MANAGING AND MONITORING SOFTWARE ECOSYSTEM TO SUPPORT DEMAND AND SOLUTION ANALYSIS

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Tese de Doutorado apresentada ao Programa de Pós-graduação em Engenharia de Sistemas e Computação, COPPE, da Universidade Federal do Rio de Janeiro, como parte dos requisitos necessários à obtenção do título de Doutor em Engenharia de Sistemas e Computação.

Orientadora: Cláudia Maria Lima Werner

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"*I've come to believe that there exists in the universe something I call 'The Physics of The Quest' – a force of nature governed by laws as real as the laws of gravity or momentum. And the rule of Quest Physics maybe goes like this: 'If you are brave enough to leave behind everything familiar and comforting (which can be anything from your house to your bitter old resentments) and set out on a truth-seeking journey (either externally or internally), and if you are truly willing to regard everything that happens to you on that journey as a clue, and if you accept everyone you meet along the way as a teacher, and if you are prepared – most of all – to face (and forgive) some very difficult realities about yourself... then truth will not be withheld from you.' Or so I've come to believe.*"

(Elizabeth Gilbert, Eat, Pray, Love)

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GERENCIANDO E MONITORANDO ECOSSISTEMAS DE SOFTWARE PARA APOIAR A ANÁLISE DE DEMANDAS E SOLUÇÕES

Rodrigo Pereira dos Santos

Março/2016

Orientadora: Cláudia Maria Lima Werner

Programa: Engenharia de Sistemas e Computação

A globalização da indústria de software tem ampliado ganhos de produtividade e vantagens estratégicas para aqueles que adquirem ou fornecem soluções de software; logo, atividades de gestão de TI têm um papel crítico. O contexto de ecossistemas de software agrega complexidade adicional, pois decisões de gestão de TI podem fortalecer (ou enfraquecer) relacionamentos na rede de produção de software. Muitas organizações adquirentes carecem de documentação estruturada para melhor visualizar e analisar os impactos de demandas e soluções sobre as suas bases de ativos em longo prazo. Neste trabalho, foi investigado como a perspectiva de ecossistemas afeta atividades de gestão de TI como a análise de demandas e soluções. Dimensões e conceitos chave de ecossistemas, além de mecanismos de gerenciamento e indicadores de monitoramento que melhoram a organização do conhecimento na base de ativos foram pesquisados por meio de um mapeamento da literatura, duas pesquisas de opinião e dois estudos de observação em casos reais. Em seguida, uma abordagem para apoiar gestores e arquitetos de TI a perceber o impacto de ecossistemas na gestão de TI foi apresentada, incluindo um estudo de viabilidade com profissionais da indústria em um cenário real. Concluiu-se que decisões de gestão de TI devem ser guiadas por critérios técnicos, sem perder de vista a dependência de tecnologia e a sinergia dos objetivos.

Abstract of Thesis presented to COPPE/UFRJ as a partial fulfillment of the requirements for the degree of Doctor of Science (D.Sc.)

MANAGING AND MONITORING SOFTWARE ECOSYSTEM TO SUPPORT DEMAND AND SOLUTION ANALYSIS

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The software industry globalization has leveraged productivity gains and strategic advantages for both those who obtain and provide software solutions; IT management activities then play a critical role. Software ecosystems context brings additional complexity since IT management decisions can strengthen (or weaken) relationships in the software supply network. In addition, several acquirers lack common documentation structured to allow visualizing and analyzing impacts of demands and solutions over their asset bases over time. We researched how the software ecosystems perspective affects IT management activities, more specifically demand and solution analysis. As such, we investigated ecosystem's dimensions and key concepts, as well as management mechanisms and monitoring indicators that improve knowledge organization within a software asset base through a literature mapping, two surveys and two observational studies in industrial cases. Next, we present an approach that helps IT managers and architects to realize impacts of ecosystems on IT management and evaluated it with practitioners in a real scenario through a feasibility study. We concluded that IT management decisions should be driven by technical criteria not losing sight of technology dependency and business synergy.

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# Abbreviations

| | |
|---|---|
| API | Application Programming Interface |
| BPMN | Business Process Model and Notation |
| BPS | Brazilian Public Software |
| CBD | Component-Based Development |
| CBSE | Component-Based Software Engineering |
| CMS | Content Management System |
| COTS | Commercial Off-The-Shelf |
| CRM | Customer Relationship Management |
| DAD | Disciplined Agile Delivery |
| DE | Domain Engineering |
| EA | Enterprise Architecture |
| EPF | Eclipse Process Framework |
| ERP | Enterprise Resource Planning |
| FOSS | Free Open Source Software |
| GQM | Goal-Question-Metric |
| GSD | Global Software Development |
| IDE | Integrated Development Environment |
| ISV | Independent Software Vendor |
| IT | Information Technology |
| IWSECO | International Workshop on Software Ecosystems |
| LOC | Lines Of Code |
| OSS | Open Source Software |
| PR | PageRank |
| Q | Question |
| R | Requirement |
| RQ | Research Question |
| SAM | Software Asset Management |
| SE | Software Engineering |
| SECO | Software Ecosystem |
| SME | Small and Medium Enterprise |
| SOA | Service-Oriented Architecture |
| SPEM | Software & Systems Process Engineering Metamodel |

| | |
|---|---|
| SPL | Software Product Line |
| SS | System Sector |
| SSN | Software Supply Network |
| TAM | Technology Acceptance Model |
| TD | Technical Debt |

# Chapter 1 – Introduction

*We have already seen major changes away from monolithic, custom-built systems to much more highly componentized distributed systems incorporating software packages, glue code and scripting. These changes have been paralleled by changes in the software business with outsourced development and community sourced middleware.*

Finkelstein (2013)

## 1.1 Context

According to BOEHM (2006), the increasing pace of change in the global industry is driving organizations towards increasing levels of agility in their software development methods, while their products and services are concurrently becoming more and more software-intensive. In other words, software has represented a crucial element for most of existing systems, since it affects functions, resources, and risks in different industry sectors (SANTOS & WERNER, 2011d). Software-intensive systems have also become increasingly ubiquitous, large, and complex, with considerable dissemination in several application domains and tightly dependent upon different technologies (BOSCH, 2012). Nevertheless, current decision-making relating to software management and development is largely done in a value neutral setting in which cost is the primary driver for every decision taken (MENDES et al., 2015).

The abovementioned software-intensive systems are usually centered in a software platform (a product or a software asset base), in which diverse elements create a socio-technical network[1], i.e., the interplay between the social system and the technical system (HANSSEN & DYBÅ, 2012). For example, suppliers, distributors, outsourcing companies, developers, acquirers, technology providers, clients, users, software applications, and technologies interact and change development process when exchanging information (IANSITI & LEVIEN, 2004a). As a consequence, the treatment of economic and social issues has been pointed out as a challenge for the Software Engineering (SE) research and practice over the last decade (BOEHM, 2006;

[1] We define a socio-technical network as a set of actors and artifacts, including their relationships, commonly represented as a graph where nodes are actors and artifacts, and relationships are edges.

CUKIERMAN et al., 2007; JANSEN et al., 2009c; SANTOS et al., 2012c; FINKELSTEIN, 2014; MENDES et al., 2015; MANIKAS, 2016).

According to JANSEN & CUSUMANO (2012), software-intensive systems engineering involves better thinking about those platforms, then increasing attention is being paid to influence and interdependency in relationships between players within a competitive market. It means that software producing organizations no longer function as independent units that can deliver separate products, but have become dependent on others for vital components and infrastructures, e.g., operating systems, programming languages, libraries, and component stores (JANSEN et al., 2009c). Inspired by other knowledge areas, SE community tried to bring and adapt concepts and metaphors in order to tackle nontechnical aspects (DHUNGANA et al., 2010). Technically speaking, for most software producing organizations, large-scale development is interconnected, expensive, slow and unpredictable (BOSCH & BOSCH-SIJTSEMA, 2010), triggering three trends which accelerate complexity in SE industry:

- the wide-spread adoption of software *product lines* (SPLs), with the challenge of exposing reusable assets and opening up the platform architecture to get contributions from external players;
- the broad *globalization* of software development (GSD) in many organizations, with the challenge of coping with complexity of socio-technical dependency and management in a distributed environment;
- the emergence of *ecosystems* (SECOs) from the network of some organizations, with the challenge of sustaining the software platform based on the management and monitoring of the supply chain.

As regards to the abovementioned trends, component-based software engineering (CBSE) is an important concept, once several pieces of software should work together to ensure a system’s proper functioning (SAMETINGER, 1997). Components can be defined as any type of software artifact internally developed, outsourced, open source based, or available on the market as commercial off-the-shelf (COTS), seen as parts of a system (SZYPERSKY et al., 2002). Mature industrial systems are component-driven and reuse existing artifacts when possible, contributing to components’ improvement and mature repositories (MESSERSCHMITT, 2007). As such, in the software industry, *suppliers* or software producing organizations (e.g., Amazon, SAP, Google, Microsoft) are developing multiple products based on a common platform, keeping up with the speed of evolution (JANSEN et al., 2009b).

At the opposite side, *acquirers* or software consuming organizations, as well as *niche players* or third-party developers, are increasingly requesting opening platforms to better realize and perform customization and integration, respectively, even though CBSE critical issues still remain: standardization, information visualization, guidelines to support customizations, and intellectual property (WERNER et al., 2009). For example, acquirers have faced difficulties in coping with the market dynamics (ALBERT et al., 2013). Supplier mergers or obsolete technologies can affect the satisfaction of acquirers' business objectives since they usually depend upon software applications running over those technologies to guarantee strategies and activities. As a result, acquirers prepare to such external, uncontrolled events, mainly asking IT advisory companies (e.g., Gartner and Forrester) to analyze their IT architecture and make some recommendations over time.

## 1.2 Motivation

Acquirers inevitably aim to maximize return on investment for each software demand they prioritize and for each agreement they establish with suppliers (FARBEY & FINKELSTEIN, 2001). Despite of what acquisition approach to use and who should complete the task, they need to be aware of nontechnical factors that mostly affect their IT management decisions (NELSON et al., 1996). For example, an analysis of market indicators and organization context sometimes leads to conflicting objectives, as both consist of different views, respectively external and internal. In a turbulent and competitive global environment, the 'dream' of any acquirer might be to get a clear notion of which IT markets it participates and how to monitor strategic decisions:

- Are the software applications aligned with different organization's business objectives, helping it to drive results?
- Which candidate applications better fit the technologies currently adopted in the IT architecture?
- Is the organization's IT management team aware of its supplier and/or technology dependency?

For the past ten years, SE community was broadly investigating such views and issues under a research topic: SECO (JANSEN et al., 2009c). According to BOSCH (2009b), a SECO consists of a set of software solutions that enable, support and automate the activities and transactions performed by the actors in the associated social or business ecosystem, and the organizations that provide these solutions. Such solutions can be seen as components of a software-intensive system and together create the acquirer's platform. As a metaphor, the platform takes place as the 'soil' of an ecosystem, where 'energy' (technical and business knowledge) is transferred among different 'species' (suppliers and acquirers' units) that interact in a 'food chain' (software supply network). A 'consumer' (organizational unit) needs 'food' (applications) to obtain 'energy' and perform its activities within the ecosystem, keeping it sustainable. In turn, 'producers' (suppliers) provide 'food' based on 'nutrients' (technologies).

