For Atkins et al. (2003) such organization of the cyberinfrastructure offers a flexible customization available for users (ensured by the upper layer) and an interoperable infrastructure that facilitates multidisciplinary research and distant collaboration.

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14 Also called e-Infrastructure.

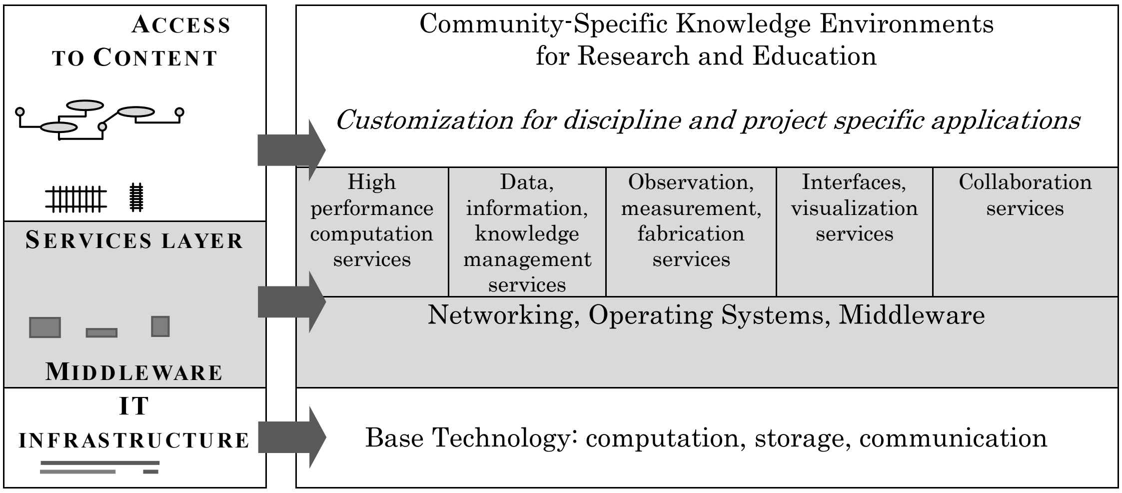

Fig. 4.1 Cyberinfrastructure layers
(adapted from Atkins et al., 2003; Griffin, 2005)

a) *A matter of grids*

Consistent with visions about infrastructure for big science, initiatives relaying on grid computing emerged as a solution. Chiang, Dove, Bovolo, & Ewen (2011) found that grids tend to be associated or used as a synonym of eScience. However the Grid is one technological solution and a type of parallel and distributed system that is capable to support complex cyberinfrastructure requirements like "sharing, selection, and aggregation of geographically distributed 'autonomous' resources dynamically at runtime depending on their availability, capability, performance, cost, and users' quality-of-service requirements" (Buyya, Yeo, Venugopal, Broberg, & Brandic, 2008, p. 601). Chiang et al. (2011) identified three types of grids depending on their specific application scope: a) data grids for easy data discovery, b) computing grids for sharing computing resources and c) collaboration grids (to enable communication). In the last years, these grids turned into a promising technology that has been the basis for cyber-infrastructure policy in several countries and regions. Relevant examples of grid-centered cyberinfrastructure initiatives are the European Grid Infrastructure (EGI)[15] that coordinates and manages national grid infrastructures in Europe, and the Latin American Grid Infrastructure promoted by the RedClara through a series of grid-based projects like EELA (E-Infrastructure shared between Europe and Latin America), EELA-2 and GISELA (Grid Initiatives for e-Science virtual communities in Europe and Latin America).

b) The arrival of clouds

In the recent years the boom of cloud computing has been explored as a complementary solution for cyberinfrastructure. Similar to grid technology,

[15] The EGI is integrated by national grid initiatives such as the National Grid Initiative for Germany (NGI-DE), the UK National Grid Initiative (NGI-UK) among others. See http://www.egi.eu/

> cloud computing is a "large-scale distributed computing paradigm" that consists of "a pool of abstracted, virtualized, dynamically-scalable, managed computing power, storage, platforms, and services are delivered on demand to external customers over the Internet" (Foster, Zhao, Raicu, & Lu, 2008, p. 1). Vaquero, Rodero-Merino, Caceres, & Lindner (2009) considered that a main characteristic of clouds is the possibility of accessing virtualized resources such as hardware, platforms and services. Thus the average user is able to access "a great variety of resources without having to acquire or configure the whole infrastructure" (Oliveira, Baião, & Mattoso, 2010). Such access to research resources is critical for scientific applications "since the scientists can be isolated from the complexity of the environment, focusing only on their in silico experiment" (Oliveira et al., 2010, p. 48).

Giacomo & Bruno (2008) perceived grid deployment as very complex and for this reason many users moved away from grids and have chosen other technologies like web services and traditional databases. Recent research has begun to evaluate cloud computing as an adequate solution to support scientific work and it has explored concrete technical requirements (Lavanya, Keith, Shane, Shreyas, & John, 2010). Some issues addressed in these early works about the suitability of clouds for eResearch are: the financial implications (Deelman, Singh, Livny, Berriman, & Good, 2008), capabilities to support scientific workflows (Hoffa et al., 2008; Juve et al., 2009) and performance analysis for scientific computing (Iosup et al., 2011; Ostermann et al., 2010). One of the first solid efforts to integrate cloud computing to eScience is the British project CARMEN[16], which aims sharing, integrate and analyzing neuroscientific data (Li et al., 2010; Watson, Hiden, & Woodman, 2010).

Both, grids and clouds, have different characteristics and offer interesting features for scientific users. But as it was mentioned, grid computing requires the deployment of complex infrastructure that has to be provided in order to get access to the different services. With the arrival of cloud computing, the issue of the end user and the set up of such infrastructure turns it into an advantage. Then clouds have raised the issue about the support for small science that does not aim to become into big science (trough open data).

[16] http://www.carmen.org.uk/

4.2.1. A Definition

In this work the term eResearch is used in its broadest sense to refer to the "integration of computing hardware, software, and network technology, along with data, information management, and human resources" to the scientific work (EDUCAUSE & CASC2009). Besides this broad scope of the term, eResearch is preferred over other like eScience and cyberinfrastructure because they tend to have an explicit agenda related to specific areas of knowledge or are limited to big scale research. In order to be clear about this work's position, eResearch is employed as:

a) *comprehensive term for all scientific fields*
For the English JISC (2011), the term eResearch is applicable to all research domains, not only science and therefore, technologies in this domain are related to a variety of supported process for research. Whit this consideration, the notion of computer support can be expanded from hard sciences to soft sciences (i.e. e-Science, e-Social Sciences and e-Humanities).

b) *an inclusive term for all levels of infrastructure*
It is claimed that the research about computer support for research implies a technical framework for both, large scale research and small-science. Considering the current institutional environment for the production of scientific knowledge, research centers, universities and private companies provide the resources and specific environment for the operation and management of the scientific work. Then, this institutional level plays also a role in providing technical infrastructure to research centers, units and sub-units. The comprehensiveness of eResearch brings into scene several stakeholders that have influence in the design, development and adoption of eResearch technologies.

Borgman (2007) claimed that in this field, a series of neologisms have appeared and disappeared. Therefore, eResearch can be used as a term that prevails over a variety of specific approaches and technologies to support different levels of computer support for research in all disciplines and within a variety of settings.

c) *a term centered on the research practice and user needs*
This work considers that eResearch technology serves "to the purposes f its users, which are to conduct research, share that research with others, and learn" (Borgman, 2007, p. 43). Precisely, Borgman (2007) argued that the success of eResearch depends on the degree of enhancement of research and even derived learning processes. Then eResearch is "not an end by itself" (p. 43) but rather a concern about effective and efficient technology operation to improve user's research practices.

Behind the term eResearch prevails the idea of technology as agent that can drive change through the action within the infrastructure (Borgman, 2007); so it is capable of "enabling new forms of knowledge" (p. 38).

d) a term close to the knowledge dimension

The relation to the notion of knowledge results critical for eResearch. Schroeder (2008) already identified the relation among eResearch technologies, knowledge and scientific practice. Through the exploration of Shinn & Joerges' notion of research technologies (2002), this author outlined the implications for the globalization of knowledge.

Nowadays the idea of knowledge society emphasizes knowledge as a high valuable asset. In this context, eResearch emerges as an attempt to generate new knowledge in a variety of disciplines or areas, which "often result in the creation of data" (Hunsinger, 2010). eResearch is what Wouters & Beaulieu (2007) called an intervention in the process of knowledge creation, which is characterized by the dependency and mediation of computing resources. Such resources generate new ways of knowledge generation and new information environments that could increase the productivity of researchers.

The link between knowledge and computing emphasized by eResearch is addressed by Foster (2006), who realized the nature of science as an activity that relies on information (collection, organization and transformation) and the role of computing as transformer of all transformation. As a result, "computing underpins science in a far more fundamental way" (p. 419).

But eResearch's intervention in the scientific knowledge production process has potential impacts as well. One of them is on knowledge itself because of the representational character of the eResearch (Hine, 2006): data need to be adapted to fit into the scheme and logic of the technology. Such manipulation of knowledge tends to be a particular characteristic of eResearch (Meyer & Schroeder, 2009). Other authors have explored other implications and claimed eResearch is a style of organization and validation knowledge, a specific and novel type of knowledge production and even a new paradigm of knowledge creation (Beaulieu, 2001; Paul Wouters & Beaulieu, 2006).

4.2.2. eResearch Landscape

Until here, a concrete definition has provided some idea about the scope of eResearch but still remains unclear its dynamics, operation and main actors. The recent interest in this domain has being oriented to the technical aspects in order to develop fundamental resources, including base technology, networks, applications, standards as well as the development and implementation of related projects around the world. Nevertheless few approaches have inquired about the dynamic development and implementation scenario of eResearch. Serious discussions and analyses have sought to determine the landscape of the grid technology in Europe (Baker & Millerand, 2007) and in relationship to scientific collaboration (David, 2004), information environment (Baker & Millerand, 2007) and the knowledge production process (Dutton & Jeffreys, 2010).

A starting point to drive the understanding about eResearch can be researchers' requirements. This exercise should consider the analysis of disciplinary requirements or the analysis of suitable elicitation techniques to be applied to researchers, as complex users. In this way, the EDUCAUSE report of the University of Washington (Lane et al., 2010) was an attempt of categorizing potential needs of its research staff. Despite the local character of this case, it offers one of the few attempts to generalize about IT needs. Table 4.1 shows a list of categories: the first three (data management, computing power and data analysis and collection) are centered on the core tasks for scientific knowledge production (collection and analysis) and technologies for communication and collaboration, as necessary processes in research teams. In addition, the case included aspects like technical advice for users (IT expertise) as a way of providing assessment about suitable IT resources offered by their organization. Finally, the last category was called additional resources and it involves instrumentation in laboratories for specific areas of research as well as the integration with eLearning (implying a close relation between academic research and teaching in Higher Education). Close to this, other EDUCAUSE case studies have inquired about the kind of services provided in institutional research to support eResearch in general or cyberinfrastructure in particular. The cases reflect the concrete reality of IT support for research in higher education (specifically in USA) and current trends in the practice, which are necessary to explore the field. Some other interesting examples are the identification of IT or CI (cyberinfrastructure) capabilities at Georgetown University (through its Advanced Research Computing Center) like: devices and facilities, systems administration, analysis and programming, and others related to user education and maintenance duties (Pirani & Metz, 2005). In the case of Pardue University, some strategic capabilities are integrated in its IT plan for research, which encompasses aspects like networking, computation and visualization (Pirani & Metz, 2005). Many other international case studies as well as policy documents and project reports are being produced to set and explore different understandings about this topic.

• Data management infrastructure • Data storage and back up • Security • Computing power • Computing power (*data crunching)* • Managing and housing computing clusters • Network access • Data analysis and collection assistance • Analysis • Visualization, modeling and simulation • Collection	• Communication and Collaboration • Video, web and teleconferencing • Traditional phone and email • Remote desktops • Wikis • IT expertise • Local technology support • Data management expertise • Socialization of IT expertise offered by the organization • Additional resources • Laboratories and equipment • Integration to eLearning

Table 4.1 IT needs of researchers at University of Washington (based on Lane et al., 2010)

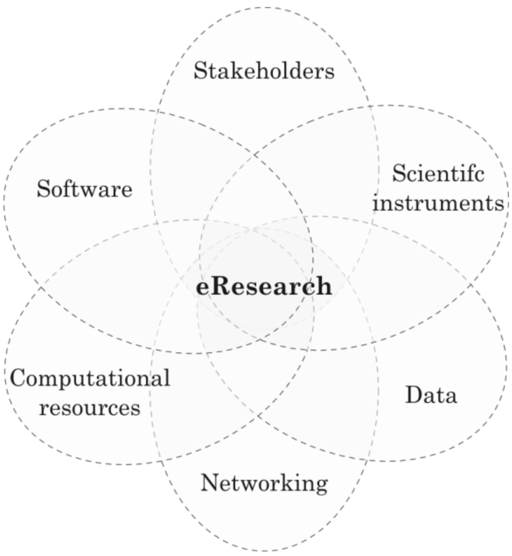

Fig. 4.2 eResearch landscape adapted from (NSF, 2007)

This overview brings some new perspectives to outline the scope of eResearch and some of its critical elements. A comprehensive model that integrates most of these angles was proposed by the National Science Foundation (NSF) in the United States. The adapted *atom model* (Fig. 4.2) presents six main spheres that integrate and operate the eResearch landscape. The model includes stakeholders or main actors (end users, organizations, institutions, networks), scientific instruments used to collect and process data, all levels of required networks, computational resources to support research work (i.e. facilities, technologies, procedures, services) as well as necessary software (computer programs and applications). More details, applications and examples of each sphere are provided in Table 4.2.

Stakeholders • Universities, government labs, research and medical centers • Libraries, research societies and organizations • Virtual organizations and communities • End users	**Scientific Instruments** • Large facilities, telescopes • Colliders, shake tables • Sensor arrays • Ocean, environment, weather, buildings, climate.	**Computational Resources** • Supercomputers • Clouds, grids, clusters • Visualization • Compute services • Data centers
Data • Databases • Repositories • Collections and libraries • Data access, storage, navigation management, mining tools, curation, privacy	**Software** • Applications, middleware • Software development and support • Cybersecurity: access, authorization, authentication	**Networking** • Campus, national, international networks • Research and experimental networks • End-to-end throughput cybersecurity

Table 4.2 Details of each aspect of the eResearch landscape (NSF, 2007)

4.3. Standardization Space for eResearch

The relation between science and standards has been already explored in previous research (Bowker & Star, 1998; Zimmerman, 2008). Closer to the specific action in the IS field, research standards have been considered as embodied elements of the science information infrastructure (Lee et al., 2006) and as enablers for sharing and reusing scientific data through transporting "knowledge from one location to another" (Zimmerman, 2008, p. 2). In few words: standards impact on the practice (Bowker & Star, 1998).

ITS in particular can be seen "as complex knots in the web of infrastructure technologies and concurrent socio-institutional provisions" (Edwards, Jackson, Bowker, & Knobel, 2007, p. 36). For Baker et al. (2005), ITS should not be exclusively viewed "as a technical issue" because they unfold "into a more complex concern in the face of bridging communities, organizations and technical enactment" (p. 1). A more comprehensive or socio-technical view of the ITS anticipates the convergence of situations, actors and processes beyond technical choices (Millerand & Baker, 2010).

ITS can be perceived as a technical bridge between small and big science. Ribes & Lee (2010) suggested that small scale scientific projects "are often wrapped up into larger assemblies of data standards, common services and shared computational infrastructures" (p. 232). Standards facilitate technology integration and interoperation across single organizations: "hard technologies such as fiber optic cables and grid computing, soft technologies such metadata standards and ontologies, and even softer on-paper agreements between institutions and agencies of science to facilitate the movement of 'siloed' data and findings" (p. 233). These authors claimed that interdisciplinary collaboration can be enabled by standardized infrastructures because heterogeneity is solved: "whether of disciplinary difference data conventions or systems integration" (p. 233). Then IT standardization "is both a goal and a method" (p. 233) within many eResearch ventures.

But the promises of the ITS face some complexities in the eResearch domain. In particular, cyberinfrastructure and eScience implementations can be very difficult and this situation is relevant for ITS research. Pierce et al. (2008) claimed that most large scale approaches to eScience and cyberinfrastructure have big limitations in terms of deployment and sustainability "as the standards and implementations are difficult to adopt and require developers and support staff with a high degree of specialized expertise" (p. 265). The authors considered that current approaches in this specific field (large scale infrastructures) follow the "Enterprise development model, which emphasizes sophisticated XML formats, WSDL and SOAP-based web services, complex server-side programming tools and models, and qualities of service such as security, reliability, and addressing" (p. 265). In order to tackle such complexities, several attempts have been made to deal with ITS for large scale infrastructures, mostly related to grid technologies (Baker et al., 2005; Foster & Liming, 2004). Besides general interoperability issues in grids (Field & Schulz, 2008; Riedel et al., 2008) other related topics are standards for job submission (Elmroth & Tordsson, 2005), service discovery (Maozhen, Bin, Rana, & Zidong, 2008), file transfer (Guanghui, Chunli, Dan, & Chengming, 2009), storage (Jensen, Downing, Ross, Hodges, & Sim, 2009) and security (Metke & Ekl, 2010).

Beyond grid computing, current research is concerned about the required ITS functionalities for scientific practice. Main focus of interest oscillate around interoperability and how it can be solved through ITS (Foster, 2005). Percivall (2010) suggested that interoperability is a necessary challenge for "seamless" scientific information systems –particularly in geosciences- and therefore technology standards are fundamental enablers. He considered that at the organization level "non-interoperability impedes the sharing of data and the sharing of computing resources, causing organizations to spend much more than necessary on geospatial information technology development" (p. 16). These perspectives point out another significant issue for ITS in eResearch: the role of disciplines to outline the scope of the standards. Despite the efforts of the information science field to cope with more institutional oriented resources like repositories (Gold, 2007a, 2007b), research with a strong disciplinary orientation is abundant (Davies, Fiege, & Lampen, 2006). Interesting examples of fields with specific work on standards are geography (Brox, Bishr, Senkler, Zens, & Kuhn, 2002; Longley, Goodchild, Maguire, & Rhind, 2005), earth sciences (Di & Ramapriyan, 2010), healthcare and medicine (Hammond & Cimino, 2006), and ecology (Zimmerman, 2008).

The eResearch landscape opens a broader perspective on available ITS that are adopted to support research: from organizational ITS to a variety of standards oriented to large scale technologies. But as it was explained earlier in this work, the definition of typologies for ITS is not a simple endeavor. IT Standardization in eResearch assumes a variety of forms closely related to the spheres in the eResearch atom model. Then stakeholders could adopt a type of organization IT standard for one of elements in the atom, like a specific metadata standard (data sphere) for a repository, security standards for the network infrastructure or a grid standard for the middleware operation (software sphere). Considering such aspects, the notion of standardization space is reintroduced in this section and applied to the eResearch domain.

ITS standardization space is presented as the convergence of at least three basic dimensions: the scope (or level, including disciplinary field), the subject matter (or technology and its components) and aspects (or features). An ITS can be characterized as following: organizational ITS (scope: i.e. adoption level, discipline), for a scientific data management system (subject matter: i.e. technology) and specifically, for authentication (aspect/feature: i.e. functionality). Besides this flexible way of characterizing standards for eResearch, a fixed typology faces the risk of being partial and missing some relevant non-formal or company ITS. Thus the spheres in the atom model still can help to situate as subject matter, outlining what is properly related to eResearch technologies, and a scope, by situating eResearch adoption levels and contexts.

4.4. Adoption Levels

Last section presented several approaches to tackle ITS adoption's issues. Rogers' perspective was considered a suitable way of understanding the dynamics of the ITS adoption process because it proposes an adopter-based focus that fits the scope of this work. As other attempts in ITS research, the analysis of the adoption levels is core to understand adoption. A pyramidal structure of the levels (end-user, organization, meso and macro) is taken up again, but considering a particular context (Fig. 4.3). An example of this situation is the format for the submission of specialized data (e.g. sequences), which is strongly network- (discipline-) based and it tends to be used in macro-settings to unify specific research outcomes at the global level. Thus the process of the adoption varies according to the perspective and diffusion of the standards across the levels: organizations provide standardized instruments that comply the ITS for the discipline in which knowledge is produced.

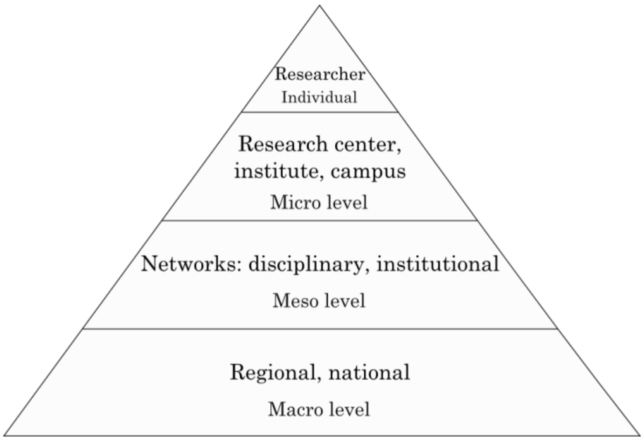

Fig. 4.3 Adoption layers in eResearch

Lynch (2008) noticed that research tends to focus on large-scale national and international projects. He claimed that "one characteristic of many of these large projects is that they are cross institutional and have sufficient scale to include expertise on relevant information technology and data and information management as an organic part of the project team, rather than simply functioning as a client of some campus-based service" (p. 76). Different levels of eResearch use require different types of solutions and possible implementations; then ITS can be characterized and dimensioned depending on the scale of the eResearch solution. The following paragraphs detail the layer model of adoption modified according to the situation of IT and ITS in eResearch, by considering Lynch's perspective.

At the macro level of eResearch adoption, implementation planning tends "to focus on making unique or near-unique scientific resources into cyberinfrastructure components that can be shared by researchers around the world" (Lynch, 2008, p. 76). Through sharing the value and utility of eResearch resources can be maximized (Lynch, 2008), thus ITS are used as a core instrument for enabling data reuse and active collaborations among researchers and institutions. IT standards at this level are strategic and seek to guarantee the functionalities (e.g. interoperability) of the implementations in the large scale. As already mentioned, during the last years Grid related initiatives have been strategically promoted by national governments like in the USA, through the National Science Foundation. In Europe, regional initiatives have decided on strategic technologies that pushed standardization processes in order to achieve global implementations. As a result of this strategic view of regional governments, the use of specific standardized technologies is promoted from a top-bottom perspective.

Lynch (2008) established a distinction between disciplines to understand development tendencies at the macro level. He suggested a development pattern in the humanities, in which explorative projects have been carried out in United States but they do not reach the national level. In this scenario, the adoption of eResearch and its ITS seems to be influenced by disciplinary factors. Foster (2005) explains that research communities standardize "the domain-specific software -and often also the hardware- that participants must deploy in order to provide required functions and resources" (p. 815). He provides two interesting examples of these initiatives: the Biomedical Informatics Research Network (BIRN) and the NFS's Network for Earthquake Engineering Simulation (NEES), which are respectively a national level infrastructure for health sciences and a national collaboratory for earthquake engineering (Foster, 2005). The first is based on standard "compute and storage clusters at 19 sites across the United States" (p. 816), while the second consists of 17 instrument sites that run a "NEES Point of Presence (a modest PC with a standard hardware configuration) with standard software enabling teleobservation, teleoperation, data collection, and related functions" (p. 816). As it is observed, discipline based standardization is originated in specialized settings and then, it is taken at the national level or remains in closed specialized networks (not as government strategy or policy).

At the organizational level of adoption, Lynch (2008) identified IT infrastructure for research and call it campus cyberinfrastructure. He claims that research organizations (in particular, HEOs) conceive "a strong obligation and mandate for a base level of universal services across the campus" and all researchers "need to be able to apply information technology in their research and to access and build on cyberinfrastructure services that include data management and data curation" (p. 78). Organizational adoption of eResearch warrantees adequate resources for end users and support at this level as the basis for large scale (disciplinary) projects. In his analysis of IT infrastructures for research in higher education, Lynch identified basic support services for research staff as employees and for scholars with not external funding support (or their projects/sub units cannot afford with their own budget); then "the campus perspective is concerned with the "average" rather than the "extreme researcher" (p. 78). This type of researchers can do:

> *"what they need to do by employing primarily local IT services and resources rather than national-level ones, and may need to consult or contribute to national or international shared-data resources at levels of intensity easily accommodated by basic campus-provided network connectivity" (p. 78).*

In this scenario, the main infrastructure challenges would be (Lynch, 2008):

- addressing local needs but at the same time, being able to "reach and work with popular, widely used national and international cyberinfrastructure components and services" (p. 78).
- "politically, financially, and technically" demarcating between "universal service and the more specialized package of support services offered to extreme users" (p. 78).
- using local and macro infrastructures for teaching and learning.

These challenges apply to ITS adoption, which deals with the provision of adequate support to local and regular needs and simultaneously, it enables access to other levels of the infrastructure (Jewett & Kling, 1991). Therefore the maturity of the campus IT infrastructure for eResearch is established in relation to its capabilities to deal with local and external needs. The role of the ITS as enablers is critical at the organizational level for the whole eResearch macro-infrastructure and it implies the adoption of a series of organization standards that fit to single institutional strategies and interests.

Finally, the adoption by end-users in eResearch has been the subject of many relevant studies. In particular Kim & Crowston (2011) addressed the likelihood of end-users to specifically adopt eResearch technologies in order to perform their work. With a focus on subjective factors, their study measured cognitive reaction, habit and affective reaction of researchers to learn about their adoption patterns. The end-user level implies a series of decisions that have been studied in eResearch, by exploring post-adoption issues as well as identifying user requirements (Thew et al., 2008). The role of end-users has resulted definitive to guarantee the routinization of any given technology; therefore some research have studied aspects like: user experience (Dutton & Meyer, 2008), characteristics of early adopters (Dutton & Meyer, 2008), gender issues (Walsh & Kucker, 2000), demographic attributes (Xu & Meyer, 2007) and generational aspects (Pearce, 2010). Another major topic has been the characterization of the users according to the discipline (Barjak, 2006; Fry, 2004). For example, Walsh & Bayma (1996) characterized the different use of computer networks based on the discipline of the researchers. In Pearce (2010), the disciplinary approach to categorize end-users was essential because "similar fields will adopt similar tools, and that variation across disciplines will be greater than variation within them" (p. 1197). However, there has been little discussion about ITS and their concrete relation to user behavior in eResearch. But this is a general tendency in the ITS and standardization field (besides the seminal work by Timmermans and Berg (1997) in the medical field). Some promising directions for the study ITS adoption at this level are the analysis of technology-task fit in local scientific knowledge production, subjective factors towards standardized eResearch technologies, and the influence of ITS in scientific work practices (e.g. data sharing).

This closer view to the issues related to adoption and ITS in eResearch has identified some research gaps, tendencies and relations in this field. The next section aims to limit more the perspective of this work and applies adoption theory to the concrete reality of the research organizations. eResearch as a way of enhancing scientific knowledge production has a rich adoption context and the importance of organizations as primary adopters is core to move forward in this field.

4.5. eResearch in Higher Education Organizations

This work is especially concerned with organizational adoption in the field of eResearch. Therefore, a closer look at this level is necessary to understand the context of adoption as well as main players, processes, structures and dynamics that might take part. As other types of knowledge production processes, scientific knowledge can be embedded in a “wider set of social and political institutions” (Bleiklie & Byrkjeflot, 2002, p. 524). Precisely, organized research has become a main actor since the last century as we as a challenge for a variety of research disciplines: from the sociology of science to policy and innovation research. From the economic perspective, research had been studied in relation to the individual researcher and it tends to marginalize the institutional context of his work. But since the 1980, a growing interest on the analysis of the institutional settings had emerged. According to Geuna (1999a), national systems of innovation consider “the role played by universities and their relation with the other producers and users of knowledge within national or regional systems” (p. 2).

However, the link between research and higher education is complex to characterize. For Altbach et al. (2009) “teaching and research do not necessarily live happily together within the same organization” (p. 139), which is understandable considering that research is not a key function of academic institutions in some university national models. In another study, Altbach et al. (2009) identified what they called the "triple helix of university/government/industry linkages” (p. xvi), which was important to activate organizational challenges for universities.

In Europe, the European Commission has outlined the research system as “intimately linked with the education system” (European Commission, 2009, p. 9). In the report presented by the General Directorate for Research, education was considered a prerequisite for high quality research and as a means “to transfer knowledge derived from research and innovation to society” (p. 9). The report outlines the role of subjects and notices that “research systems cannot be limited by organizations restricted to conducting research only” (p. 9), therefore research occurs often in organizations that educate or innovate. In this framework, HEOs “function as the organizational bridge between education and research, whereas enterprises serve as bridging organizations between research and innovation” (p. 9).

The role of HEOs in performing research has becoming more transparent and is increasing its importance. During the past 20 years, research in higher education has "*gained ground*", particularly in basic research. Vincent-Lacrin (2006) referred that in 2003, HEOs within the Organization for Economic Cooperation and Development (OECD) area performed 64% basic research, against 5% business, 29% government and 46% non-profit private sector. In a more recent study, the OECD informed that the expenditures on R&D were: 69.9% industry, 17.1% higher education and 11% government (2011). Another interesting indicator is the percentage of researchers that has increased 50% since 1995, thus in 2008 the total number of researchers in the OECD area was 1 171 274 and in 2006, 27.5% was employed in HEOs (OECD, 2011).

Research in HEOs has been subject of extensive analysis and it is important to understand the contextual conditions of the IT implementations. Ideally IT should be aligned to tasks and roles as well as organizational objectives; therefore the deep knowledge of such aspects is particularly relevant. The next section outlines the characteristics of these organizations in relation to scientific knowledge process and opens possible analytical directions to understand adoption decision based on such configurations.

4.5.1. Research Universities

Universities are considered a special type of organization (Altbach, 2011a) that defines its success based on their conception about teaching and research in the in its decision-making (Altbach et al., 2009). The focus on research has addressed the emergency of using the category of research universities because of their specific organizational configuration. For Altbach, Reisberg and Rumbley (2009), this differentiation tends to separate research-intensive "versus teaching and research or teaching-only universities and within them" (p. 141).

As socioeconomic organizations, universities have a multiplicity of objectives; therefore generalizing about them is a difficult task. Some research considers the action of government, academic staff and administrative personnel "as actors shaping the definition of the objectives" (Geuna, 1999b, p. 13). In one of the many relevant attempts, Schimank & Winnes (2000) studied organizational configurations of HEOs in Europe according to the relationships between research and teaching. These authors classified university systems according to three patterns (Schimank & Winnes, 2000):

a) The *Humboldtian university* was originated and is institutionalized in Germany[17] (Rhoads, 2011). It is based on the situational differentiation of research and teaching tasks, thus some situations are devoted to teaching and others to research. The idea behind this pattern is "the advancement of knowledge through research" (Schimank & Winnes, 2000, p. 399). Roles are not differentiated, institutional funding and resources are common, and the mission of the organization is dual (reaching-research).
b) The *post-Humboldtian university* has moved towards a differentiation of roles, organizations and resource for research and teaching. This pattern has been observed in university systems of countries as United Kingdom, Sweden and Netherlands. In the UK case, since 1985 a new model was introduced to separate expenditure for teaching and research. Through intra-organizational differentiation, two different types of universities can be differentiated: research oriented and teaching oriented (Bozeman & Boardman, 2003).
c) The *pre-Humboldtian university* follows an existent tradition in Europe before the Wilhelm von Humboldt' model and it is characterized by "a subsystemic and functional differentiation" of teaching and research (Schimank & Winnes, 2000, p. 404). Since 1666, France has followed this pattern with the establishment of the *Académie des Sciences*. Teaching and research are separated subsystems: the first is responsibility of universities and *grandes écoles,* while the second is a duty of specialized research organizations with their own budget and scientific personnel.

The patterns in Latin America are discussed by Bernasconi (2008) and Altbach (2011b), who observed the tendency towards the third pattern, but some "old, largest and most prestigious" (Bernasconi, 2008, p. 42) HEOs also participate in research activities. In these Latin American universities, research is separated from the teaching activities of undergraduate and professional training programs. This author refers to the case of the National Autonomous University of Mexico (UNAM), which has a campus planned to separate research institutes and *facultades* (academic departments), where mainly teaching and some research take place. But today, new institutional programs have begun to promote research in academic departments and UNAM has allocated infrastructure resources for this type of activities. To understand the relevance of this university, it must be considered that at UNAM takes place 30% of the research papers produced in Mexico (Bernasconi, 2008).

[17] This pattern remains in spite of the adjustments that took place in the 1970s with the introduction of *Fachhochschulen* (Universities of Applied Sciences) for professional training.

Rhoads (2011) analyzed the situation of HEOs in United States and characterized them as “highly regarded around the world” (p. 2), which implies that the American university system has influenced the way how other countries are organizing reforms to their own systems. After the remarkable influence of the German system; in *post-Humboldtian* institutions, research takes place in the so called research universities, which have an entrepreneurial focus towards knowledge or academic capitalism (Rhoads, 2011). The American research university emerged in the 1950s and became a “gold standard” (Altbach, 2011b, p. 15), through the combination of expenditure provided by the Defense Department (related to the cold war in that time) and the support from states, as well as academic governance that differentiated research on the top (Altbach, 2011b).

Despite the differences between patterns and the different systems, the category of research university or research HEO can be established. It does not elude the discussion about the balance between teaching and research activities, but rather considers it as a factor that could drive the allocation and management of IT resources and ITS adoption (White, 2007). The literature suggests the growing interests on these institutions by researchers or students as well as sources of funding (Altbach, 2011b). On the other hand, their impact on national research systems contrasts with their number. Altbach (2011a) claimed that “smaller countries may have only one research university, while larger nations may have many – although only a small minority of the total postsecondary institutions in the country” (p. 65). For example in USA, there are 150 relevant research universities (out of around 4,800 HEOs), in India only 10 out of 18,000 and in China 100 of 5,000 (Altbach, 2011b).

Research oriented HEOs tend to offer a unique academic mission and therefore their configuration and organization can be differentiated. Such research focus tends to impact aspects such as: bigger budget, infrastructure needs as well as managerial and governance requirements. The attention to these aspects is seen as a way to perform research “at the highest levels” (Mohrmana, Mab, & Baker, 2008, p. 6). Another relevant consideration is the scope of the research in HEOs and their participation in big science. Altbach et al. (2009) affirmed that financing for big science used to be provided mostly to government institutions and university research institutes were isolated; but in the recent decades, basic and applied large scale research has been encouraged. This growth of university research's impact is described by Altbach (2011a):

> *'Research universities are complex institutions with multiple academic and societal roles. They are both national institutions that contribute to culture, technology and society, and international institutions that link to global intellectual and scientific trends" (p. 11).*

Then it is possible to affirm that university research is more relevant and its impact on the national research outcomes is unquestionable. This expansion towards big science uncovers the role of the infrastructure as enabler. Then eResearch occurs in research universities at the same time as eLearning and IT support to managerial activities.