A crucial element in this context is the *acquirer's platform*, also known as software asset base (ALBERT et al., 2013). The acquirer's platform is a portfolio or virtual catalogue of software assets (i.e., software applications and technologies) with registering data, e.g., details, suppliers, dependencies, business objectives reached with them, and stakeholders who are benefited from them (WILLIAM & O'CONNOR, 2011; LIMA et al., 2014). In this context, decisions on which IT demands and solutions to select and prioritize somehow modify the platform architecture, e.g., requiring integration with existing applications and then redefining software product dependency matrix (MACCORMACK et al., 2012). Thus, in order to prepare acquisition rounds, IT management activities take place to ensure business objectives satisfaction, change control, traceability to applications, metrics on stability, and continuous stakeholder involvement (NOVAK, 2005).

Unfortunately, all abovementioned knowledge is scattered through a mass of confused information sources hampering organizations to drive results, optimize use of resources and maximize profitability, similar to well-known obstacles to CBSE. In fact, acquirers' platform data are tacit, outdated, sparse and/or not of high quality (CHRISTENSEN et al., 2014). Additionally, SECO brings additional complexity to IT management since IT management decisions can strengthen (or weaken) relationships in a software supply network (FINKELSTEIN, 2011). In other words, acquirers commonly lack structured, shared knowledge that allows them to realize the impacts of demands and solution over their platforms over time, e.g., changes on technology dependency or business synergy. Only market reports delivered by IT advisory companies are not sufficient for analyzing demands / recommending software solutions without considering the organization’s platform.

## 1.3 Problem

As stated in Section 1.2, demand and solution analysis is critical for IT management. Although selection and prioritization activities have been investigated by SE community (ALVES, 2005; BAKER et al., 2006; CORTELLESSA et al., 2008b; FREITAS & ALBUQUERQUE, 2014), **two challenges** for acquires’ IT management still remain: (1) *IT architectural matching taking into account supplier and technology dependencies over time* (LAGERSTRÖM et al., 2014); and (2) *multiple selections of software applications to help customers satisfy their different business objectives* (FINKELSTEIN, 2014). According to BAKER et al. (2006), from the set of demands and solutions (i.e., candidate components), the IT management team should search for a subset that balances these competing, conflicting concerns as good as possible.

Most IT management teams have regular meetings to discuss and deliberate about such components based on their expertise (including spreadsheet analysis and distributed documents) and IT market reports. This reality brought acquisition management to play a critical role in software development in industry, as concluded by a benchmarking study for project management recently conducted by the Project Management Institute (PMI, 2014). Additionally, the traditional IT management stated that requirement specifications and available budget serve as traditional criteria to help IT managers and architects to analyze demands, lacking a structured software asset base to analyze other indicators, especially the ‘hidden effects’ of their long-term decisions.

In order to face such a problem faced by IT management teams, the power of an ecosystem to bounce back from a disturbing event is a key property of an organization wishing to guarantee its operational continuity and meet business objectives (DHUNGANA et al. (2010). In an acquirer’s point of view, this property is known as *diversity* and is an indicator of the ecosystem’s health, i.e., how sustainable the platform is over inherent changes, e.g., technology obsolescence or business evolution. Such current industry challenges motivated us to investigate *how SECO perspective can aid*

*IT management teams to perform their daily activities within a software supply network, more specifically demand and solution analysis*.

## 1.4 Objectives

Consider some facts identified in previous studies:

- Software products are normally acquired taking into account local rather than shared needs of the organizational units, mainly due to obstacles to socialization (FINKELSTEIN et al., 2008; RODRIGUES et al., 2013; PICHLIS et al., 2014; VALENÇA et al., 2014);
- Acquirers have difficulties in coping with selection and prioritization because knowledge often depends on different stakeholders, applications and technologies, due to architectural issues (LIM & FINKELSTEIN, 2012; OLSSON & BOSCH, 2014; SANTOS et al., 2014b);
- Information on software capabilities and market are not so useful when analyzed as the only support for IT management decisions, without data from the asset base, due to the lack of IT governance (BANNERMAN, 2009; WAREHAM et al., 2013; ABREU et al., 2014);
- Similar applications are acquired from a network of intertwined third-parties or commercial suppliers/resellers that are dependent upon several technologies and can affect platform sustainability[2] (SAARENKETO et al., 2010; SANTOS & WERNER, 2010; ANGEREN et al., 2011).

From the challenges pointed out in Section 1.3 and the facts stated above, our **hypothesis** can be defined: "*Managing and monitoring SECO affect IT management activities, more specifically demand and solution analysis*". From this hypothesis, some research questions (RQ) were established throughout our work. First of all, some effort was spent in mapping literature studies on SECO modeling and analysis as part of a pioneering work: RQ1 – *What are the SECO dimensions and key concepts that allow researchers to analyze an organization's platform?* As an output of RQ1, we identified SECO management and monitoring as a critical element for IT management activities in this context. For SECO management, two forces were observed: *governance* in a top-

[2] Sustainability is the capacity of a SECO to increase or maintain its user/developer community over time and also survive inherent changes, e.g., new applications/technologies from competitors that can change the population (users/developers), or attacks/sabotage of the platform (DHUNGANA et al., 2010).

down way, and *socialization* in a bottom-up way. Then, we conducted two surveys with experts to identify and rank mechanisms that impact such forces: RQ2 – *What are the most relevant mechanisms for SECO platform management?*

In turn, two observational studies were performed in real scenarios in order to identify what health indicators are critical to IT management regarding SECO monitoring in: RQ3 – *What are the most critical health indicators for SECO platform monitoring?* Once acquirers face challenges in making decisions in the SECO context, we finally developed an approach to combine SECO management and monitoring to support IT management activities, more specifically regarding demand and solution analysis: RQ4 – *Is SECO management and monitoring feasible to aid managers and/or architects to perform IT management activities, more specifically demand and solution analysis, with efficiency and effectiveness?* A feasibility study was conducted with practitioners in a real scenario in order to evaluate our proposal.

In summary, this research aims to examine SECO perspective in order to propose and evaluate an approach for managing and monitoring SECO to support IT management activities, more specifically demand and solution analysis. Our research starts an investigation of an environment for SECO modeling and analysis (SANTOS et al., 2012c). Some specific objectives were identified from the objective of this work:

- Develop a *framework* to help researchers to better understand SECO dimensions and key concepts and to analyze organizations' platforms;
- Identify *management mechanisms* that are critical for IT management regarding governance and socialization in the SECO context;
- Identify *monitoring indicators* that are critical for IT management regarding sustainability of a platform in the SECO context;
- Develop an *approach* for managing and monitoring SECO to support IT management activities, more specifically demand and solution analysis;
- *Ensure* that this approach helps IT managers and architects to perform demand and solution analysis in a real scenario.

## 1.5 Methodology

Our research methodology was inspired by Design Science paradigm (HEVNER *et al.*, 2004). It is a problem solving paradigm based on some guidelines to create and evaluate artifacts developed so as to cope with real, organizational problems. Some real cases were used to help us to develop our approach in the form of real cases due to its practical nature. Figure 1.1 shows the research methodology adopted in this PhD thesis, composed of five phases, adapted from (NUNES, 2014). In the first phase, *Problem Perception and Definition*, we investigated the basics of SECO and performed some analysis of platform prototypes in order to identify critical problems and then derived relevant questions related to IT management activities. For example, a platform prototype in the Software Reuse domain: a component and services repository named *Brechó* (SANTOS et al., 2010ab; WERNER & SANTOS, 2010).

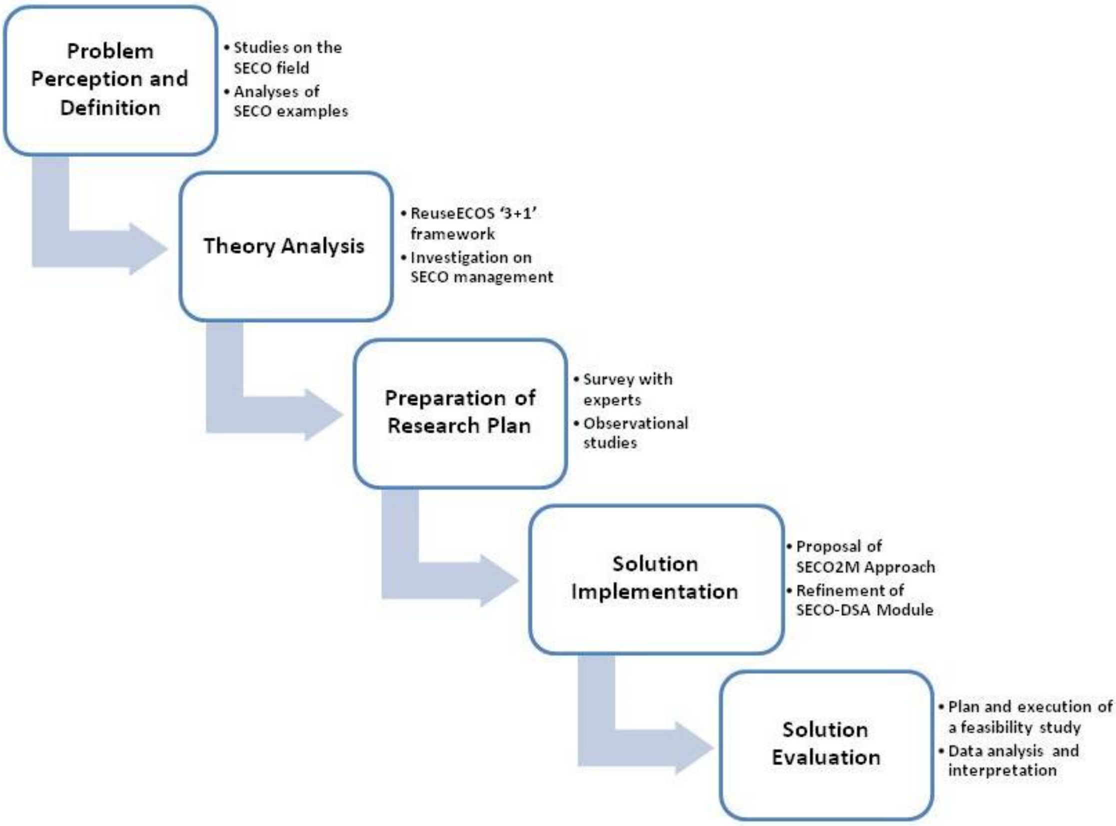



Figure 1.1. Research methodology

In the second phase, *Theory Analysis*, we then investigated the SECO literature. Despite the initial advances in SECO research, our investigations helped us to identify two critical issues: (1) the novelty and complexity of SECO research produced a vague and diverse terminology; and (2) the impacts to the SE area seem to be dependent on the SECO multidisciplinary nature that considers the treatment of economic and social elements along with the technical ones. We categorized SECO key concepts (and their relations) published in the proceedings of the International Workshop on Software

Ecosystems (IWSECO) 2009-2012 into a framework known as *ReuseECOS '3+1'* in order to answer RQ1. The goal was to initially understand SECO key concepts by classifying them in four dimensions (with steps and activities) to help researchers to analyze organizational platforms (SANTOS & WERNER, 2011bd; 2012ab). We also strengthen our findings after combining our results with those obtained in a systematic mapping (BARBOSA & ALVES, 2011). This collaborative initiative produced a more consistent roadmap of the SECO field (SANTOS et al., 2012c; BARBOSA et al., 2013).