4.5.2. Organization of Institutional Research

HEOs are conceived as "large bureaucracies with complex management needs" (Altbach, 2011b, p. 68) as well as specific norms, incentives and organizational structures that drive their behavior (Geuna, 1999a). Previous studies have discussed the particularities of these organizations and explored aspects such as management (Goodhall, 2000), decision making mechanisms (governance) and the degree of professional power (Altbach, 2011b). Moreover some research has inquired about the university units that perform research tasks and their operational structure, as well as other governance structures. In Higher Education, governance consists of "forms and processes through which universities govern their affairs" (Shattock, 2006, p. 2). Thus it concerns on how academic decisions are made (Altbach, 2011b). In research HEOs, academic and research communities are included and involved in key decision making institutional procedures. For Marginson and Considine (2000) offer a more comprehensive perspective and HEOs specific governance is related to the following aspects:

- the determination of value,
- systems of decision,
- resource allocation,
- mission and purposes,

- patters of authority and hierarchy, and
- the relationship with other academic and government institutions, as well as with business and the community.

Thus governance "provides the conditions which enable teaching and research taking place" (Marginson & Considine, 2000, p. 7). In order to explain governance in research HEOs', Bozeman and Boardman (2003) pointed out the role of university research centers and academic departments, while Etzkowitz & Kemelgor (1998) focused exclusively on research centers as basic structures for research units in HEOs. In a study with 25 new research universities in OECD countries, Hazelkorn (2005) found out they tend to conduct research mostly within academic centers and academic departments, as well as individually. In the same study, other areas that produce research outcomes to a lesser extent were identified: centers of excellence, industry centers, science parks, incubator units and business parks/enterprise centers (Hazelkorn, 2005). This author not only lists the organization units that participate, but he includes three main patterns of decision making in HEOs:

- Centralized or top-down approach: "priorities and funding are determined primarily by the Pro-Vice Chancellor for Research (or equivalent)" (p. 77).
- Decentralized or bottom-up approach: "priorities are set mainly by individual researchers or departments". The approach takes place in organizations "with a strong tradition of individual scholarship" (p. 77) or a tradition of autonomous academic/research units.
- Combined top-down/bottom up approach: "priorities are set via the involvement of different levels or committees of university personnel and boards, viz. Rector, Pro Vice Chancellor, Senate, Deans, Directors of Research". (p. 77)

Hazelkorns' categorization (2005) pointed out the need of understanding beyond macro-organization. Within the decision making process, the role of research units is critical because of their character and the relevance for the IT and ITS adoption. But before proceeding to the specific aspects of IT infrastructures, a brief overview of the configuration and roles of the relevant types of research units is provided.

Research Unit Type		Horizontal Relations	External Relations	Extra-Research Activities	Research Problem Focus
Academic Departments		• Minimal, mostly related to curriculum administration	• Simple • Decentralized	• Teaching • University • Professional service	• Discipline-based
University Research Centers	Simple	• Simple, mostly to other departments	• Simple • Negotiated by researchers with professional networks and funding agencies	• Few/none	• Based on a narrow set of problems • Usually discipline-based "normal science"
	Complex	• Simple, mostly to other departments	• Moderate complexity • Include academic networks and other knowledge user types (e.g. industry)	• More extensive • Expanded educational role, industrial outreach or brokering diverse network members	• Mix of problem driven topics and discipline demands
	Multipurpose/ Multidiscipline	• Variable, usually very complex • Cutting across many units	• Complex • Often including multiple external industry, government and university actors	• Multiple • Often including educational role, industrial interaction, scientific and professional brokering, community outreach	• Almost entirely problem driven • Not tracking closely to disciplines and established scientific and technical specialization

Table 4.3 Taxonomy of research centers (adapted from Bozeman & Boardman, 2003)

Bozeman and Boardman (2003) as well as Etzkowitz and Kemelgor (1998) analyzed the role of research units. For the first, research centers are more formal scientific organizations that a research group and they claimed that centers vary in scale: from individuals of several departments, to various universities and even companies, as well as entire departments. This notion of research center implies a "type of collective research" (Bozeman & Boardman, 2003, p. 73) within an organizational framework to manage internal resources and provide support. On the other hand, Bozeman & Boardman (2003) argued that academic departments and research centers are two different types of research units; and according to them, departments have three main missions: teaching, research and service. But in comparison to research centers, "the research role of the academic department is precarious" (p. 18).

Bozeman & Boardman (2003) believed that department chairs split their duties between motivating the research productivity and instruction quality assurance. Specifically research centers can be classified in three main categories considering the relations with other organizational units and involved stakeholders, the scope of the research activities and their research focus (Table 4.3). A recent study shows that in top US research universities, research centers are prominent but most scientific activity "is conducted and administered within the academic department" (Bozeman & Boardman, 2003, p. 18). Funding schemes support these institutional structures by awarding resources to HEOs and not to individuals. This specific organizational and departmental focus occurs because of accountability reasons, the need of preserving institutional funds (in case the researcher leaves the institution) and a broader view of organizational resources, such as equipment, computing and facilities (Bozeman & Boardman, 2003).

Academic departments in universities tend to be organized by discipline and their priority remain at the teaching and management levels, while supporting internal and decentralized research carried out by main scientist in contact with sponsors (Bozeman & Boardman, 2003). On the other hand, research centers have a more diverse organizational design and tend to interact with extern actors such as industry, government agencies and other universities (Bozeman & Boardman, 2003). Evidence suggests that one of the most important peculiarities of centers is their research problem orientation (instead of disciplinary basis) and a block-grant funding model, which tends to centralize the allocation of university and external resources.

4.5.3. eResearch and IT Management

Research universities are expensive institutions (Altbach, 2011b). For these reason they require more funding to attract qualified scholars and provide them the infrastructure necessary to perform their research activities: "adequate salaries for faculty, well-equipped libraries and laboratories" (p. 25). In particular, large-scale investment in research facilities, laboratories, equipment and programs are subject of a very selective institutional base (Altbach et al., 2009).

HEOs are organizations that are responsible of providing local infrastructure to units and end-users involved in research as well as administration and learning/teaching processes. Stratman and Kerres (2008) conceptualized the relation between strategy and the processes to be supported with IT infrastructure (e-Strategy). Figure 4.4 presents the three main supported processes that take place at research HEOs, including learning and administrative, as well as research process. This integrated vision of the process is necessary to understand adoption for each one and how strategy and decision making can occur within this framework.

Local infrastructures for eResearch cannot be fully separated of the whole IT strategy in these organizations because of the strong relation between the processes. Then the interaction of process and the strategic perception of the organization about such interaction results relevant to define structural arrangements towards IT support and how to evaluate their performance. This is also the scope of primary ITS adoption because they are used as operators of the strategy to align IT and process performance.

HEOs tend to manage IT according to their needs and entrust these duties to specific organizational sub-units. The way how organizations allocate responsibilities among departments/units/sub-units relies on the organizational perception about their own needs to be satisfied. In the particular case of HEOs, some core infrastructure services tend to be responsibility of specific units (e.g. IT offices). But as it was referred, the structure of research activities in such institutions plays also a role for the adoption of the IT. A bidirectional pattern of adoption within research centers and academic departments can be observed because of the impact of academic networks and disciplines with specific requirements. On one hand academic departments provide systematic and planned technology to support faculty and staff, including sophisticated work environments, network infrastructure, processing capacity, access to digital libraries, massive data bases, data mining technology, etc. (National Research Council, 2001). This departmental level of adoption is included in the budget assigned for technology, which is also part of research grants. Departments and whole faculties can arrange the availability of some specific IT resources. But on the other hand, some university units might also take part in these decisions, such as libraries or even dedicated centers for institutional assessment of eResearch.

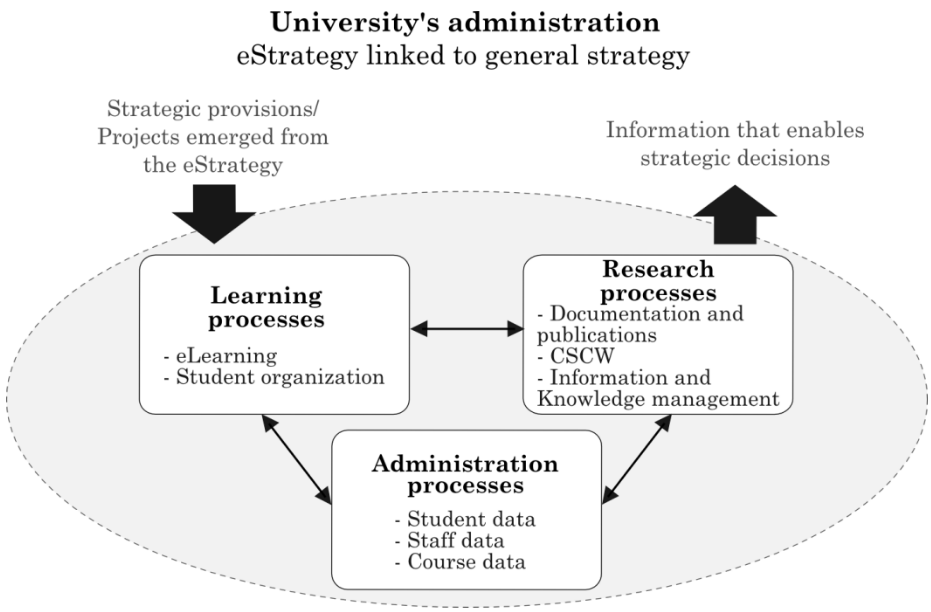

Fig. 4.4 Strategic information management in HEOs (Stratmann & Kerres, 2008)

4.5.4. eResearch in Higher Education: Some Examples

The definition and/or operation of IT management within HEOs can have several configuration patterns and involved actors. The organizational strategy relies strongly on the role of departments, centers and other organizational units (e.g.

libraries, media centers) that participate in IT related decisions, including ITS. This discussion is continued in the following sections, which document three examples of how IT management for research is allocated within research oriented HEOs. They show that no single strategy or approach exists to deal with IT support for research. The selection of following cases was performed based on their focus as *humboldtian* (case *b*) and *non-humboldtian* (cases *a* and *c*) research oriented HEOs:

a) *Universidad Complutense de Madrid (UCM)*

The Complutense University is a research HEO founded in 1499. With a central campus located in Madrid, this institution has 21 faculties and 20 research institutions that are integrated by a teaching and research staff with 6,206 members, as well as 4,626 employees for administrative and service duties (Complutense University, 2012). Research infrastructure is possible through several facilities like the *Centro de Asistencia a la Investigación* (the Research Assistance Center), as well as a variety of eResearch related services provided by a centralized office: the *Vicerrectorado de Innovación* (Vice-rector of Innovation). This office works collaboratively with other campus areas to offer a catalog of IT services for the whole organization (administration, teaching and research). The available IT services are categorized as direct, indirect and infrastructure services and involve four areas that are linked to other university units (Vicerrectorado de Innovación y Nuevas Tecnologías, 2003).

The Systems Office and peripheral IT units use a common institutionalized catalog of services that distinguishes support for eResearch. Most of these services are responsibility of the central office and operate through a series of centers and units as front desk for end-users (Fig. 4.5). Other independent university units are users of the Systems Office and their duties include planning and regular system administration (Vicerrectorado de Innovación y Nuevas Tecnologías, 2003). The same dynamic is followed by the IT support unit of the library (BUC), which can be considered a user of the central Systems Office and provides IT services for researchers and universal users.

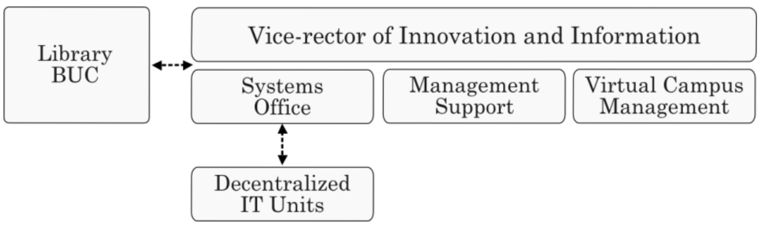

Fig. 4.5 IT organization at the UCM

The provision of services for researchers includes those available for universal users as well as specific “support for research work” (Vicerrectorado de Innovación y Nuevas Tecnologías, 2003) like the following:

- IT assessment for research projects

- Access to central servers for scientific use
- Assessment on scientific software and applications
- Applications for data analysis
- Assessment on programming and data visualization
- Assessment on open source software (i.e. Linux) for research
- Support to the digital media lab

Some indirect services include the support of software and applications for research management and institutional reports generation. Specifically, infrastructure services cover planning, implementation, maintenance and administration of infrastructures. In the case of eResearch systems, a sub-unit called *Servicio Informático de Apoyo a la Docencia e Investigación* (SIADI, Informatics Support for Teaching and Research) works directly with end-users. Access to big science infrastructure is managed by the *Centro de Supercomputación Complutense* (Complutense Center of Supercomputing) (Vicerrectorado de Innovación y Nuevas Tecnologías, 2003).

The extensive reference to assessment programs for research staff is evident at the software and application level. However the catalog warns about the process of hardware acquisition relying on budgetary aspects that are out of the scope of the office. The offer of eResearch services has a specific unit to promote open standards and free software, such as Linux for scientific work. This last aspect provides some insights about ITS at the policy level, indicating a participative approach towards adoption decision.

b) ETH Zürich

The *Eidgenössische Technische Hochschule Zürich* (ETH, Swiss Federal Institute of Technology Zurich) is a HEO founded in 1855 in Switzerland to teach and research in a variety of disciplinary areas: engineering, architecture, mathematics, natural sciences, system-oriented sciences, management and social sciences. Today the ETH is integrated by 416 professors who work with more than 17,000 students from 80 countries (ETH Zürich, 2011b). The organization of ETH's IT relies mainly in five university units as service providers (Arangeh & Dudler, 2008; Breiter & Fischer, 2011):

- Central IT services
- Decentralized IT units in departments and institutes
- An ICT group at the ETH library
- The *Centro Svizzeri di Calcolo Scientifico* (CSCS), the Swiss Supercomputing Center maintained by the ETH Zürich.
- A group of specialists in the Network for Educational Technologies (NET)

Operationally, the first four areas are responsibility of the Vice-President for Personnel and Resources (ETH Zürich, 2012b). The last three units of the list have a very specific scope of tasks, while the first two on the top (central IT services department and the decentralized IT units) provide more basic and general support for the whole organization.

For the ETH, IT decentralization brings a beneficial balance for the support of eResearch because the offered solutions are close to research requirements in each department and institute. This strategic approach for supporting researchers is evidently impacting the way how IT units are structured in the institution.

Two instances play an important role to shape the IT landscape (Fig. 4.6) at the ETH (Arangeh & Dudler, 2008): the *IT-Expertenkommission* (ITEK, the Commission of IT Experts) (ETH Zürich, 2012a) and the *ICT-Kommission* (ICT Commission) (ETH Zürich, 2011a). The first is integrated by the manager of the IT departments and advisers at the *Lehrzentrum* (Learning Center), representatives of the library and corporate communications office as well as the director and section manager of IT services (Arangeh & Dudler, 2008). The second commission (ICT) advises the university's direction about supply and use of IT in all application fields, through defining and establishing priorities of the organizational strategy (Arangeh & Dudler, 2008). At this top level, the support for eResearch has a special consideration, because devices with a higher cost of 250,000 CHF or projects with a significant outlay for IT must be approved by top decision makers (Arangeh & Dudler, 2008).

IT support for research has being part of the strategic vision of the ETH. The central points of the IT services at the ETH cover: learning (inc. lifelong learning) and teaching, research, cooperation with economy and society, specific eServices for ETH community and generalities (e.g. communication, media competence, virtual workplaces, workplace standardization) (Arangeh & Dudler, 2008). The specific planning of IT for research has emphasized some dedicated initiatives in order to support primary research data management; to deal with big amount of data (focus on big science); to support data simulation and modeling (including: tools, algorithms for specific applications, financial support for software development and external commercialization, development of a knowledge platform, dissemination among ETH researchers and cooperation with external partners); to develop parallel computing; and to support projects for long term archiving for primary and secondary data, in cooperation with the ETH library and the *Konsortium der Schweizer Hochschulbibliotheken* (Consortium of Swiss Libraries) (ETH Zürich, 2006a). Other compromises acquired to support research include the set up of small clusters built from single work stations in research groups as well as the use of last generation equipment to satisfy performance requirement (ETH Zürich, 2006b).

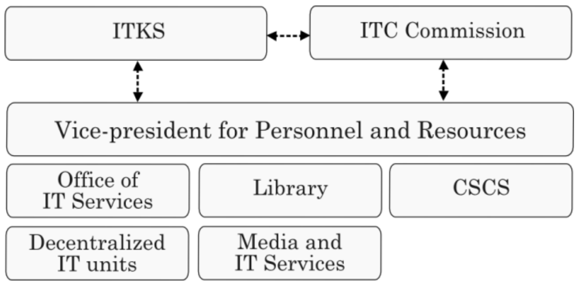

Fig. 4.6 IT organization at the ETH

Other relevant IT services for research have been included as part of the general catalogue for universal users of the ETH community. Some examples of them are video-conferencing and collaboration, Sharepoint and polyphone (Arangeh & Dudler, 2008). The IT Services office is also responsible of the Operative Information System (IOS) at the ETH, it includes components for student and personnel information, learning management, finances (SAP), facilities management and for research: reporting applications (annual report and research database) (Arangeh & Dudler, 2008).

The ETH includes a brief section about standardization in its formal ICT strategy. The document refers to the need of standardizing IT work tools and IT services for the different types of use (teaching, research and administration) and levels (organization wide, department, institute, professor, and central administrative organs) (ETH Zürich, 2006a, 2006b). With an orientation towards organization standards, the ETH expects financial benefits for the institution and for all user profiles, as well as improving the quality of service delivery through predefined universal configurations (ETH Zürich, 2006a).

The organization of related eResearch services shows a high degree of centralization at the strategic level. Apparently, the ETH considers a top/bottom combined approach of decision making about IT, but with a limited scope for end-users by applying mechanisms like incentives for the acquisition of standardized preconfigured equipment (hardware).

c) *Georgetown University*

Georgetown is an American private HEO funded in 1779. It is the oldest catholic university in the United States. Located in Washington, D.C., this research university has almost 1,300 full-time faculty members and the period 2010-211 awarded more than 2,700 master students and 102 PhDs. According to Pirani and Spicer (2006), this institution conducted more that 130 million USD in sponsored research in 2004.

In Georgetown, the organization of IT services is responsibility of the Vice President of Information Services and CIO, who works with several advisory groups (Fig. 4.7). The two main components of this area are the University information System (UIS) and the Office of Information Systems (OIS) (Pirani & Spicer, 2006). The UIS focuses on "financial planning, strategic initiatives and policy areas related to information technology" (Georgetown University, 2012c) and has five primary divisions:

- Center for New Designs in Learning and Scholarships(CNDLS) works on technology support for learning and teaching activities through digital media (Center for New Designs in Learning & Scholarship, 2012).
- KeyBridge was a division contracted to supply web design, hosting and custom application development to university departments (Georgetown University, 2012d).
- Business Service Center (BSC) provides financial management and administrative support for the strategic and operational functions of the UIS (Georgetown University, 2012c).
- Advanced Research Computing (ARC) is a division to support researchers' super computing needs (Pirani & Spicer, 2006).
- University Information Security Office (UISO) runs the university's information security program and equips "students, faculty and staff with the tools needed to better protect their computers and data" (University Information Security Office, 2012).

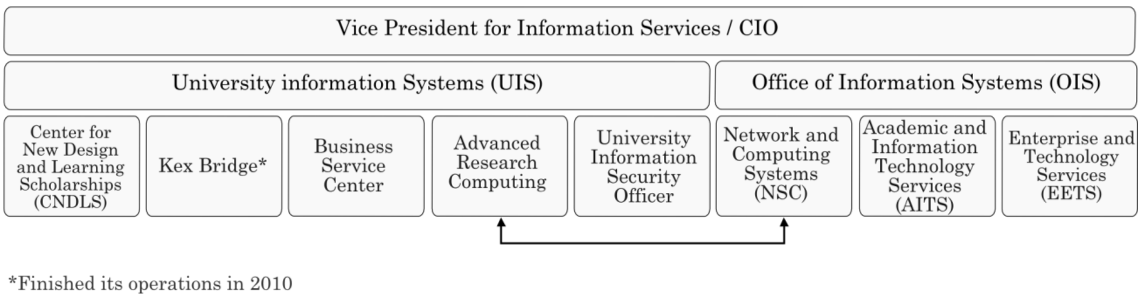

Fig. 4.7 IT organization in Georgetown

On the other hand, the OIS carries out daily technical operations like the development and support of IT infrastructure, as well as assistance and support (Pirani & Spicer, 2006). The OIS has three main divisions:

- Network and Computing Systems (NSC) develops and manages infrastructure for voice, data and video networks, including hosting, storage, network capabilities and high-performance computing. This division aims to work closely with university departments, faculty and staff to provide effective IT solutions (Network and Computing Systems, 2012)
- Academic and Information Technology Services (AITS) provides technical support services to facilitate teaching, research, learning outreach and administrative services (Georgetown University, 2012a). It operates the help desk, desktop support, student technology services, new media and classroom services, identity management (NEtID) and general support services (training, maintenance, IT use guidelines and executive support) .
- Enterprise Engineering and Technology Services (EETS) aims to ensure efficient, integrated and secure Enterprise Class application, through: Enterprise Architecture and Engineering (EAE), Enterprise Infrastructure and Engineering (EIE), and Enterprise Information Systems (EIS) (Georgetown University, 2012b).

Besides these divisions, the UIS has campus partners with agreements to cooperate in IT related areas such as the Lauinger Library (support of the Media Center and planning for NED digital services) as well as the Law Department's Information System Technology (IST) and the McDonough School of Business Technology Center (Georgetown University, 2012e). Related advisory and operational units that involve research and faculty staff in IT decisions are the Information Services Management Council, the UIS Advisory Committee, the Guide Committee and the Department Technology Representatives (DTR) (Georgetown University, 2012e).

Pirani and Spicer (2006) studied the operation of the ARC, which is a unit particularly focused on research technology. It offers capabilities related to grid computing, cluster design as well as analysis and programming (database programming and maintenance, data manipulation, high end computational programming, simulation, modeling, etc.), scientific device design and manufacture, computational core facility management, and assessment (Pirani & Spicer, 2006). The ARC offers organization-wide services through the OIS/NSC but the strategic focus emerges from work with the UIS. This structure enables "to meet researchers' unique IT requirements" and it works as a "service-oriented organization" (p. 9). With a specific scope, the ARC unit at Georgetown centralizes a specific range of IT support for research for the whole organization and offers direct interaction with end-users. On the other hand, the contact with academic departments is a constant in this HEO as a way to address disciplinary and specific requirements out of the ARC scope.

These three cases provide some initial insights about current practices that suggest the complexity of HEOs as environments for eResearch, pointing out a series of forces that shape adoption decision. These, as any other organizations, have certain priorities that are translated into strategies to be implemented by different units through certain mechanisms. The main goal of HEOs is to align IT strategies and profit from IT performance.

The HEOs mentioned above tend to conceive three main areas of IT application: learning, research and administration. The IT services for each one were distributed within a series of offices or departments that organize the operation. Through this approach to users, HEOs aim to warrantee the operation of IT not only to align the strategy, but to meet new requirements that emerge from the research practice. IT departments tend to collaborate with other units in the organization as support and the outcome is also a series of services that are related to eResearch, such as libraries or supercomputing centers. An example of the cooperation between IT departments and libraries are digital repositories, which can be disciplinary when faculty or a group of researchers in a knowledge area requires this specific service. Some knowledge emerged from the cases is summarized in the following list:

- eResearch organizational support is result of strategy, policies and management decisions that shape internal deployment.
- Research HEOs tend to combine a top-down/bottom up approach to IT adoption in order to balance between organization strategy and disciplinary/project requirements. Decentralized IT units are seen as a way of providing dedicated IT management and assessment to researchers. Thus there is a contingent authority adoption decision but involves expert-users participation in the decision making.
- eResearch tends to be service-driven and it is offered by a variety of IT related units in HEOs.
- Some specific eResearch services (specifically those related to universal infrastructure) are centralized to provide technology assessment on demand.
- Specialized services for eResearch can involve internal providers like libraries, which define their specific conditions of technology adoption. Thus coordination is required for the adoption of end-users.

This work considers the need of understanding those *enabling* organizational mechanisms because such institutional conditions are determinant for IT and ITS adoption. In the particular case of standards, there are two main flows that are relevant to understand the disciplinary environment and its pressures. Support in academic departments does not only consist of practical arrangements to avoid the overload (because of the centralization), it is also a way of coping with the requirements of expert users and their specific disciplines. Figure 4.8 shows both flows: organization's IT management on the left side with standards strategically adopted to satisfy those problems perceived internally and the research and disciplinary use of IT that sets domain standards on the right side. Then eResearch ITS are situated in the middle, as result of the balance between these two flows that operate through organizational structures and experts' action as project and discipline authorities.

Fig. 4.8 Pressures towards eResearch ITS in HEOs

In the case of eResearch, expert users push the adoption of specific ITS based on their knowledge about a domain and other subjective criteria to deal with specific IT needs. Despite researchers' relative freedom to adopt expert software and hardware, HEOs play a role to manage these assets in a way they are sustainable and affordable for the whole organization, taking into account available resources and the alignment with its own strategy. Organization IT standards in HEOs contribute to such alignment by providing a solution to an identified requirement. In each one of the three cases can be observed a tendency towards the establishment of a basic and universal infrastructure for all users within the HEO, generating conditions that enable or constrain the use of new and specialized IT resources. Such basic infrastructure turns into an *installed base* through the action of technical and organizational ITS, activating mechanisms like *lock-in* effects (Arthur, 1996). In order to tackle adoption in eResearch in HEOs, the next section approaches to trend research and presents a qualitative meta-analysis of factors that serves as basis for a conceptual model.

4.6. Modeling Adoption in eResearch

ITS, adoption and their relation to research in HEOs have not been studied together. In an exhaustive literature review was not possible to find a comprehensive research that integrates these three topics or areas. Taking into account HEOs as scenario for standardization, some studies tend to consider related areas like eLearning or university administration (Dawson, Heathcote, & Poole, 2010) but not research support. Due to researchers' important role in decision making, these works focus on individual adoption of eResearch (Pearce, 2010) and the influence of IT in the scientific practice (Kim & Crowston, 2011; Lane et al., 2010). However other studies have considered that institutional environment for scientific research, including IT policies and standardized procedures could impact positively the research process, like data sharing (Tenopir et al., 2011).

In his analysis about the role of IT in HEOs, Agre (1999) discussed ontological standardization as a way "to uniform the most fundamental categories of their internal workings" (p. 9). Furthermore, ontological standardization is a prerequisite "to employ compatible software or to achieve economies of scale" (p. 10) and in this way, some benefits as interoperability are achieved but could also impact relevant processes within HEOs. In a later work (Agre, 2000), this author considers that IT infrastructure in HEOs brings relationality, integration of heterogeneity and sustainability, as well as standardization (as goal and a technique). For Ribes and Lee (2010) the adoption of specific standards for eResearch is a "matter of changing the everyday practice for many kinds of actors" (p. 235) and refers to the effects of standards as mechanisms potentially able to change local practices and to collectivize research practice (Ribes & Lee, 2010).

Besides the adoption of open standards in HEOs (Kelly, Wilson, & Metcalfe, 2007), a consistent concept has not been developed to tackle the analysis of ITS in the eResearch domain. The next sections are an attempt to build a conceptual framework that could help to understand how standardization occurs in this type of organizations and with IT standards for the eResearch domain. Despite the variety of eResearch applications, hardware, products and processes susceptible to standardization, this framework considers all those implementations decided at the micro-level that could be considered organization standards.

4.6.1. A Meta-Analysis of Adoption Factors[18]

A previous step to define a model was a first analysis of research about ITS adoption. With a particular focus on factors that could be integrated into a model, an analysis was carried out to make deductions that facilitate empirical assessment and to provide an overarching perspective to understand and integrate research (Turner, 1990). The purpose of this step was to provide evidence that could drive the establishment of guidelines towards a solid model. This type of interpretative analysis (called meta-analysis) was centered on the synthesis of scientific knowledge. This analysis tackles the structure and implications of existent research, which allow: a) evaluating the clarity and adequacy of concepts and models; b) suggesting similarities, convergence and divergence; c) bringing together existent empirical studies to assess plausibility; d) synthesize theories with other theories, e) reformulating theories; f) precising and restating theory; g) making deductions to facilitate empirical assessment (Turner, 1990). Meta-analyses have also been employed in information systems (Dennis, Haley, & Vanderberg, 2001; Turner, 1990) in order to provide: a) an overarching perspective to understand and integrate research; b) guidelines for context-specific models and theories in information systems; c) a deeper understanding of the theory. Specifically in ITS research, van de Kaa, de Vries, van Heck, and van den Ende (2007) designed a meta-analysis of factors to study standard dominance.

The papers for the analysis were selected according the procedure applied by Atkis et al. (2008). First, one influential publication in this field was chosen to track the path of adopter studies. The International Journal of IT Standards and Standardization Research (IJITSR) is a peer-reviewed journal that aims to include all aspects of IT standards and standardization. 53 research papers published from 2003 to 2009 were analyzed and 14 of them were identified as adopter studies based on the object and level of analysis, but only four of them focused on

[18] Part of this section was published in (Castro Estrada & Breiter, 2010a).

organizational adoption and therefore four additional articles from other peer-reviewed publications related to IS were added. Besides the methodological implications for the sample selection, the precision of the article's topic as tacit and directly related to ITS and IT standardization was established as basic criteria. The last aspect was considered particularly relevant because of the conceptual implications related with ITS embeddedness.

In Table 4.4 can be observed that the studies are uniform (among the two quantitative and among the six qualitative) and study mostly private firms. Most articles tend to use case study as method of research and for this reason, the meta-analysis is operated in a qualitative way (Rahimi, Vimarlund, & Timpka, 2009). The rest of the control variables obtained from the sample was considered not relevant but they inform about the variety of adoption contexts (location and ITS type).

Author(s)	Code	Unit	ITS	Sample /Domain
Chen (2003)	CH03	Firm	E-business standards (XML)	Two firms (telecommunications and car rental)
Delhaye (1995)	DE95	Firm	EDI standards	Two firms (retail and manufacture)
Ellingsten (2004)	EL04	Health organization	Health Information System	One (hospital)
Gerst et al. (2005)	GE05	Firm	Web Portal	One firm (manufacture, automotive)
Nelson (2003)	NE03	Firm	Inter-organizational IT	102 firms (several sectors)
Thomas et al. (2008b)	TH08	Government organization	Exchange Product Data (STEP)	One (army)
Tung and Reick (2005)	RU05	Firms	eGovernment services	128 firms(several sectors)
West (2006)	WE06	Firm	OS (Linux)	14 firms (several sectors)

Table 4.4 Analyzed articles on ITS adoption

As analytical framework for the meta-analysis, we adapted Kast and Rosenzweig's (1985) model of organizations, which is based on the open systems approach. For these authors, organizations are integrated by subsystems that interact each other and with the environment (Fig. 4.9). In spite of its evident limitations (Giddens, 1990), this model is structured enough to offer a conceptual separation of organizational components on a way that the classification and analysis of the identified factors are possible.

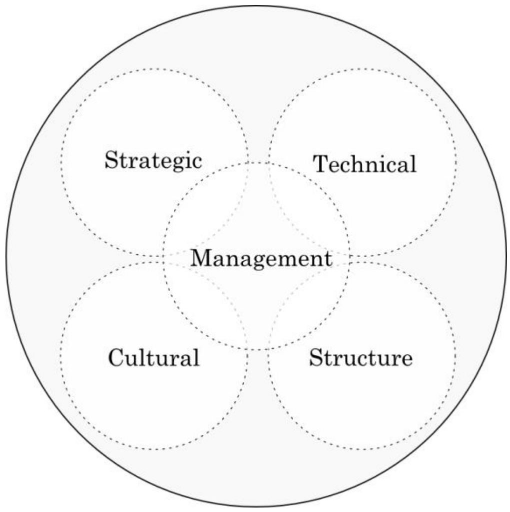

Fig. 4.9 Organization system: overview of internal subsystems (adapted from Kast & Rosenzweig, 1985)

Kast and Rosenzweig's model identified five sub-systems inside the organization boundaries (1985): strategic (all rules and institutionalized values), technical (material infrastructure, specifically resources and technology), cultural (perceptions, values and visions, collective as well as individual), structure (operative characteristics, communication system, responsibility and task allocation, performance and general organization characteristics – e.g. size), and management (mechanisms of control and decision making in the entire organizational system). The central role of the management is clearly emphasized and appears as link among different organizational practices and structures. The last relevant part of the system is the environment that surrounds all the subsystems; and in this way, the authors recognized the openness of the organization and the interaction that its components have with the external world. This systematization is presented in the table 4.5 and shows the presence of one or more factors with a proportional number of (+). During the analysis, some subcategories were identified in order to offer more information about each organizational component and the specificity of the factors. Thus the defined categories do not fully describe a subsystem but instead they focus on the similarities of the factors. The next list shows the subsystems and the subcategories based on the matched factors:

- Structure: attributes (descriptive characteristics), performance (operational domain) and micro-economics (financial aspects)
- Environment: market (competence, clients and suppliers), standardization, framework (ITS governance and general standardization environment), and IT supply (industry tendencies, services and suppliers)
- Management: profile (characteristics and values) and performance (actual)
- Technical (IT): installed base and attributes (specific characteristics of the IT)
- Strategic: vision (long term strategic domain) and standardization (policy)
- Cultural: generalities (general aspects) and perceptions (individual perception of the organizational members)

Factors/ Reference Code	**Structure**			**Environment**			**Management**		**Technical**		**Strategic**		**Cultural**	
	Performance	Attributes	Micro-economics	Market	Standardization framework	IT supply	Profile	Performance	Installed base	Attributes	Vision	Standardization	Generalities	Perceptions
CH03		+		++		+	+		+		+		+	
DE95	+			+										
EL04		+												+++
GE05	+		+											
NE03	+			+	+			+	+					
TH08	+	+	+	+	+			+	++			++	++	
TU05			+				+	+		+	+			+
WE06	+++		+	+		+				+		+		

Table 4.5 Matrix with the systematization of adoption factors

A first look at the collected factors shows that around half of them were related to structure and environment, specifically to performance and market subcategories respectively; while the number in the other subsystems remains balanced (Fig. 4.10).

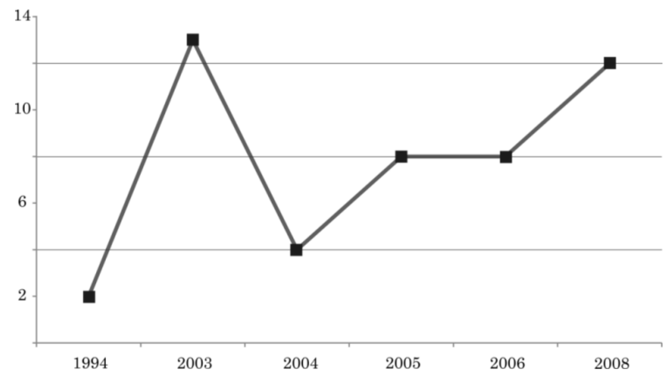

Fig. 4.10 Average number of factors per year of publication (within the sample)

Another general consideration is related to the specificity of the articles. As part of their scope, some of them delimited their research to one or two subsystems, mostly related to structural issues as in (Delhaye & Lobet-Maris, 1995; Ellingsen, 2004; Gerst et al., 2005; Nelson & Shaw, 2003). This confirms what mentioned before about the strong focus on the structure subsystem as determinant. The only study with negative results about the influence of the structural factors was given by Tung and Rieck (2005). But for Chen (2003), the structural characteristics are relevant because they allow situating organizations as early or later adopters, a pattern already explored in innovation research.

In the structure subsystem (Table 4.6), performance and micro-economic factors are more frequent together. This can be interpreted as the correspondence between IT standardization and performance fit, which is influenced by the relation between business units, general operation structure and task specialization. In second place, economic factors are considered determinant in a general sense, but one factor measures the sensibility to standardization costs in particular.

Code	Performance	Attributes	Micro-economics
DE95	• Intra-firm relations (communication and coordination)		
EL04		• Structure reflected on quality	
GE05	• Tension between business units		• Cost pressures
NE03	• Feasibility (financial and technical)		
TH08	• Organization restructuring	• Contractual agreements	• Costs
CH03		• Organization size and type	
WE06	• Performance and reliability • Fit to specialized tasks • Scope deployment • Timing of deployment		• Costs (standards)
TU05			• Sensitivity to cost

Table 4.6 Structure related factors

The environment subsystem (Table 4.7) is linked to organization's market, standardization framework for ITS setting as well as IT supply. The factors represent what in standards and innovation research is known as network externalities. For Nelson & Shaw (2003), "the external environment should be considered a potential significant factor in the diffusion of IOS standards" (p. 267). He claimed that the "external environment attributes will have a positive (and significant) relationship with IOS SPI adoption" (p. 267). The market subcategory covers three external factors that tend to influence standardization: suppliers, competitors (industry) and customers. The network effects generated by standardization practices within the market has been studied and considered as a specific driver of ITS adoption in organizations. Less frequent are the factors that connect organizations to the ITS standard governance and participation in standards setting (e.g. Standards Development Organizations); as well as those related to the specific IT suppliers (vendors), including their service and support.

Code	Market	Standardization framework	IT supply
DE95	• Market environment - Suppliers - Buyers - Competitors		
NE03	• Competitive pressure	• Participation level in standards setting	
TH08	• Industry reluctance	• Remoteness of the standard community	
CH03	• Customers and suppliers		• IT Vendors • Systems integrators
WE06	• Network effects		• Vendor support

Table 4.7 Environment related factors

The managerial subsystem (Table 4.8) is seen as a facilitator factor for ITS adoption (Thomas et al., 2008b). For Tung and Rieck (2005), this perspective is considered to study Singaporean firms, in which the presence of the factor was positive but insignificant for ITS adoption decision. ITS research applied to this subsystem is still incipient, but two main subcategories are visible: one about the general management profile, and another specific related to the performance (e.g. support). The data in the articles about this subsystem was general and further research might focus on the specific operationalization and evaluation of managerial influence in ITS adoption.

Code	Profile	Performance
NE03		• Top management support
CH03	• Decision Maker	
TU05	• Management profile	• Management readiness
TH08		• Managerial influence

Table 4.8 Management related factors

The technical subsystem (Table 4.9) is also analyzed by a reduced number of factors considering the embeddedness of ITS in the IT resources. According to Thomas et al. (2008b), IT related factors are seen as facilitator as well as barrier by showing the positive impact of related implementation technologies, and the legacy technologies around ITS as hindrance (Thomas et al., 2008b). In spite of the reduced number of papers referring to the technical system, the studied factors are clearly centered on the available installed base and only in Tung & Rieck (2005), ITS attributes as compatibility (with other technology not only that installed in the organization) and IT skill set are seen as particularly relevant.

Code	Installed base	Attributes
CH03	• IT infrastructure	
NE03	• Technology conversion	
TH08	• Legacy technology • Related implementation technologies	
TU05		• IT skill set
WE06		• Compatibility

Table 4.9 Technical system factors

The strategic aspects (Table 4.10) are related to the organizational decision criteria captured by long term strategic vision and policy. According to Thomas et al. (2008b), organizational policy (for IT and ITS) is considerate a facilitator of adoption as well as the support of managerial actors. An example is given by the statement of a worker in the Ministry of Defense in UK, who affirmed "I have a business to run. It is called the Royal Navy. The best way for me to run my business is by applying standards. That is my corporate rule." (Thomas et al., 2008b, p. 63).

Code	Strategy	Standardization
CH03	• Decision criteria	
TH08		• Position and policy towards standards • Internal drivers
TU05	• Strategic importance of IT	
WE06		• Internal standardization

Table 4.10 Strategic related factors

Finally, the cultural subsystem (Table 4.11) is analyzed by general factors called *organizational culture* (Chen, 2003; Thomas et al., 2008b). For Chen (2003), an innovative organizational culture is more likely to experiment with ITS at earlier stages; whereas Thomas (2008b) considered it as a barrier because of the relation with organizational attitudes towards change. Another subcategory of this subsystem encompasses factors related to the individual imaginaries influenced by the organizational structure, including perceptions about: ITS quality, social costs associated to the usage and the possible benefits. Ellingsen's work (2004) on human cultural factors applied to ITS adoption is a descriptive and analytic exercise that specifically address the relation between individual members of the organizations and ITS. As well as in the strategic subsystem, the notion of cultural factors is still general and more specific operationalization is needed to report on a consistent way the implications of both components in the adoption of ITS.

Code	Generalities	Perceptions
CH03	• Organizational culture	
EL04		• Perceptions about standards quality • Individual perceptions • Perception about (social) costs
TH08	• Organizational culture • Lack of information (communication)	
TU05		• Technological perspective: Perceived benefits

Table 4.11 Cultural factors

There are some evident limitations of this first analysis because of the incipient production in ITS adoption. The number of the articles matching the selected criteria could be considered relatively low (numerically, but not conceptually); however the rigorousness about the emphasis on ITS adoption was considered as a priority. In spite of this issue, the presented meta-analysis has also proposed a framework so it can be successively applied to integrate more studies in order to extend the results.

Considering this brief analysis and the evidence of the eResearch standardization practice, the pertinence of the types of factors for this domain can be determined:

- Structural: it offers measurements about organization configuration to deploy IT and ITS. In HEOs, these factors could help to identify organization design and capabilities that might enable standardization. Relevant factors to be taken into account are organization structure and resources issues.
- Environmental: it covers aspects outside HEOs that could impact adoption. In this case, general factors such as market and IT supply seem not to describe the concrete situation in eResearch.
- Managerial: it is consistent with the theory on contingent authority adoption (Zaltman et al., 1973) and the role of managers. Therefore relevant factors to be observed are management support and profile.
- Technical: it focuses on the IT infrastructure and its capability to embrace the ITS. This set of factors seems to be too general to establish a causal relation. A more detailed focus of these factors is necessary to be operationalized.
- Culture: it covers mainly end-user attitudes. Considering the scope of this work, this approach to organizational culture does not result pertinent.

4.6.2. Conceptual Model

Taking into account the factors derived from the systematic analysis of the literature, a comprehensive conceptual model is presented. However, it should be considered that factors' articulation is based on Gallivan's (2001) differentiation between primary and secondary adoption. Thus the model limits its application to organizational aspects and assumes that HEO's management makes decisions about ITS to enable researchers' adoption (called secondary). The implications of primary adoption are outlined based on Zaltman's (1973) contingent authority theory, which assumes that user adoption is contingent on a prior event (high level authority).

The notion of process is a second relevant aspect to be considered for modeling. Existent ITS adoption models (Chen, 2003) tend to offer explanations in a concrete time of the adoption process or suggest temporal facts that are not attempted to be part of their models (Thomas, 2010). This aspect could be called *dynamics* and aims to situate the factors within a series of events. The model tests this process approach (Thomas, 2010) in order to explore the presence of factors through the specific adoption path. By explicitly addressing process aspects as occurring over the time (van de Ven, 1986), those phases introduced in Rogers' adoption theory (1995) can be operationalized.

Fig. 4.11 covers all these issues and addresses the main aspects related to the organizational deployment of IT and subsequent ITS adoption. The following explanation of the model includes not only the relation among the categories, but a first proposal of main factors to be incorporated and tracked later in the field work. Here checklists are used as a suitable tool to qualitatively operationalize the factors and this first model will be later complemented as suggested by Thomas (2010).

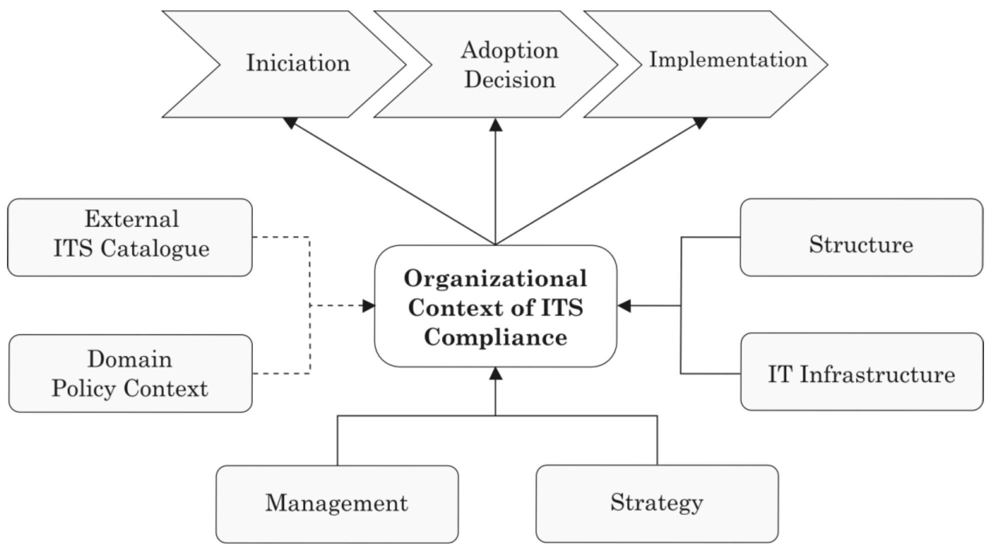

Fig. 4.11 Proposed conceptual model

In the model, a subset of three main branches constitutes a context of compliance that occurs in a specific stage of the adoption process. The context of compliance is shaped by the specific mix of conditions that drive the organizational embracement of ITS. The left branch considers external factors to conform the context of compliance, in particular the effect of available ITS (general and specific to the domain) that influence decision making as well as specific eResearch policy context. The environmental related categories (Table 4.12) cover the context of the standard outside the organization, including pressures and communication mechanisms that promote adoption. In the same way, domain related standardization is incorporated as a specific mechanism to be consistent with findings in past studies (Fry, 2006).

Categories / Factors	
1.	**External ITS catalogue**
1.1	The standard is used by other HEOs
1.2	The standard is communicated/disseminated
1.3	The standard has external support (documentation, consultancy, communities)
2.	**Domain policy context**
2.1	The standard is supported/required by a domain community (external pressures)
2.2	The standard has a critical mass within the domain
2.3	The standard is embedded within an IT product with critical mass

Table 4.12 Checklist: Environmental related categories

The upper part of the model focuses on structural aspects, including the IT sphere (Table 4.13). Basically, it considers HEOs' configuration, practices and characteristics as supportive or not to a given standard. The IT units in departments, centers or libraries play a role as well as the relation of research units with HEO top level management.

Categories / Factors	
3.	**Structure**
3.1	HEO structure for research support
3.2	HEO structure is decentralized (coordination mechanisms)
3.3	HEO has available resources to support the standard
3.4	A HEO unit requires the standard for a (specialized) task
3.5	A HEO unit is open to the standard
4	**IT infrastructure**
4.1	Formal relation of the IT units with HEO's central IT department
4.2	HEO's IT organization tacitly supports research
4.3	Installed base capabilities
4.4	IT units have the skills to support the standard
4.5	IT staff has skills to deal with the standard

Table 4.13 Checklist: Infrastructure related categories

Finally, a set of strategy and management related factors are included too (see Table 4.14). Considering this model is driven by the notion of authority; management and strategy are core to organization standardization because through these mechanisms, end-users have access to the standard (Gallivan, 2001). These categories refer to high level decisions that facilitate adoption as well as operative management to deal with all phases of the standardization.

Categories / Factors	
5.	**Strategy**
5.1	The HEO tends to formalize and centralize
5.2	The HEO has a policy related to the standard
5.3	The HEO's strategy is open to the standard
5.4	The HEO considers IT as strategic
6.	**Management**
6.1	Management supports the standard

Table 4.14 Checklist: Strategy and management related categories

As mentioned previously, the model has been tough to be applied considering a process dimension. For the purpose of this work, the visualization of the factors should include the different stages of the adoption as process. In their analysis of an electronic device, Hoeber and Hoeber (2012) presented their findings with a display that was able to summarize the results as process.

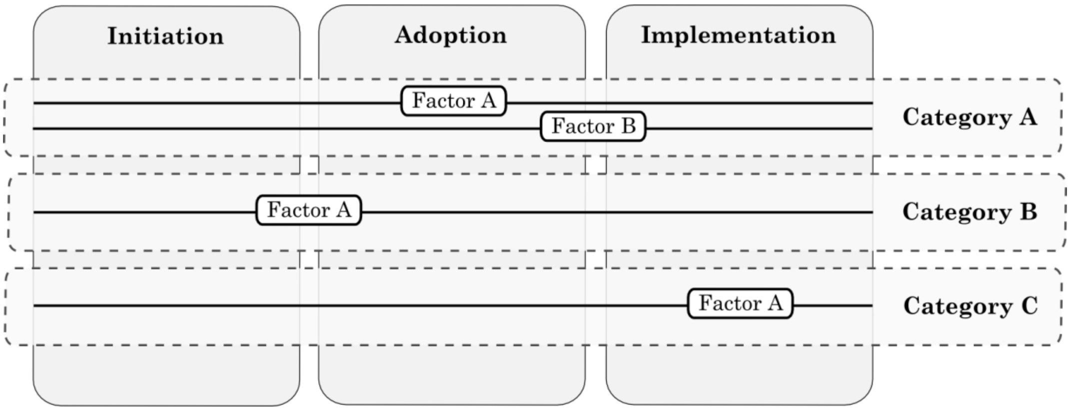

Fig. 4.12 Suggested visualization of the factors for the model
(based on Hoeber & Hoeber, 2012)

Figure 4.12 presents an adapted version of this display, which includes three organizational contexts of compliance, one for each part of the process. As it is showed, the factors of each category can be displayed according to their impact through the whole process.

4.7. Applying the Model

This chapter aimed to present a full overview of the application domain of this work. The perspective on ITS and adoption was taken beyond and transferred to eResearch. IT support of research activities is a rich area that has emerged and become important in the recent years. The importance of eResearch is evident and it is a fertile ground to inquire about standards. The model presented in this section brings together a field in development (ITS research), a young one related to IT for research and a specific focus on organizations. The mix of these three areas constitutes the specific interest of this work and it is the basis of the conceptual model. The next chapter presents a concrete strategy and outlines the methodological way to be followed.

CHAPTER FIVE

5. Research Strategy

This research is focused on the dynamics of IT standards adoption in eResearch services for HEOs. Moreover, a deeper understanding of the adoption process was gained and modeled a series of factors presented in the last chapter. In order to achieve this general purpose, two case studies were designed and carried out to fulfill the following specific research objectives:

- Build a conceptual model that explains ITS dynamic adoption at the organizational level and specifically for eResearch services in HEOS.
- Identify the organizational factors that shape the adoption context of compliance in HEOs, specifically observing the repository technology.

The next sections address such objectives and introduce the research strategy, which has been defined based on the existing body of knowledge in the Information Systems (IS) field. Specifically, the chapter includes an examination of the research paradigms underlined and discussed in IS as well as the use of case study and the implications of dealing with a highly qualitative research process (methods). By the end, a summary includes the design aspects that are observed to ensure the scientific rigorousness of this work.

5.1. Research Philosophy

For Creswell (2007) good research makes explicit assumptions, paradigms and frameworks to report its results in order "to be aware that they influence the conduct of inquiry" (p. 16). Choosing qualitative research implies a series of assumptions about "the nature of the reality (ontology), how the researcher *knows what she or he knows* (epistemology), the role of values in the research (axiology), the language of the research (rhetoric) and the methods used in the process (methodology)" (p. 16).

Before to precede to the formal definition of a philosophy, some remarks about the object of the study need to be made. Working with ITS imply dealing with a an embedded element of an information system (Thomas, 2010). Then two terms emerge: information technology and information systems that, according to Thomas (2010), tend to be used interchangeably. Considering the research production in the field it is evident the preference for the IT term (see the International Journal of Information Technology Standards), in spite IS has a more "multidisciplinary and pluralistic" perspective (Sawyer & Huang, 2007):

> *'The information system of an organization consists of the information technology infrastructure, application systems and personnel that employ information technology to deliver information and communication services for transaction processing/operations and administration/management of an organization" (Davis, 2000, p. 67)*

For Davis (2000), the term information system is wider and includes the technical dimension of the IT infrastructure. The relation between terms is more than causal and implies the pertinence of studying standards from an IS perspective. Thus adoption is dimensioned as a more complex process that involves IT, applications and human factors while delivering a service in an organization.

The nature of the inquiry in IS has been widely discussed (Khazanchi & Munkvold, 2003; Orlikowski & Baroudi, 1991; Pather & Remenyi, 2004; Pratt, Smatt, Furner, & Keane, 2005; Weber, 2004) . Therefore studying ITS from the IS perspective involves the necessary relation to its disciplinary perspective and philosophical assumptions "regarding the nature of a phenomenon under investigation" (Thomas, 2010, p. 63). This discussion oscillates between positivism, interpretivism and critical research (Khazanchi & Munkvold, 2003; Orlikowski & Baroudi, 1991; Pather & Remenyi, 2004), while others establish a dichotomy only between positivism and interpretivism (Weber, 2004) or consider critical research together with action research and consultancy as interactive interventions (Choudrie & Dwivedi, 2005). For Miles and Huberman (2001), the lines between epistemologies "have become blurred", and argued that their perspective on qualitative data analysis was hard to situate because "they do away with correspondence theory [...] and include phenomenological meaning (p. 5).

5.1.1. Brief Overview of Research Philosophies in IS

a) Positivism

Several authors (Alavi & Carlson, 1992; Chen & Hirschheim, 2004; Galliers & Land, 1987; Orlikowski & Baroudi, 1991; Thomas, 2010) refer that positivism has been the dominant approach in IS research since the late 1970s. In Orlikowski and Baroudi (1991), a meta-study of 155 journal articles published between 1983 to 1988 showed that 96% were related to positivist strategies. Later, Chen and Hirschheim (2004) examined 1893 articles published between 1991 and 2001 and reported that 81% are positivist research. Positivist inquiry assumes that reality can be objectively accessed by the research with the use of structured instrumentation (Orlikowski & Baroudi, 1991). Babbie and Mouton (2001) characterized positivism as a philosophy that emphases the quantification of constructs, assign numbers to the perceived quality of things and assigns variables a central role and controls experimental or statistical control for sources of error.

For Orlikowski and Baroudi (1991), the positivist research perspective reflects much of Western science and has influenced IS because of its attachment as a computing discipline. Lincoln and Guba (1985, p. 36) and Orlikowski and Baroudi (1991) defined the following characteristics of the positivist philosophy:

- The phenomenon is single, tangible and fragmentable, and there is a unique, best description of any chosen aspect of the phenomenon.
- The researcher and the object of inquiry are independent, and there is a sharp demarcation between observation reports and theory statements.

Thus researcher's role is to "discover" it through modeling and measurements.

- Nomothetic statements are independent of time or context and imply that scientific concepts are precise, having fixed and invariant meanings.
- The researcher follows specific methodologies (standard instrumentation) as the only way in which valid knowledge can be obtained (methodological monism).
- Support the existence of real, unidirectional cause-effect relationships that are capable of being identified and tested via hypothetic-deductive logic and analysis.
- Inquiry is objective (value-free).

A strict attachment to the positivist line is not free of limitations. For Orlikowski and Baroudi (1991), situated research (e.g. in organizations) is problematic because of its embeddedness in the social context and positivists tend to ignore the historical context. A second limitation referenced by these authors is the aim to explain and predict reality, which implies that subjects are not active agents of their reality.

b) Critical research

This type of studies "*critique the status quo*", through the exposure of what is believed to be structural contradictions within social systems (Orlikowski & Baroudi, 1991). They have an evaluative dimension and the researcher aims "to transform the social reality under investigation" (Orlikowski & Baroudi, 1991, p. 19).

This research philosophy is "gaining a foothold in information systems research" (Pather & Remenyi, 2004, p. 144), drawing attention to the fact that IT is not neutral and affects corporate power structures, individual work patterns, remuneration and control. Critical studies deny researcher objectivity and they "often conduct their research in the context of Marxism, feminism, corporate power structures, anti-racism and anti-colonialism" (p. 144).

Orlikowski and Baroudi (1991) referred to the capacity to enact change as constrained, so the critical research's objective is to create awareness of the domination and act with people to eliminate them. Other relevant aspects identified for these authors are listed:

"Social reality is understood to be produced and reproduced by humans, but also as possessing objective properties which tend to dominate human experience" (Orlikowski & Baroudi, 1991, p. 19). It emphasizes the processual development of the phenomena and tends to be longitudinal.

- The research methods of choice are qualitative, including long-term historical and ethnographic studies of organizational processes and structures.
- The role of the researcher is to initiate social change. He or she points out the restrictive conditions of the *status quo* and help to "eliminate the bases of alienation and domination" (Orlikowski & Baroudi, 1991, p. 19).

The critical approach is not free of weaknesses. One of them is the selectivity of the perspective by the researcher; for example the focus on economic factors might blur others, like gender. Orlikowski and Baroudi (1991) noticed the lack of critical view to evaluate concepts and models emerged in this type of studies.

c) Interpretivism

Interpretivism has a long intellectual history and it is justified by Dilthey's thesis: "human discourse and action could not be analyzed with the methods or natural and physical science"(Miles & Huberman, 2001, p. 8). In Pather & Remenyi, (2004), interpretive researchers do not suggest that research can be objective but through certain procedures (e.g. triangulation) some bias can be effectively controlled. For Klein & Myers (1999), interpretative IS research can be considered as that gained "through social interactions such a language, consciousness, shared meanings, documents, tools, and other artifacts" (p. 69). In IS, the impact of interpretive research has increased, but, as already mentioned, positivist approaches are still dominant. The meta-analyses performed by Orlikowski and Baroudi (1991) and Chen and Hirschheim (2004) categorized as interpretive research around 3,5% of the published articles between 1983 to 1988 and 19% between 1991 and 2001, respectively. For Chen and Hirschheim (2004) this tendency has been "*remarkably*" constant.

Such research approach has the aim of integrate the social aspects of IS and understand "how members of a social group, through their participation in social processes, enact their particular realities and endow them with meaning" (Orlikowski & Baroudi, 1991, p. 7). These authors addressed the main characteristics of the interpretivism:

- It emphasizes the importance of subjective meanings and social-political aspects. Thus meanings are formed, transferred, used and contextualized.
- The social world is not given, but instead it is produced and reinforced by humans through their action and interaction.
- It assumes that understanding social processes involves getting inside the world of those generating it (Rosen, 1991). Thus the researcher "can never assume a value-neutral stance, and is always implicated in the phenomena being studied" (Orlikowski & Baroudi, 1991, p. 7).

For Orlikowski and Baroudi (1991), the contribution of the interpretive research philosophy in the IS field focuses on revealing the connections among the different parts of the social reality, through the examination of social rules and meanings that allow social practices (Gibbons, 1987). Moreover social processes can be studied "with an interpretive perspective, which is explicitly designed to capture complex, dynamic, social phenomena that are both context and time dependent" (Orlikowski & Baroudi, 1991, p. 7).

5.1.2. Discussion and Rationale

The understanding of the three philosophies is not complete without a final reflection about their concrete implications for this research work. Considering the research questions that drive this work, the established objectives and the nature of the ITS phenomenon, this work could oscillate between positivist and interpretivism.

From a strict perspective, some researchers in the interpretive approach (Orlikowski & Baroudi, 1991; Pather & Remenyi, 2004) argue that positivist is limited for the nature of the phenomena investigated in IS. This suggests that positivist approaches might "not be complex enough to reflect the inherent complexity, ambiguity, and instability of complex" of the information systems (Orlikowski & Baroudi, 1991).

Weber (2004) used six categories to compare and discuss the rhetoric of the research philosophies. These categories are going to be used to drive the discussion and finally assume a position.

a) ***Ontology***

There is a difference between the objective and subjective view of the reality, "*whatever it is*" (Weber, 2004). However, from the practice point of view, biases and prejudices are recognized to happen in both paradigms. This research work assumes the presence of biases when working with the complexity of ITS adoption in organizations. It is recognized the IS perspective (in the sense described at the beginning of this chapter) is prevailing over other possible perspectives to study the organization sub-unit in which adoption process is occurring.

b) Epistemology

Positivist and interpretivist perspectives recognize the "inherent limitations of the knowledge they seek to build" (Weber, 2004, p. vi). Such limitations are also linked to the methods that establish the relationship between the researcher and the research object. In this work is required that the researcher interact with the subjects to make sense about the process and in order to be able to identify the complexity of the involved factors. Then, the relation with context (as seen by the subjects and documented in artifacts) is a way to interact with the reality.

c) Research object

The nature of the interpretivist research emphasises that through the interpretation process, researchers become themselves measurement instruments (Weber, 2004). But according to the positivist, the quality of the research is affected when attempting to perform any kind of measurement. This is what Werner Heisenberg called *uncertainty principle* (Weber, 2004).

Approaching to organizations and their processes require certain interpretive work that is result of a sense making process between the researcher and the informants. This work assumes that the researcher has access to the organizational reality through the vision of the subjects and the material objects that are produced (e.g. policies, regulations, etc).

d) Research method

It is assumed that the selection of methods does not imply the adoption of one specific philosophy. Since case study can allow to deeply observe organization adoption of ITS and the interrelation of factors, it is considered the most adequate strategy to establish a relationship with the object of study in context. Although case study is seen as an interpretative method, this work follows Yin's (2009) positivist focus.

e) Theory of Truth

The subjectivity of the reality is recognized by the interpretivist paradigm. The value of preconceptions and their impact are considered in this work, but such concern is also shared by both research positions. Then it is taken into account that instruments are fallible and therefore a pilot study was performed previous to this work.

f) Validity

The research endeavor by itself has a compromise with validity, which is concerned about "the defensibility of knowledge generated via different research methods" (Weber, 2004, p. vii). This work assures validity by attaching case study construction to Yin's positivist strategy and observing Paré's framework (2004); as well as internal validation based on triangulation of information and methods (usually employed in interpretative research).

g) Reliability

Interpretivist and positivist approaches have different notions about what reliability is but both are concern about the replicability (Weber, 2004). For Weber (2004), positivist methods are more straightforward, defined and routinized; but interpretivist also outline and document methods to layout how certain kinds of interpretations are achieved. Reliability is achieved in many ways in the case studies; the most important was the development of the case study protocol.

This section aimed to present a position about the research philosophies of this research work. After this brief reflection, the interpretative nature of this work has emerged through the discussion based on the six assumptions referred by Weber (2004). The position that better describe this research was proposed by Miles and Huberman's (2001), who referred to the pragmatic view of the research work (oscillating between interpretivism and positivism). They referred to the flexibility of this study to adopt a positivist approach in the case study. Furthermore, this work's main concern was to assure the accuracy, validity and reliability of the research through a solid design of the instruments.

5.2. Research Design

The research strategy can be defined as a "generalized plan for a problem which include structure, desired solution in terms of research and an outline of planned devices necessary to implement the strategy" (Singh & Bajpai, 2008, p. 188). Galliers (1987) and Thomas (2010) affirmed that a strategy is centered on data collection and though the research objectives, the selection of data analysis procedures is driven. Thus it is necessary an outline the required steps to achieve the objectives. The basic assumptions to be met by the research strategy are the following:

- ITS are embedded in IT systems, which also are integrated into complex organizational settings.
- It is necessary a deep understanding of the adopted system, its standards, as well as the factors and their relations.
- The identification of factors can be complemented with a process perspective on adoption.
- The amount of examined contextual/process data requires a feasible sample to be handled.

Taking these assumptions into account, case study was selected as a suitable strategy. Case study's particularities are presented in the next section, with a special emphasis on the relevance and pertinence for IS research.

5.2.1. Case Study as Strategy

Case study has gained a greater importance as research strategy in the social sciences as well as in the IS field. Chen and Hirschheim (2004) found out this strategy has been used in 40% of the IS-related articles they analyzed. In this field, case study has been used because of a variety of reasons and some of them are: the possibility of learning about innovations put in place by practitioners and the access to necessary data to define "prescriptive management guidelines" (Benbasat, Goldstein, & Mead, 1987, p. 370).

As other research strategies, case study's efficiency relies on an adequate design that meets the particularities of the research project as well as the strengths of the used methods. A widely accepted approach has been proposed by Yin (1984, 2009), who conceived a structured (positivist) approach to work with this research strategy. For him, case study is defined as an empirical inquiry:

- *It investigates a contemporary phenomenon in depth and within its real life context specially when the boundaries between phenomenon and context are not clearly evident.*
- *It copes with technical distinctive situation in which there will be many more variables of interests than data points, and as one result.*
- *It relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result.*
- *It benefits from the prior development of theoretical propositions to guide data collection and analysis. (Yin, 2009, p. 18)*

Yin (2009) outlined the strengths of the case study strategy and referred as a way to "understand a real-life phenomenon in depth" (p. 18). This characteristic is particularly relevant when the context is an important component of such phenomenon or cannot be separated. Then case study can be described as an all-encompassing strategy that is able to handle multiple variables and multiple sources in their natural settings.

Taking into account the singularities of this strategy, case study is considered a suitable approach to test the proposed conceptual model and to identify factors because:

- The analysis of ITS embeddedness requires a wider and flexible perspective of the systems' operation.
- HEOs as complex adoption environments require extensive data collection about organizational structures (within a limited and specific setting).
- The complexity of the adoption process requires a deeper work that brings together a variety sources (policy documents, informants, IS systems) and case study integrates them to ensure validity through triangulation.

Besides that, the explanatory perspective of this work to track factors pointed out case study as a comprehensive strategy. Despite its limitations, it offers a level of analysis that is consistent with the main dissertation's assumptions.

a) Case study focus

Case studies can be classified as: exploratory, descriptive and casual (explanatory) (Yin, 2003). The exploratory case study aims to create a framework of study in order to support the definition of research questions or hypothesis to be used in a subsequent study or to determine the feasibility of the defined procedures. The descriptive case studies "cover the scope and depth of the object (case) being described" (Yin, 2003, p. 23). Finally, the casual (explanatory) case studies are designed to find explanations of a phenomenon and they are usually linked to factor or explanatory theories.

The selected focus for this research takes the form of an explanatory case study. Miles and Huberman's (2001) pointed out that *explaining* include a range of activities like: "providing requested information or descriptions, justifying an action or belief, giving reasons, supporting a claim or making a casual statement" (p. 144). Kaplan also viewed explanation as a "concatenated description", making it intelligible (Miles & Huberman, 2001). The decision of an explicative approach considers not only the identification of factors that shape ITS adoption, but it aims also to explain certain causalities and dependencies among them. This analytical perspective has driven instrumentation and data analysis procedures, which are defined in the following sections.

b) Type of design

There is more than one way of designing case studies (Yin, 2003). Design decisions affect the essence of the research work by providing the possibility of compare more than one case or to go deeper in one that represents a common or situation but requires also a very deep research work. Yin's situated four types of designs that can be selected by the researchers who use case study. The types are organized according to their comprehensiveness (holistic vs. embedded) and number of cases (single vs. multiple), then the list includes: holistic single case, embedded single case, holistic multiple cases and embedded multiple cases (Yin, 2009).

i. *Single case vs. multiple cases*
One of the main discussions around the selection of the case study strategy is the number of cases to be addressed. Based on this first aspect, the researcher should differentiate which one fill outs the research objective and answer the research questions. Table 5.1 shows a comparison of both rationales, for single and multiple case studies and presents the main arguments to choose one over the other.

Rationale for single case study	Rationale for multiple case studies
• It represents a critical case • It represents an extreme or unique case • It is representative or typical case • It is a revelatory case • It is a longitudinal case	• They predict similar results (*literal replication*) • They predict contrasting results for anticipated reasons (*theoretical replication*)

Table 5.1 Comparison of rationales: single vs. multiple case study (based on Yin, 2009)

For this work, multiple case studies were selected to achieve literal replication (driven by the statements of the theoretical framework and the model) and to find patterns between adoptions in two HEOs. Through the identification of similarities between the two cases, it was expected to cover two different adoption processes in the same type of organizations but with different standardization mechanisms (one carried out organization-wide and another, by a department). Through this commonalities in the results, it was aimed to generate a more solid framework to set a list of factors of the ITS adoption in eResearch in more than one case.

ii. *Holistic vs. embedded case*
Another design aspect for the case study is the selection of the holistic or embedded view. For Yin (2009), this differentiation is centered on specific subunits or whole organizations. The definition of the approach can assure that

> the holistic nature of the case study is considered or the need to achieve operational detail and avoid "unduly abstract level" (p. 50).
>
> In this work, relevant organizational subunits are identified for the comprehensive characterization of the adoption as process; and each one of such units might have specific influence in one or more stages (choice, implementation or usage). For this reason the cases are initially characterized as holistic, although the level of analysis in one of the cases is a department, data collection took into account the context of the entire organization.

c) Limitations

As any research strategy and method, case study has advantages as well as limitations inherent to its characteristics and essence. Yin (1984, 2009) refers to them as prejudices, but some of them have implications that must be considered to understand case study's scope. Here, three of such limitations are presented according to the aims of this work as well as the strategies that methodologists as Yin or in the IS field have already worked to overcome case study' limitations.

First, one of the main concerns about case study is scientific generalization. As already stated, multiple cases' strategy suggests certain logical replicability, based on the fact that results are found in more than one case. However, sampling logic, used in surveys, requires "an operational enumeration of the entire universe or pool of potential respondents and then a statistical procedure for selecting a specific subset of respondents to be surveyed" (Yin, 2009, pp. 55-56). For this reason, sampling logic in case study is not possible and therefore it "is not the best method for assessing the prevalence of phenomena" (p. 56). Instead of sample logic, the use of replication logic makes case study "eminently feasible" (Yin, 2009).

The second concern of Yin (2009) is scientific rigor, caused by the lack of systematic procedures or the allowance of equivocal evidence or biased views that might influence the conclusions. In the IS field, Paré (2004) considered that a positivist view on case study strategy can assure the scientific rigor and therefore, it is taken into account for this work.

The third and last concern about case study is related to the report, which tends to be massive and captured in "unreadable documents". Yin (2009) proposes alternatives ways of writing a case study but this work follows the strategy of Van der Blonk (2003), who has already tackled this issue in case studies for IS.

5.2.2. Case Study in IS

Besides Yin's extensive work used as reference to outline the research strategy, but in the IS field some extensive work has also been done to explore the disciplinary focus on its use, impact and particularities. The interest on the case study from the IS community has been referred as a tradition (Lee, 1989) and an increasingly popular method for IS research (Shakir, 2002).

The applicability, rigor, characteristics and best practices are the main topics that show the reflection about case study in IS. As already mentioned, Benbasat et al. (1987) pointed out the pertinence of the case study to capture knowledge from practitioners and define prescriptive management guidelines, as well as to document cases of success or failure in IS. Precisely, implementation is a recurrent topic (Benbasat et al., 1987) and case study is presented as an adequate strategy to show the complexity of these processes (Paré, 2002). These authors claimed that the exploratory and explanatory character of the case study can be used to "describe and explore a phenomenon that was not well understood" (Benbasat et al., 1987, p. 378). Moreover Allen (1989) defined it as an important and "special" methodology for IS.

In the German research production, Wilde and Hess (2007) considered that *Wirtschaftsinformatik* (WI) is a plural discipline that employs methods from a variety of engineering fields and has a different perspective in comparison to the Anglo-American perspective on IS. However, their content analysis of 300 articles published between 1993 and 2006 showed case study was the second method more used in German WI research production. Thus in spite of the research focus (reengineering or behavioral), case study is recognized by scholars as a strong strategy and explanatory tool.