In the third phase, *Preparation of Research Plan*, we investigated SECO management element. We planned and executed surveys with experts in order to collect information related to IT management activities. Researchers and practitioners were asked to rank SECO management mechanisms that affect such activities (RQ2). The goal was to set up the problem in its entirety (SANTOS, 2013b; 2014). Additionally, some real cases were analyzed in observation studies in order to collect monitoring indicators that also affect those activities (RQ3), as follows:

- a real scientific platform in the public policy domain: a web information system named RPP Portal to support the management of a community of researchers and scientific artifacts (OLIVEIRA et al., 2011; SANTOS et al., 2012d; 2013a);
- a real public platform in the governmental domain: web information systems to support e-gov modules to improve participatory democracy (FERREIRA et al., 2013ab; LIMA et al., 2013ab; ROCHA et al., 2013; RODRIGUES et al., 2013; BURD et al., 2014; SILVA et al., 2014).

Motivated by those two scenarios where acquirers had faced difficulties to perform IT management activities, more specifically demand and solution analysis (ALBERT, 2014; SILVA et al., 2014), we identified the root causes of the problem discussed in Section 1.3 to state RQ4. In the fourth phase, *Solution Implementation*, we isolated and modeled the problem of supporting IT management activities in the context of SECO. We then proposed *SECO2M* as a solution to aid IT managers and architects to realize impacts of SECO management and monitoring on the long-term sustainability of a SECO platform, and refined it with the *SECO-DSA Module* to allow IT management teams to analyze demands and solutions over time. Finally, in the fifth phase, *Solution Evaluation*, we verified *SECO2M* / *SECO-DSA Module* with practitioners in a real scenario through a feasibility study.

## 1.6 Outline

This PhD thesis is organized in seven chapters. This chapter presented the context of our work and the motivation for this research. The problem identified as a gap in theory and practice and the objective of this thesis were explained, as well as the methodology that guided us towards our scientific contribution.

Chapter 2 discusses the background of this research. As such, we introduce ecosystem in SE area and investigate the SECO literature, organizing SECO dimensions and key concepts into the *ReuseECOS '3+1'* framework. The framework's steps and activities are also explained, from which critical elements for an acquirer's IT management in the SECO context were pointed out.

Chapter 3 extends the background of this research to investigate mechanisms for SECO management since this aspect was identified as critical for IT management activities in Chapter 2. We present two surveys with experts to characterize how governance and socialization forces affect IT management in this context.

Chapter 4 describes and analyzes two real situations that we assisted in the third phase of our research methodology as observational studies. Results were very important to help us to define our last RQ and develop our approach as well, including health indicators to be considered for SECO monitoring.

Chapter 5 presets *SECO2M* as an approach for managing and monitoring SECO to support acquirer's IT management activities, more specifically demand and solution analysis. Details of the model, architecture and components, and tool support are provided in this chapter. In addition, related work is discussed at the end.

Chapter 6 explains a feasibility study we executed to evaluate *SECO2M*. We focused on how feasible *SECO2M* is to aid managers and architects to realize impacts of SECO management and monitoring on IT management activities, more specifically those supported by the *SECO-DSA Module* and its infrastructure. It also discusses the main findings we observed while conducting the study. Strengths and weaknesses are summarized, as well as opportunities and threats to validity.

Chapter 7 concludes this document. We present some final considerations, contributions of the thesis, and limitations of this research. Finally, we propose some future work.

# Chapter 2 – Software Ecosystems

*We should finally resolve that the discovery of new software engineering ideas is, by now, naturally incremental and evolutionary. This insight is not novel at all. (...) The key ideas – among them, abstraction, modularity and information hiding, reuse, better communication, and attention to human aspects – for dealing with essential difficulties have been around quite a while.*

Erdogmus (2010)

## 2.1 Introduction

Large organizations, where the business structure is sometimes more complex than in small and medium enterprises (SMEs), have several software applications to support their activities (FINKELSTEIN, 2014). As such, IT management is very important once the success of a software application directly depends on how well it satisfies users' demands (SIM & BROUSE, 2014). Information overload in large software projects, difficulties in identifying and managing stakeholders and bias in prioritizing demands represent some barriers for decision-making regarding IT management (LIM & FINKELSTEIN, 2012). Also, such demands have arisen from the complex network of stakeholders who are spread out in many organizational units that constitute the organization.

A grand challenge for IT consuming organizations (or acquirers) is to coordinate software application demands and candidate solutions within a network of suppliers who independently evolves them in the market (BOUCHARAS et al., 2009; RIOS et al., 2013; SILVA et al., 2014). This scenario affects acquisition preparation (ALBERT et al., 2013), known as software ecosystems or SECOs (MESSERSCHIMITT & SZYPERSKY, 2003). Despite the growing interest in this topic, the novelty and complexity of SECO research have produced a vague and diverse terminology because of its multidisciplinary nature (BARBOSA et al., 2013).

The objective of this chapter is to provide an overview of SECO and identify challenges faced by an acquirer to perform IT management activities in this context. We discuss the origin of the topic in the Software Engineering (SE) area as well as some concepts and relations regarding SECO in Section 2.2. In Section 2.3, we investigate the

SECO literature from which we identified and classified those elements into a framework to answer our first research question (RQ), i.e., RQ1 – *What are the SECO dimensions and key concepts that allow researchers to analyze an organization's platform?* In Section 2.4, we strengthen our findings after combining our results with those obtained in a systematic mapping study (BARBOSA & ALVES, 2011). This collaborative initiative produced a more consistent roadmap of the SECO field (SANTOS et al., 2012c; BARBOSA et al., 2013). We conclude the chapter, pointing out critical elements for an acquirer's IT management in the SECO context in Section 2.5.

## 2.2 Overview

SECO represents a new metaphor in SE area and several research initiatives have been performed in the last decade. However, there is little consensus on what constitutes a SECO, few analytical models exist, and the field still lacks research with real-world data (MANIKAS & HANSEN, 2013). The most cited definition of SECO was introduced by JANSEN et al. (2009c): *a set of businesses functioning as a unit and interacting with a shared market for software and services, together with the relationships among them, frequently underpinned by a common technological platform or market, and operating through the exchange of information, resources and artifacts*. Amazon, Microsoft, SAP, Apple and Google are some of the pioneers in analyzing SECOs and have produced relevant knowledge for SE community (BARBOSA et al., 2013). Another famous definition was presented by BOSCH (2009b): *the set of software solutions that enable, support and automate the activities and transactions performed by the actors in the associated social or business ecosystem and the organizations that provide these solutions*.

Examples of SECO are Microsoft SECO, iPhone SECO and Drupal SECO (SANTOS et al., 2012c), from which some typical ecosystem's characteristics can be observed: (a) SECO can be *part* of another SECO, e.g., Microsoft CRM SECO is contained in Microsoft SECO; and (b) one might refer to iPhone SECO with its app store as a *closed* SECO, whereas a software platform can sustain an *open* SECO in the context of Free Open Source Software (FOSS), e.g., Drupal SECO is a FOSS maintained by a community of thousands of users and developers across the world. We can observe that a SECO is characterized by software producing (or consuming) organization’s connections with third-party developers, communities and/or other organizations to foster components development, supply and evolution in a large ecosystem created over a common technological platform (e.g., operating system, software asset base etc.). In this case, components are applications and technologies.

In other words, the ecosystem metaphor aims to highlight the fact that external and/or unknown actors are contributing to maintain and evolve components, changing the traditional, organization-centric value chain towards a software supply network, where multiple components developed over different platforms co-exist and affect acquirer’s businesses (BOUCHARAS et al., 2009). In fact, software as an artifact becomes a first-class citizen for all industry sectors that depend on it to produce goods and services to society (SECHTER et al., 2010). Components developed in the software industry have a direct relation with users’ participation in promoting, distributing (or selling) and evolving them, charactering sociotechnical applications (LATOUR, 1988; MESSERSCHIMITT & SZYPERSKY, 2003). Thus, suppliers and acquirers have to carefully consider their strategic role within their interrelated ecosystems to survive regardless of market turbulences or movements (JANSEN et al., 2009c).

SANTOS (2013ab; 2014) introduced a simple conceptual map for SECO definition inspired by the work of IANSITI & LEVIEN (2004b) and BERK et al. (2010) on the similarities between SECO and Business Ecosystems (Figure 2.1). It aimed at helping one to understand the underlying elements when thinking on (or modeling) a given SECO. In this conceptual map, one can observe that a SECO can be related to other SECOs. A SECO has a *platform* on which *products* and *services* provided by it can be included, modified or extended as software *artifacts*. A SECO is also composed by a *community* of (1) *hubs*, i.e., main agents in a SECO (e.g., leading organizations that polarize a SECO), and (2) *niche players*, i.e., all stakeholders who collectively affect a SECO from individual actions onto the platform (e.g., each of them can influence, commit to, contribute to, promote, or extend the platform). Both types of central players in a SECO are associated to a *role* (e.g., keystone, developers, reseller, end-user etc.).

From the work of SEICHTER et al. (2010) and MANIKAS & HANSEN (2013), LIMA et al. (2013c; 2014) analyzed the conceptual map presented in (SANTOS, 2013ab) to organize SECO elements through a socio-technical approach to better visualize, organize and use the underlying networks within a SECO. Due to the different types of interactions derived from artifacts that compose a SECO, the created network is no longer exclusively social; it includes both actors and artifacts. Figure 2.2 illustrates the most common roles of actors in a SECO. Some actors who are out of a SECO may positively or negatively impact the platform, e.g., those with roles of *third-party developer*, *end-user*, and *external partner*. For example, from the iPhone SECO perspective, many Android third-party developers may decide to extend applications to run on iOS. This event can motivate/cause migration of end-users to iOS platform, and also promote the emergence of external partners focused on the applications' businesses, e.g., banks, supermarkets, colleges etc. (COSTA et al., 2013).