A series of guidelines have emerged to assure the adequate use of case study within IS discipline. Some research articles were particularly concern about aspects like: case selection (Shakir, 2002), writing case report in IS (van der Blonk, 2003), scientific rigor (Dubé & Paré, 2003), the replicability problem (Lee, 1989) as well as positivist case strategies (Paré, 2004) and interpretive focus (Walsham, 1995). Then, case study can be considered as well known in the IS research community and recognized as a strategy that "encourage IS case study researchers to reflect on the basis, conduct and reporting of their work" (Walsham, 1995, p. 80).

In this work, it is addressed the concern of the IS community of assuring case study rigor through a positivist perspective. Paré (2004) suggests the assessment of case study strategy through the application of well-defined methodology[19] (see Table 5.2).

Stage	Concepts, techniques and tools
1. Case study strategy	1.1 Research questions 1.2 Prior theorizing 1.3 Unit of analysis 1.4 Number of cases 1.5 Selection of cases 1. 6 Case study protocol
2. Conduct of the case study	2.1 Qualitative data collection 2.2 Quantitative evidence 2.3 Sampling strategies for interviews 2.4 Data triangulation 2.5 Theoretical saturation
3. Analysis of the case study evidence	3.1 Field notes 3.2 Reflective remarks 3.3 Coding of raw data 3.4 Case study data base 3.5 Dominant mode of analysis 3.6 Visual display techniques 3.7 Project reviews 3.8 Cross-case analysis
4. Writing up the case study report	4.1 Resonance criteria 4.2 Rhetoric criteria 4. 3 Empowerment 4.4 Applicability

Table 5.2 Framework for the assessment of positivist case studies in IS (adapted from Paré, 2004)

[19] The applied checklist of Paré (2004) is included in Appendix A.1

5.2.3. Sample Design

A core part of the research design is the case study selection. Considering the complexity and variety of the contextual information related with each case and the need of some logical replicability and external validity, a multiple cases approach was selected.

As it was already referred in the introduction and in the last subsection, the need of applying the ITS adoption model to a specific technology and domain was considered. Therefore, research repositories were selected as a type of eResearch technology that is implemented in HEOs to satisfy needs like: long time preservation and visibility of the research outputs. Repositories were already referred in the eResearch landscape and as a service offered in HEOs. These platforms are containers of technical IT standards and at the same time, they become an *organization* standard[20]. From the technology point of view, this software embeds a set of technical standards that are required to achieve important functions as interoperability. Examples of this embedded technical ITS are the OAI-PMH protocol for harvesting and Metadata standards for digital object description (Fig. 5.2). Besides these ITS, this work has a special focus on organization standards for repository services, which implies that some processes (e.g. storage of research outputs) are standardized through the use of IT.

Fig. 5.1 IT standards and repositories: a first panorama (Foulonneau & André, 2008)

Considering the defined research problem, the feasibility of the project and the proposed conceptual model, the following criteria for the case study selection were defined:

[20] The term company standard tends to be used alternatively (Van Wessel, Ribbers, & de Vries, 2007).

- Should be an institutional repository.
- Should be a repository in a HEO
- Should be a research oriented repository
- Should be a active (ingest in the last 6 months)
- Policy should be documented in English or Spanish languages
- Informants should be able to provide information in English or Spanish languages

The search of potencial cases was performed using OpenDOAR (Directory of Open Access Repositories), which is a well known index of open repositories around the world. The directory is supported by the British SHERPA and offers a qualitative overview of the repository implementations. In 2010, this database listed around 1,600 repositories with content mostly in English, Spanish and German languages. Currently, Europe has 47% of the listed repositories, followed by Asia (19.5%), North America (18.8%), South America (7.8%), Africa (2.8%), Australasia (2.8%) and other regions (1,3%). Open DOAR classifies the repositories according to the type of repository as well: institutional (83%) and disciplinary (11%), government and aggregated (6%). Taking into account these numbers, it was decided to include one case study in Europe and one in a Spanish speaking country. The search was reduced to UK and Latin America because of geographic and language reasons. UK has not only the highest proportion of repositories in Europe (19.7%), it runs a series of official initiatives and programs that have supported repository implementation in HEOs as well as a series standardization initiatives. A total of 156 institutional repositories matched the first criteria in the UK, but it was decided to consider only those institutions that were members (15 HEOs) of the SHERPA-LEAP project (for the implementation of repositories). Considering their participation in this federation-based repository program, two HEOs of the University of London federation were invited to participate in the study: the Institute of Education and Royal Holloway (RHUL). The second HEO accepted to participate in the case studies through the instructions of the Library's Manager of E-Strategy & Technical Services and the Repository Manager.

On the other hand, the scenario in Latin America offers a different implementation context. In comparison with the UK repositories (200 implemented), Spanish speaking countries in the Americas have less implementations[21]; for example, Mexico has 21, Brazil 64 or Argentina 23. Considering feasibility, two HEOs were contacted in Mexico: the *Instituto Tecnológico y de Estudios Superiores de Occidente* (ITESO, Western Institute of Technology and Higher Education) and two faculties at the *Universidad Nacional Autónoma de México* (UNAM, National Autonomous University of Mexico). The Faculty of Philosophy and Literature (founders of the UNAM's repository federation) accepted to participate in the study through the repository manager.

As already explained in the conceptual model, centralization and decentralization can play a role in organization standards (van Wessel, 2008). The sample covered these both adoption scenarios. The Mexican case was a department repository, whereas the one in UK was a convenient institution to tackle organization-wide adoption:

a) eQuella Royal Holloway University of London (RHUL)
This repository was implemented in 2008 and it emerged under the financing of the SHERPA-LEAP Project, a University of London consortium that aimed to create several repositories at various institutions. When the project finished, RHUL implemented eQuella as organization-wide ITS standard based on the SHERPA-LEAP guidelines.

b) DSpace RU-FFL, Faculty of Philosophy and Literature (FFyL) at the National Autonomous University of Mexico (UNAM).
RU-FFL is an open access repository that was implemented by the FFyL in the biggest Mexican university: UNAM. It was implemented in 2008 as indirect outcome of a research project and three months after its technical implementation, it was integrated to an intra-organizational network (federation) of repositories (called RU-RAD).

5.3. Research Methods and Instruments

The instrumentation constitutes what is going to be found out, from who or what, and why (Miles & Huberman, 2001). Instruments provide a specific view of the sources and how they will contribute to the case study, with their advantages and limitations. The instrumentation was designed to fit both cases but flexible to meet the particularity of each one. Since relations among factors of ITS adoption have been slightly documented, certain margin of uncertainty was expected. It should be

[21] Source: OpenDOAR

noticed that instrument design was part of a full case study protocol (included in Appendix A.2).

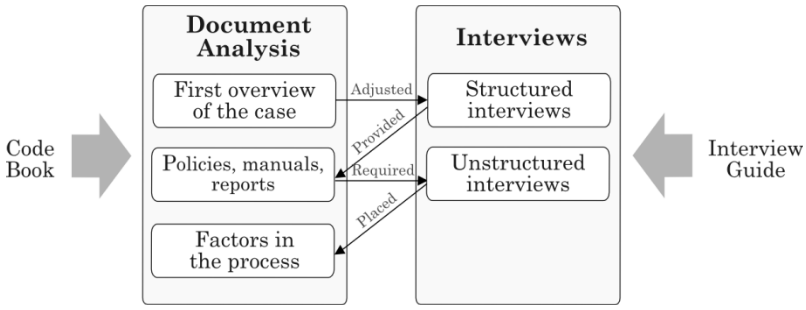

Fig. 5.2 Case studies' mixed methods

Two methods were used for data collection in each case study: interviews and document analysis. Figure 5.2 presents how the methods were mixed for data collection. After the participation acceptance, public available data was collected to adjust the interview guide for the structured interviews with involved HEO's staff and in both cases, additional internal documents tended to be provided by interviewees. After the analysis of the new material, complementary contact was necessary to place each factor in the adoption process model. Once the sequence and purpose of each method has been recognized, their pertinence and design is discussed in the following sections.

5.3.1. Interviews

Interviews are one of the most important sources of information for case studies (Myers & Newman, 2007). They are conversations with subjects that can provide relevant information about the studied phenomena. Yin (2009) identified three different types of interviews:

- structured (use a question-answer dynamic),
- focused (used for a short period of time and oriented by the protocol)
- in-depth (open way to approach to the informant's opinion and perception about the facts)

On the other hand, Creswell (2007) focused on the adequate design of interviews and he considered sampling and type of interview as important for the method performance. About the first aspect, the internal sampling for the interview in each case considers two main kinds of informants, according to their role:

- Repository manager: who has current control over the every-day operation of the repository and assures metadata quality standards are assured.
- Staff for IT support: who participated in the technical implementation of the system and provides technical support to maintain the infrastructure.

The contact with at these informants aimed to reframe the adoption process from the subjects' point of view. In this way, policies and ITS documented guidelines are contrasted with subject's perspective to make sense of their content.

It should be noticed that the interview guide was elaborated as a standard instrument for all the informants/interviewees, integrated around five main aspects: technology, each phase of the adoption decision (pre-adoption, adoption decision and implementation) and eResarch services offered by the institution/unit. It was expected that after the first interview, some early insights could provide a framework to interpret the collected documents. Subsequent contact (also informal) aimed the verification of facts derived from new documents or the identification of inconsistencies. Thus instruments were conceived to enable a first approach to the subjects. The interview guide is included in Appendix A.3.

5.3.2. Document Analysis

Documents were a core source of evidence for this research. Because the unit of analysis are ITS, they tend to be formalized in official documentation like project plans, designs and policies. Besides that, related IT and information policies can be considered factors that influence ITS choice and provide design guidelines or legitimize ITS routinization after the technical implementation. Due to the variety of the situations that repository implementation might imply, the list of documents to analyze might not be exhaustive. This following list was initially defined:

a. *Organization description and vision*
    i. *Sub-unit description and vision*
    ii. *Organization structure*
    iii. *Organization strategy*
    iv. *Organization annual plan*
b. *IT policy*
    i. *IT services catalogue*
    ii. *eResearch services*
c. *Information policy*
    i. *Open access policies*
d. *Repository documentation*
    i. *Master plan*
    ii. *Requirements*
    iii. *Repository administration manual*
    iv. *Repository population statistics*
    v. *System's technical documentation*
    vi. *Systems provider's documentation*
e. *External policies (HEO's context)*
    i. *Network documentation*
    ii. *National open access policies*
    iii. *Government programs*

About the pertinence of document analysis for case studies, Yin (2009) claimed that "documents are useful even thought they are not always accurate and may not be lacking of bias" (p. 103). This author considered them as literal evidence of the facts and interviews can contribute to make sense of such facts. The specific characteristics of ITS as formal policy related objects should be officially documented and therefore, part of this work is to explore documents as evidence of the continuous formalization processes in HEOs.

5.4. Data Analysis Strategy

Analysis is the step in which data is prepared and organized, coded thematically and finally, represented in a display or discussed (Yin, 2009). Here, the researcher takes a look at the collected data and makes sense of them based on a rigorous scientific strategy.

This work takes Carney's model (1990, cited in Miles and Huberman, 2001) as basis. It separates the analysis in three main phases (Fig 5.3). The first implies the preparation of the data by doing the (selective) transcription of audio material and coding it together with other collected material. Then, for the initial phase, a code book[22] was inductively generated based on the theoretical framework here presented and the Computer Assisted Qualitative Data Analysis Software (CAQDAS) MAXQDA was used as a support tool.

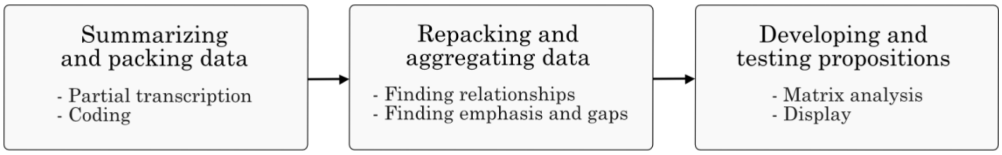

Fig. 5.3 Path of analytical abstraction
(adapted from Carney, 1990; cited in Miles and Huberman, 2001)

The second phase of the analysis was related with repacking and aggregating data in order to find relationships, emphasis and gaps. Then in the last phase, the explanatory framework was generated through testing propositions (check lists of the model) with the support of displays (to set factors within the adoption process). As suggested by Yin (2009), visual display techniques can help for two reasons: they make sense the data and help the target audience to understand better case study outcomes.

[22] See Appendix A.4

CHAPTER SIX

6. Results: Cases & Analysis

Higher Education Organizations are carrying out a considerable amount of research produced within the national innovation systems. Their contribution to build eResearch infrastructures is unquestionable. Taking into account such scenario, this research has inquired about their adoption of IT standards and the factors that influence such process. Available research in the field is still few and the model proposed in Chapter 4 addressed already certain theoretical understanding about this issue.

This section is concerned with empirically testing the conceptual model. The adoption process was analyzed in HEOs as organizational context and in relation to eResearch technologies. The sample was integrated by two HEOs considered digital repositories as *organization* standards and their embedded technical ITS. Each case is presented separately in order to provide a single overview of the institutions, their vision on eResearch and the current operation of their repository system. At the end of each single case, a first analysis of the adoption is presented through a process approach. The interpretive work performed with the collected data was the basis of a comparative analysis of both cases. By the end of the chapter, a summary with some learned lessons and meaningful management aspects are provided to conclude the analysis.

6.1. Repositories as eResearch

In Chapter 4, the term eResearch was presented as a field that encompasses a variety of technology applications used to support research processes. In HEOs such applications are implemented and integrated into their IT infrastructure. The choice of data repositories as an eResearch application is particularly relevant. For Lynch (2008) building a campus cyberinfrastructure capabilities implies a universal set of services across the organization and a focus on an *average* scholar. In this way, local IT services allow researchers to do their work, but considering the collaboration with national or international initiatives (big science). According to this author, data management and curation are aspects of organization eResearch and they imply that HEOs take technical, financial and legal responsibility of their research data (Lynch, 2008). Institutional Repositories are a way of dealing with these data management and curation needs emerged from the research activities of local scholars.

Repositories can be technically defined as an IT system that stores data and metadata. This type of eResearch systems is relevant because its goal is the preservation of knowledge and therefore, international initiatives have perceived them as an opportunity to achieve the dissemination of research. The well known Open Access (OA) movement has used repositories as a technological solution to ensure that research outputs are openly available through the Internet (*Max-Planck Gesellschaft*, 2003). Preservation and openness are strong drivers to support the implementation of repository software in HEOs; but from the research point of view, repositories play an important role within the research lifecycle. Considering the four stage[23] model proposed by Voss and Procter (2009), repositories play a role for dissemination and the discovery of ideas, through enabling the access to state of the art publications and resources that might lead to new knowledge. Research outputs in repositories benefit not only local researchers, who preserve their data, but external users (researchers) profit also from the produced knowledge.

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[23] Stages: (1) dissemination of research findings, (2) idea discovery, (3) funding acquisition, and (4) experimentation, collaboration and analysis (Voss & Procter, 2009).

Available software in the market includes a variety of proprietary and open source. According to the OpenDOAR, the most implemented software systems are the following[24]: DSpace (898), EPrints (313), Digital Commons (94), OPUS (74) and dLIBRA (56). In this work, it is argued that the implementation of a repository software can be considered an organization standard when it is a *repeated and continuous solution to a specific problem*. Repositories solve problems like data storage, management and dissemination; their usage implies it was accepted by the involved parties in the HEO (or network of HEOs) to solve such problems on a *unified way*. This first level situates repository software as an agreed organization standard. In the presented cases, standards are adopted within an inter-organizational and an intra-organizational network respectively. At a second level, the standard software has other technical standards embedded that are inherent to the technology (thus every adoption decision implies their implementation as well). Here, the embeddedness of two specific standards is particularly taken into account because they solve interoperability functions:

- OAI-PMH (Open Archives Initiative Protocol for Metadata Harvesting), "a standard protocol that defines a set of principles and tools to establish communication between a data provider and a service provider" (Foulonneau & André, 2008, p. 21).
- Simple Dublin Core, a standard user to convey descriptive metadata in a repository (Foulonneau & André, 2008).

This approach to the ITS has been used to design the case studies because it is very likely that similar eResearch standard software is adopted in this way. The embeddedness in specific and unified IT products shared by more HEOs or departments can be considered a basic assumption to tackle the analysis of the adoption problem.

6.2. Case A: Royal Holloway, University of London

The Royal Holloway University of London (RHUL) is an English HEO that is part of the University of London federation. As already mentioned, this case was selected considering that adoption decision began centrally, thus it was expected a

[24] Consulted in August 2012

higher degree of formalization and the deployment of organizational resources on a structured way.

The case considers a repository software adopted in consistency with open access initiatives and internal requirements of data storage. The ITS scenario for this case study consisted on:

- The adopted software repository (eQuella) as an organization IT standard, which solves research data' storage and open access.
- The embedded IT standards within the adopted software, including: metadata (Dublin core) and harvesting (OAI-PMH).

Particularly relevant in this HEO was the influence of the network to decide on the embedded ITS, but internal requirements showed to be decisive for the adoption of the repository software (e.g. integration with Learning Management Systems and a Current research Management System as well as the storage of learning objects).

Data collection for this study was performed between 2011 and 2012 and focused mostly in qualitative data collection, which included:

- Content analysis of more than 13 institutional policies and a variety of online documentation and resources[25], including reports from the repository.
- Contact and interviews with HEO's staff, including the eStrategy manager, repository manager and information officer of IT Services.

Considering the amount of the collected data, a single case report is presented to provide an overview of the whole organizational context, as well as the status of the technology and the standards, including the process and a structured analysis.

6.2.1. Overview

Royal Holloway (RHUL) was founded by the philanthropist Thomas Holloway in 1879 as a women-only university and later, in 1886, it was officially opened by Queen Victoria in 1886. Following these events, this university was admitted as a

[25] See a complete inventory of documentary sources in Appendix A.5

School of the University of London in 1900 and began to admit male students in 1965.

The history of Royal Holloway is closely linked to the Bedford New College, the first HEO for women in UK that was founded 20 years before. In 1982, a partnership between both institutions was signed to face government cuts on higher education spending. But later in 1985, a merger between both institutions was decided and it was officially inaugurated in 1996 as a single HEO. Through this strategic decision, it was attempted to increase financial security as well as to raise the academic diversity and strength (RHUL, 2012c).

Initially conceived exclusively as a teaching institution, the RHUL has a research orientation. In 2008, the Research Assessment Exercise (RAE)[26] carried out an evaluation to assess the quality of research and it ranked 60% of the departments as 4* level ("*quality that is world-leading*") (RHUL, 2012a). Organizationally, research activities are allocated in research groups and decentralized academic departments within three faculties:

- Arts & Social Science
    - Classics and Philosophy
    - Drama and Theatre
    - English
    - History
    - Media Arts
    - Modern Languages, Literatures and Cultures
    - Music
    - Politics and International Relations
    - Social Work
- Management & Economics
    - Economics

[26] The RAE has being carried out in 1986, 1989, 1992, 1996, 2001 and 2008. The last evaluation was conducted by the Higher Education Funding Council for England (HEFCE), the Scottish Funding Council (SFC), the Higher Education Funding Council for Wales (HEFCW), and the Department for Employment and Learning, Northern Ireland (DEL). The RAE2008 was performed based on 2,344 submissions by 159 HEOs in UK. The RAE will be replaced by the Research Excellence Framework (REF) in 2014 (http://www.ref.ac.uk)

  - Management
- Science
  - Biological Sciences
  - Computer Science
  - Earth Sciences
  - Geography
  - Information Security Group
  - Mathematics
  - Physics
  - Psychology

With around 2,000 staff members and graduate students performing research activities, RHUL conceives scientific research as strategically relevant and it is subject of strategic planning that sets levels of expected operation and the focus of the formal institutional support. Relevant considerations about the role of research are expressed in the Corporate Strategic Plan 2009-13:

> *'To be in the top tier of UK universities, renowned for using our agenda-setting research, which responds to the biggest cultural, social, scientific and economic challenges of the day, in innovative ways, and to offer an unparalleled learning experience to all who can benefit." (RHUL, 2009a)*

This statement points out the two main activities of the university: research and teaching. In this document, some strategic links were established towards: the quality of research, relevance of internationalization, social responsibility and collaboration, as well as some enablers: employer vision, estate management, infrastructure improvement, information infrastructure, and marketing and communications capabilities. The formal support of research is outlined in this document as well and considers prioritizing "the investment in areas of strength and in the improvement of our research facilities and infrastructure" (RHUL, 2009a). The definition of the role of research activities and the way of assuring its quality have deeply impacted the decisions about IT and infrastructure. Beyond the guidelines, such focus brought into scene a situation that extended the initial requirements. This relevant aspect related to the operationalization of the high level strategy is considered later in the description of the adoption process.

6.2.2. Governance and Organization

To explain the governance structure of the RHUL , a relation with the Federation of the University of London and the internal mechanisms of governance must be established. Considering the autonomous status of every college, the attachment to the federation implies high level decisions and access to common infrastructures supported and offered by all the members of the university federation. But before explaining these specific governance conditions, the internal aspects are detailed.

RHUL has a committee based structure that allocates a series of responsibilities for the actors involved in the governance and as a way of assuring the inclusion of several interests in decision making processes (Fig. 6.1). The College Council is the main governing body and is integrated by 25 members (external and internal). The lay or externally appointed consists of 16 members, who can be elected every five years based on their skills and experience. The internal members of are:

- Principal,
- three members elected by the non academic staff
- two members elected by the academic teaching staff,
- one member of the academic teaching staff elected by the members of the Academic Board from among the members of the Academic Board, and
- one student member elected by the student body

The College Council meets four times a year and some of its responsibilities include: approval of the high level strategy, long-term academic and business plans as well as key performance indicators; delegate management duties and authority to the principal; ensure the establishment and monitoring of financial audit; and ensure monitoring and evaluation of HEO operation (RHUL, 2011a). Other duties include self evaluation, appoint a secretary for managerial tasks, establish a personnel strategy, assume the responsibility of staff, students and visitors health and safety on campus, ensure equal opportunities, be the main financial and business authority (incl. annual budget acceptance), be legal authority, manage various high level student's affaires (i.e. constitution of Student's Union) and ensure that College's constitution is followed (RHUL, 2011a).

Several committees, sub-committees and the Academic Board support the College Council with a series of specialized duties to be attended like: audit and compliance, research ethics, risk management, equality and diversity, finance, investment, enterprise, nominations, remunerations, discipline, fees, etc. (RHUL, 2011a). In particular, the Academic Board centralizes top level decisions about academic y research activities. This board regulates the promotion of research as well as its quality and infrastructure procurement. Considering these and other responsibilities, its configuration obeys to several considerations about academic and research activities, and therefore it is integrated by: the principal, vice principals (Education, Research & Enterprise, and Staff & Student Experience), faculty deans and deans of the graduate school, director of IT, the director of Library Services, representative members of academic departments, elected staff members and student members. The configuration and detailed responsibilities of this council and committee structure is documented in the College Statutes as well as in the Committees Handbook.

Committees as well as strategy and audit oriented entities rely on the operational vision of the senior management structure or formal managerial constitution of the RHUL. Figure 6.1 shows the principal on the top of the structure in relation to the managers of a variety of areas that cover the whole HEO operation. The hierarchical configuration separates actual department management of strategic processes (e.g. education, research) from tactical, financial and services.

Based on this governance and organizational aspects, it is possible to affirm that decision making is a mix of top/bottom decision making. Consistent with the theory explained in this work, the participation of researchers and academics as expert staff is required for institutional decision making, not only at the operational level, but at the strategic. Considering this situation, the HEO has implemented a committee based structure that brings together staff and other university's members in order to achieve consensual decisions (at least formally).

Relation to the University of London Federation

The attachment to the University of London federation has several advantages for the research and academic activities at the RUHL. Some of these evident advantages are the possibility of joint degrees as well as collaborative research projects. However, this membership might influence or increase the influence in internal decisions.

The University of London consists of 18 independent and self-governing institutions and 10 smaller research institutes. Some of them set their own criteria for education operation, offer specific services to students and could even award their own degrees. Founded in 1836, the University of London was established initially as an examining body but after 1859, it expanded and awarded its first degrees.

RHUL as well as the other members must contribute to the costs of running the university federation through the payment of an annual subscription. By assuming these costs, members benefit from centralized services such as a library, housing services and the career center. Besides the services for students, the University of London also offers support for academic quality, finance, human resources, governance support, estate administration and IT services.

The main structures of governance in the federation are the Collegiate Council (chaired by the Vice-Chancellor and integrated by the heads of the member universities) and the Board of Trustees that is the main governing body. Together with these two entities, a series of committees operate to manage specific aspects of the administration.

6.2.3. eResearch Strategy

IT services RHUL can be categorized in four main fields: basic IT services for general users, for administration, for teaching/learning and for research. However, according to the Formal Head of Analysis and Design of this HEO, IT is service oriented and eResearch requirements are gathered as part of projects and later, they turn into a service when they are fully operational. She referred to the process for the research repository:

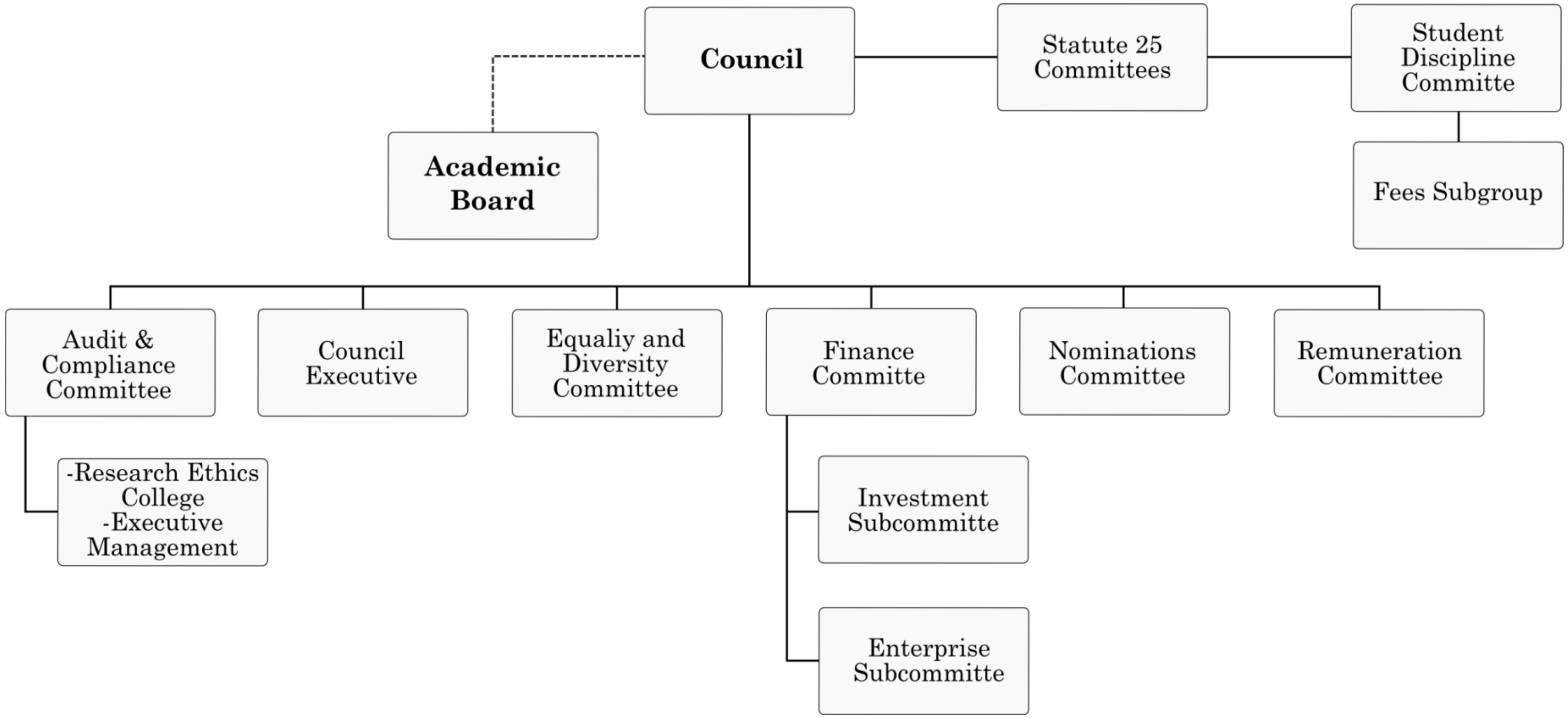

Fig. 6.1 Governance at Royal Holloway: Council and committee structure (RHUL, 2011a)

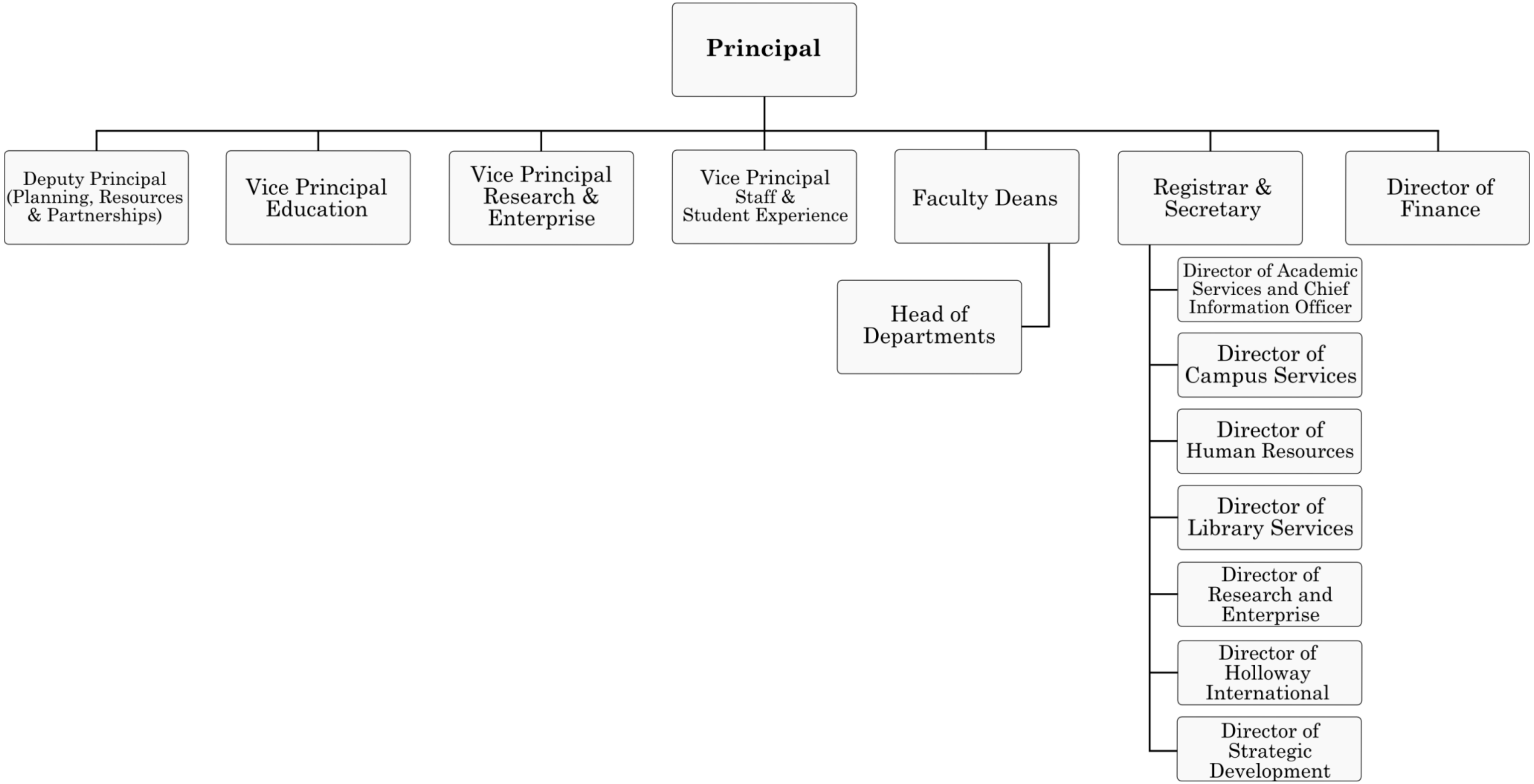

Fig. 6.2 Management structure at Royal Holloway (RHUL, n/a)

> *"... the implementation of the repository was a project and then it became a service [...] The platform is managed within IT, as part of a service team [...] And I am directly responsible of managing the service as platform, I am the product manager."*

To accomplish this comprehensive eStrategy, the IT service department works as a technical provider and partner for the implementation of services and solutions. In the concrete case of the repository, the role of the IT department changes during the implementation: first as a strategic expert partner and later as a responsible of technical maintenance, while content management relies on the Library Services.

The IT services area is part of the Registrar ad Direction of operations. The Head of this area is the formal CIO of the university (Director of Academic Services and Chief Information Officer), which has other formal decision making attributes as part of the Academic Board and the Students' Union Liaison Committee. IT services is integrated for a central unit and a series of sub-units that are result of the autonomous situation of the academic departments. The strategy for provision and support considers three main categories of departments: a) centrally funded departments (mainly administrative), b) locally funded departments, and c) departments with IT dedicated support staff. To the first category belong all administrative departments (see Fig. 6.2), while to the second all academic departments with exception of those within the Faculty of Science (which tend to have specific computing requirements and manage their IT needs with a dedicated IT unit).

Researchers as regular users receive universal IT support for workplaces, which is provided through a shared catalog of services to assure: adequate infrastructure, facilities and applications for network, computer centers, and electronic information resources, as well as user education and training (RHUL, 2012b).

As it was referred before, the University Library participates in strategies and practices to support the use of IT for research activities. With a focus on information management and dissemination of research outcomes, the Library - through its eStrategy and the Direction of Technical Services- has launched a series of services such as research skills training sessions[27] and scholarly communication (including e-Thesis submission and institutional repository support). To accomplish the delivery of electronic services, the library has management personnel but development and maintenance tend to be performed by IT Services.

Research Management: RIS and PURE

On the top of IT Services and Library, RHUL has a comprehensive vision of research management that defines the way how some digital services for research are provided. Research support consists of the provision of resources for the workplace and labs as well as some managerial aspects. Such integration between research and management has influenced the strategic implementation of IT infrastructure and the derived workflows for the storage/dissemination of research outcomes.

A motivationsto integrate research management to the basic infrastructure of the RHUL is the institutional interest on the Research Excellence Framework (REF) 2014, a program to measure the quality of research in English HEOs. The REF requires exhaustive documentation of formal research practices and the staff, including their outcomes as indicators of quality. For this purpose, the RUHL established the College REF Steering Group, chaired by the Vice-Principal of Research and Enterprise. In particular, the Data (Sub) Group is on charge of the technological support for REF data management. Considering the implications of data collection and management for REF, a restructuration process took place in 2009 and it implied the implementation of a Current Research Management System (CRIS) that could be part of an integrated IT architecture. Such integration covered research management as well as e-Learning and digital repository services among others.

The implementation of a CRIS at RUHL was required to address REF's data requirements, but at the same time this situation was seen as an opportunity to populate the repositories and the visibility of the current research activities beyond

[27] It is usually related to information management (incl. data bases), software and online publishing.

the communities of production. Figure 6.3 shows the initial generic model of CRIS use and interaction. The system was planned a standard-based application to operate as a front-end for the repository. Thus researchers would be able to submit their data while librarians could perform curatorial duties and research officer could generate reports for the REF.