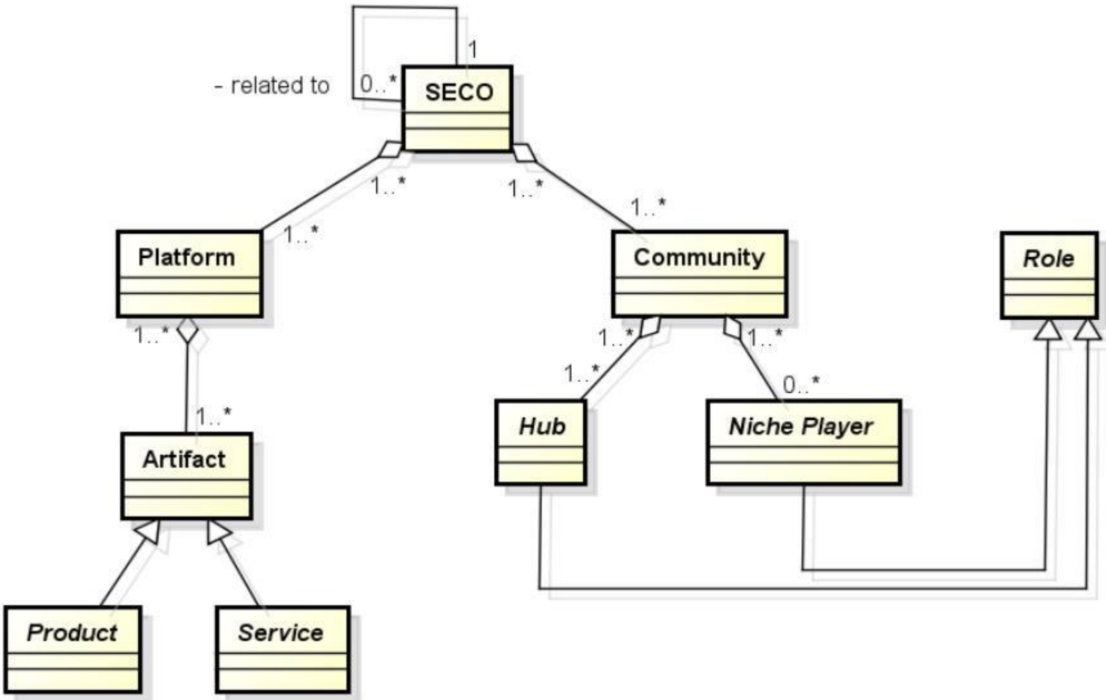



Figure 2.1. Preliminary conceptual map for the SECO domain.
Source: (SANTOS, 2014)

On the other hand, the possible roles of a *hub* within a SECO can be: (1) *keystone*, i.e., organization that leads a SECO platform and shares value with the whole ecosystem elements; or (2) *dominator*, i.e., leading organization who extracts value from a SECO when providing an alternative platform. In turn, there are several roles for a *niche player*: (1) *customer* (also known as *acquirer*): who needs software products and services; (2) *supplier*: who provides the ecosystem with software products and services; (3) *vendor*: who sells software products and services, classified into: a) *value-added reseller* (VAR): who resells value-added software products and services from the platform; b) *reseller*: who distributes software products and services as a broker; and c) *independent software vendor* (ISV): who develops or distributes its own software products and services; (4) *competitor*: who extracts value from the platform but represents no threat to the SECO; and (5) *developer*: who develops software products and services internally to a SECO working with hubs, classified into: a) *disciple*: who commits exclusively to one platform; b) *hedger*: who develops its products or services to support multiple platforms; and c) *influencer*: who commits early and prominently to one strategy, contributing to trigger the platform.

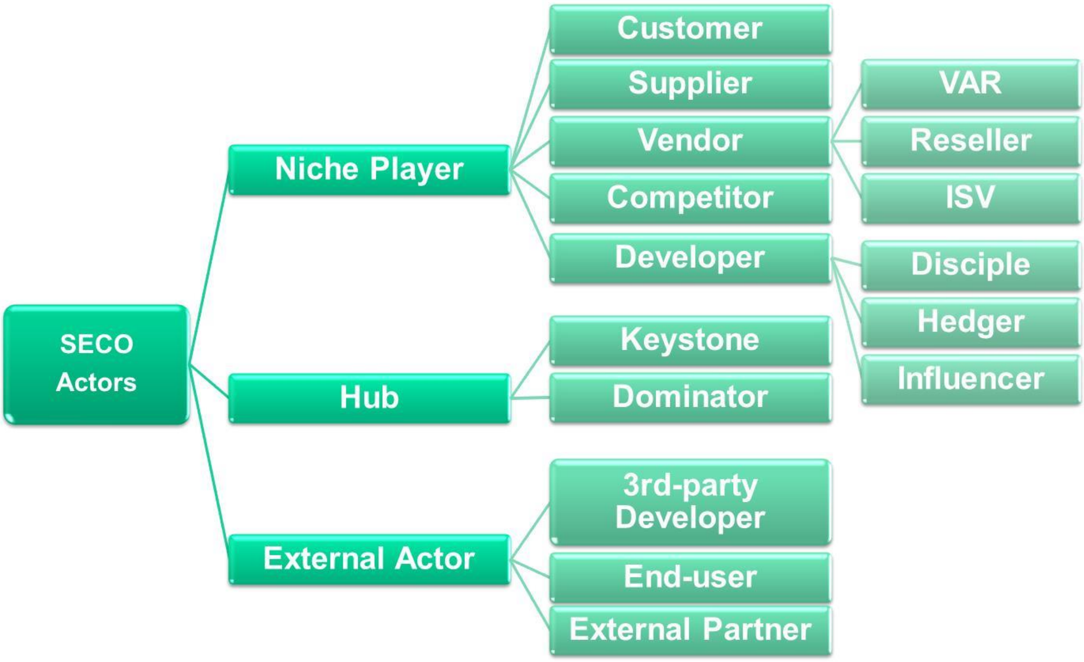



Figure 2.2. Roles of actors in a SECO.
Source: (LIMA et al., 2013c; 2014)

### *2.2.1. Origins*

The study of SECO in the SE community was initially motivated by the evolution of a Software Product Line (SPL) and Software Reuse towards allowing external developers to contribute to hitherto closed platforms in a global software industry driven by the Component-Based Development (CBD) paradigm (BOSCH, 2009b). According to SEICHTER et al. (2010) and JANSEN & CUSUMANO (2012), SECO is a framework for reuse dealing with challenges in modeling and analyzing (i) groups of organizations creating software, on high level; and (ii) nets of software tools and artifacts providing solutions, on low level. However, different research directions indicated by literature, industrial cases and reports reinforce important perspectives to be explored, such as architecture, socio-technical network, distributed development, modeling, business, mobile platforms, and organizational management (JANSEN et al., 2009c). In addition, SECOs has a multidisciplinary nature, including studies on Sociology, Communication, Economy, Business, and Law (SANTOS et al., 2012c).

Considering the well-known relations between SPL and SECO (BOSCH, 2009ab; SANTOS & WERNER, 2011b; MCGREGOR, 2012; SEIDL & AßMANN, 2013), Figure 2.3 shows four generations of Software Reuse established from some literature studies (SAMETINGER, 1997; SZYPERSKI et al., 2002; BIFFL et al., 2006; SANTOS & WERNER, 2010; BARBOSA et al., 2013): (1) *monolithic systems*: SE was in its infancy, when software was developed based on the integration of routines towards the productivity and scalability in the object-oriented paradigm; (2) *component-based systems*: SE focused on exploring the technical dimension, when reuse was emerging with Domain Engineering (DE) and CBD as well as model-based techniques; (3) *product lines*: SE started focusing on the business dimension, when reuse with SPL emerged in a market perspective dealing with different methodologies, critical systems, web services, and legacy systems; and (4) *ecosystems*: SE also starts focusing on the social dimension, when reuse needs to consider the Free Open Source Software (FOSS) scenario as well as systems-of-systems, hybrid business models, open innovation, and distributed development.

As observed in the fourth generation, networks of multiple software products and services over the existing platforms should be used to support the governance of the organizations' relationships in the SECO context, giving rise to a *business sense* (SANTOS & WERNER, 2011d). On the other hand, social impacts should be taken into account due to the socialization of SE processes and activities (MENS & GOEMINNE 2011). The cycle of creating, providing, and operating software-intensive systems occurs over a network of different stakeholders. This cycle contributes to (depends on) the propagation, amplification, and expansion of platforms in software industry. Thus, a *community sense* emerges because business models are revisited to treat transactions in open value chains (SANTOS & WERNER, 2012a). Both senses (Figure 2.4) represent hybrid models to manage and engineer software-intensive systems (POPP, 2012). It means that the perception of SECO elements (definition and modeling) can affect software lifecycle since development becomes dependent on open business models, new roles, collaboration patterns, innovation, and value proposition/realization (HANSSEN & DYBÅ, 2012). Other interferences are strategic goals, intentions, and relationships of each actor in a network of both actors and artifacts (BARBOSA et al., 2013).

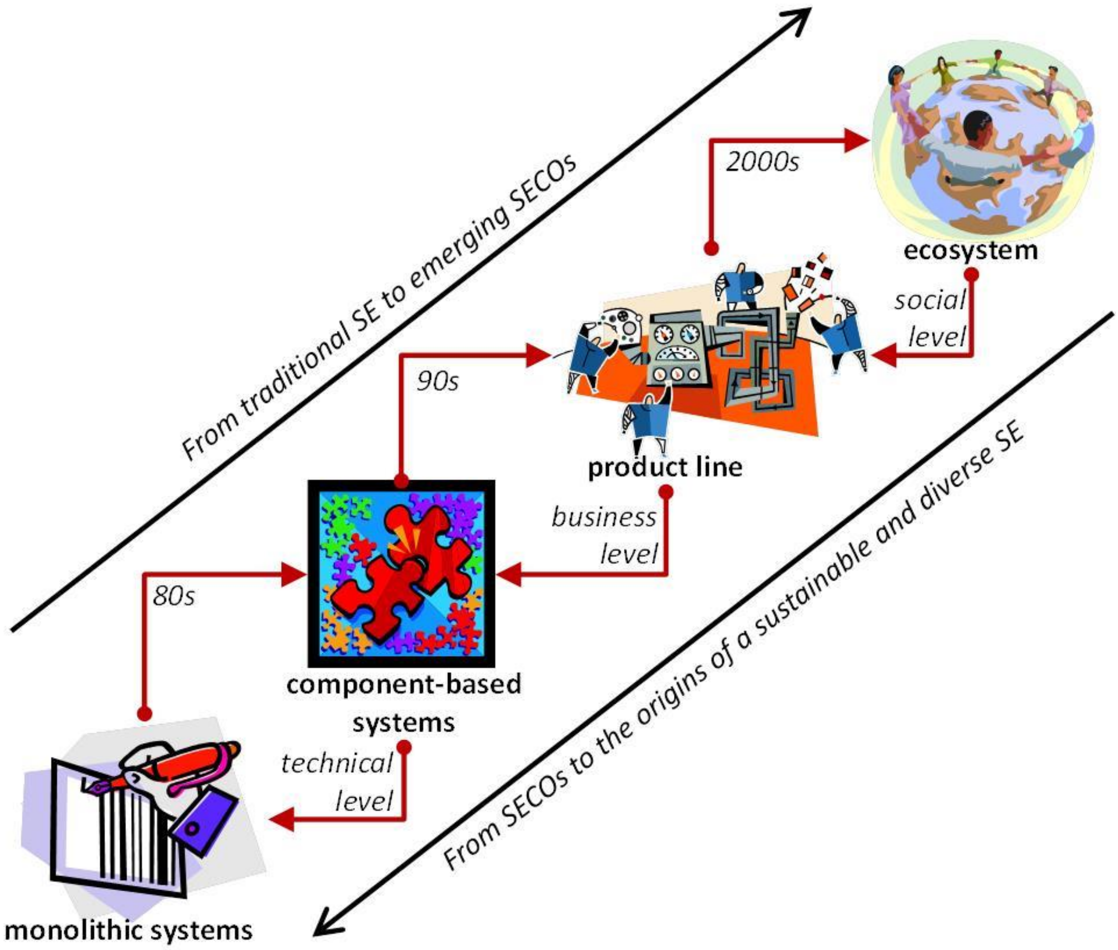



Figure 2.3. Towards SECO from the Software Reuse trajectory in four generations. Inspired by (Bosch, 2009a)

In an interorganizational scenario, SECO analysis should consider platform's internal and external elements (MANIKAS & HANSEN, 2013). So, it is important to realize to which extent these interferences affect software development and it requires seeing beyond the technical dimension – the abovementioned business and community senses. For example, plotting these senses in a chart, some reuse-driven SE scenarios towards SECO can be observed, as shown in Figure 2.4. In this context, one can state that the SPL approach explores the business sense since it drives reuse based on market strategies. In turn, FOSS environment explores the community sense since it drives reuse based on innovation promoted by communities. Thus, Software Reuse can benefit from the SECO metaphor in order to investigate the potential of interorganizational reuse (BOSCH, 2009b).