PURE was the application that best met RHUL requirements. Based on JAVA and developed by the Danish company Atira[28], this CRIS is a proprietary supplication that offers systems integration capabilities and incorporates standard data provision mechanisms (OAI-MPH and XML metadata in Dublin Core). Considering the existence of a repository service, PURE could be integrated to a variety of repository systems such as EPrints, the standard of the SHERPA-LEAP[29] project.

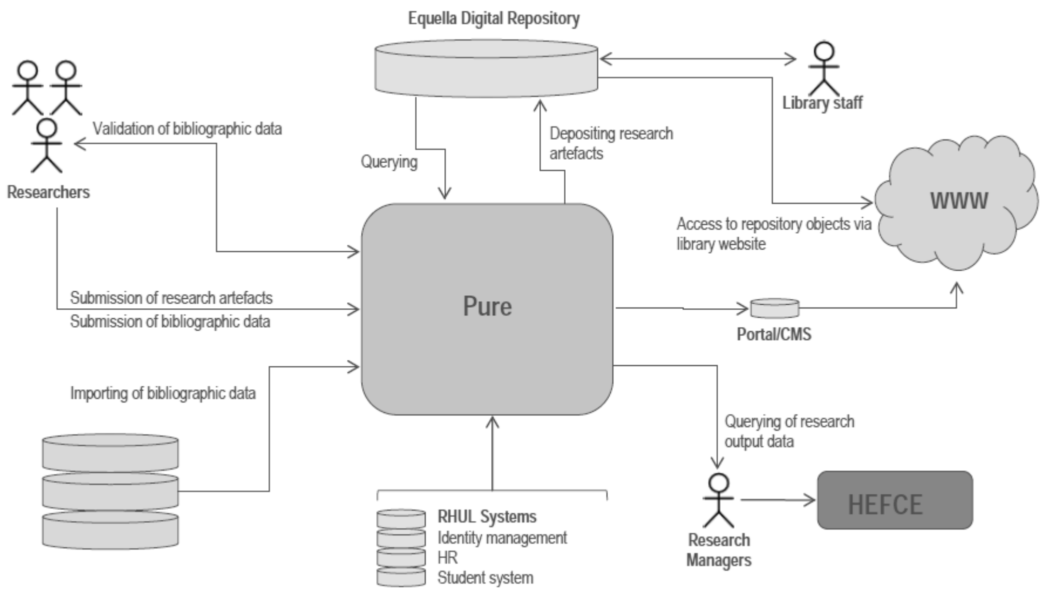

Fig. 6.3 CRIS interaction and integration (RHUL, 2011b)

[28] See http://www.atira.dk

[29] RHUL was hosted by this group until 2010.

The procurement process of PURE involved several senior members like the Vice Principal for Research & Enterprise as well as the Directors of Strategic Development and Research and Enterprise (Tate, 2012). Dominic Tate, current Repository Manager, reported that PURE implementation included a portal to display research information in the designed style sheets that were deployed simultaneously "*around the same time as the new-look College website was rolled out*".

In relation to PURE, the role of IT Services through the project manager is to: mediate with the software provider, coordinate with internal College systems, manage software updates, provide technical representation in the Pure UK user group, be the point of reference for user support, and to provide IT infrastructure for hosting and maintenance to run PURE "as a business-critical service" (RHUL, 2011b).

6.2.4. The RHUL Repository

The RHUL repository emerged as part of the activities of the Sherpa-LEAP consortium. When the project finished in 2008, the RHUL moved from EPrints to the proprietary software eQuella. Until June 2012, more than 2,250 records were available in the Royal Holloway Research Online (RHRO) collection (Fig. 6.4) and 321 in the Early Music Online collection.

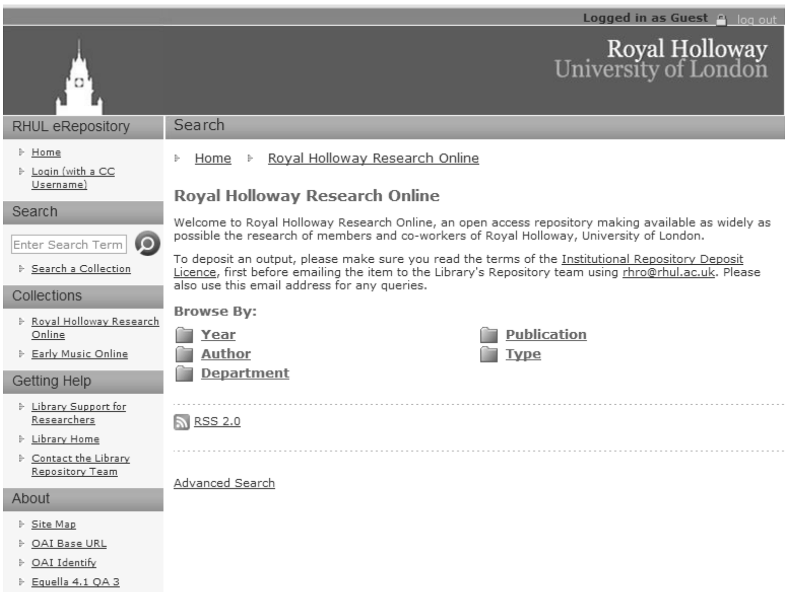

Fig. 6.4 RHRO repository's look & feel

Over 5,200 authors are listed with resources in English language and with digital objects in PDF format. The RHRO collection includes books, book chapters, journal articles, monographs and thesis (PhD and Master). Table 6.1 shows the number of items stored in this collection per publication year and it is divided in periods of five years (between 1990 and 2009) as well as before 1989 and after 2010.

Year	Items
Until 1989	36
1990-1994	75
1995-1999	223
2000-2004	535
2005-2009	800
2010-present	553

Table 6.1 Number of digital objects by publication date (Source: RHOR)

The repository management is responsibility of the Library, in particular de Digital Assets and Repository Manager, who is part of the eStrategy area. The technical support, maintenance and software updates are run by the Repository manager in the IT Services area. Both areas and the Research Commission decided the implementation of an internally hosted and web-based system called eQuella to substitute the services provided through the open source software EPrints.

The new implementation considered the interoperability standards promoted by SHERPA-LEAP as well as international *good practices* in Open Access. Thus the repository employs the OAI-MPH protocol to comply with Open Access initiatives as well as Dublin Core metadata schema and PDF as preferred storage format. With these considerations, the standards remain although a new system was implemented to satisfy needs that the EPrints implementation did not.

But before referring to the context of operation, a brief description of the current configuration of eQuella is necessary. This software is a proprietary application developed by Pearson Education and it offers services for digital storage of research publications and learning objects, as well as integration to Learning Management Systems. In RUHL, such functionality was considered to choose eQuella as repository software and in this way the internal workflow could be improved. Seen as a central storage solution, eQuella was chosen to satisfy the need of a repository in a single platform beyond the mere Open Access initiative.

With the acquisition of PURE, the workflow to deposit in the repository changed. Now a connector allows that the CRIS works as a front-end for researchers and they submit their research outputs only once in order to: accomplish REF requirements and to publish in the Open Access repository (eQuella). In the regular submission process, PURE automatically deposits the metadata and objects in to the repository, and at the same time it takes the necessary data for REF and web publishing. Then the research data for open access is preserved in eQuella.

Digital objects stored in eQuella are available for the online profiles of the researchers and for the LMS. RHUL expected to strengthen the link between research and teaching through the integration with Moodle; thus from one single digital source, researchers would be able to use their stored material for their own teaching activities.

Figure 6.5 shows the content architecture of eQuella and how different systems operate as front-end, such as Pure, Moodle and the web page. Using Dublin Core metadata standards, digital objects are stored considering the OAIS preservation model for long term archiving (Consultative Committee for Space Data Systems, 2002).

This repository software uses the OAI-PMH standard protocol for harvesting, which is internationally accepted in Open Access initiatives. Through XML based interfaces, the repository is able to be plugged with other components of the architecture and in this way, the services can be delivered.

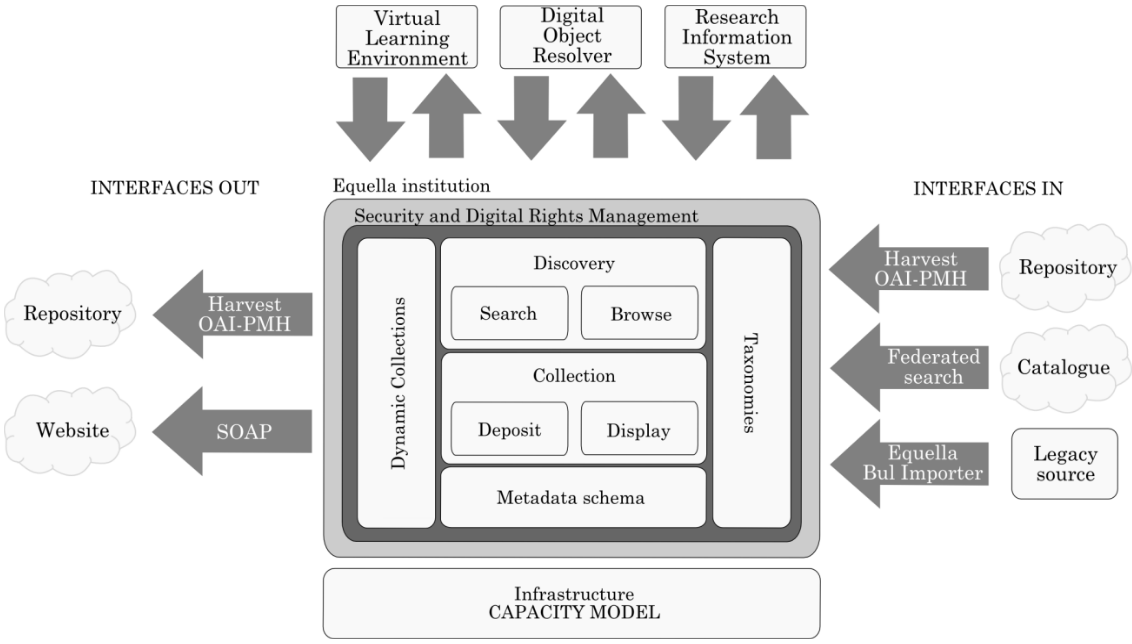

Fig. 6.5 eQuella architecture, current elements (Source: Pope, A.)

Repository management is officially a responsibility of a service team integrated by the IT Services department, the Library and the Research Committee. One of the interviewees from the IT department (platform's product manager) described the commission and the decision making in the following way:

> *"(The) cross functional service team has representatives from the Library, IT and Research and they are responsible for managing the overall service as a platform [...] Then based on the business requirements that the service team considered important, I am responsible for making decisions about the platform: upgrades, which features we think we'll develop."*

After the repository was concluded as a project, the fully operational platform was managed under a model of service provision. The IT service department is on charge of technical aspects like security, software updates and incidents management. On the other hand, the Library, through the Repository Manager, has the responsibility of the repository's content management as well as the advocacy programs to ensure population and end user participation. The

Library is also responsible of assessing repository performance and the generation of evaluation reports for HEO's decision makers (committees).

6.2.5. Standards and Repository's Operation Context

Repository's operation context includes the strategies and policies that might influence adoption. In order to have a more complete perspective on these formal aspects, three different contexts were explored: the national context, relevant networks and finally, the regulatory environment within the HEOs boundaries.

a) National context and ITS landscape

The repository landscape in UK has been influenced by policy makers and particularly by official statements about the access to research outputs. Since 2005, different government and non government institutions in UK have being involved in the promotion of open access to research outputs. This policy environment emerged slightly after the beginning of the repository technology movement, but it has contributed to legitimize and incentive initiatives as well as to assure that the technology has certain functionalities.

The UK Research Councils as major bodies of the government in charge "of investing public money in research" have taken the responsibility of guaranteeing the openness of the research outputs (RCUK, 2012b). Historically, four main documents have being published about this matter: a position statement (RCUK, 2006), an independent study on open access (LISU Research & Consultancy & SQW Consulting, 2006), a report on accessibility to research publications (RCUK, 2012a) and an official open access policy (RCUK, 2012b). These documents point out the role of the repositories as enablers of policies and as sources of some requirements. Similar documentation has being produced by other non government institutions in UK, which are especially relevant to scientific activities like the Royal Society. This association is a fellowship of researchers in order to promote the excellence on science. They published a response to the Research Councils UK's consultation on access to research outputs (The Royal Society, 2005) and later, in 2012, an official statement about the character of science as open (The Royal Society, 2012).

However, the Joint Information Systems Committee (JISC) has being the most influential public body on standardization initiatives related to research repositories. The JISC was created in 1993 to substitute the work of the Computer Board (established by the UK government in 1965) and the Information Systems Committee (JISC, 2012c). This body aims to promote the use of ICT for research and education (JISC, 2012d) and in the area of open technologies has included four main aspects: open access, open resources, open source and open standards (JISC, 2012b).

With 29 programs and 157 projects in the last years, the JISC has worked four main strategies: the activities of the Open Access Implementation Group, work with publishers, commissioning research (reports) and building repositories (JISC, 2012b). This institution reported that repository infrastructure in UK is integrated by more 200 repositories which are supported by several projects like SHERPA RoMEO (related to deposit licenses) and OpenDOAR (registry of repositories). In relation to standardization, JISC has supported 25 related programs, 155 projects and 6 services in the last years, many of them related to repository technology in HEOs.

Considered as a second step to build an integrated eResearch infrastructure, the Research Management program of the JISC aims to improve the creation and use of research records (publications and raw data) as well as research activity. This program has integrated past actions related to the openness and preservation of research data through repositories in a way that the whole research process is supported. The JISC concreted three program strands to build the necessary digital infrastructure: research data management, the infrastructure to support open access repositories and curation; as well as: *"Research information management, that is the management of administrative data related to research."*

Together with the support of the repositories as solution for an integrated eResearch environment, the JISC has supported since 2005 the use of open standards (JISC, 2005) and a series of recommended practices (InfoJISC, 2011). In Figure 6.6 the structure of the JISC's repository program is presented to show how the center of the initiative relies on *open* standards (JISC, 2012a).

In its infokit about repositories (InfoJISC, 2011), the JISC established the need of interoperability and how this functionality can be achieved through the use of open standards. Specifically, this body supports the activities of two related institutions: UKOLN and Cetis that work on aspects related to standardization. The first has pointed out the pertinence of the OAIS model (Consultative Committee for Space Data Systems, 2002) as standard reference model for repositories (Allinson, 2006) and explored, through a series of projects, the use of OAI-PMH standard to achieve interoperability between the members of the JISC community. While the second, known as the Center for Educational Technology and Interoperability Standards, provides advice on those aspects, but specifically for learning objects.

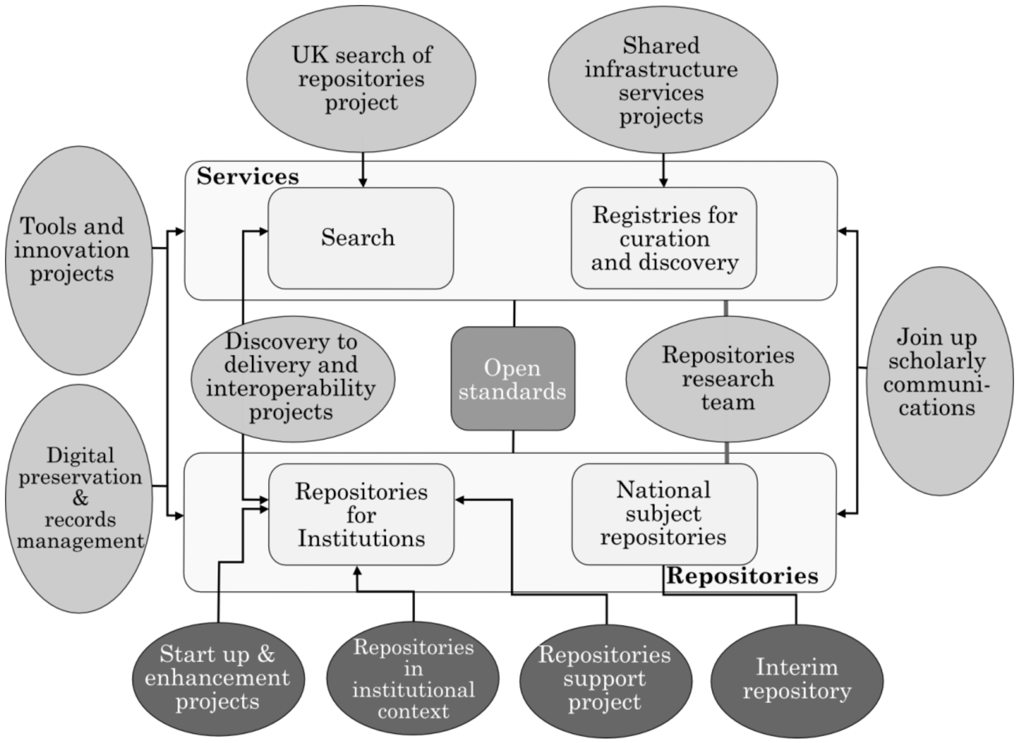

Fig. 6.6 Open standards and the structure of the JISC's repository program (adapted from: Joint Information Systems Committee, 2012e)

On the other hand, UKOLN is a "centre of expertise" that advises on "digital infrastructure, information policy and data management" (UKOLN, 2012a).

Besides the creation of standards as SWORD[30], UKOLN works together with the JISC to support repository standardization based on a three-layer approach to use standards. Taking into account the strategy for digital libraries programs, the following layers can be identified (Kelly et al, 2005):

- Contextual layer: context of standard use, including mainstream, small scale, community, experimental, etc.
- Policy layer: relevant policies like standards, open source, accessibility/usability, project management, finance, etc.
- Compliance layer: mechanisms that ensure an implementation complies with the requirements, such as external validation, self assessment, learning, etc.

This theoretical path drawn by Kelly et al. (2005) was adopted and adjusted by the JISC to the standardization carried out through their programs. Table 6.2 is an example of how this vision was operationalized by the JISC for the digital repository program (JISC, 2012a; UKOLN, 2012b). It shows how this body enables standardization through its programs. In this way, those projects defined as good practices emerge as the embodiment of a standardization policy. Through such "cultivation" process, the user community around the standard is shaped.

b) Networks: The SHERPA-LEAP Project

ITS adoption cannot be fully understood without referring to the SHERPA and the SHERPA-LEAP consortium. Their origin was a project called Securing a Hybrid Environment for Research Preservation and Access, which aimed to establish "a new concept of open access institutional repository" (SHERPA, 2012). In 2003, one year after the beginning of the project, the seven original development partners formed a partnership and other six institutions joined too. SHERPA has now 34 members (32 HEOS, the Science and Technology Facilities Council and the British Library) and some of them were grouped later into the SHERPA LEAP consortium (London E-prints Access Project).

[30] The Simple Web-service Offering Repository Deposit (SWORD) is a standards protocol founded by the JISC in 2007 (Allinson, François, & Lewis, 2008). It is known as a deposit API and allows the deposit of content from multiple sources in different formats (see: http://swordapp.org/)

Layers	JISC operationalization	Example
1. Contextual (mainstream, small-scale, community and experimental)	The JISC program manager (incl. associated bodies and other individuals) define the application of the standards for funded projects as well as the reporting procedures and quality assurance processes.	Through the JISC program manager, the implementation of open standards (such as HTML and CSS) is necessary for project websites. The full documentation of the project is required as well.
2. Policies (standards, accessibility and usability, project management and finance)	The document describes the technical standards related to the projects.	
3. Selection (added by the JISC)	The JISC program manager advises about the areas in which projects are free to decide by themselves and about those that need to be ratified.	A project may choose HTML 4 and CSS 2.0, implementing them using a CMS. These technical decisions are documented and communicated.
3. Compliance (external validation, self assessment, learning)	The project develops quality assurance procedures to guarantee an adequate implementation. Self assessment may be needed for management purposes and for the notification of deviation from best practices.	Project compliance regime may include systematic validation. Some legitimated deviations can happen, like the use of .ppt files converted to HTML that not full fill 100% the HTML standards.

Table 6.2 Layered approach to the use of standards in the JISC (adapted from JISC, 2012a; Kelly et al., 2005; UKOLN, 2012b)

SHERPA-LEAP was formally established in 2004 as a consortium of seven HEOs members of the University of London Federation. The initial project (set-up) was funded by the Vice-Chancellor and aimed to implement repositories and populate them (SHERPA-LEAP, 2012). The development partners were the following HEOs: Birkbeck, Imperial College London, King's College London, London School of Economics and Political Science (LSE), RHUL, School of Oriental and African Studies (SOAS) and the University College London (UCL). The UCL leaded the project and initially hosted the EPrints repositories of all project members in a single server (SHERPA-LEAP, 2012). In the second phase (expansion) of the project, original partners migrated away from centralized hosting at the UCL, to local platforms and more institutions joined the consortium: Goldsmiths, Queen Mary, the School of Pharmacy, School of Advanced Study, the Institute of Cancer Research and the Institute of Education. A third phase of SHERPA-LEAP called LASSO (LEAP Aggregated Search Service Online) began in 2007 to deliver a cross-searching service for the member repositories (development of new services) And finally, the fourth and final phase (community and network building) with official funding ran until 2010 in order to support repository management by several types of digital content (such as images, multimedia and primary data). The LEAP original project is considered finished but the network continues as a space for sharing experiences, support and networking activities.

The first RUHL repository was launched in 2006 in an official ceremony and researchers were invited to submit their materials. As part of SHERPA-LEAP, the RHUL repository was initially hosted at the UCL as a discrete archive running in a single copy of EPrints (Moyle, Stockley, & Tonkin, 2007). EPrints was initially chosen because of three main reasons:

- It was an open source solution,
- the technical officer had expertise on it and support was more feasible, and
- the possibility of unproblematic migrations in case of changing platform.

The organization of the consortium allowed that in spite of the centralized hosting at the UCL, each member was able to take technical and policy decision (Brown, 2009). According to the SHERPA-LEAP Project Officer[31], this implementation model was necessary due to the lack of expertise about repositories and it was a way to face operation costs for small institutions. However, in that time some disadvantages emerged from the technical structure (Moyle, Stockley, & Tonkin, 2007):

- Limited technical support (not dedicated) due to financial limitations.

[31] Period 2009-2010

- Inconsistent documentation about the repository software.
- Insufficient support a variety of technical skills in each institution.
- Risk of data loss in the whole network because of software issues[32] in a single repository.
- Impossibility to modify shared code above the single repository level to meet single member requirements.

With the end of the SHERPA-LEAP Project, officers at the RUHL decided to implement a local repository service that would solve some of the issues mentioned before, but at the same time it would provide some extended features to satisfy growing needs of storage of teaching materials as well.

c) Organizational policy and strategy

At the HEO level, strategies and policies emerged in the RHUL to push and reinforce the acceptance of the repository as organization standard. Based on the interviews and the analysis of all the available documentation, three areas of implementation of policies and strategies were identified: research, library and IT (Fig. 6.7).

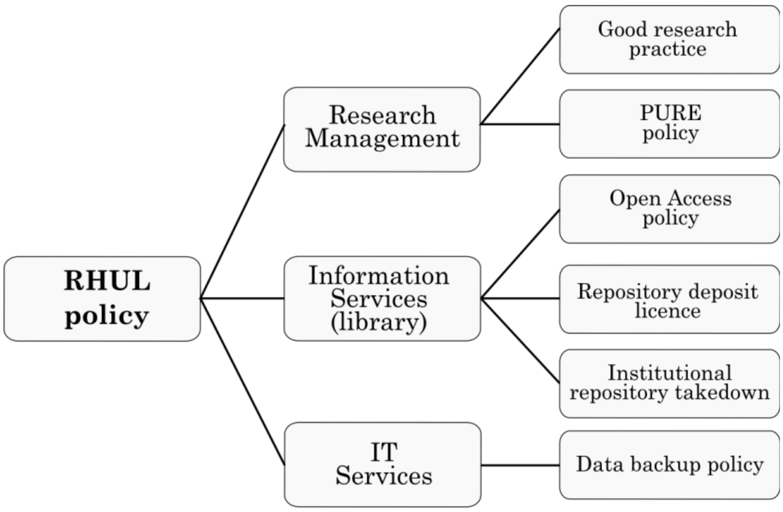

Fig. 6.7 Policies related to repository ITS.

[32] Moyle et al. (2007) reported problems related to archives "going down" because of file compilation after configuration changes in one repository.

It should be noticed that high level strategy (i.e. Corporate Strategic Plan) might be operationalizated through a series of actions focused in two or more specific areas (e.g. research data management to enhance research practice). This can be understood as the prioritization of particular aspects (useful for decision making) and the assurance of resource availability to accomplish the outlined objectives. Precisely, the Corporate Strategic Plan 2009-2013 of RHUL encompasses a series of aspects that can be related to standardization and research repositories (RHUL, 2009a).

Table 6.3 shows that since 2009, the main corporate plan objectives might have pushed standardization of research data management and open access in repositories through the operation of PURE and eQuella. The four main themes and the three enabling themes are defined at the RHUL, those related to research quality and management performance are relevant to the standardization and repository topic. As it can be observed, the quality of the research is explicitly linked to the data about the process that can evidence the excellence of the process. Thus the operation of a CRIS and other linked mechanisms are supported by the organization. For this reason, the incorporation of eQuella to the PURE workflow extends the repository service to other service areas. Through such process, the repository turned into the organization standard for data storage in the CRIS.

On the other hand, the third enabling theme of the corporate strategy takes into account the management process in different areas of the HEO. For this work, the relevant points to observe are from O1 to O3 that prioritize performance, cost, documentation and task efficiency but specifically address the role of IT. The second objective of this enabling theme resembles the use of standard in IT implemented by HEOs for different applications in learning, teaching and administration. Besides the reference to best practices in the field, the objective 03 points out qualities such as time and data quality for decision making. All these as strategic aspects for the high level management in the HEO are consistent with the path followed for the adoption of eQuella because:

- It was integrated to PURE in order to enable the storage of data records for the excellence evaluation and at the same time it would impact the population rate.

- The standardization work by the JISC and best practices within the SHERPA-LEAP project were taken as input to outline the requirements for a repository. Thus the repository software implementation cannot be fully understood without this reference.
- The decision towards internal hosting of the repository can be linked to the third objective (03) because the technology could be handled internally to satisfy on time the required data from the repository.

Section	Aspect	Relation to the repository and involved standards
Theme 1	Quality of the research activity	• High quality research in academic departments, which have to be ready for evaluation (O1).
Theme 2	Quality of student experience	
Theme 3	Performance of the intellectual and physical assets	
Theme 4	Internationalization	
Enabling theme 1	Staff recruitment and retention	
Enabling Theme 2	Campus infrastructure (estates)	
Enabling Theme 3	Management performance (governance, communication and operational infrastructure)	• Management process to assure (**O1**): - Performance - Cost-benefit - Documentation and task efficiency • IT infrastructure and services consistent with sector best practice (**O2**). • Management information systems for decision making and required data available on time (**O3**).
Enabling Theme 4	Marketing and communications capabilities.	

Table 6.3 Main aspects of the RUHL strategy related to repository standards (based on RHUL, 2009a)

About the policies, the eQuella -as the organization standard for storing research data for open access- might be influenced by a series of organizational regulations for different purposes but with strong relation each other. Table 6.4 shows an overview of the analyzed policies to track the entire (internal) regulatory environment in relation to the research repository and its associated standards. It is consistent with the areas referred as being involved: research, information services (library) and IT (Fig. 6.7). Research related policies point out two main aspects that are relevant enablers and source of requirements for repository implementation in this case study:

- The openness of research outputs
- Research information management

The research perspective is close to the open access embraced mainly by information services. In the case of RHUL, the open access policy endorses the influence of external institutions, agreements and standards as fundament. At the same time, it addresses the character of the repository as the organizational IT standard that supports open access and long term preservation. These series of policies institutionalize such solution and its repetition in order to accomplish a unified process with centralized resources.

Concrete guidelines in relation to data formats, backups, takedown and versioning are also provided as part of these policies. Relevant rules for repository operation are included in the copyrights policy and documentation of takedown procedures. Besides them, IT services' policies on data backup are used to achieve the preservation goals of the repository (and of PURE as well).

The presented analysis of the policies and their content initially suggests a strong regulatory framework that might have enabled adoption. But as it is evident in document dates, policies were applied later in order to reinforce operation.

Policy	Date	Main aspects related to repositories and involved standards
Guidelines on Research Governance, Research Ethics and Good Research Practice (RHUL, 2008)	2008	• Openness of research results
Policy on the population and maintenance of a RIS (PURE) (RHUL, 2011b)	2011	• Integration of workflows • Pure as interface of the repository • Target user profiles and roles
Open access publication policy (RHUL, 2009b)	2010	• Official position about the Berlin Declaration on Public Access to Knowledge and RCUK's open access initiatives. • Official endorsement of the repository as IT support to preserve and to provide open access to all research outputs • Call to all researchers to submit their research outputs to the repository • The repository as a way to assure the comply REF data requirements • Compliance with publisher and funders policies (i.e. SHERPA/ROMEO and SHERPA/JULIET) through the assessment of Library Services. • Compliance with embargoes • Preservation standard procedures (data formats, backup, take down and versioning)
Institutional repository deposit license (RHUL, 2010b)	2010	• Copyright and license to deposit in the repository
Institutional repository takedown policy (RHUL, 2010c)	2010	• Policy and procedure to minimize the risk of *inappropriate* material available through the repository.
Data backup policy (Royal Holloway University of London, 2010a)	2010	• Institutional data backup policies (frequency, time and disaster recovery/business continuity)

Table 6.4 Main policies at RHUL related to the repository and the ITS

6.2.6. The Adoption Process

The first documentation had established a complex series of aspects that have occurred before, during and after the implementation of eQuella at RHUL. The collected data suggested a timeline that involves a series of actions within the organization but also at other levels (i.e. networks and macro). Thus a first overview of the whole adoption process is relevant for this case in order to understand organizational activities and decisions about adoption. Fig. 6.8 presents the general adoption process considering the four adoption levels. It shows the role of SHERPA at the network level as a driving force towards the adoption of research repositories and promotion of good practices in the UK. With the parallel work of the JISC, both organizations reinforced their recommended practices and have influenced the ITS panorama with a series of repository related projects. But the participation of SHERPA-LEAP (as an initiative of the University of London Federation) was particularly significant for the operation of a first repository at RHUL and the adoption of a series of ITS that were key to understand eQuella later adoption. The main outcome of the SHERPA-LEAP project was the establishment of repositories (including one for RHUL) using EPrints software and the harvesting protocol (OAI-PMH) as well as the adoption of the metadata standard embedded in the selected. These last aspects conformed what it is called ITS context of compliance and it is also included in Fig. 6.8. Such scenario implies the action (dotted arrows) of SHERPA, SHERPA-LEAP and JISC activities/guidelines on repositories in order to assure specific solutions are repeated to guarantee a specific level of operation as well as standard functionalities (e.g. interoperability).

The adaptation of EPrints at Royal Holloway was part of the network action. But once that SHERPA-LEAP was finished, a series of conditions motivated the adoption decision of an organization standard to store and guarantee open access to research outcomes. With the conclusion of SHERPA-LEAP and the identification of needs to implement new standard software, the initiation phase concluded.

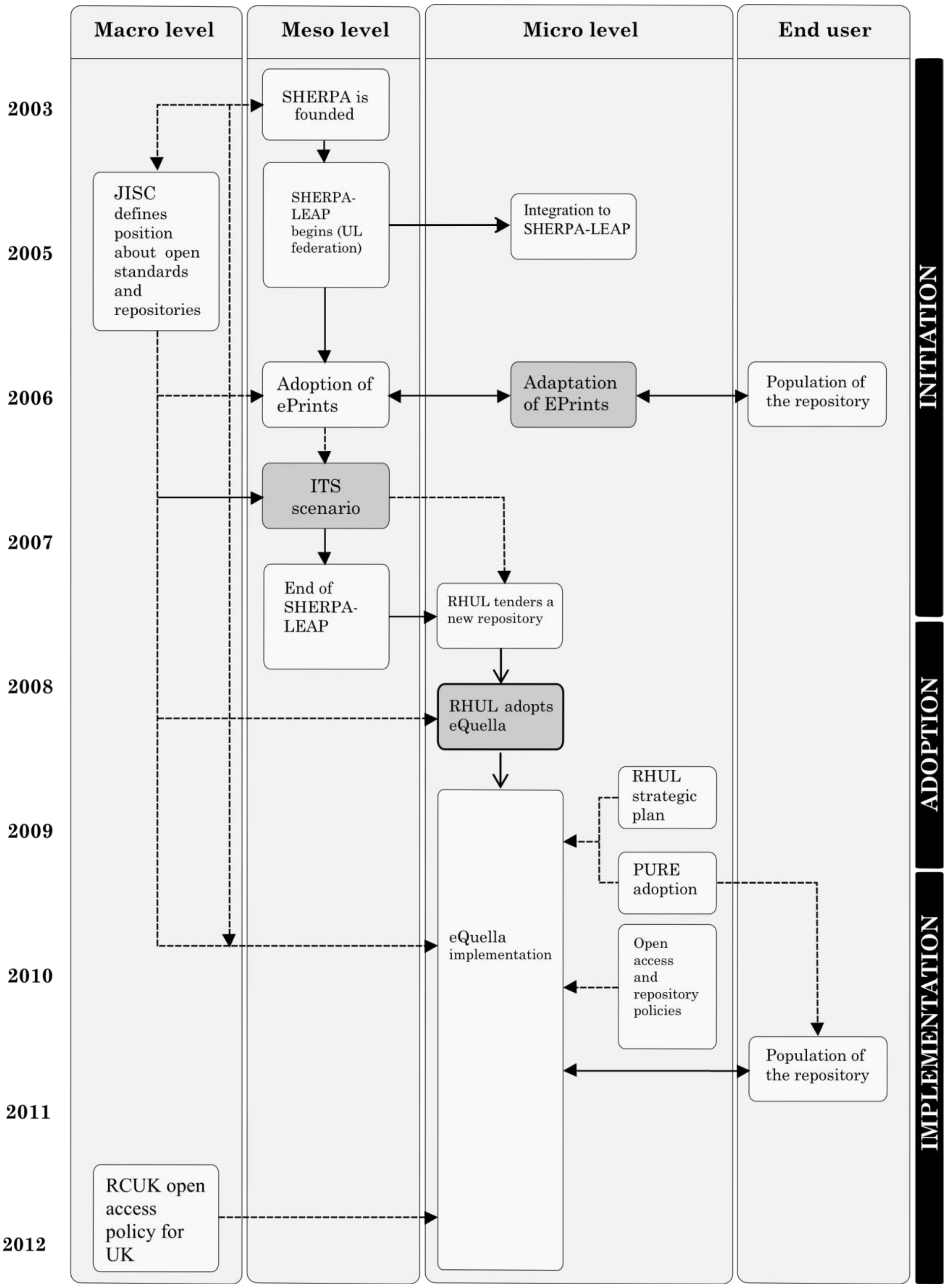

Fig. 6.8 Repository and related ITS' adoption timeline

For the RHUL, the use of EPrints was problematic and according to the repository manager, the socialization of the tool was poor and user participation was deficient. At the same time, the IT services department conceived a Service Oriented Architecture that expanded repository functions to learning objects and therefore, an integration with the Learning Management System was needed. At that time, the future integration of a CRIS was in perspective as well.