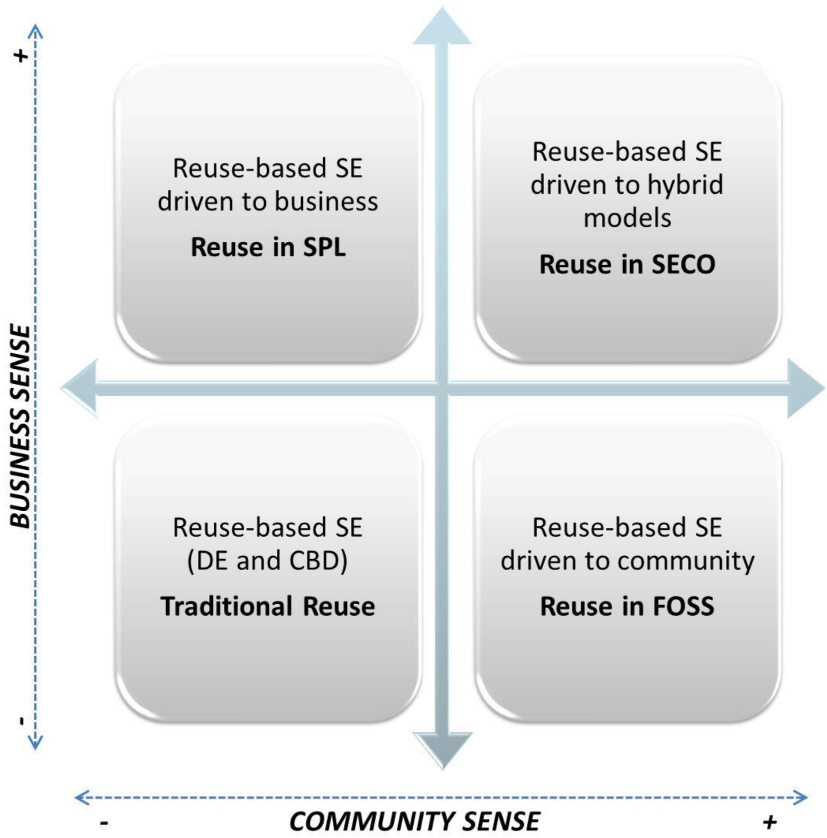



Figure 2.4. Software Reuse scenarios towards SECO.
Source: SANTOS (2013ab)

### *2.2.2. Concepts and Relations*

As an important initiative to make SECO concepts and relations clear, BOSCH (2009b) proposes a taxonomy to organize the existing SECO in two dimensional spaces, considering that SECOs emerge from multiple domains, as shown in Table 2.1. Dimension #1 refers to *categories* in which SECOs are grouped in terms of their abstraction level: (1) *operating system*: platforms here are domain independent, i.e., run in different devices and constantly need to extend features, trying to simplify their adoption by developers; SECO success is defined by the applications built on top of the platform, and also on the number of users; (2) *application*: platforms usually start from successful, integration-driven online software, allowing extensions to domain-specific functionalities; SECO success is defined by effort to maintain interfaces and by understanding the frontiers of business strategies between the platform and its products; and (3) *end-user programming*: platforms support developers with no computer science or engineering degree, mostly based on the pipes-and-filters architecture and on a creative composition of building blocks; SECO success depends on a stable domain which allows for low maintenance effort, considering such developers.

Table 2.1. SECO Taxonomy. Source: (BOSCH, 2009b)

| *platform* / *category* | ***DESKTOP*** | ***WEB*** | ***MOBILE*** |
|---|---|---|---|
| **OPERATING SYSTEM** | ***MS Windows, Linux, iOS*** | ***Google AppEngine, Yahoo Developer, Coghead, Bungee Labs*** | ***Nokia S60, Palm, Android, iPhone*** |
| **APPLICATION** | ***MS Office*** | ***SalesForce, eBay, Amazon, Ning*** | **None so far *(2009)*** |
| **END-USER PROGRAMMING** | ***MS Excel, VHDL, Mathematica*** | ***Google's mashup editor MS PopFly, Yahoo! Pipes*** | **None so far *(2009)*** |

In turn, dimension #2 refers to *computing platforms* in which SECOs are grouped regarding their platforms' infrastructure: *desktop*, *web* and *mobile*. According to BOSCH (2009b), the complexity of many hardware configurations becomes a major source of inefficiency for the mobile platform regarding *operating system-centric* SECOs. Additionally, *application*- and *end-user programming-centric* SECOs represent an exciting field with many opportunities to perform empirical studies, as concluded by a systematic mapping study in mobile SECO (FONTÃO et al., 2015a). In fact, software producing organizations in mobile SECO have spent time and effort to enrich their operating systems with development tools, training sessions (or evangelism) and social media to keep their communities vibrant (FONTÃO et al., 2014; 2016). This fact has motivated the emergence of *application-centric* mobile SECOs (e.g., WhatsApp, Waze, Facebook etc.) after the taxonomy proposed by BOSCH (2009b) was published. However, more research is needed for *end-user programming-centric* mobile SECOs. Finally, BOSCH (2009b) states that mainframes and mini-computers existed before the desktop and that there are other platforms besides mobile in the era of ubiquitous computing; then his taxonomy tries to cover the "lion's share" of software development.

In the SECO context, the central software organizations are known as ISVs, i.e., organizations specialized in developing or distributing software products and services (POPP & MEYER, 2010). An ISV resorts to virtual integration through alliances to create and keep networks of influence and interoperability, generating SECO (JANSEN et al., 2009a). JANSEN et al. (2009c) state that an ISV needs to analyze many elements and present a three-tier perspective model (Figure 2.5). At the *ISV level*, the objects of study are all products and services maintained by the ISV and the ISV itself. *Evolvability* and *performance* should be analyzed as properties that depend on the ISV's product/service portfolio, knowledge management and relationship control. Evolvability indicates how engaged an ISV is to align the platform with business objectives and supporting technologies, and performance indicates how successful an ISV is driving results when developing or distributing products and services (JANSEN et al., 2009a).

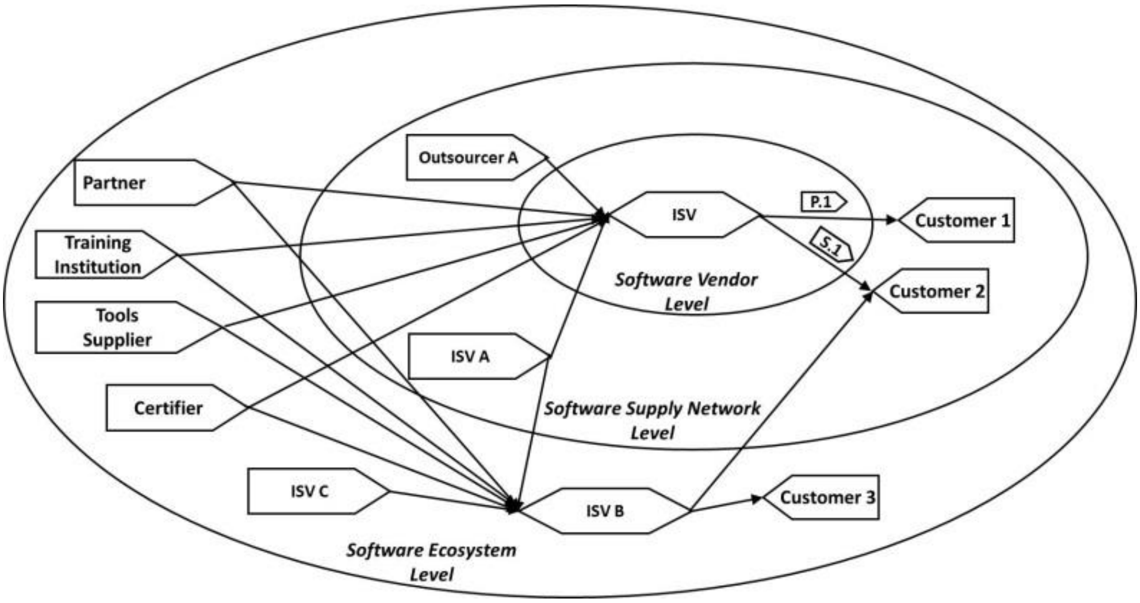



Figure 2.5. SECO Perspectives, where: ISV = Independent Software Vendor, SSN = Software Supply Network, SECO = Software Ecosystem, P = Product, S = Service. Adapted of (JANSEN et al., 2009b)

At the *Software Supply Network* (SSN) *level*, the objects of study are the network of customers and suppliers who are in contact with the ISV. SSN level is one of the most used approaches for SECO modelling (BOUCHARAS et al., 2009). SSN is a series of linked software, hardware, and service organizations cooperating to attend to market demands (JANSEN et al., 2007). SSN basically considers four main elements: ISV (at center), suppliers (at left), customers (at right), and the software products (P) and services (S) they exchange. Despite the complexity of SSN shown in Figure 2.5, Figure 2.6 shows a typical SECO scenario, where two overlapping SSN that show the same actor (e.g., SAP) has different roles (*acquirer* and *supplier*) in distinct SECOs (SECO SAP and SECO SWCompany). This is a critical issue when one is trying to define and model many interrelated SECOs, given the variations of actors' roles as described previously, hindering SECO comprehension (SANTOS, 2014).