The adoption of eQuella occurred as result of a centralized decision with the approval and assessment of the Academic Commission and the Advisory Board. In 2008, several providers were put out to tender. The Repository Manager explained the process:

> *'We previously used EPrints - from 2005 to 2009. The EPrints was a University of London Project wide[33]. It put EPrints on circulation to all the Universities of London. That was moderately successful. At the time when it came to end, the College IT CIO explored different options of software and they did a tender so different companies were invited to participate with proposals to run a repository for us (...)"*

eQuella was adopted as part of an official tender leaded by the IT department, the Library and the Research Committee. The official set of scoring criteria included:

- Types of objects that could be imported
- Available end user functionalities
- The possibility of cataloguing different items in their workflow
- Integration capabilities and expanded compliance
- Price
- Provider training and support
- Integration capabilities (types of education assets and other systems)

After the definition of the criteria, some technology providers were invited for short trials to score their systems. Based on the results, Pearson Education with its eQuella was selected as provider. For the Information Officer, who coordinated the process, the technical implementation of the repository occurred

[33] SHERPA-LEAP

without technical problems under the provider's assessment and only budgetary aspects had to be solved. The participation of the IT services department was particularly active to assure the adequate technical implementation and the development of staff skills. This was described by the Head of Analysis and Design:

> *'We had a sheet with full scoring criteria. So our scope covered things like: the type of objects is supported, availability of end user functionalities, ability to catalogue different items on the workflow, licensing and permissions. Particularly important for us was integration and standards compliance. So basically, the technical specification was responsible for the half of the choice and then we also considered reference price and training and support. Inflecting eQuella, we saw the best match to our desires to have a single repository that could cope with many different types of assets, educational assets, and could integrate with many types of systems."*

Fig 6.8 presented the relation with the ITS scenario generated during the operation of EPrints. The compliance to the ITS used by that software was relevant for the configuration of eQuella. Knowing this relation, it is possible to understand the decision about harvesting, metadata and data formats because of the legacy of the vanished EPrints and network actions.

Considering the decision making process that implied the adoption of the repository, further organizational actions took place in order to ensure the adequate operation of the implemented systems. Contrary to the idea that ITS adoption is consistent with a direct strategy, this case shows that such tacit strategy and policies emerged after the technical implementation, as a way to support the routinization and to make official the position of the organization about the standard. Thus the relation between policy and ITS can occur in other stages of the adoption and with different effects in the process.

Relevant organizational actions during the implementation phase took place at the top level through the four-year strategy (2009-2012) as well as the open access and repository policies. Technologically, the implementation of PURE and its policies impacted on eQuella workflow and operation. During this period, a responsible for the repository was hired as part of the library staff in order to manage the content of the repository, while the technical maintenance remained as duty of the IT Services office.

The role of the repository was straightened not only with the extension of the workflow through PURE and the definition of internal strategies and policies. At the macro level, the definition of national policies (e.g. open access by the RCUK) increases the official character of the repository and its role outside the organization.

6.2.7. Structured Analysis

In order to integrate the theoretical perspective presented in this work, a further analysis was carried out in this case study. Considering the checklist approach introduced in Chapter 4, it is possible to abstract organizational aspects that shape the context of compliance within the standards adoption process (consistent with the three-step model as well). This work proposed placing the listed aspects and distinguishing between their absence and their passive/active inference. The checkmarks (✓) on the right side of each table indicate not only if the aspect was present, but also if it was active in the phase (a *bold* **✓** means active). In order to facilitate the reading, the *mechanisms* (i.e. factors) have been abbreviated in brackets (e.g. DNA,MA, EC) and the text refers to them in this way.

	Aspect	How	When*		
			In	A	Im
1.1	The standard is supported/required by a domain community (external pressures)	• **Domain network actions (DNA)** • SHERPA/ SHERPA-LEAP actions • **Macro level actions (MA)** • JISC actions	**✓**	**✓**	✓
1.2	The standard has a critical mass within the domain	• **Extended coverage (EC)** • Consequence of JISC actions • Selected good practices in repository services for open access	**✓**	**✓**	✓
1.3	The standard is a IT product used as organizational unique solution or is embedded within an IT product with critical mass	• **Standard based software** available in the market **(SBS)** • EPrints is a standard based software • eQuella as standard based software	**✓**	**✓**	**✓**

Table 6.5 Checklist of the domain context

*Legends: In=Initiation A=Adoption Im=Implementation

The first two categories are domain context (Table 6.5) and the external ITS catalogue (Table 6.6) are related to the environment branch of the model. The context in this case was strongly influenced by a series of network actions about standardization, which: a) occurred prior to the adoption decision in the organization, b) influenced the scoring criteria to select the technology and c) continued with on-going updates (at maintenance level for the organization). The critical mass of the standard within the network (DNA) and at the macro level (i.e. country) remained constant because of different initiatives (e.g. policy and funding). Such macro level actions (MA) have impacted on the ITS critical mass (EC) because "good practices" implied certain functionalities enabled by standards and embedded in the available software in the market (SBS). In this case, all aspects were particularly relevant when the repository implementation was responsibility of the HEO's network (HNA in Table 6.6), However with the internal adoption of eQuella such aspects remained.

	Aspect	How	When*		
			In	A	Im
2.1	The standard is used by other HEOs	**HEO network actions (HNA)** • SHERPA actions • SHERPA-LEAP actions • JISC actions	✓	✓	✓
2.2	The standard is communicated/disseminated	**Dissemination of the standard (DS)** • Network experience • Application of the organizational knowledge about the standard	✓	✓	✓
2.3	The standard has external support (documentation, consultancy, communities)	**Support for standard implementation (SSI)** • eQuella provider dealt with the standard • Actions by SDOs[34]		✓	✓

Table 6.6 Checklist of the external ITS catalogue

*Legends: In=Initiation A=Adoption Im=Implementation

[34] In relation to the embedded ITS for harvesting, metadata and data formats. Actions linked to this aspect were not included in the figure 6.8 since EPrints include them as a pre-selection of open standards. Later, the lack of support for EPrints raised technical support as need and the embedded ITS turned into a condition for the new repository system.

The other environmental category refers concretely to the standards catalogue (Table 6.7). The dissemination of the standard (DS) was present through the network actions and it turned into criteria for the adoption of the new repository system. Communication activities took place as well as a way to exchange current experiences and practices within the adoption community (e.g. remaining network of SHERPA-LEAP). Finally, the external support of the standard (SSI) was available through the macro and network actions as well as the technology provider activity during and after the adoption decision (EPrints was not implemented by RHUL, therefore it is not included in the initiation stage).

	Aspect	**How**	**When***		
			In	**A**	**Im**
3.1	HEO structure for research support	**Research support units (RSU)** • Research Committee, faculties, library, IT services	✓	✓	✓
3.2	HEO structure is decentralized (coordination mechanisms)	**Organizational coordination (OC)** • Committees	✓	✓	✓
3.3	HEO has available resources to support the standard	**Organizational support (OS)** • Technical support by the IT Services and management support by the Library		✓	✓
3.4	A HEO unit requires the standard for a (specialized) task	**Requiring unit (RqU)** • Library • Later: Research Committee, faculties, IT services	✓	✓	✓
3.5	A HEO unit is open to adopt the standard	**Receptive unit (RpU)** • Library • Later: Research Committee, faculties, IT services	✓	✓	✓

Table 6.7 Checklist of the structure

*Legends: In=Initiation A=Adoption Im=Implementation

The structural aspects of the adoption in the HEO were analyzed too (Table 6.8). Prior to the adoption, several organization structures (e.g. research committee, faculties, library and IT services) participated in the support of research (RSU) but only the library acted actively prior to the adoption (as organization's representative in the network). Since decision making is delegated to committees, organization coordination occurs (OC) through committees' action in cross-functional teams; but not modification was observed in these organization procedures. However, the local adoption of the repository involved more organizational units as the original that participated in the previous network activities. About the allocation of resources to support the standard (OS), in this case the adoption of the repository service implied a strong financial support that enabled the decision making process and later, the assignation of support duties and the hiring of new staff were part of the adoption scenario. As already mentioned, by considering the committee structure of RHUL, the repository as project was responsibility of a cross-functional team, who gathered the requirements (RqU), and later, the platform's service administration and content management were transferred to the IT Services and to the Library, respectively (RpU).

	Aspect	How	When*		
			In	A	Im
4.1	Formal relation of the IT units with HEO's central IT department	No supported			
4.2	HEO's IT organization tacitly supports research	Not supported			
4.3	Installed base capabilities support the standard	• **IT resources assurance (ITRA)** • Acquired resources for eQuella		✓	✓
4.4	IT units have the skills to support the standard	Not supported			
4.5	IT staff has skills to deal with the standard	• **IT staff skills (ITSS)** • Provider support and training			✓

Table 6.8 Checklist of the IT infrastructure

*Legends: In=Initiation A=Adoption Im=Implementation

In relation to the IT infrastructure, the decentralization of the IT units did not play a role for this technology and set of standards (see 4.1 and 4.4 in Table

6.8). Considering the service orientation of the IT projects, the repository was specifically managed by the central IT services in cooperation with other HEO's units (the library and Research Commission). The dedicated support to research activities by the IT department did not follow a strategy emerged from it, but from other units that later request the service. In this case the infrastructure for the implementation of the repository software was built based in the acquisition of new equipment for local hosting (ITRA) and the redesign of the corporate website. The development of the IT staff skills (ITSS) to support eQuella operation as organization standards was responsibility of the technology provider who advised about compliance to interoperability standards.

	Aspect	How	When*		
			In	A	Im
5.1	The HEO tends to formalize and centralize	• **Formalization and documentation (FD)** • Policies and strategies are documented	✓	✓	✓
5.2	The HEO developed a policy related to the standard	• **Supportive policies (SP)** • Open access, repository and PURE policies			✓
5.3	The HEO's strategy is open to the standard	• **The standard in the strategy (SS)** • Strategy 2009-2012 refers to research data infrastructure and research practices			✓
5.4	The HEO considers IT as strategic	• **IT in the strategy (ITST)** • IT infrastructure referred in the strategy 2009-2012			✓

Table 6.9 Checklist of the strategy

*Legends: In=Initiation A=Adoption Im=Implementation

Strategic factors in the HEO are presented in Table 6.10. The first aspect was positively identified, considering that all institutional policies, regulations and procedures are documented and available for organizational members (FD). This tendency did not change during the adoption process and remained constant. Policies that specifically address and support the standard (SP) were officially issued once that the adoption decision had been made. The later formalization of eQuella and required functionalities could be explained through the level of organizational commitment towards open access (a condition for the research excellence program) and the need of a standard solution. Such situation was strengthened by the issued four year strategy (SS) that included specific support to IT related initiatives (ITST) and was defined one year later after the adoption decision.

Finally, a last category of analysis is related to managerial actions that supported the standard and those events that warranted its performance (Table 6.11). In this case, the HEO hired a new manager to be responsible of repository. This managerial human resource began his duties once that the decision was made, thus his focus remained mostly in information controlling activities (MSP). But top management support towards the standard began before with the decision by itself (MS).

	Aspect	**How**	**When***		
			In	**A**	**Im**
6.1	Management supports the standard	• **Management support (MS)** •New repository manager hired		✓	✓
6.2	Managerial actions occur to control standards performance	• **Management and standards performance (MSP)** •Periodical reports for the academic board			✓

Table 6.10 Checklist of the management

*Legends: In=Initiation A=Adoption Im=Implementation

This analysis from the single case perspective has presented a more structured view of the adoption process based on the available data. Although some aspects were not supported, the model allowed a deeper approach to the context of compliance in each one of the adoption phases. The second case showed some significant differences, considering the characteristics of the adoption but such variations will be analyzed at the end of this chapter in a cross case analysis.

6.3. Case B: Faculty of Philosophy and Literature, National Autonomous University of Mexico

The *Facultad de Filosofía y Letras* (FFyL, Faculty of Philosophy and Literature) is part of the *Universidad Nacional Autónoma de México* (UNAM, National Autonomous University of Mexico). This academic and research department was selected considering that the adoption decision began locally. The early adoption of the repository and the role of the management as champion motivated later the creation of an internal repository network.

The FFyL-UNAM case explores the repository software adopted to promote the open access to the research outputs of this department, in order to stimulate scholarly communication and increase the visibility of such production. Thus EPrints was adopted by the FFyL as:

- An organization IT standard, which solves research data storage and open access. Initially it was a single solution and later got institutionalized as best practice for the inter-organizational project: *Red de Archivos Digitales* (RAD, Digital Archives Network).
- The embedded IT standards within the adopted software, including: metadata (Dublin core) and harvesting (OAI-PMH).

This case is interesting because the adoption did not begin centrally (top-bottom) or by a central unit (e.g. library), but rather as a departmental initiative (bottom-up). The data collection for this study was performed between 2011 and 2012 and focused mostly in qualitative data collection, which included:

- Document analysis of more than 14 institutional policies and a variety of online documentation and resources[35], including reports from the repository.
- Contact and interviews with a variety of HEO staff, including the manager, repository manager/implementer and coordinator of the RAD network.

As well as the RHUL case, this single report presents first an overview of the organization, specifically the department and the status of the technology and

[35] See a list in complete list in Appendix A.6

the standard, followed by a detailed description and analysis of the adoption process.

6.3.1.Overview

The UNAM is the oldest university in Latin America and one of the most important HEOs in the region (UNAM, 2012k). According to the available documentation, the idea of a university for the New Spain colony was conceived by the Spanish Bishop Juan de Zumárraga in 1536. After the support of Viceroy Antonio de Mendoza, the Spanish King signed its foundation in 1547 (UNAM, 2012k); but the official royal document was issued in September 21th 1551 and two years later, the university was opened. After Mexico's independency from Spain, the UNAM closed several times because of the complex social environment. But the idea of a Mexican national university emerged in 1881 and it was considered a reality once that the Ministry of Education was created in 1905 (UNAM, 2012k). Thus in 1907 the president agreed on a national university with a structure based on the ideas of the pedagogue Ezequiel A. Chávez, who deeply analyzed the European and US American university systems.

Today, this Mexican university has more than 300,000 students[36] (8% in graduate programs, 57% in undergraduate, 34% in high school, and 1% in vocational) (UNAM, 2012a). UNAM's academic offer includes: 40 graduate programs, 34 specializations, 100 bachelor programs, 23 vocational programs and 23 vocational careers (UNAM, 2012a). UNAM's structure relies mainly on 13 faculties, five multidisciplinary units and four schools; as well as 30 institutes, 16 centers and nine university programs (UNAM, 2012a). The full list of faculties and research centers and institutes is provided in the Table 6.11.

[36] Data of the 2011-2012 period.

Faculties	
• Accounting and Management • Architecture • Chemistry • Economics • Engineering • Law	• Medicine • Odontology • Philosophy and Literature • Political and Social Sciences • Psychology • Sciences • Veterinarian Medicine and Zootechnics
Centers and Institutes	
• Institute of Anthropologic Research • Institute of Bibliographic Research • Institute of Bibliotechnologic and Information Research • Institute of Economic Research • Institute of Aesthetic Research • Institute of Philological Research • Institute of Philosophical Research • Institute of Historical Research • Institute of Legal Research • Institute of Social Research • Institute of University and Education research • Research Center on North America • Research Center on Latin America and the Caribbean • Center on Interdisciplinary Research in Humanities and Social Sciences • Regional Center on Multidisciplinary Research • Research Center on Industrial Design • Research Center on Teaching of Foreign Languages • Institute of Biology • Institute of Biotechnology • Institute of Ecology • Institute of Cell Physiology • Institute of Neurobiology • Institute of Chemistry • Centre of Research n Ecosystems	• Institute of Research on Materials • Institute of Mathematics • Center of Applied Sciences and Technology Development • Institute of Astronomy • Institute of Physical Sciences • Institute of Nuclear Sciences • Institute of Physics • Institute of Applied Mathematics and Systems • Center of Sciences of the Condensed Matter • Center of Applied Physics and Advanced Technology • Research Center on Energy • Center of Radio-astronomy and Astrophysics • Institute of Geophysics • Institute of Geography • Institute of Geology • Institute of Engineering • Center of Atmosphere Sciences • Centre of Geosciences • Research Center on Environmental Geography • Institute of Sea Sciences and Limnology • Institute of Biomedical Research

Table 6.11 List of UNAM's faculties, research centers and institutes (UNAM, 2012a)

More than 36,000 academic employees work at this HEO and between 2011 and 2012, 11,805 did in on a full time basis. The full time staff with research duties was 4,554 (including researchers, research technicians and assistants) and the institution has the highest rate of researchers attached to the *Sistema Nacional de Investigadores*[37] (SNI, National System of Researchers).

The UNAM has a campus with more than 2 million km^2 and it is focused on teaching and research activities. The expenditure on research is about the 26% of the annual budget but its specific role can be better understood by analyzing its institutional purposes described in the organic law (UNAM, 1945):

- To provide higher education in order to form professionals, researchers, university teachers and technicians needed by the society.
- To organize and perform research, mainly closer to national problems
- To extend the possible benefits of culture.

The research function is highly important and the HEO recognizes his position as leader in the country and its prestige (UNAM, 2012i). In the most recent strategic plan (UNAM, 2012i), this institution defined its purpose of increasing the quality, productivity and international projection of the research.

6.3.2. Governance and Organization

The organization structure of this HEO has been designed to cope with a complex management environment. UNAM's organic law specifically defines its governance structure, attributions and characteristics of the six main types of authorities that participate as decision makers (UNAM, 1945):

a) Board of Governors: body integrated by 15 prestigious members of the academic community (elected by the University Council). Its main responsibilities are: appointing the rector and the directors of faculties, schools and institutes, as well as the members of the Main Board (UNAM, 2012f).
b) University Council: maximum authority integrated by the rector, the directors of faculties, schools and institutes, representatives of researchers, teachers and students, as well as a member of the employee group. Its main responsibility is

[37] It is a program of the *Consejo Nacional de Ciencia y Tecnología* (CONACYT, National Council of Science and Technology) that aims to recognize scientific research and its quality. Researchers apply and if they are accepted, they are categorized in three levels (I, II or III) and get financial support as well as access to some funding benefits for research (CONACYT, 2012).

the definition of norms and policies; and it meets in closed periodical sessions (UNAM, 2012d).

c) The Rector is main responsible for the University's managerial structure and the fulfillment of the organic law, policies and regulations, including the steps for appointing the members of other authorities (UNAM, 2012g)
d) Main board: an authority integrated by three external persons that focus mainly on budgetary aspects (UNAM, 2012h)
e) Academic directors, who integrate a series of internal associations and committees, including the Informatics Advising Council and Bureau of University Rights (UNAM, 2012e).
f) Technical councils are integrated by: the Coordination of Humanities, the Coordination of Scientific Research and the Coordination of Cultural Diffusion (UNAM, 2012c).

This description of the university organization shows an attempt to achieve the representativeness of all actors. This HEO developed a series of mechanisms to "control" the operation of councils and boards. However its structure enables certain operation freedom in faculties to implement their own programs and strategies. Through the participation of (academic) directors, academic and research departments take part in main decisions.

FFyL's structure

The Faculty of Philosophy and Literature (FFyL) was founded in 1945 after a presidential grant. Today the FFyL is located in the main campus in Mexico City (called "*Ciudad Universitaria*") and its academic offer consists of 13 undergraduate, 14 graduate and 7 online bachelor programs (see Table 6.13).

Currently the FFyL is integrated by 247 full-time and 968 part-time teachers. The student population consists of more than 10,000 undergraduate, 1,200 master and 900 PhD students, as well as 2,300 within the open university system. In order to operate and provide academic services to the student, the department has a well defined organization structure (Fig 6.10), leaded by a dean. In FFyL and all departments, the directors are selected by the University Board and is on charge for a period of four years (FFyL-UNAM, 1956). Close to the dean, the Technical Board works as a consulting body and it is integrated by teachers and students to assure the representativeness of all department's members (FFyL-UNAM, 1956). Additionally, the department's management team works in operative tasks to support a variety of administrative duties, such as: student affairs, infrastructure, finance and accounting, staff administration, student support, as well as student, information and legal services.

Type	Program
Undergraduate	• Bibliotechnology • Intercultural Development and Management • Latin American Studies • Philosophy • Geography • History • Classic Literature • Hispanic Literature • Modern Literature • Drama and Theater • Pedagogy (Education)
Postgraduate	• Anthropology • Bibliotecnology and Information Studies • Bioethics • Latin-American Studies • Mesoamerican Studies • Philosophy • Philosophy of Science • Geography • History • Art History • Literature • Linguistics • Pedagogy (Education) • Teaching for Secondary Education
Open university/ SUAyED[38]	• Bibliotechnology • Philosophy • Geography • History • Hispanic Literature • English Literature • Pedagogy (open university) • Pedagogy (distance)

Table 6.12 List of academic programs offered by the FFyL (UNAM, 2012a)

[38] System of Open and Distance University (*Sistema de Universidad Abierta y a Distancia*)

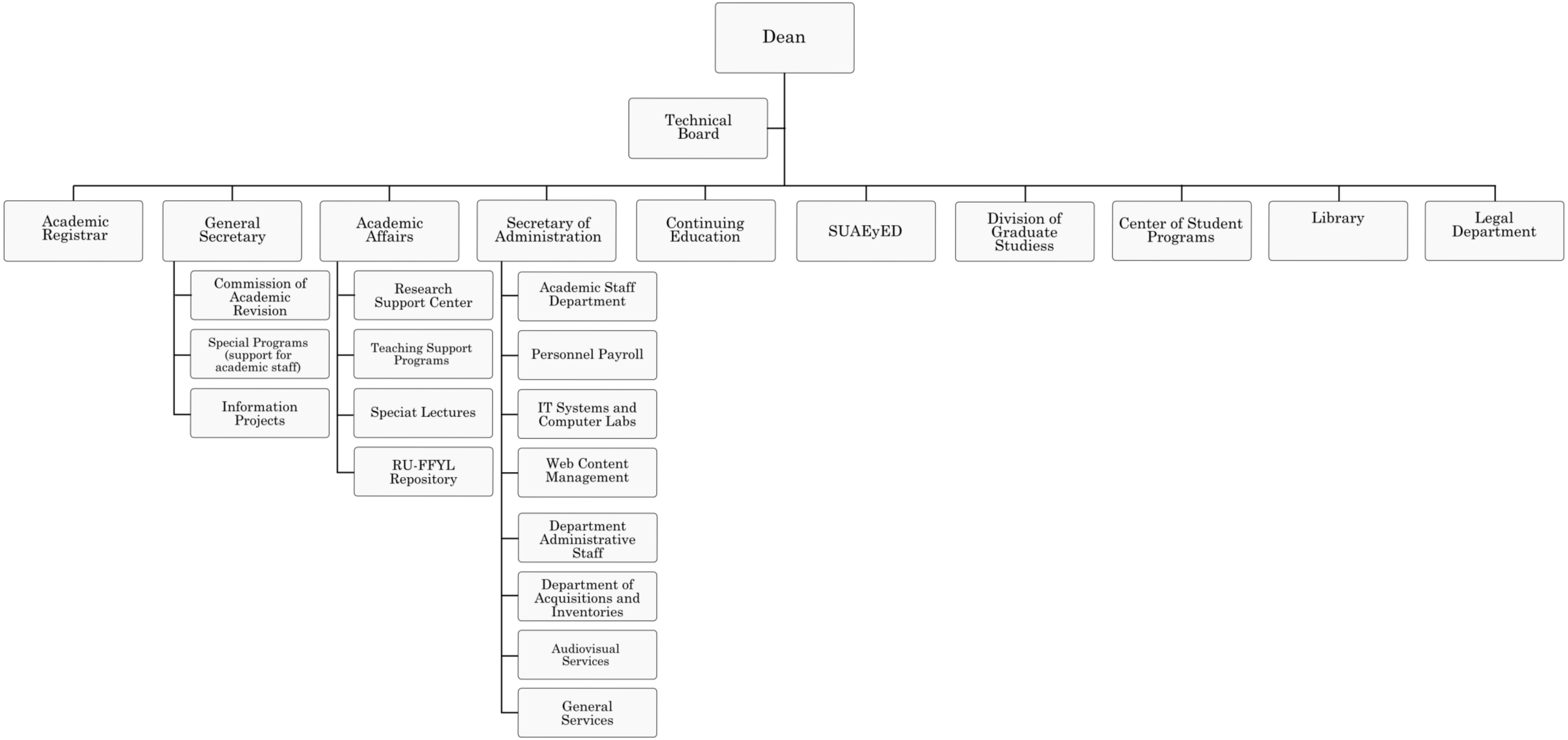

Fig. 6.9 Organization of the FFyL (based on FFyL, 2012b)

Because faculties work decentralized, they have a wide scope to decide about administrative and academic duties. Despite some services must remain centralized, the size of the organization favors this decision making mode. As other UNAM's faculties, the FFyL is focused on teaching activities but, considering the purpose of the university, an importat amount of research is carried out as well. The number of research outputs is significant and the FFyL has a special unit on charge called *Centro de Apoyo a la Investigación* (CAI, Center of Research Support). The CAI works with a variety of internal and initiatives in order to support and increase the research involvement of the faculty. Examples of these programs are: the *Programa de Apoyo a Proyectos de Investigación e Innovación Tecnológica* (PAPIIT, Support Program for Research and Technological Innovation), the *Iniciativa de Apoyo Complementario a la Realización de las Obras Determinadas* (IACOD, Initiative of Complementary Support to the Realization of Specific Works), *Programa de Becas Posdoctorales en la UNAM* (POSDOC, Program of Postdoctoral Grants), *Proyectos de Investigación de la Facultad de Filosofía y Letras* (PIFFyL, Research Projects of the Faculty of Philosophy and Literature) and all calls by the CONACYT (FFyL, 2012a).

According to data provided by the FFyL's Research Support Center, research activities in this department are mainly collective (85%) and include student participation (FFyL, 2011). The research outputs in 2010 consisted of 77 books, 197 research articles and book sections, 148 magazine articles, 35 articles in proceedings as well as diverse media (videos, technical reports, informs, manuals, etc.) (FFyL, 2011).

FFyL's configuration is a way of organizing internal processes for teaching, administration and research. In particular, it can be observed how IT services are placed apart of information services (library and repository). Thus the organization of the repository service is conceived as support service for academic duties rather than an administrative or a library service. But this aspect is analyzed in the next section about IT support for research.

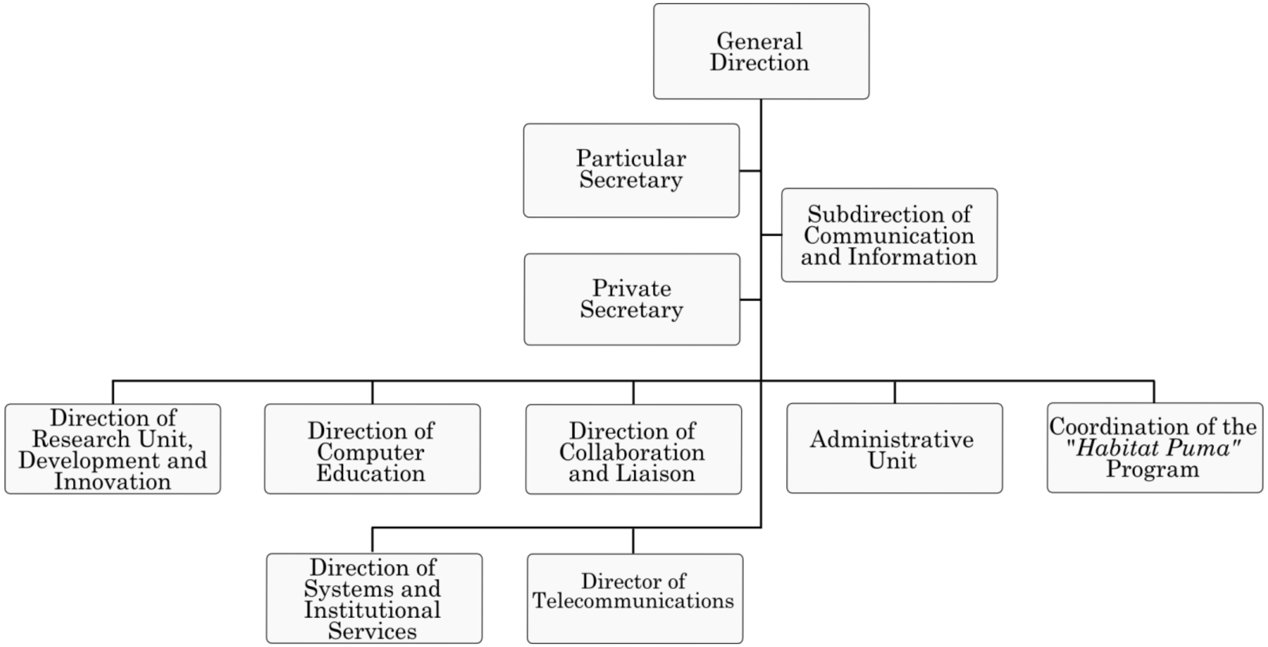

Fig. 6.10 DGTIC's organization chart (Source: DGTIC)

6.3.1. eResearch Strategy

Since 1958, when the first computer was installed, the UNAM has aimed to incorporate IT for research, education, administration and culture diffusion (DGTIC, 2012a). But until 1981, the IT services were institutionalized as an organizational unit and in 2010, the Rector changed its name to *Dirección General de Tecnologías de la Información y Comunicación* (DGTIC, General Direction of Computing and Information Technologies).

a) The DGTIC reports to the General Secretary, one of the main management university offices. This direction is organized in a way that besides internal management duties (Fig. 6.10), five main directions take over and represent strategic areas of action (DGTIC, 2012a). The Direction of Research Unit, Development and Innovation focuses on the research, evaluation and discussion about current IT initiatives implemented in the UNAM as well as prospective technologies.
b) The Direction of Collaboration and Liaison focuses on the assessment, development and management of internal and external IT projects (for the government, industry and other public organizations) (DGTIC, 2012c).
c) The Direction of Computer Education is responsible of implementing training initiatives for internal and external users. It has developed more than 150 courses and workshops (DGTIC, 2012b).
d) The Direction of Systems and Institutional Services is the core office for the management and provision of IT services in the university (DGTIC, 2012d).
e) The Direction of Telecommunications is the responsible of the administration, monitoring and operation of the RedUNAM, which enables network services for the whole institution.

This institutional configuration is used to provide a catalogue of services for all university's members. This direction offers a catalogue of IT services that are thought to fit one or more user profiles. Their provision is not conceived as specifically suited for eResearch, but rather as a good practice in IT that could be offered to all UNAM scholars, academic departments or external partners. Some of these services are available at extra cost (even for internal users) but rely upon human and material resources.

Table 6.14 shows the central IT service catalogue, which has been structured in four main categories: IT infrastructure (software, hardware and other material basic resources), information management and publishing (in order to deal with data lifecycle and publishing), advanced services (for complex research projects that require super computing power, virtual reality, modeling and visualization) and computer education and consulting (user training, consulting and required human resources preparation).

Relevant to the eResearch Strategy is the program called *Toda la UNAM en línea* (All UNAM online), which began in early 2012 and aims to be an open access initiative for all collections and digital materials of the university (UNAM, 2012j). Such initiative integrates a series of cataloged resources as well as search functionalities in a unique web portal.

Basic IT Infrastructure	**Information Management / ePublishing**	**Advanced Services**	**Computer Education and Consulting**
• Advice on the identification of software and hardware problems • Advice on the acquisition of ITC • Audio conference • Definition of the technical characteristics for generic computer equipment • Web conference • Podcast UNAM • LATINDEX and portal • Computer rooms Multimedia rooms • Consultancy on the implementation of media rooms • Advanced electronic signature • Webcast UNAM • Audiovisual services • Videoconference	• Advice on edition and management of digital documents • Cataloguing • Digitalization of documents • Design and impression of optical forms • Edition of books and digital journals • OCR • High volume impression • 3D impression • Digitalization and edition of audiovisual material (UNAM) • Online voting • Research and development of technologies for digital repositories management • UNAM Scientific journals • University's electronic magazine • Network of Digital Repositories	• Advice on the implementation and use of virtual reality • Advice on scientific visualization • Development of scientific visualization projects • Development of immersive and non immersive digital reality applications • Supercomputing • Immersive virtual reality and IXTLI observatory • Digital reconstruction of tridimensional objects	• Advice on good ITC practices • Advice and technical consultancy • Evaluation of computing, audiovisual and teleconference technology • Education of human resources in IT

Table 6.13 DGTIC catalogue of eResearch services (Source: DGTIC)

UNAM's eResearch strategy

Besides the central provision of IT services by the DGTIC, faculties have their own IT units and IT projects to support research activities. The available IT infrastructure for research within the departments is integrated by regular employee workstations and equipment for labs, (public) computer and multimedia rooms. Thus Faculty's IT units focus mainly on basic IT support to keep the quality operation of the equipment and the network. Beyond basic IT infrastructure, faculties apply for internal funding in order to obtain computing resources required to do research. This requires that they list concrete technical requirements as part of their financing statements in funding applications.

The next sections describe the case of the RU-FFL, which emerged from a research project and got departmental support to continue its operation once the project vanished down. Thus repository operation was an eResearch resource with no direct relation to the central DGTIC until it was considered as strategic some time after.

6.3.2. The RU-FFL Repository

The RU-FFL is the FFyL's digital repository. The idea of department repositories emerged from the research project called 3R, which aimed to explore suitable IT solutions for the storage and visibility of the University's research outputs. In 2008 after the 3R project was vanished down, the FFyL and the Institute of Biology adopted the idea. Until June 2012, more than 2,200 records were available in the RU-FFL collections and the work of more than 1,200 authors was stored. This repository has digital objects in Spanish and includes textual records (PDF) as well as multimedia (audio). The research resources stored in the repository are diverse: articles conferences' presentations, books, book sections and magazines published by the faculty (mostly post-prints).

Fig. 6.11 RU-FFL repository's look & feel

RU-FFL uses DSpace as standard software. It is an open source solution developed by the HP-MIT alliance in 2000 (Smith et al., 2003). The first official release was available in 2002 (version 1.0). Later, in 2007 the DSpace Foundation was formed as a nonprofit organization. This software was created to solve the management of research materials and publications by building a production quality system (Smith et al. 2003). The RU-FFL implementation with DSpace integrated the establishment of the so called "communities", which are groups managed by domain administrators. Workflows (see Fig. 6.12) allow quality control through multiple administrators, assuring the quality of the records entered by users in self-administration processes. This feature has been used in the RU-FFL to establish collections but all of them are managed by one single administrator or repository manager, who explained:

> *'The population of the repository is performed by me. Although DSpace integrate communities, our users have not the culture of self deposit. The academics belong to a pre-digital generation and therefore the service provision includes deposit. In the future, with the increase of the digital culture, this feature might be used, but for now it is not."*

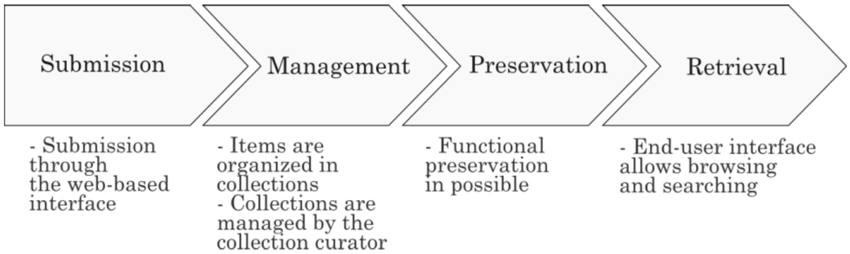

Fig. 6.12 DSpace workflow (based on Smith et al., 2003)

The current version of the DSpace implemented in the RU-FFL is the 1.5 and it is installed in a dedicated UNIX server. The implementation of the software was done by non expert users and therefore a systematic system management was initially not properly performed. In an interview, the current repository manager indicated some aspects that suggest such situation, like the fact that some security vulnerabilities kept the system down for several months and some data were lost as well. Some perceptions about the set-up process of DSpace were referred by him:

> *'It was very difficult to achieve de desired configuration, because of the installation type, the basic platform of Unix. I mean, which one: Unix Ubuntu, Unix Fedora. We installed one and we had issues with the circumflexes in the database [...] It was very complicated. The first implementation was difficult; we had to install it on a test server. It was difficult to set up a specific configuration for the Spanish language. Although it is very easy define a language, I decided a more difficult way and I translate the whole body text for the interface [...] But the main problem was that someone hacked the system, it was a huge security problem... the server was "packed" and "externally sealed."*

In 2010, with the formalization of an intra-organizational network called, *Repositorios Universitarios - Red de Archivos Digitales* (RU-RAD, Universities Repositories - Digital Archives Network), standardized some practices in the two implemented repositories. RU-RAD established that FFyL and the other repositories of the federation operate under the following guidelines (Galina & Giménez, 2010):

- Content is produced by UNAM scholars
- Compliance to standard technical and content requirements established by the federation.