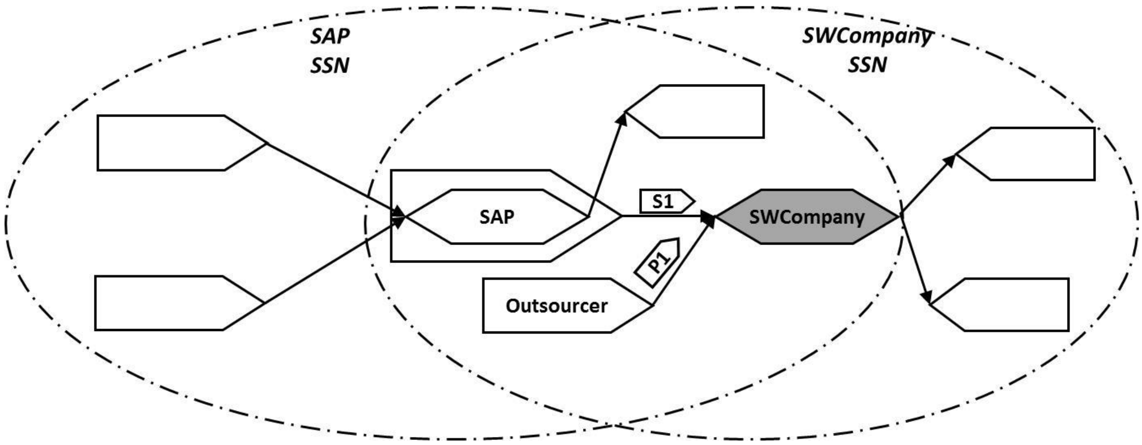



Figure 2.6. Role variation in SECO business networks.
Source: (SANTOS, 2014)

Internal characteristics related to the SECO (e.g., size, types, roles, connectedness etc.) are analyzed to develop strategies to an ISV to maintain the platform, e.g., a supplier's product or service, or an acquirer's software asset base. Such properties refer to the notion of *health* and *stability* in the SECO. Health indicates the organization and platform's longevity and prosperity based on performance from the ISV level (JANSEN, 2014; SANTOS et al., 2014b). It is still a "weak" metaphor extended from Business Ecosystems since it is not possible to give absolute values to health but only indicators (HARTIGH et al., 2013). Health is determined by the *robustness* (e.g., how well a SECO can recover from major stress), *productivity* (e.g., how much business/value is created/added, and how many new players are joining), and *niche creation* (e.g., how much opportunities are created for new entrants and old actors) within a SECO (JANSEN et al., 2009a). In turn, stability depends on the ISV's orchestration capacity and is defined by the "faithfulness" of members, i.e., how frequently members leave the SECO (JANSEN et al., 2009a).

Finally, at the *SECO level*, the objects of study are all related organizations, inside or closer to the SECO, as well as their relationships. Profitability is a property that needs to be approached in a SECO through short and also long-term strategies in order to keep it vibrant. As such, the notions of *sustainability* and *diversity* were introduced in the SECO literature (SANTOS & WERNER, 2011d). Sustainability consists of the capacity of a SECO to increase or maintain its community over longer periods of time, surviving inherent changes that can modify the population or even attacks/sabotage of the platform, e.g., new technologies or products from competitors (DHUNGANA et al., 2010). In turn, diversity consists of involving different profiles/groups of actors inside the SECO, e.g., maintaining components from different programming languages, software infrastructures, and hardware devices to create a larger set of software producers and consumers (DHUNGANA et al., 2010). Both notions help a SECO to survive to a community loss, although *resilience* appears to be a fundamental capacity of an ecosystem to resist damage and recover from disturbance.

The three-tier perspective model requires focusing on the SECO *scope*, i.e., each level has different challenges starting from the effect of platform's architectural changes to the development of business strategies and the measurement of the SECO health (BARBOSA et al., 2013). Beyond scope, different *elements* are part of the SECO levels (JANSEN et al., 2009a): (i) software; (ii) networks, and social or business ecosystems; and (iii) actors, organizations, and businesses. In other words, organizations play with their SE processes and directly dependent on business models, involvement with third-parties and strategies for opening the platform architecture. Nevertheless, some challenges are emerging in this context (JANSEN et al., 2009c): (1) ISVs have to be aware of their related SECOs; (2) they want to know survival strategies that exist among SECO stakeholders; and (3) they need to seek possible ways to open up the platform without intellectual property issues.

Additionally, it is possible to distinguish *dimensions* for analyzing SECOs (SANTOS & WERNER, 2011b). From a three-dimensional view, CAMPBELL & AHMED (2010) state that the SECO concept in SE has roots in the theories of common architecture development and social networking. 'Ecosystem' would be a useful metaphor to ground transitional, evolutional and innovative methods for SPL in the context of a broad, interorganizational reuse (SANTOS, 2014). Architecture dimension focuses on the SECO platform, where some SE techniques are critical: *DE* (lifecycle definition), *commonalities and variabilities management* (platform features definition), and *SPL* architecture (platform as a SPL). Business dimension focuses on the SECO knowledge flow (artifacts/resources/information), driven by three factors: *business vision* (establishment of strategic objectives and action plans), *innovation* (capability to be creative and pioneer in product development), and *strategic planning* (clear understanding of how, when, where and who will perform the objectives). Finally, social dimension focuses on the SECO stakeholders, and consists of *utilitarianism* (engagement strategies), *promotion* (recognition strategies) and *knowledge gain* (skills and interactions).

The three-tier perspective model allows understanding another element in the software market: the SECO *lifecycle*. SECO lifecycle is a series of steps that reflects a deeper and more creative relationship among organizations throughout the process of creating a SECO centered into a platform (FARBEY & FINKELSTEIN, 2001). In parallel, a SECO has overlapping frontiers, e.g., a market, a technology, a software infrastructure, or an organization, as well as geographic restrictions, component specifications, license availability, its age and history (JANSEN et al., 2009a). It is analyzed through four phases (BARBOSA et al., 2013):

1. the establishment of a market relationship with a dominant, focal organization, using a variety of contracts and skills;
2. the emergence of a preliminary network with no active learning, i.e., the organization is gathering experience of how informal relationships are;
3. the reduction of the dominant, focal organization's power, and the stimulus of new communities of practice and/or supply chain partnerships to exchange experiences;
4. the existence of a community of creation, where no dominant organizations exist and the power is distributed.

Finally, we can summarize some benefits and difficulties when looking at the SECO context in SE (WERNER & SANTOS, 2015). Engineering software in SECOs allows software producing organizations to sustain, evolve and diversify software products and services (with the support of niche players), or platforms (with the support of keystones), against external forces (dominators). As such, some benefits are pointed out in literature and industrial cases (BARBOSA et al., 2013): (a) to improve the notion of value for products and services; (b) to attract new customers; (c) to get time-to-market based on co-innovation (i.e., create new functionalities and tools upon the SECO platform aided by the community's members); and (d) to reduce maintenance costs. In turn, managing software in SECOs allows acquirers to better select, adopt and maintain products and services, as well as technologies, to keep their businesses alive and profitable in a dynamic market (ALBERT et al., 2013). On the other hand, some barriers lie upon: (a) to manage the network's knowledge; (b) to maintain the platform architecture (stability, security etc.); (c) to cope with a diversity of licenses and risks; (d) to coordinate and communicate requirements; and (e) to seek decision support.

## 2.3 ReuseECOS '3+1' Framework

Both suppliers and acquirers face some challenges regarding thinking about SECO elements during SE activities, e.g., how can an organization realize that its own SSN affects (or is very affected by) a given technology? One reason is the fact that the terminology varies in the SECO community and the concept is still vague and diverse, used as a "buzzword" (SANTOS, 2014). It implies in difficulties to perform SECO modeling and analysis since the definition is still not so clear (COSTA et al., 2013; MANIKAS & HANSEN, 2013). This scenario motivated us to investigate our RQ1 – *What are the SECO dimensions and key concepts that allow researchers to analyze an organization's platform?* To answer that, we organized SECO researches published in the International Workshop on Software Ecosystems (IWSECO) to support analyses of SECO platforms, named *ReuseECOS '3+1'* framework.

*ReuseECOS '3+1'* framework is one of the contributions of our research and was developed from an analytical literature review. SECO's key concepts and dimensions were initially extracted from 16 papers published at the IWSECO 2009-2010. However, we updated the review with 13 papers from IWSECO 2011-2012 (SANTOS, 2013a), as shown in Table 2.2. The framework provides a step-by-step process to serve as an instrument to help researchers to characterize and analyze organizational platforms considering the SECO context in the IT management teams' point of view. SECO's key concept(s) and their relations were firstly collected based on the main contribution of each paper (regarding SECO analysis).

Then, such elements were classified into three basic dimensions extended from (CAMPBELL & AHMED, 2010), which were integrated through a fourth dimension, *engineering and management* (E&M), according to a SECO "3+1" view (Figure 2.7). To do so, four researchers organized those elements through a set of steps and activities which compose each framework's dimension, based on a peer-reviewing process: two researchers (a PhD student and a Master student) worked in organizing/developing the framework, and two researchers (a senior research and a Master student) worked in verifying/validating it. Each dimension was published in workshop and conference proceedings (SANTOS & WERNER, 2011bd; 2012ab).

*ReuseECOS '3+1'* framework has served as an initial body of knowledge to support empirical studies to properly investigate a specific SECO concept and/or relation each time. The framework was also verified against a systematic mapping on SECO (BARBOSA & ALVES, 2011). This effort allowed us to improve *ReuseECOS ‘3+1’* dimensions, published as a chapter of the SECO international reference book (BARBOSA et al., 2013). The next sections present the goal, steps and activities of each dimension, with some examples derived from a preliminary analysis of four platforms of the Software Reuse Lab (LENS/REUSE) at COPPE/UFRJ (Table 2.3).

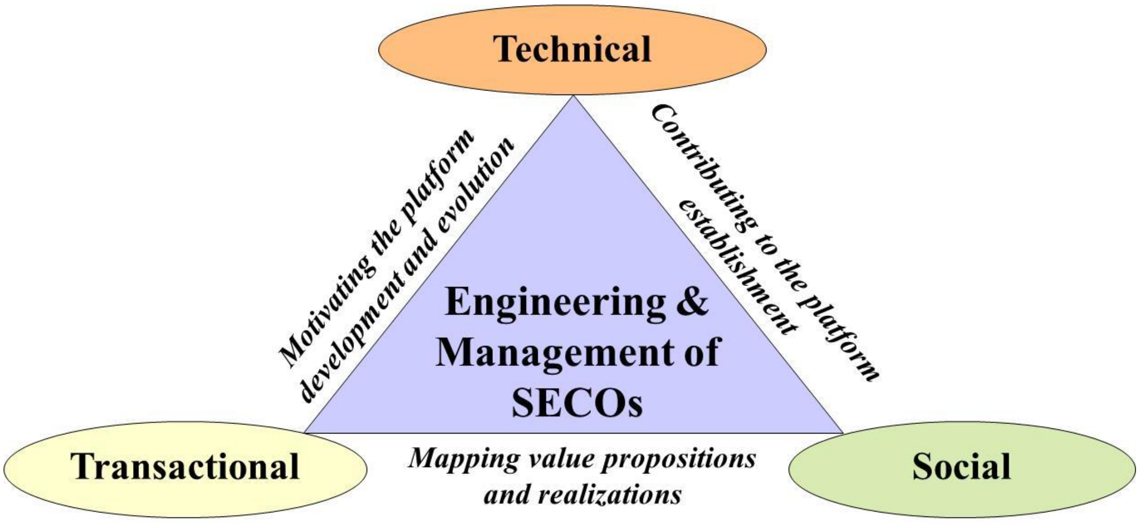



Figure 2.7. Overview of *ReuseECOS ‘3+1’* Framework

Table 2.2. Classification of 29 papers published at IWSECO 2009-2012

| DIMENSION | DESCRIPTION | REFERENCES |
|---|---|---|
| **Technical** | explores decision making in architecture using design and code visualization | ALSPAUGH et al. (2009); ANVAARI & JANSEN (2010); BOSCH (2010); CATALDO & HERBSLEB (2010); PETTERSSON et al. (2010); YU & DENG (2011); MOLDER et al. (2011); SANTOS & WERNER (2011b); IYER (2012); SALMINEN & MIKKONEN (2012); HYRYNSALMI et al. (2012). |
| **Transactional** | explores analogies with other ecosystems and provides models for classifying and evaluating SECOs | JANSEN et al. (2009a); WERNER (2009); BERK et al. (2010); CAMPBELL & AHMED (2010); DHUNGANA et al. (2010); HUNINK et al. (2010); MCGREGOR (2010); SANTOS & WERNER (2010); ANGEREN et al. (2011); BARBOSA & ALVES (2011); POPP (2011); HANSSEN & DYBÅ (2012); POPP (2012); JANSEN & CUSUMANO (2012). |
| **Social** | explores social, technical and socio-technical networks in SECOs | FRICKER (2009); CAPURUÇO & CAPRETZ (2010); SEICHTER et al. (2010); MENS & GOEMINNE (2011). |
| **Engineering and Management** | explores the relations among the other dimensions to get insights from SECOs and impacts on SE | Derived from all papers. |