- Local policies define deposit of digital objects
- Local policies define metadata management procedures

The following figure (6.13) presents how the federation has being conceived as the interoperation of the departmental repositories. This functionality is achieved through the adoption of "international standards" for repository operation (Galina & Giménez, 2010), like the use of Dublin Core as metadata standard and the OAI-PMH protocol for harvesting.

The FFyL and other members of the federation are responsible for the repository operation and the definition of own policies and deposit procedures, as well as the design of advocacy programs. Thus each department defines strategies and policies that suit better to the own information needs and more content might be stored (Rusell, 2011).

The network recommended the use of DSpace because of the experience and know-how generated with the RU-FFL and the RU-IB repositories. New implementations in other departments can profit from this knowledge and use the available resources for this standard software.

The UNAM repository requires that once that a department has set up their own platform, it should inform the RAD central coordination (part of the DGTIC). Then it is possible to retrieve information through a designed interface that uses Lucerne as indexer and Solr as search platform.

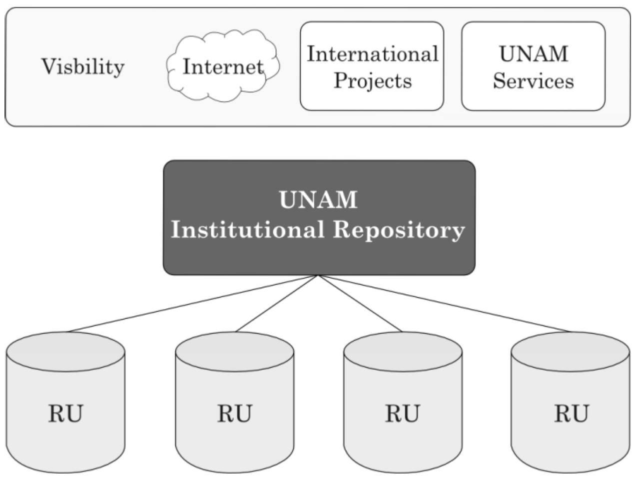

Fig. 6.13 RU-RAD federation (Source: Galina, I.)

6.3.3. Standards and Repository's Operation Context

After a systematic research, some few initiatives and networks to support the storage of research outputs in Mexico were found. Mexico is the most productive country in the Latin American region (Galina & Giménez, 2008), but its investment in research has been very low (only .4% of the GDP). Since 1970, the national investment in Research and Development (R&D) has increased very little: only two times in comparison to Brazil, who grew five times (Castaneda, 2009). These indicators allow understanding why there is a lack of resources for the establishment of a research infrastructure and the set up of technologies such as the repositories. The number of repositories per country can be considered a consequence of the policies and incentives in this field. In the case of Mexico, the absence of macro initiatives has influenced the low implementation rate[39] (20 repositories active in OpenDOAR) in comparison with Brazil (64), Spain (94), Germany (163), UK (208) and USA (393). Based on the registration in OpenDOAR (see Table 6.15), current repository scenario in Mexico shows a tendency towards open standards and open source software (60%), while the rest are mostly dedicated implementations (no commercial). From the implementations with open source software, 75% have adopted DSpace, which implies the adoption of the embedded technical standards like those for metadata (Dublin Core) and harvesting (OAI-PMH).

Some concrete high level initiatives in Mexico that are directly or indirectly related to repositories are mentioned in the following list:

a) The *Corporación Universitaria para el Desarrollo de Internet* (CUDI, University Corporation for Internet Development) is an association to promote the development of internet for research and education applications. It was founded in 1999 and is integrated by research centers, universities, private companies and government institutions. CUDI has a community involved with the development of digital libraries (RABiD).
b) The *Red Abierta de Bibliotecas Digitales* (RABiD, *Open Network of Digital Libraries*), it is a network that support open access since 2006. It is integrated by HEOs and financed by the CUDI. The institutions that integrate the RABiD are required to comply with some interoperability standards.

[39] Source: OpenDOAR

Repository	Institution	Software	Subject
Acervo Digital del Instituto de Biología de la UNAM (Irekani)	UNAM	DSpace	Biology
Artemisa en Línea	National Institute of Public Health	Unknown	Biology
Library Sor Juana Inés de la Cruz	University of the Cloister of Sor Juana	DSpace	Multidisciplinary
Center of Teaching and Learning Resources (CREA)	University of Guadalajara	DSpace	Multidisciplinary
Tales (Collection of Digital Thesis)	Interactive Center of Information and Learning Resources, University of the Americas Puebla	Unknown	Multidisciplinary
Collection of Digital Thesis UDLA	University of the Americas Puebla	Unknown	Multidisciplinary
Collection of Digital Thesis UAEH	Autonomous University of Hidalgo State	DSpace	Multidisciplinary
COLPOS digital	Postgraduate Studies College	DSpace	Agriculture, food and veterinary
Develop, Learn and Re-Use	Monterrey Institute of Technology and Higher Education	DSpace	Learning Objects
CC-DOC	Department of Sociocultural Studies, Western Institute of Technology and Higher Education	Catia	Communication
DSpace on the National Polytechnic Institute	National Polytechnic Institute	DSpace	Multidisciplinary
EduDoc	Institute of Technology and Higher Education	Catia	Education
Publications of the Interactive and Cooperative Technologies Lab	University of the Americas Puebla	Unknown	Computers and IT
Redalyc	Autonomous University of Mexico State	Unknown	Multidisciplinary
Academic Digital Repository UANL	Autonomous University of Nuevo León	EPrints	Multidisciplinary
RU-FFL	Faculty of Philosophy and Literature, UNAM	DSpace	Humanities
Digital Repository of the University of Veracruz	Universidad of Veracruz	DSpace	Multidisciplinary
RAD-UNAM	UNAM	Federation	Multidisciplinary
RU-Economics	Institute of Economic Research, UNAM	EPrints	Multidisciplinary
Scientific Electronic Library Online – Mexico	UNAM	SciELO	Science

Table 6.14 List of Mexican repositories in OpenDOAR, registered until September 2012

c) The *Red Mexicana de Repositorios Institucionales* (Mexican Network of Institutional Repositories, REMERI) is a new project of the CUDI. It was formalized in 2011, it has nine members (HEOs) and it aims to integrate a national federation of HEOs' repositories to become a node of the Project BID-BPR (a network of interoperable Latin-American repositories in HEOs).

However UNAMs institutional participation seems to be vanished in initiatives related to repositories. Staff involved with RU-FFL pointed out the internal federation as priority. The RU-RAD coordinator commented:

> *'For now, our priority is to develop UNAM's repository federation. We just got the resources and technical staff to support its operation. However, the decision relies on every department and we work on advocacy to achieve a full internal coverage."*

a) Intra-organizational networks: 3R and RAD

A meaningful antecedent is the 3R project, which began as part of a funding scheme for applied research projects within the UNAM between 2005 and 2008 (Galina & Giménez, 2008). A steering group was integrated by members of the DGTIC, the Library, the Biology Institute and the Centre of Applied Sciences (Guzmán et al, 2006). A year later, in 2006, an official proposal was presented. It aimed to explore approaches to solve the visibility and scattering of digital resources and design a model of implementation for a network that integrates all university repositories (Galina & Giménez, 2008). The 3R project was structured in four main phases (Guzmán et al, 2006):

a) Exploratory research on international case studies, available technologies and protocols for information exchange; as well as cognitive behavior of users and usability (Guzmán, Arredondo et al., 2006).
b) Conceptual model design: it was developed with the description of the operative and technology architecture, including documentation and implementation guidelines. In this phase the DSPACE and FEDORA were evaluated, the second was selected (Guzmán, Arredondo et al., 2007).
c) Systems and application development, in particular the administration based on FEDORA and the user interfaces were set up. Population policies were defined and some adjustments were performed to comply with the Dublin Core metadata standard (Guzmán, Quevedo, Arredondo, Aguirre, & González, 2007).
d) Implementation of the prototype in which the module are integrated to be intercommunicated (single front-end for the federation). This stage involved the evaluation to analyze the technical effectiveness and efficiency (Guzmán, Arredondo, & Aguirre, 2008).

The 3R Project was finished because of organizational and administrative process. The evaluation stage could not be performed on a fully functional prototype and therefore the project cancelled once that the funding finished (Rusell, 2011). During the last phase of the 3R, two repositories (one of them RU-FFL) were established in faculties that support them (economically and administratively) (Rusell, 2011).

By the end of 2008, a renewed project began and was called *Red de Archivos Digitales* (RAD, Network of Digital Collections). As already mentioned, RAD is based on the use of international standards for research repositories and such initiative has used them to enable the operation of the federation. New objectives were defined as part of this "second" release (Galina, 2008):

- Increasing the visibility of UNAM digital collections, through improving the discovery of external search engines.
- Providing digital infrastructure to academic departments in order to enable the storage, management and dissemination of their resources.
- Supporting the implementers with the improvement of usefulness, operation and applications of digital collections through the design of new tools.
- Promoting the generation of indicators to prove the relevance of the academic work with repositories.
- Setting up a university cyberinfrastructure.

This list of objectives translates the new priorities of the network, which distributed responsibilities among all members of the network. In this way, the central funding is used ideally to finance the federation and to provide technical support to the individual members. But in reality, the lack of resources is still a barrier to maintain the requirements of the federation.

A main difference between 3R and RAD was not only the access to budget. A more institutionalized structure was developed and the new hired staff included a coordinator, programmers and several consultants.

b) Organizational policy and strategy

In order to understand the organizational context of the repository operation, a detailed review of the internal policies and strategies was planned for this case study as well. For this purpose the analysis was performed at two levels: first, at the whole institution and second, at the department level.

During the data collection phase, a series of regulations were provided as complementary material. Those policies and guidelines are mostly detailed extensions of the main statutes, which were written since 1945 and updated in 1990 (UNAM, 1990). Considering the assumptions about the adoption of eResearch, the following regulations were selected to be analyzed and to find content related with repository operation of open access initiatives.

Subject	Regulations
Institutional organization	Regulations of the Directors and Schools' Board (UNAM, 1998) Internal regulation of the Technical Council of Scientific Research (UNAM, 2011) Internal regulation of the Technical Council of Humanities (UNAM, 1986b)
Research staff	Statue of the academic staff (UNAM, 1985) Regulation of security and coordination on Health Research (UNAM, 1989)
Research activities	Regulation of Editorial Activity (UNAM, 2006)
Publications	General regulation of the library and information systems (UNAM, 2010) General regulation for editorial processes and distribution of publications (UNAM, 1986a)
Online communications	Guidelines of the Advising Council in Information and Communication Technologies[40] (UNAM, 2012b)
Repositories	Check list for digital repositories (DGTIC, 2012)
Transparency	Agreement for the transparency and access to UNAM information (UNAM, 2003)

Table 6.15 Analyzed regulations

[40] It includes guidelines for web usage (usability, visibility, accessibility and statistics), structural (corporate image guidelines), technologies (animations, codifications standards and support) and institutional accounts in social networks.

Table 6.16 shows that most of the material does not to include aspects related to repositories. Only the Checklist for Digital Repositories (DGTIC, 2012) addresses in concrete good practices for repository operation in the research and academic departments. These guidelines by the DGTIC are mostly concerned with the use of the corporate image and a standard use of the domain's name, as well as with the use of indexes, generation of statistics and the registration conventions (DGTIC, 2012). After a detailed analysis, no evidence of a relation with repositories was found in the other reviewed documents.

At the departmental level, the main local policy is the general regulation of the Faculty of Philosophy and Literature (FFyL-UNAM, 1956). But its content is also mostly related to the unit's main aspects of operation and structure. However not further evidence was found about repositories' regulation.

A second aspect covered in this study is the organizational strategy, as enabler or barrier of the adoption. In UNAM, strategy is defined at two levels as well: centrally and departmentally. The central strategy involved a document called Development Planning, which aims to specifying and being a reference for the whole institution (DGPL, 2012). Particularly, this document relates to the general usage of IT to a variety of process and applications, including institutional research.

In the *Development Plan 2008-2011* (UNAM, 2008), IT was seen as an enabler of variety of university services and a differentiator within the Higher Education landscape. Such plan outlined strategies for the reorganization of processes, evaluation and services, considering IT current development. Thus IT should have being designed for a higher degree of decentralization that assures more operative efficiency.

Research as core aspect has been linked to the development of adequate infrastructures to be performed in the institution and a line related to the improvement of the digital collections (within the library) (UNAM, 2008). UNAM outlined an strategy that considers internet as a space for the dissemination of research outputs and therefore new initiatives for digitalization and population of collections were started up (UNAM, 2008).

The version presented in 2012 of the UNAM's development plan shows less contentment related to IT and it states:

> *The UNAM will warrantee the best conditions for the creation and dissemination of knowledge. Teaching and research will keep their social and strategic functions. In this way the country gets advantageously adapted to the changes in order to face changes and without dismissing the fight against ignorance, poverty, inequality and injustice (UNAM, 2012i).*

Thus the Development Plan of 2011-2015 aims to assure a top level perspective on IT for research as part of what they call best conditions (administrative, academic and infrastructural) for research's development. In relation to policy guidelines related to repositories, the section about "university management and administration" addresses the need of organizing, planning and evaluating an information system for university's staff. It should assure that research outputs are online and open (UNAM, 2012i). Here the role of the "*All UNAM online*" program is pointed out as well as the need of a second phase initiative called "*Visibility UNAM*"[41] (UNAM, 2012i).

Finally, the faculty has its own development plans. For the period 2009-2013, the FFyL addressed directly the strategic objectives of the repository. The department planned the use of IT as support for the humanities research in virtual spaces and the dissemination of research outputs in national and international environments (FFyL, 2009). Thus the repository was seen as a valuable tool for these processes.

6.3.4. The Adoption Process

The analyzed material shows the adoption of a repository with strong connection to the internal or intra-organizational networks. Internal projects have provided a context of operation that resulted positive to set up initiatives in several academic departments at UNAM. This case study showed that the know-how emerged from the network was accepted (or not) later for the departments. In the case of the

[41] Term used in the RAD network architecture for the federation. See Fig. 6.13

FFyL, a department with strong influence of scholars in library sciences, the adoption was successfully carried out.

Figure 6.14 outlines the process with the related levels (macro, meso, micro and end-user) and the corresponding time. This approach matches the proposed adoption stages with the specific process in the UNAM's academic department. Based on the documents, three networks were identified at the meso level. The first (CATI) was the fundament of the other two programs. This level had very low or not considerable influence in the RU-FFL adoption path, considering that 3R began almost at the same of CATI but later, no one of the UNAM repositories was part of the proposed federations.

The core activity of the adoption process occurred inside the organization. The proposed visualization was not designed to differentiate between internal networks and single organizational units (departments), thus this separation was not directly addressed (at least for the visual display). Keeping the intra-organizational networks at the micro level, the whole process is identified in the correspondent level for comparative purposes later in this work. This situation is understandable considering that the observed unit of adoption is the department (FFyL). At the micro level, the project 3R was the result of the cooperation between several university units to explore the implementation of a federation of repositories. And at that time, a set of criteria was defined:

- A free open source solution
- Evidence of implementation in similar federations to 3R
- Last generation of repository technology and extension towards semantic web

Initially, FEDORA and DSpace were selected as suitable solutions to be adopted as network standard. The general arguments in favor of the two options were (Guzmán, Arredondo et al., 2007):

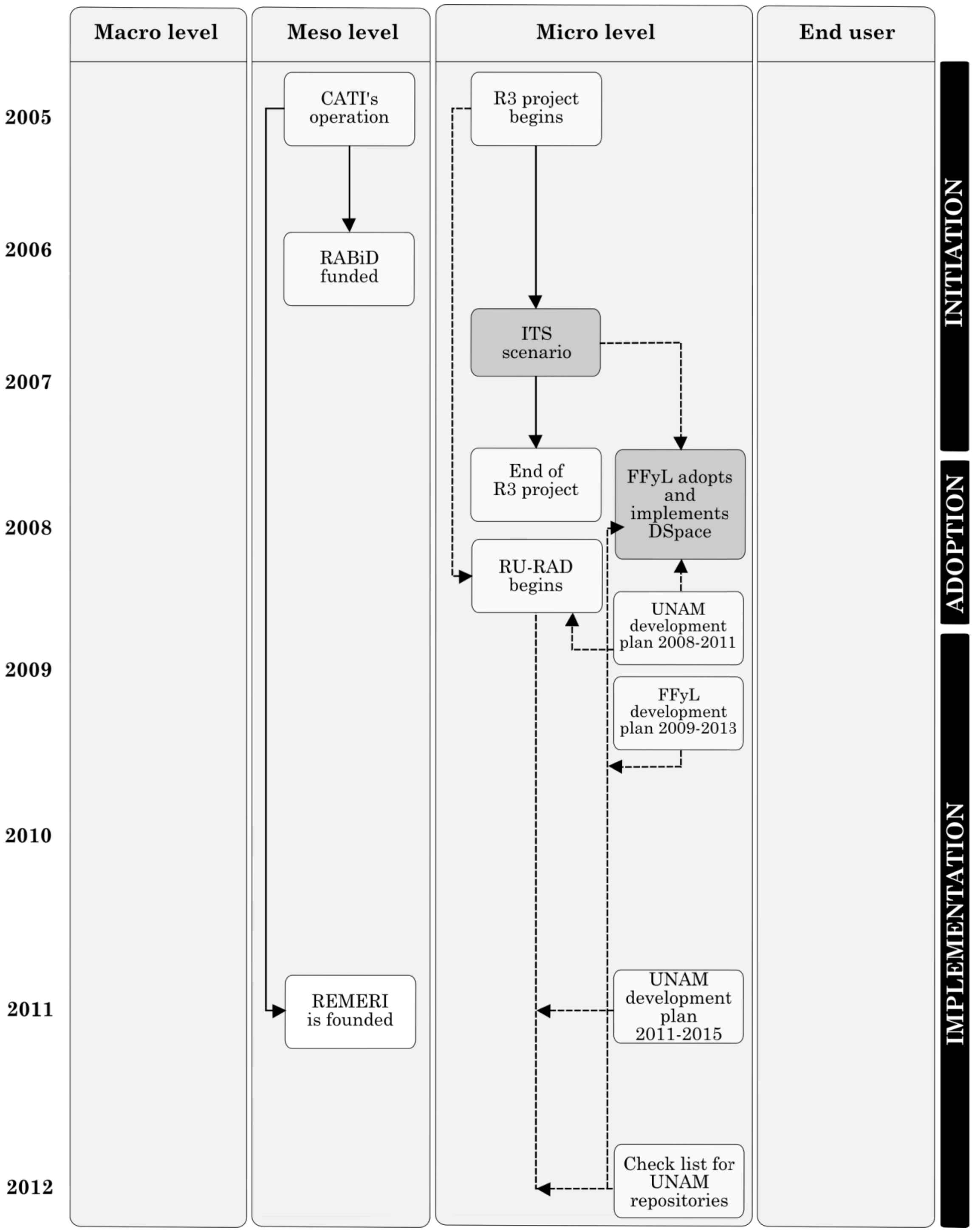

Fig. 6.14 Repository and related ITS' adoption timeline

- DSpace: a free open source solution ready to use and with minimal requirements of additional software. Widely used, this tool allows dedicated customization to meet specific local needs.
- FEDORA: a free open source solution with an abstract working model that allow a variety of customizations and full interoperability with other external systems. Its development moves towards semantic web but it does not have pre-programmed interfaces for basic repository functionalities.

The 3R project decided finally on FEDORA to research a more novelty technological solution, considering the research orientation of the project. Thus the potential of the tool aimed to be explored as well.

Once the project finished, the FFyL implemented DSpace as standard software for the repository. The selection of this standard software was influenced by a previous analysis performed as part of the 3R project. At the department, the project was welcomed by the Faculty's dean, who received the proposal from of one of the 3R members and assigned the required material (server) and human resources (a full time repository manager).

The hired manager was former member of 3R and used the produced knowledge to decide on suitable software that might standardize the publication process of research outputs in the faculty. According to the Repository Manager, the assigned resources were very limited and on that time, technical support services were not available. However, management support was core for the start-up of RU-FFL, as it is referred by the Repository Manager:

> *'Every project at UNAM is a very difficult bureaucratic issue, when he (the Dean) authorized the server and I got one. Thus a project can survive in this context you require real support from the decision makers: finances, salaries, support… and having the average resources to operate: a server, technical support – which we had, but very limited."*

In spite of a defined criteria listed by the 3R project and the selection of FEDORA, the repository management decided on DSpace because he had an initial perception about its relative easiness and stability. Considering that he is a librarian and not a formal IT professional, there were some technical barriers that complicated the process (although the selected software was the "easier" solution).

The implementation did not involve directly and systematic support of the former IT unit, because this service is not part of its catalogue and demands of IT support are very high. From this perspective, the change from FEDORA to DSpace as a suitable software can be understood due to the technical limitations; but the diagnostic on the technology previously considered DSpace as compatible. Then it is possible to establish that although the ITS scenario differed at the software level, the main criteria prevailed (technical standards, i.e. metadata, harvesting), but the organization (department) standard software was decided from the available options previously outlined.

Later the evolution of 3R as RU-RAD brought the implementation process to a new level. With formal institutional support at the department level (FFyL) and the whole organization (UNAM), the new RU-RAD began with a more supportive organizational environment that cultivated a new cooperation network of department repositories. The RU-RAD coordinator explained this change:

> *'The 3R project did not survive. A time later it restarted again. It was taken by the DGSCA, now called DGTIC. Now there is IT staff, we are now a group. We meet and have infrastructure."*

Such new context was influenced by generated know how about DSpace and it was a strong factor to select DSpace as a recommended good practice for department repositories. By deciding on DSpace, the new adoptions profit from:

- Compliance to international standards (emphasis on OAI-PMH as good practice)
- An internal network of expertise (informal assessment)
- Availability of internal documentation in Spanish
- Warrantee of compliance to the federation's technical requirements

The growth of the RAD network and the establishment of institutional policies on visibility of research outputs have impacted positively. Until August 2012, RAD had integrated new IT staff for technical support and further developments for the federation. Despite it is aimed to achieve a full coverage (all UNAMs departments and institutes), the assurance of sustainability at the local level remains as a strong barrier.

6.3.5. Structured Analysis

As it was presented before, this case study is also integrated with the perspective of the conceptual model. The analysis through the checklist is the same like the one applied to the RHUL case. Six tables concentrate the most relevant data collected about the adoption process in the FFyL at UNAM.

The environmental conditions are described in the two first tables. For this case, the evidence suggested a strong influence of an internal network (intra-organizational) (Table 6.17). In a phase prior to the adoption decision (at the department level), the network legitimized best practices and a set of criteria that were later decisive for the adoption (DNA). This network was based on a research program, a community of committed members (EC) was cultivated and they motivated early adoption in their departments, at least in the FFyL (although the network was inactive during the formal department decision and initial implementation). As already mentioned, the generated know-how and a supporting community were a condition during the whole adoption process that was formalized later with the choice of standard software (DSpace) recommended by the network (SBS).

The other environmental category refers concretely to the standards catalogue (Table 6.18). Specifically the current framework refers to HEOs network (not the internal network formed by organizational units). As already mentioned, DSpace is the most adopted repository tool and organization standard for research output storage in Mexican HEOs (HNA). This fact was part of the adoption context during the process, but no evidence suggests that it was a core enabler of the process. On the other hand, the initial low expertise of the implementer (repository manager) required a strong reliance on software documentation and the cultivated community inside and outside the campus (SSI), especially for the adoption decision and implementation. The knowledge about the tool was already existent and communicated by the 3R's researchers, thus there was a higher influence of internal communication channels. But the tool had external (and international) dissemination mechanisms too (DS).

	Aspect	How	When*		
			In	A	Im
1.1	The standard is supported/required by a domain community (external pressures)	• **Domain network actions (DNA)** •3R / RU-RAD	✓	✓	✓
1.2	The standard has a critical mass within the domain	• **Extended coverage (EC)** •Internal network of experts •DSpace community •RU-RAD community	✓	✓	✓
1.3	The standard is a IT product used as organizational unique solution or is embedded within an IT product with critical mass	• **Standard based software available in the market (SBS)** •DSpace as standard software	✓	✓	✓

Table 6.16 Checklist of the domain context

*Legends: In=Initiation A=Adoption Im=Implementation

	Aspect	How	When*		
			In	A	Im
2.1	The standard is used by other HEOs	**HEO network actions (HNA)** •DSpace is the most used repository software in Mexican HEOs •DSpace was being implemented in other department at the same time.	✓	✓	✓
2.2	The standard is communicated/disseminated	**Dissemination of the standard (DS)** •Well known solution for the repository community	✓	✓	✓
2.3	The standard has external support (documentation, consultancy, communities)	**Support for standard implementation (SSI)** •Online documentation •International community (also in Spanish)	✓	✓	✓

Table 6.17 Checklist of the external ITS catalogue

*Legends: In=Initiation A=Adoption Im=Implementation

About HEO's structural aspects (Table 6.19), the collected data suggests that the strong decentralization (because of the organization's size) was a strong factor. HEO's decision making processes relied strongly on the unit's understanding (OC) about its own academic, research and administrative needs. However, central organizational structures like the Technical Councils and the central IT department influenced one part of the decision making process (through policy and evaluation). The 3R project was a materialization of the HEO structure for research support and became core as initiation. Later, the role of the IT services enabled the articulation of the RU-RAD network (RSU).

The adoption of the repository tool as standard was performed by the department (RqU) during the whole process. But it turned even more relevant once that the decision had to be made and during the local implementation. The openness of the adoption unit was evident because of the participation of department's researchers and scholar in the 3R project. However, such openness covered more importance when the project was presented to be supported by the dean.

Aspect		How	When*		
			In	A	Im
3.1	HEO structure for research support	**Research support units (RSU)** • Technical Council, departments, IT services	✓	✓	✓
3.2	HEO structure is decentralized (coordination mechanisms)	**Organizational coordination (OC)** • Departments	✓	✓	✓
3.3	HEO has available resources to support the standard	**Organizational support (OS)** • Resources are determined by the department	✓	✓	✓
3.4	A HEO unit requires the standard for a (specialized) task	**Requiring unit (RqU)** • Department	✓	✓	✓
3.5	A HEO unit is open to adopt the standard	**Receptive unit (RpU)** • Department • Later: internal network	✓	✓	✓

Table 6.18 Checklist of the structure

*Legends: In=Initiation A=Adoption Im=Implementation

Contrary to the other case, central IT services did not play a role in the early stages of the ITS adoption in the RU-FFL. The decentralization structure of UNAM situated the process mainly at the department level and therefore the relation of between IT units and central IT services was not supported (4.1 in Table 6.20). In spite the catalog and policies of the IT central services (eRS) were part of the context, such situation has being significant in the last stage (once that ITS were already routinized). The installed base was not a barrier to the adoption since the resources were acquired (ITRA) by the department. About the expertise, IT units and staff might have the technical skills to deal and to support the standard (ITSS); but they provided formal technical support in later stages of the implementation (central IT department, not department IT units).

	Aspect	How	When* In	When* A	When* Im
4.1	Formal relation of the IT units with HEO's central IT department	Yes, but out of scope. Not supported			
4.2	HEO's IT organization tacitly supports research	• **eResearch Support (eRS)** • Policy, programs and projects	✓	✓	✓
4.3	Installed base capabilities support the standard	• **IT resources assurance (ITRA)** • Acquired resources		✓	✓
4.4	IT units have the skills to support the standard	Not supported			
4.5	IT staff has skills to deal with the standard	• **IT staff skills (ITSS)** • Provider support and training			✓

Table 6.19 Checklist of the IT infrastructure

*Legends: In=Initiation A=Adoption Im=Implementation

Strategic aspects in the HEO were also part of RU-FFL adoption process (Table 6.21). Some evidence was found in the four operationalized aspects of this category. In spite the formalization practices, not relation could be established between documentation practices and the early stage of the adoption. However the conformation of the federation was a sign of technology formalization managed centrally (FD). Supportive policies (SP) and strategies (SS) emerged after repository set up at the department and whole organization levels.

	Aspect	How	When* In	A	Im
5.1	The HEO tends to formalize and centralize	• **Formalization and documentation (FD)** • Policies and strategies are documented	✓	✓	✓
5.2	The HEO developed a policy related to the standard	• **Supportive policies (SP)** • Check list for repository			✓
5.3	The HEO's strategy is open to the standard	• **The standard in the strategy (SS)** • Strategies (2008-2011/ 2008-2013) support adoption.			✓
5.4	The HEO considers IT as strategic	• **IT in the strategy (ITST)** • IT infrastructure referred in the strategy 2009-2012			✓

Table 6.20 Checklist of the strategy

*Legends: In=Initiation A=Adoption Im=Implementation

Finally, the last category of analysis involves the managerial actions that support the standard and their effects (Table 6.22). As already mentioned, dean's support was core to begin the repository project at the faculty level and the technology champion (afterwards, the former repository manager) was crucial to bring the know-how of the 3R project (MS). Some central support was available for the initiation stage in the form of a research project (not addressed as a standardization process). About the control mechanisms of the standard, the decision implied basic administrative reporting to the faculty board about the progress of the project (MSP). Some analytics are periodically required by the HEO's central administration, by the network and at the department level in order to evaluate the visibility of the resources (efficiency of the standard use).

	Aspect	How	When*		
			In	A	Im
6.1	Management supports the standard	• **Management support (MS)** • Dean's support • New repository manager hired		✓	✓
6.2	Managerial actions occur to control standards performance	• **Management and standards performance (MSP)** • Periodical reports for the academic board			✓

Table 6.21 Checklist of the management

*Legends: In=Initiation A=Adoption Im=Implementation

This structured analysis supported the model as well. Considering that the organizational adoption context was different, the model was able to track each set of factors in the adoption process. The next section provides offers a cross analysis to bring together these results as well as some initial conclusions on the adoption context in each one of the analyzed HEOs.

6.4. Comparative Analysis of the Cases

This final section aims to present a comparative analysis of both cases characterizing their concrete situation. Using the checklists (as operationalization of the model), the specific adoption situations were compared in order to identify commonalities and to find an explanation of possible differences. The framework build through the model will be used in a comparative manner to assess the adoption process too. It is claimed that by isolating and analyzing the concrete core factors, it is possible to evaluate those that influenced every phase within the two different organizational contexts.

The section is structured in a way that after profiling the adopters, the cross analysis can be more precise considering their differences. The cases with the two HEOs will be referred from here on as case A (RHRO-RHUL) and case B (RU-FFL-UNAM).

6.4.1. Adopters' Profiles

The two selected research HEOs matched the sampling criteria, case A as a central implementation and case B as a departmental implementation. Beyond geographical differences, some relevant aspects were: organization size and character (private/public). The first can be defined based on the total number of employees in academic/research areas, which is 2,000 in the Case A and 36,000 in the case B. Such difference is significant to understand the creation of intra-organizational networks in case B. From the management point of view, departments facilitate the administration of services for a big amount of personnel (1,000) and at the same time support a disciplinary logic. Thus, it can be expected that bigger HEOs tend to decentralize processes and each department can be an adoption unit within or not an intra-organizational network.

The second aspect is the character of the HEO. In spite of budgetary issues are not covered in this work. The evidences in the cases suggested more flexibility in the decision in case A, which is a private HEO. During the interviews, the struggles with budget were considered a barrier but the selection criteria favored a proprietary solution. On the other hand, Case B is result of an analysis that took into account financial sustainability. Knowing that departments might face budgetary issues, the choice toward open standards and open source software were a condition for technology pre-selection.

6.4.2. Adoption Factors

In the presentation of the single cases, an analysis of the factors was performed at a descriptive level. Such factors are referred in this section again considering the adoption phase. A compact visualization of the factors is presented in Fig. 6.15 (case A) and 6.16 (case B). The purpose of the visualization and how it contributes to the analysis was already explained in Chapter IV. With this tool, the interpretive work of the last sections is summarized.

a) Environmental factors

In the analyzed domain of eResearch (repositories), the so called good practices were identified as de facto standards with a critical mass within the domain (ITS network). For this reason, they tend to be embedded in IT products with their own critical mass. In both cases, the selection of a different software (to the one used in the network) was possible because of such de facto standards. The behavior of the domain networks was very similar in both cases, since it is shared. In relation to the HEOs' own networks, both cases A and B involved contact with them. HEOs carried out the standardization process in relation with a network. But it should be noticed that two different types of networks were identified:

- Case A: Inter-organizational network, integrated by the members of a university federation grouped into a consortium that supports a set of ITS.
- Case B: Intra-organizational network, integrated by academic departments who share implementations with the ITS (federation).

In ITS research, the work on networks effects has been widely studied and the empirical data validate the relation between standardization and the networks. However, the focus on process used in this work suggest a continuous presence and of the networks but with a strong influence in the initiation stage. Since the implementation runs local in both cases (and no performance controls are carried out); the influence of the networks remains but not as critical.

The external ITS catalog consisted of factors with different emphasis in each part of the adoption process. In case A, the change of the software implied a difference because the network's software was not implemented. While in case B, the federation emerged in the late implementation phase but other related HEOs had some experiences at the time of the decision.

The core influence of the standard's dissemination occurred in different moments as well. It depended on who collected the information about the standard and if local implementation met this knowledge base. Case A relied on their own tender to get to know their software, while case B used the same knowledge base (although a different software). Support was, in both cases core for the decision and the implementation.