Table 2.3. LENS/REUSE SECO platforms

| PLATFORM | DESCRIPTION |
|---|---|
| **Odyssey** <http://reuse.cos.ufrj.br/odyssey> | Large Java project developed since 1997. It is a standalone IDE to support DE and software reuse. It comprising the platform kernel (Odyssey-light) and several plug-ins (subprojects). Odyssey is evolving to support process lines. Several Brazilian research groups contributed to this platform, e.g., IFF, PUCRS, UFJF, UFF. |
| ***Brechó*** <http://reuse.cos.ufrj.br/brecho> | Medium Java EE project developed since 2005. It is a component repository to support reuse management. *Brechó* uses open source frameworks (Struts and Hibernate) and is a self-contained platform, currently in a refactoring phase. Some Brazilian research groups contributed to this platform, e.g., LabBD/UFRJ and UFF. |
| **EduSE** <http://lab3d.coppe.ufrj.br/portaledues> | Medium Java EE project developed between 2009 and 2011. It is a content management system to support execution of systematic reviews and surveys, as well as learning object and experience report management. It uses an open source framework (Seam), developed in collaboration with a UFLA research group. |
| **RPP** <http://www.rpp.ufrj.br> | Medium Java EE project developed since 2010. It is a content management system to support public policy research, developed upon open source technology (HSQLDB, JSF2, Richfaces 4, EJB 3.1). RPP Portal helps 10 research groups over Rio de Janeiro State to share videos, interviews, reports etc. IPPUR/UFRJ is leading RPP and a supplier was involved in the platform development. |

### *2.3.1. Technical Dimension*

The first dimension focuses on the platform (SECO element) and refers to the ISV and SSN levels (internal view) more than the SECO level (external view) (Section 2.2.2). In this context, a *platform* is a software product (supplier) or an asset base/ catalog (acquirer). First of all, some activities help one to select a target platform and contextualize its project/development (*case*) based on identifying actors' roles and health indicators. Next, there are activities regarding the platform architecture's opening process, i.e., the definition of levels, factors, and licenses to allow suppliers and external developers to take part in a specific SECO. Last activities in this dimension aim to consider some critical elements to balance modularity (componentization) and transparence (visualization) throughout the platform's evolution and maintenance (i.e., SECO engineering). According to the previous analysis performed in (BARBOSA et al., 2013), the technical dimension highlights four challenging areas for SE in the SECO context: architecture, operating system, evolution, and SPL. This dimension was published in (SANTOS & WERNER, 2011b). Steps and activities of this dimension are shown in Figure 2.8 and described next.

**Step 1**: *contextualize platform's project and development* helps IT management teams with elements to characterize a SECO. The concepts were extracted from the business ecosystem (BERK et al., 2010) and process modeling (PETTERSSON *et al.*, 2010):

**Activity 1**: *select SECO platform* represents a decision point in which one chooses a platform of interest, depending on the SECO boundary (i.e., market, technology, infrastructure or organization). In the Software Reuse Lab, Odyssey and *Brechó* platforms were selected for a preliminary analysis, although some examples mention EduSE and RPP in the following steps.

**Activity 2**: *identify SECO roles* aims to define what the actors' roles are based on business ecosystems (JANSEN et al., 2009a). As discussed in Section 2.2, SECO roles are classified into two categories: hubs and niche players. For example, LENS/REUSE is the SECO keystone and Eclipse Foundation is such a dominator, since the ecosystem developers are gradually creating their tools out of Odyssey or *Brechó* platforms. Examples of niche players (PETTERSSON et al., 2010): Quality and Empirical SE Groups at COPPE/UFRJ (influencers), SE groups from other Brazilian universities such as UFF, PUC-RS and IFF who are partners (hedgers), and a SE group of UFLA who was integrated into the SECO (disciple).

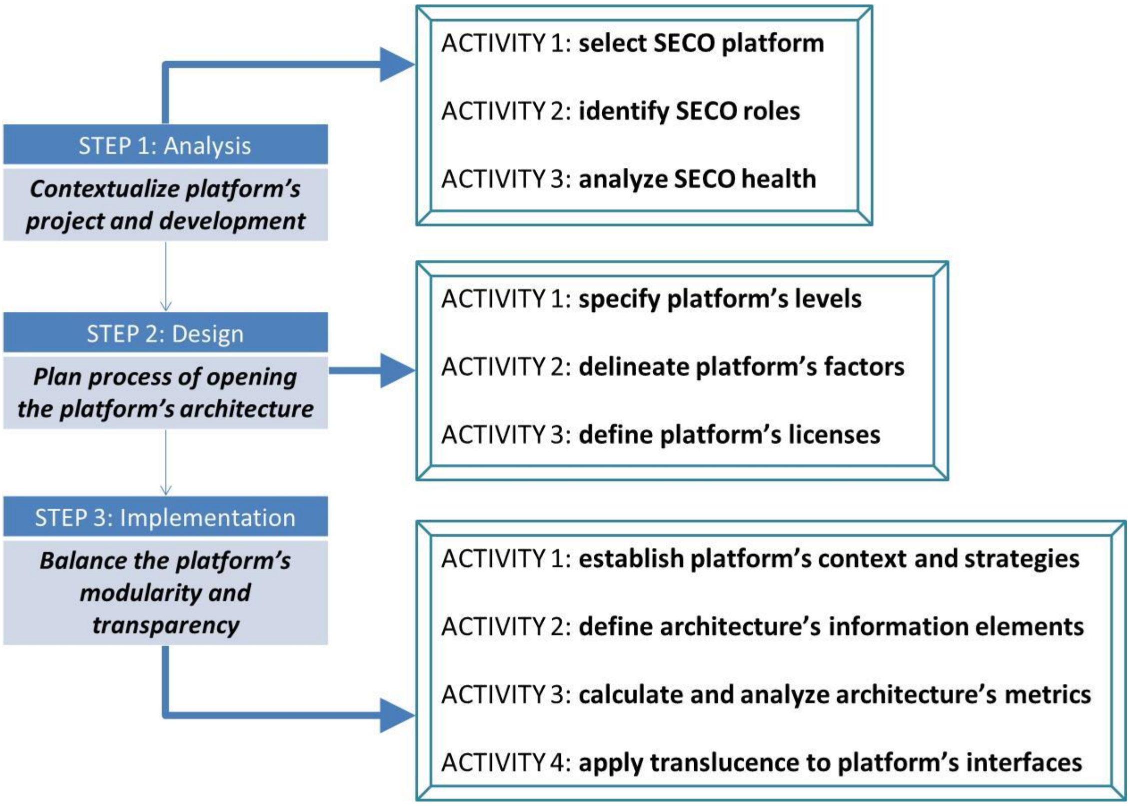



Figure 2.8. Technical dimension of *ReuseECOS '3+1'* Framework

**Activity 3**: *analyze SECO health* consists in quantifying and qualifying some health measures (JANSEN et al., 2009a; DHUNGANA et al., 2010, MCGREGOR, 2010; BARBOSA & ALVES, 2011; JANSEN & CUSUMANO, 2012; HARTIGH et al., 2013). As explained in Section 2.2.2, the main three health indicators are: productivity, robustness and niche creation. For example, in May 2008, *Brechó* platform had an intense period of development as reported by the StatSVN[3] tool (Figure 2.9). Recently, the effective exit or loss of Master and PhD students due to

[3] StatSVN retrieves information from a SVN repository and generates several tables and charts describing the project development. Available at: <http://www.statsvn.org>.

industry opportunities or faculty positions reduced the number of members developing and/or leading Odyssey plug-ins or *Brechó* extensions. Finally, the continuous search for agencies for financial support (e.g., CNPq, CAPES, FAPERJ) allows new research groups to join the SECO (e.g., UFLA in EduSE, IPPUR/UFRJ in RPP), strengthening LENS/REUSE as the keystone.

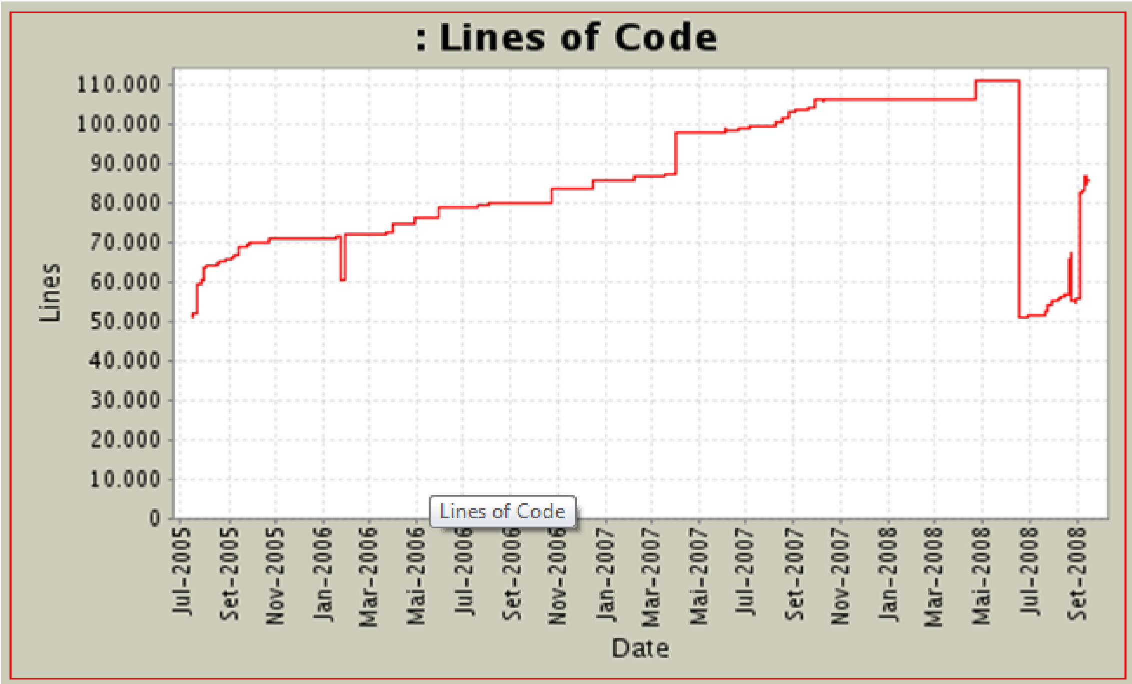



Figure 2.9. SVN Commits in LoC (*Brechó* platform)

**Step 2**: *plan the process of opening the platform's architecture* helps IT management teams to characterize the platform's architecture of the selected SECO:

**Activity 1**: *specify platform's levels* aims to identify the platform's modules or components based on the layer-based architecture in order to support different roles with a particular abstraction level (ANVAARI & JANSEN, 2010). For example, *Brechó*, EduSE and RPP run on the web platform, and Odyssey runs on the desktop platform. All of them have three levels: (i) *extended applications* developed by external developers (other SE groups in Brazil); (ii) *native applications* developed by internal developers and sometimes not modifiable; and (iii) *kernel* developed by internal developers who are responsible for the platform's core, where low-level components such as device drivers, security, framework etc. are treated.