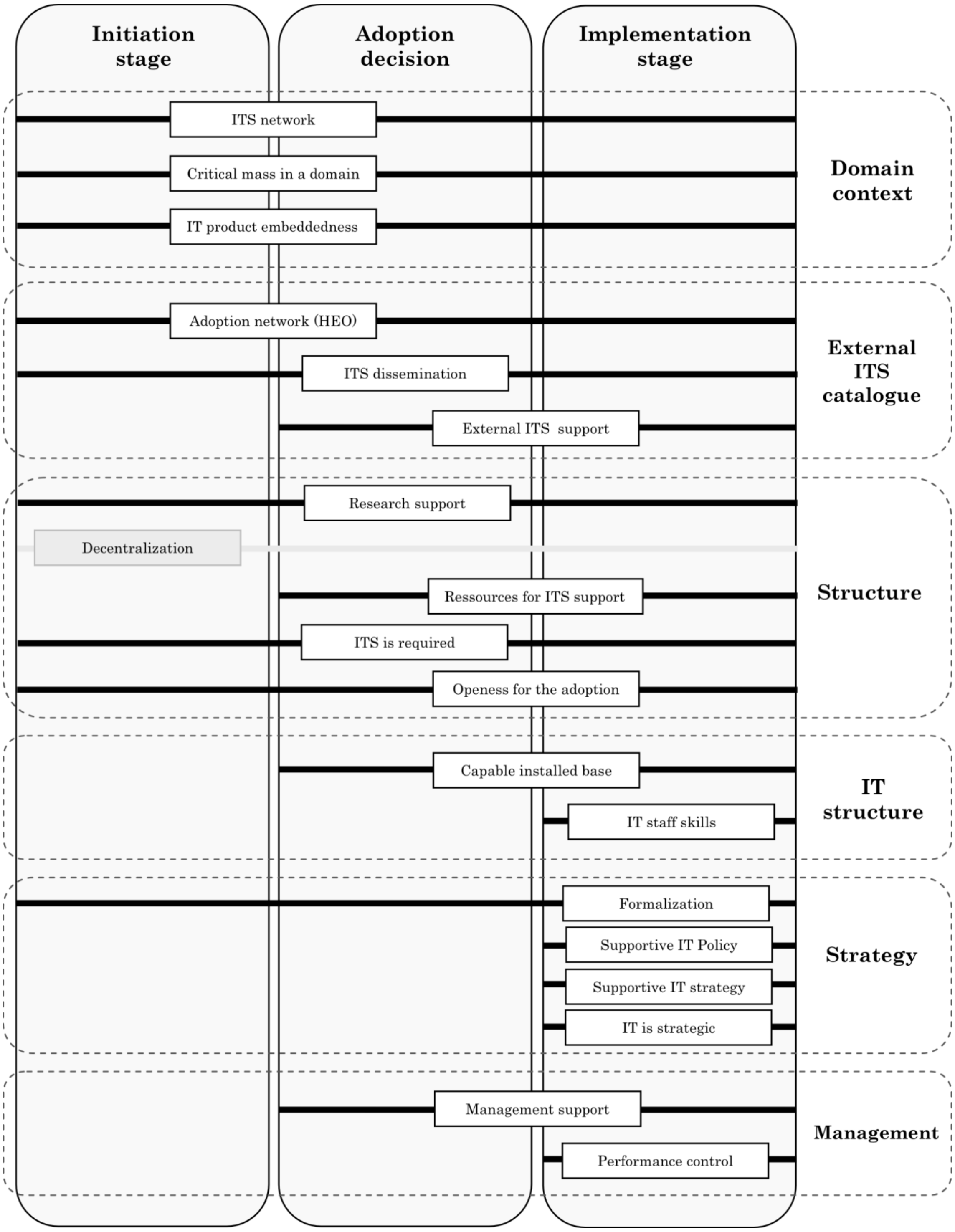

Fig. 6.15 Overview of factors in Case A

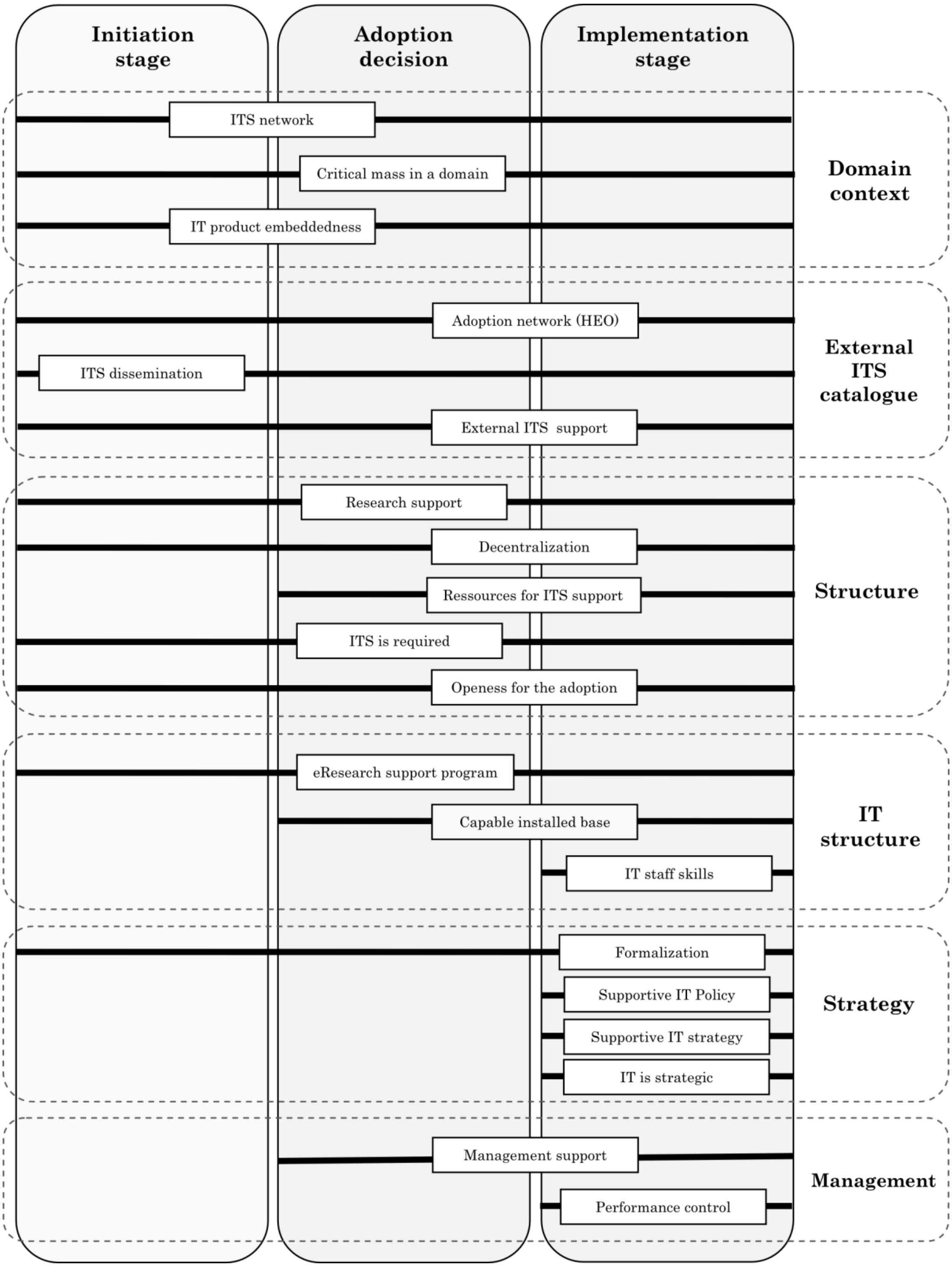

Fig. 6.16 Overview of factors in Case B

b) Structural factors

The structural factors (general and IT in concrete) refer to the concrete status of organizational units during each phase of the adoption process. Basically, all these factors were a stable part of the adoption context. But a significant difference was the eResearch strategy: in case B, concrete services were established for user with a research profile; and in case A, the service orientation did not differentiate eResearch services and only identified service requirements. In both cases, institutional support to research activities was considered an organizational priority and specific organizational structures were generated for governance (e.g. research committees).

A second difference to analyze was the influence of the decentralization. In case A that was not a factor (although there are decentralized IT units) and in case B defined the decision maker of the adoption (department). As already mentioned, organization size can be linked to decentralization and the organization of IT services according to such structure conditions.

With a latent need of the standard, organizational structures and IT infrastructures were relevant for adoption decision and implementation. In both cases, the specific technical capabilities (i.e. hardware) did not exist previous to the implementation and equipment was acquired to support the process. In case A, the provider was responsible of setting up ITS and training the IT staff afterwards. Staff's skills and the provision of IT support in relation to the ITS was an issue in case B; although the implementation was successful, some security issues were not easily solved and the service could not be provided for several months. Such incidents difficult the adoption, but the decision had been already made. Further research could inquire about the influence of staff training and the effect on the quality of ITS functionalities.

c) Strategic and management factors

Strategy related factors were placed almost exclusively in the implementation phase of both cases. The adoption timeline suggests that policies and strategies were mostly reactive or happened after the adoption decision. However the situation of a CRIS adoption in case A was different, because its implementation was preceded by policies, strategies and planning defined in advance. It should be noticed how the ITS were managed in both cases. In case A the decision was top-button and centralized through the joint requirement of the Library, the Research Committee and the IT department. On one hand, the Library aimed to continue with a standard service provided by an intra-organizational network; and on the other hand, the IT department planned a re-structuring process of the IT architecture. However a policy framework was properly formalized once that the eResearch system was technically available.

The role of management was valuable for both HEOs. With the adoption decision and the provision of the repository service, dedicated management staff was hired. The repository manager supported the implementation in both cases and performed the technical decisions in B. As already mentioned, the dean (top manager) in case B was especially supportive with the project and, in cooperation with the repository manager, early adoption was possible (in comparison to other departments in the HEO). Here, the decision was button-up (decentralized) and the adoption of two departments began a network that later was institutionalized (federation) using their implementations as standard practices. It implied that initial management practices began and remained local; but, with the formalization of the intra-organizational network, a federated structure was created to warrantee some minimal requirements to achieve interoperability.

The decision making processes enabled by the organizational structures and the stage adoption process by itself (in implementations within an organizational network) were significant in both cases. In case A, the IT service orientation enabled a more integrated solution within the whole campus infrastructure. When the repository service was required, the provision was seen as an opportunity to rework current workflows towards a new eventual CRIS implementation. This strategic view about the provision was possible because it was conceived centrally. Contrary, in case B there was previous work but the first implementations were conceived locally. Such local know-how was valuable and the software turned into a network standard when it was transferred. Of course these implementations tended to be isolated from the central campus IT management and although governance emerged with the network, decentralization empowers local managers' decision making.

6.5. Some Generalizations

In general, it can be affirmed that the behavior of the factors showed similar tendencies in both cases. In spite of some minor differences emerged because of the adoption unit and the type of adoption process (centralized/decentralized), it is possible to generalize some conditions that tended to enable primary standardization in both cases:

1. Involvement with one or more close networks that communicate and look for standard comply
2. Involvement of at least one HEO unit in the process
3. Perception of the adopter unit about the ITS (as good practice within a domain).
4. The implementation of an IT product that complies a set of technical standards and has a critical mass.
5. The acquisition of IT infrastructure elements (human and material), required for ITS implementation.
6. Involvement of the IT central department.
7. Knowledge support for the technical implementation of the standard (through staff training and communities of practice).
8. ITS as a solution for HEO activities (e.g. research) recognized as strategic for the whole organization.
9. Top management support.
10. An ITS management framework linked to HEOs policies and strategies.

These 10 points were observed (in some degree) in all cases and their insertion in some of the process resulted critical to assure specific adoption conditions. Consistent with the model, points 1 to 4 are environmental; 5 to 8 are structural and 9 to 10 are strategic.

CHAPTER SEVEN

7. Conclusions

The benefits of standardization are the drivers of organizational efforts to achieve compliance. In IT, standards allow functionalities and levels of operation that are possible only if the solution is uniform and repeated. Based on such assumption, this work aimed to contribute to the body of knowledge about standards and at the same time, to offer an analytical approach that could guide tailor-made management. In particular, ITS adoption was researched at the organizational level, called primary adoption. It implied a close analysis of the processes and conditions that could influence to accomplish the goals of the standardization in organizations.

This dissertation has focused on the specific conditions of the eResearch domain. It has given account of the adoption context at the organizational level and explained how the process occurs in HEOs. Thus it set out to determine the conditions of ITS for eResearch as part of the campus infrastructure. The relevance of this domain is evident because of the impact of the IT infrastructure and its standards on researcher's work practices. The goal was to determine how the adoption process of ITS for eResearch occurs in HEOs. Through the development of a research model, a series of factors were articulated in each phase. The application of the case study strategy in two HEOs allowed to identifying the incidence of the factors and their behavior.

In this last section, the main findings of this work are summarized and it is clarified how all research objectives were achieved. Together with the contributions to theory and practice, the last part of this chapter presents a reflection on the limitations of this research and future research directions in these fields.

7.1. Research Findings

This work was designed to study IT standards for eResearch in HEOs. After a detailed literature review, the following main question was established:

> *How does the adoption process of IT standards for eResearch services occur in Higher Education Organizations?*

The question implied the analysis of the primary ITS adoption process from the IS perspective. According to Thomas (2010), the research on adoption is one of the four directions in this area and focuses on the organizational decisions and processes behind the ITS selection and standardization processes. And on the other hand, such deep understanding of adoption was applied to a specific domain: eResearch in HEOs. In order to answer the main question, the following objectives were defined and achieved through the course of this research:

O1. Build a conceptual model that explains ITS dynamic adoption at the organizational level and specifically for eResearch services in HEOS.

O2. Identify the organizational factors that shape the adoption context of compliance in HEOs.

The O1 required a series of steps defined as part of the research strategy. The first was the extensive literature review on IT and ITS adoption to build a solid theory based model. The outcomes of this first part of the process were a qualitative meta-analysis of factors and an abstracted model.

The objective O2 consisted on the operationalization of the model with the identified factors and its application to the adoption process in two HEOs. The main contribution was an analysis of two primary adoption processes through the use of the model, and a list of guidelines emerged from the comparative analysis. For this purpose, case study was chosen as strategy for data collection and a way to test if theory could be identified in practice.

About content and concrete outcomes, this work recognized relevant aspects and practices for the ITS field. Such contributions to this research area are extensively detailed along this work and the next sections summarize the main achievements. The secondary questions are used as reference and a way to present the outcomes of this work:

Q1. How does the IT standards adoption process occur at the organizational level?

The pertinence of the categorization according to "levels of the adoption" was confirmed and it contributed to distinguish among different adoption environments. At the organizational level, two different processes were identified based on the decision making unit: central adoption and decentralized adoption. The first implied an organization-wide coverage of the standard, while the second takes place within one or more units/departments. The processes in both cases showed the influence of a series of factors that were grouped in three main groups: structural, environmental and managerial. Such factors were placed in a three-phase process based on the broadly accepted model of organizational adoption by Rogers. The results showed a more precise understanding of the factors based on the process perspective.

Q2. How are organizational ITS standards managed in HEOs?

An initial preconception of this work was the central control over all ITS management (through distributed IT units). However the evidence showed different management and decision making procedures in both studied HEOs. Considering the analysis of one centralized and one decentralized adoption processes in HEOs, some differences were identified. In the first, the scope of the adoption is organization wide and the adoption was strategically linked to top level strategy. This centralized process involved governance structures and decision making processes that were defined depending on the project: while universal campus IT infrastructure was managed by IT services, large scale special services are agreed by top level structures (committees or boards) and through a commission. Some eResearch services belong to this large scale implementations and their ITS involved several units. Thus ITS management followed the same path: universal ITS are a technical decision by the IT central department and large scale ITS for eResearch tend to be decided by the involved boards.

The decentralized adoption process exhibited a delegation of the decision making to faculties for the dedicated eResearch services. The central IT department kept the control over universal IT services but some *special* eResearch services were managed directly by the faculty structures. The analyzed decentralized adoption process, showed, however, a federated management structure built after the first system implementation. The creation of a federation is another central management structure that took control over ITS decision, but it got influenced by early implementations and will influence the subsequent.

Q3. How can different ITS adoption factors be identified in each part of the adoption process?

This work was based on the construction of a conceptual model, which required a systematic literature review and a meta-analysis. The work with theory and research production in the ITS field allowed a first identification of adoption factors. Those factors were classified in six paired categories: ITS external catalogue/IT domain policy context, structure/IT infrastructure, and strategy/management. Based on the approach tested successfully with ITS by Thomas (2010), a detailed checklist was developed based on the model. Then, by using a process approach (well known in innovation research), a novelty perspective for the model was developed. The factors were chronologically placed in independent timelines (separated in adoption stages).

With this approach as basis, the case study strategy was designed and with an interpretive approach, the collected data was coded considering the adoption phase. Particularly relevant was the contact with the interviewees, because they supported the understanding of the collected documents, but in particular the informal interviews helped to make sense of the adoption process and the perception about the possible influence of the factors.

Q4. Which organizational factors enable ITS adoption in research organizations?

The conceptual model was applied in two case studies of two primary adoption situations (centralized and decentralized). The collected data was analyzed and three categories of factors were tracked. The analysis of these factors showed their incidence within the sample and therefore, their pertinence for the ITS adoption research. Main observed behaviors based on the factors were the following:

- Networks were relevant for ITS diffusion and subsequent adoption in intra- or interorganizational organization (network effects).
- Specialized IT products (with a set of embedded ITS) that comply specific domain requirements and have critical mass in an adopter community are more likely to be adopted.
- ITS documentation and support were core criteria for adoption and implementation.
- HEO's size was an indicator of decentralization: the small university tended to centralize more that the big university.
- The adopter unit involvement is one indicator of the adoption scope of the standard. Adoption by central units (e.g. library and central IT department) tended to imply organization-wide adoption.
- Central IT department involvement changed according to the scope of the adopted ITS.
- ITS are related to the support of an extended HEOs task. It means that a process is continuously repeated by several users and the organization uses a uniform solution to achieve a set of functions, including cost savings, integration, interoperability, etc.
- Required infrastructure for the ITS was acquired to support its operation.
- Top management support was present in both cases and was core for the adoption decision.
- IT system (and ITS) administrator was a mechanism to perform daily operative management. HEOs assured ITS performance through skilled personnel on charge.
- HEO's police was established at certain point of the adoption process as organizational mechanism to legitimize the ITS.

Factors involved on building the list were set within the adoption process timeline. Some of the factors were structural and remained stable during the whole process (because they are essential and part of the organization), while other were defined as significant in certain phase. For example policies were mostly reactive to the implementation and that can be interpreted as formalization procedures to extend and legitimize ITS operation.

7.2. Contributions

This part of the conclusion offers a reflection on the impact of the research presented here, as an academic contribution to a body of knowledge and as insight for practice. In his work, van Wessel(2008) suggested that the contributions of a dissertation should be separated in two levels: theory and practice.

a) Contributions to theory

In first place, these findings enhance the understanding of ITS adoption field. Considering that there has been little discussion about organizational ITS adoption behavior, this work addressed the topic from the process perspective. Several studies have produced quantitative and cross-sectoral insights, but there was no evidence about similar works that established a relation between the adoption as process and how factors can be dynamic. Trying to situate the factors into specific phases was considered relevant because it could provide a perspective in which the factors are not static through the process. Trying to build an abstraction of such behavior was considered a novelty perspective in ITS research and a promising direction to deal with the "black box" of ITS implementation.

The second set of theory contributions concentrates on organizations and organizational ITS. The model offered a conceptual and explicative framework to deal with the complexity of adoption at the organization level. Little research work has distinguished the pertinence of creating analytical frameworks specifically for ITS adoption in organizations. These units are relevant considering that primary adoption occurs there and the outcomes tend to address managerial action.

Finally, this work produced knowledge for a specific domain. Addressing the characteristics of specific contexts of adoption helps to a wider understanding of the involved organizations, their structures, processes and tendencies. HEOs were found to be complex adopters with mechanisms that tend to include high profile users (scholars as experts) in their governance structures. The analysis contributed to situate two patterns of adoption (centralized and decentralized) that can be useful to continue theorizing in this direction and towards a clearer map of all the components of HEO's IT infrastructure. In the same way, eResearch as a specific set of eStrategy support (research processes) was introduced as a useful category of analysis, more general and comprehensive than other terms used that refer to IT infrastructure for research. The concrete focus on HEOs' eResearch opened a more integrative approach for IS to tackle the bridge between local and external research IT infrastructures.

b) Contributions to practice

The contributions of this work to the practice of ITS are valuable because of its focus on organizations. This type of adopters are one the main actors that bring innovations and open ITS to end-users. This study aimed to offer a deeper understanding of the adoption that could bring certainty to managers in organizations about the variety of influential factors. In particular by addressing such notion of process, it was expected to bring some awareness on the changing conditions that pressure adoption and how centralized or decentralized adoption process might cope with them.

On the other hand, it was assumed that HEOs' eResearch adoption offers new insights to the practice, considering that the amount of available literature is still incipient. Key decision makers in eResearch adoption can profit from research on ITS because of the benefits that standard solutions bring to campuses. The model, as insight to the practice, is based on a deep understanding of this domain and could bring a closer perspective to HEOs specific needs and concrete implementation requirements.

Both types of contributions (for theory and practice) cope at the end with the production of knowledge on eResearch and ITS. Research driven IT management can have in this work empirical evidence to develop better decision making tools that increase the success rate of adoption process in their organizations.

7.3. Limitations

Some limitations need to be noted regarding this dissertation. The research project was limited in several ways, particularly related to scope (linked to a broader understanding of sociotechnical systems) and design aspects. First, this work is entirely focus on primary adoption in organizations (and organizational factors), which implied that although secondary adoption (end-users') is relevant, it required other instruments and research strategies. But instead, the author focused on a closer view on formal structures and discourses in which standards operate and that management can strategically build and influence. Second, the emphasis on organizational ITS (in compliance with other external standards) is a specific type of standard within an organization. Because of the focus of this work, further studies could test the generalization of the model to other types of ITS. Third, the application domain can be considered a limitation from the ITS research perspective, because the model was operationalized based on eResearch and HEOs characteristics. And fourth, the selection of repositories as organizational ITS (and their embedded technical standards) limits also the score of the process that might be different for other eResearch services. Based on the available information it was not possible to generalize that the all adopted ITS for eResearch will have the same behavior, because they might involve other decision making processes and governance structures.

Besides the design aspects, the findings of this work are subject to at least three methodological limitations. The use of multiple case studies can be seen as a way to achieve external validity; however the selected cases achieve theoretical replication and they are not statistically significant. Case study as strategy offered an adequate perspective to collect a variety of data about the complex process of adoption, however further work needs to be done to test the model in other environments that extend the scope of the outcomes presented here. Other methodological limitation is the sampling because, although the HEOs were selected based on the type adoption process (centralized/decentralized), it was not possible to establish a theory-driven typology of campus eResearch strategies. This aspect limited the establishment of prior assumptions between HEOs organization, campus IT management and eResearch Strategy; then such assumptions and linkages were established a posteriori based exclusively on the empirical evidence. Finally, during the case study selection and in a preliminary pilot-study it was noticed that research on retrospective adoption process is problematic. The contact with staff involved during the adoption was difficult, since they were not employed at the HEO anymore. For this research it was evaluated if documents might be enough to build the cases, but it was determined that the contact with main actors was required to assure the reliability of the interpretive process and to achieve internal validity in the cases. Thus in spite a different sample was initially chosen, the active involvement of the informants in the adoption decision and implementation was considered as a priority for the quality of the sample.

7.4. Future Work

The mentioned limitations are more than just restrictions of this work. They point out new research directions that can continue the issues identified in this dissertation. Further studies are needed to thrown up new questions in different scenarios. The possibilities that emerge from this work can be separated according the main topics of this work: eResearch, Adoption and IT Standards.

eResearch is a field full possibilities for the study of IT in general and ITS in particular. In this work, a model that fit to this domain was proposed and applied to the repository services. It is recommended to determine the applicability of the model to other eResearch technologies and ITS, that might involve different decision making procedures, tasks and organizational actors. Taking into account the variety of services for *big* and *small science,* a more elaborated categorization could contribute to the identification of adoption patterns. Beyond repositories, the deployment of HEOs infrastructure requires conceptual tools that reduce uncertainty about factors that could constrain adoption. It would be interesting as well, a comparative analysis of ITS adoption in HEOs from the eStrategy perspective. That means, comparing the processes and factors that influence the adoption process but at the same time, establishing a differentiation based on the type of organizational task: learning, researching and administrating. Such deep level analysis would lead to a comprehensive understanding of how HEOs can successfully achieve the benefits IT standardization in more than one application domain.

But eResearch services are not only offered by HEOs, the landscape suggested other organizations that implement these technologies and they can be analyzed as well. Labs, research centers and institutes in private companies or government implement IT to support scientific knowledge production and they are very rich contexts that have their own specific dynamics. The profile of these organizations could also be explored to find out significant differences that contribute to differentiated research instruments.

Secondly, adoption is a very relevant topic for IS. The analysis of secondary adoption would be the natural path to complete a more integrated view about adoption in organizations. In this work, the relation with end users as individual was not established at all, thus more information can help to associate primary and secondary adoption factors. The link between those levels within a process perspective in ITS is still missing. Although the view on primary adoption relied mostly on formal process and channels, the analysis of the role of the individuals could give insights about organizational culture, subjective perceptions and informal processes related to the factors that drive individual interaction with the standards.

Finally, further research on IT standards might continue inquiring about adopters. Their role as agents of change and active contexts opens comprehensive perspectives about the active participation of individuals, organizations, networks and regions or countries. Specifically, the process perspective adopted in this work can be worked to outline new methods that cope with this dynamics. Thus complementary models can continue working with the assumption that IT standards are part of a dynamic process influenced by adopters.

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9. Appendix

A.1 Case Study Assessment: Checklist

Stage	Concepts, techniques and tools	Used	Details	Reference
1. Case study strategy	1.1 Research questions	√	How / Why	Chap. I
	1.2 Prior theorizing	√	Adoption models	Chap. IV
	1.3 Unit of analysis	√	Organization (HEO)	Chap. III & IV
	1.4 Number of cases	√	Two	Chaps. V & VI
	Selection of cases	√	Literal replication	Chap. V
	1.6 Case study protocol	√	- Interview protocols -Code book	Chaps. V & Appendix
2. Conduct of the case study	2.1 Qualitative data collection	√	Documents Interviews	Chap. VI
	2.2 Quantitative evidence	√	System population statistics	Chap. VI
	2.3 Sampling strategies for interviews	√	Role within the organization	Chap. VI
	2.4 Data triangulation	√	Yes	Chap. VI
	2.5 Theoretical saturation	√	Yes	Chap. VI
3. Analysis of the case study evidence	3.1 Field notes	√	Not necessary	-
	3.2 Reflective remarks	√	Yes	Chap. VI
	3.3 Coding of raw data	√	Yes	Chap. VI
	3.4 Case study data base	√	Yes	Chap. VI
	3.5 Dominant mode of analysis	√	Pattern matching	Chap. VI
	3.6 Visual display techniques	√	Case dynamics matrix	Chap. VI
	3.7 Project reviews	√	Yes	
	3.8 Cross-case analysis	√	Yes	Chap. VI
4. Writing up the case study report	4.1 Resonance criteria	√	Pragmatic	Chap. VI
	4.2 Empowerment	√	Evokes action and reflection about the practice	Chaps. I, V & VI
	4.3 Applicability	√	Insights for the practice	Chaps. VI and VII

A.2 Case Study Protocol[42]

Every case study should be presented according to this protocol. Collected data in the Higher Education Organization (HEO) should be analyzed, interpreted and summarized to be included.

1. Overview

General description of the institution and indicators about size and maturity. Required data are:

a) Size indicators:

- Number of students
- Number of researchers
- Number of administrative staff
- Academic offer

b) Research orientation

- Strategic focus on research
- Organization structure and research management

c) Research Maturity (institutional and in research)

- History
- Indicators of research production

2. Governance and organization

General description of the structure subsystem. Particular emphasis is necessary on decision making structures:

a) Organization and governance structure

- Organization chart

3. eResearch strategy

Organization of the IT provision, in particular eResearch service catalogue:

a) Organization of the campus IT infrastructure

b) Campus eResearch services and organization

4. The repository

Description of the selected repository and status of the adopted ITS

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[42] This protocol was elaborated to drive data collection and to organize data in a suitable way for a comparative analysis.

a) Description of the repository service:

- General description
- Collections
- Maturity (year of implementation)

b) Platform

- Standard repository system
- Characteristics of the implementation
- Embedded ITS

5. ITS and repository's operation context

Description of the policy contexts in all levels (i.e. *macro* and *meso*)

a) National initiatives and external networks that support repository standardization

b) Internal policies and strategy related to the repository

6. ITS adoption process

Description of the adoption process. It should relate the policies with the process.

- Graphic with the whole adoption process

7. Analysis of the adoption process

Operationalize the model and presents the checklists as tables. It includes:

- Matrixes with the checklists

- Graphic with the adoption process and factors

A.3 Semi Structured Interview Guide[43]

Institution:	
Interviewee:	
Position (functions):	Date:

1. The repository
   - 1.1 When was the repository created?
   - 1.2 What is the objective of the repository?
   - 1.3 Which services does the repository offer?
2. Pre-Implementation
   - 2.1 Which needs do the repository satisfy?
   - 2.2 How were such needs identified?
   - 2.3 Was there any relation with institutional policies?
   - 2.4 Was another repository system implemented before?
   - 2.5 Did the implementation match with an institutional restructuring process?
3. Decision / Implementation
   - 3.1 Which areas were involved in the adoption decision?
   - 3.2 Who had the decision responsibility?
   - 3.3 How was the decision made about the repository system?
   - 3.4 Which criteria did you consider for system's selection? (support, equipment, training)
   - 3.5 How did you agree about the OAI-MPH and metadata standards?
   - 3.6 Did you face any difficulty during the implementation? (customization)
4. Post-Implementation
   - 4.1 How is managed the maintenance process?
     - Technical support
     - Advocacy
   - 4.2 Which area manages the repository? (content and technically)
   - 4.4 How your area does relate to the central IT Services office?
5. Context
   - 5.1 What is the relation of the repository with the IT department?
   - 5.2 Which other eResearch services are provided to researchers?
   - 5.3 Does your institution have an eResearch program?

[43] This interview guide was used only for the first formal interview. Further interviews were unstructured (oriented to exchange information about documents and policies).

A.4 Codebook

HEO: HEO	
1	HEO_RHUL
2	HEO_FFL
Document: DOC	
3	DOC_TYPE_WHITEPAPER
4	DOC_TYPE_PROCEDURE
5	DOC_TYPE_SERVCATALOG
6	DOC_TYPE_CORPORATEWEB
7	DOC_TYPE_DIRECTORY
8	DOC_TYPE_REPORT
9	DOC_TYPE_PLANNING
10	DOC_TYPE_REGULATION
11	DOC_TYPE_POLICY
Environmental factors: ENVIR	
12	ENVIR_RESEARCH_INITIAT
13	ENVIR_REPOSITORY
14	ENVIR_UOL
15	ENVIR_UOL_REGUL
Technology: TECH	
16	TECH_IT_APP
17	TECH_IT_APP_PLATFORM
18	TECH_IT_APP_PLATFORM_EQUELLA
19	TECH_IT_APP_PLATFORM_DSPACE
20	TECH_IT_APP_IMPLEMENTATION
21	TECH_IT_APP_REP_SERV
22	TECH_IT_APP_REP_REGUL
23	TECH_IT_APP_REP_CONFIG
24	TECH_IT_APP_CRIS
25	TECH_IT_APP_CRIS_REGUL
26	TECH_IT_APP_CRIS_SERV
27	TECH_IT_APP_CRIS_CONFIG
IT department: TECH_UNIT	
28	TECH_UNIT_IT
29	TECH_UNIT_IT_STAFF
30	TECH_UNIT_IT_FINANCE
31	TECH_UNIT_IT_CONFIG
32	TECH_UNIT_IT_SERVICE
33	TECH_UNIT_IT_SERVICE_RESEARCH
34	TECH_UNIT_IT_REGUL
Strategy: STRAT	
35	STRAT_VISION

36	STRAT_PLANNING
37	STRAT_POLICY_
38	STRAT_POLICY_OPENACCESS
39	STRAT_ITPOLICY
40	STRAT_ITPOLICY_DATA
41	STRAT_RESEARCH
42	STRAT_RESEARCH_ERESEARCH
43	STRAT_POLICY_COPYRIGHT
Structure: STRUCT	
44	STRUCT_FINANCE
45	STRUCT_GOVER_
46	STRUCT_GOVER_CONFIG
47	STRUCT_GOVER_REGUL
48	STRUCT_UNIT
49	STRUCT_UNIT_LIBRARY
50	STRUCT_UNIT_LIBRARY_CONFIG
51	STRUCT_UNIT_LIBRARY_STAFF
52	STRUCT_UNIT_LIBRARY_SERVICE
53	STRUCT_UNIT_LIBRARY_REGUL
54	STRUCT_UNIT_DEPT_CONFIG
55	STRUCT_UNIT_DEPT_STAFF
56	STRUCT_UNIT_DEPT_SERVICE
57	STRUCT_UNIT_DEPT_REGUL
58	STRUCT_UNIT_DEPT
Adoption: ADOP	
59	ADOP_INICIATION
60	ADOP_DECISION
61	ADOP_IMPLEM

A.5 Royal Holloway University of London: List of Analyzed Documents [44]

Regulations
College Statutes
Committees Handbook
Guidelines on Research Governance, Research Ethics and Good Research Practice
Policy on the Population and Maintenance of a Research Information System (PURE)
Data Backup Policy
Institutional Repository Deposit License
Open Access Publications Policy
Institutional Repository Takedown Policy
IT Services Policy IP Allocation and Management
Strategy
Corporate Strategic Plan 2009-2013
Other documentation
IT Services Catalogue
Induction for Staff
Current Research Information System for Royal Holloway, University of London and St George's; University of London. Requirements Specification

[44] Confidential documents are nor listed here (source request).

A.6 Faculty of Philosophy and Literature: List of Analyzed Documents[45]

Regulations	
Reglamento de la Facultad de Filosofía y Letras *Estatutos y Reglamentos*	Regulations of the Faculty of Philosophy and Literature Statutes and Regulations
Disposiciones generales a las que se sujetarán los procesos editoriales y distribución de publicaciones de la UNAM	General Dispositions for Editorial Processes and Distribution of Publications at UNAM
Reglamento Técnico al Interior de Consejo Técnico de Humanidades	Technical Regulations of the Technical Council of
Acuerdo para Transparencia y Acceso a la Información de la UNAM	Agreement about Transparency and Access to UNAM's information
Estatuto del Personal Académico de la UNAM.	Statute of UNAM's Academic Personnel
Estatuto General de la Universidad Nacional Autónoma de México	UNAM General Statute
Reglamento Interno del Consejo Técnico de la Investigación Científica	Internal Regulations of the Technical Council of Scientific Research
Reglamento de Consejo de Directores de Facultades y Escuelas.	Regulations of the Directors Councils of Schools and Faculties
Disposiciones Generales para la Actividad Editorial de la UNAM	General Dispositions for the Editorial Activity at UNAM
Reglamento General del Sistema Bibliotecario y de Información de la UNAM.	General Regulation of the Library and Information System UNAM
Strategy	
Plan de Desarrollo 2008-2011	Development Plan 2008-2011
Plan de Desarrollo de la Universidad 2011-2015	Development Plan 2011-2015
Reports	
3R Red de Repositorios Universitarios de Recursos Digitales. Etapa 1: Investigación. Primer Informe Técnico.	3R Network of University Repositories of Digital Resources. Report Phase 1: Research. First Technical Report.
3R Red de Repositorios Universitarios de Recursos Digitales. Etapa 2: Modelo Conceptual.	3R Network of University Repositories of Digital Resources. Report Phase 2: Conceptual Model.
3R Red de Repositorios Universitarios de	3R Network of University Repositories of

[45] All the documents are available only in Spanish langaguage.

Recursos Digitales. Informe de la Etapa 3: Desarrollo del Sistema y de Aplicaciones.	Digital Resources. Report Phase 3: Systems Development and Applications
3R Red de Repositorios Universitarios de Recursos Digitales. Informe de la Etapa 4. Implementación del Prototipo.	3R Network of University Repositories of Digital Resources. Report Phase 4. Implementation of the Prototype