**Activity 2**: *delineate platform's factors* defines extension mechanisms to control the access to different platform's levels and components (ANVAARI & JANSEN, 2010). For example, three actions are used to make clear the notion of architecture opening for *Brechó* platform: (i) *integrate*: an API is provided so as to ease communication with other development tools, e.g., a plug-in to integrate Microsoft Team Foundation Server (TFS)[4] with *Brechó* aiming to support component release storage; (ii) *extend*: new functionalities can be developed on an external layer, e.g., the evolution of *Brechó* from a component repository to a component marketplace, creating a distribution named *Brechó*-VCM; and (iii) *modify*: some components can

[4] Microsoft TFS. Available at: <https://www.visualstudio.com/en-us/products/tfs-overview-vs.aspx>.

be made replaceable or modifiable, e.g., evolution of a trade mechanism to support pricing models in *Brechó*-VCM.

**Activity 3**: *define platform's licenses* restricts the actors' participation in the platform development based on rights and obligations that govern the process of opening the SECO (ALSPAUGH et al., 2009). Licenses should consider some types of common elements in software architecture, e.g., source code components, executable components, web services, APIs, software connectors, connection methods, and systems and subsystems configured architectures. In addition, JANSEN & CUSUMANO (2012) defines two associate models: (i) *partnership*: a new member can be accepted and committed with a SECO platform, subject to rules and taxes; and (ii) *membership*: a new member can engage in the cooperative SECO to add value and also to benefit from the existing platform (taxes may apply). For example, LENS/REUSE SECO always requires allowance to integrate, extend or modify the kernel of *Brechó* platform, as shown in Table 2.4.

Table 2.4. Comparison among architecture opening strategies in LENS/REUSE SECO, where: P = Possibility, L = License status, Po = Possible, Pc = Possible for some components, Np = Not possible, Pn = Permission is not needed, Ps = in some cases, permission is needed, and Pa = Permission is always needed.

| | | ***Odyssey* (1997-…)** | | ***Brechó* (2005-…)** | | ***EduES* (2009-2011)** | | ***RPP* (2010-…)** | |
|---|---|---|---|---|---|---|---|---|---|
| **FACTOR** | **LEVEL** | **P** | **L** | **P** | **L** | **P** | **L** | **P** | **L** |
| **Integrate** | *extended applications* | **Po** | **Pn** | **Po** | **Pn** | **Po** | **Ps** | **Po** | **Ps** |
| **Extend** | | **Po** | **Pn** | **Po** | **Ps** | **Po** | **Ps** | **Po** | **Ps** |
| **Modify** | | **Po** | **Ps** | **Po** | **Ps** | **Po** | **Ps** | **Po** | **Ps** |
| **Integrate** | *native applications* | **Po** | **Ps** | **Po** | **Ps** | **Po** | **Ps** | **Po** | **Ps** |
| **Extend** | | **Po** | **Ps** | **Po** | **Ps** | **Po** | **Ps** | **Po** | **Ps** |
| **Modify** | | **Po** | **Ps** | **Po** | **Ps** | **Po** | **Ps** | **Po** | **Ps** |
| **Integrate** | *kernel* | **Pc** | **Pa** | **Pc** | **Pa** | **Po** | **Pa** | **Po** | **Pa** |
| **Extend** | | **Pc** | **Pa** | **Pc** | **Pa** | **Po** | **Pa** | **Po** | **Pa** |
| **Modify** | | **Np** | **Pa** | **Pc** | **Pa** | **Po** | **Pa** | **Po** | **Pa** |

**Step 3**: *balance the platform's modularity*[5] *and transparency*[6] helps IT management teams to characterize the platform translucence, i.e., the visibility or hiding of information elements and behaviors regarding the development process based on the clear definition of the SECO roles (CATALDO & HERBSLEB, 2010):

**Activity 1**: *establish platform's context and strategies* aims to detail the SECO's platform scope according to the *abstraction*[7] and *type*[8] of knowledge manipulated in the SSN level, as well as the *actor profile*[9]. This activity is strongly related to CBD techniques such as interfaces, since the architecture is layered. For example, *Brechó* platform is a web system developed on top of Java EE platform using MVC pattern, Sun's Java Code Conventions, and frameworks for web applications (Struts) and persistence (Hibernate), and run over Tomcat container and MySQL database servers. SVN version control system presents 20 developers since 2005.

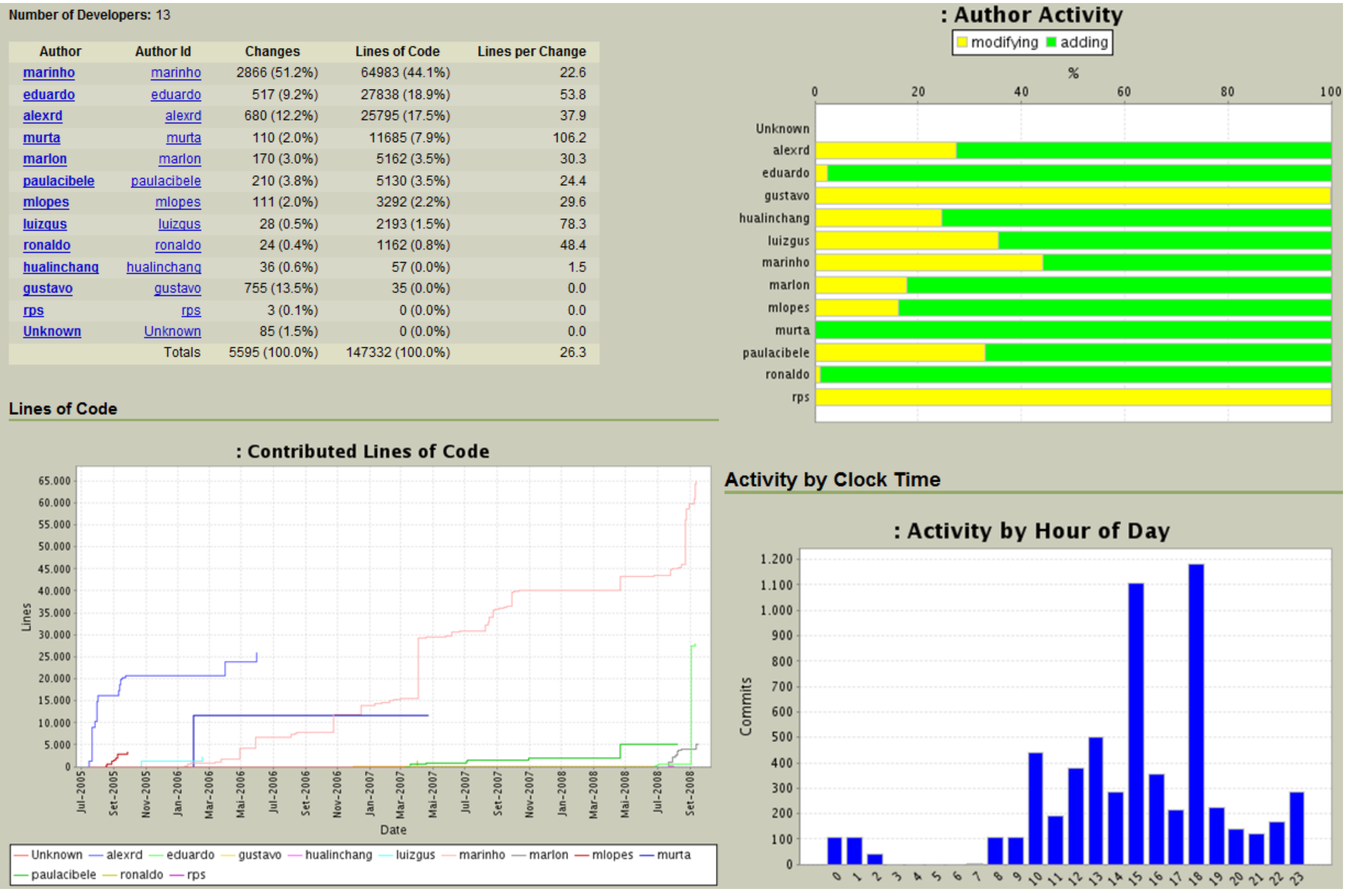
[5] Modularity consists in applying the traditional engineering principle related to decomposing a system in manageable modules, minimizing the technical coupling (CATALDO & HERBSLEB, 2010).
[6] Transparency consists in making all kinds of development information available, including design and code, tasks, defects and interactions among stakeholders (CATALDO & HERBSLEB, 2010).
[7] For example, requirement, design, code, documentation etc.
[8] For example, functionalities, components, crosscutting concerns etc.
[9] For example, platform manager, IT architect, requirement engineer, internal or external developer etc.

Finally, the platform mostly deals with code artifacts, based on modules and components, and has a manager (member since 2007) and already had developers in different locations (Rio de Janeiro, Niterói, and Lavras). The lacking of formal documentation and the high turnover motivated the frequent use of *javadoc* and design patterns, as well as known, free technologies, though it is difficult to update and/or migrate the platform's technologies because sometimes there is no human/financial resource.

**Activity 2**: *define architecture's information elements* aims to make three platform architectural key elements explicit, extracted of (CATALDO & HERBSLEB, 2010): (i) *uncertainty*: the probability of interface changes affects the platform stability. For example, Odyssey developers work in different locations (Juiz de Fora, Campos and Porto Alegre), and they spend efforts to refactor (or 'slim') the platform kernel (BOSCH, 2010); (ii) *complexity*: the property of exploring the information hiding principle to aid niche players activities based on standards (CAMPBELL & AHMED, 2010). For example, *Brechó* platform uses known code patterns and web frameworks, being an advantage to newcomers; and (iii) *activity awareness*: the capability of actors to know process activities and dependencies in two perspectives, *artifacts* and *roles* (PETTERSSON et al., 2010). For example, Odyssey, *Brechó* and EduSE platforms are submitted to a version control system (SVN) and a bug tracking system (Bugzilla) to allow niche players to communicate and collaborate, including Yahoo and Google groups.

**Activity 3**: *calculate and analyze architecture's metrics* aims to extract platform architecture knowledge from the information elements discussed in Activity 2: (i) *measuring uncertainty* requires data collected from actors' experiences when they try to understand the platform trajectory based on historical similar projects within platform. For example, time and effort (LoC) to develop a new component or extension can be extracted from SVN data to analyze *Brechó* platform (Figure 2.10); (ii) *measuring complexity* requires data collected from components' interfaces in different layers, from architectural descriptions and from platform's nonfunctional or crosscutting concerns. For example, in *Brechó* platform, *javadoc* improves the code legibility and maintainability, and such characteristics can be verified through the use of product metrics on component interfaces over time; and (iii) *measuring activity awareness* requires data collected from contracts or links among artifacts and actors and from architectural design tools used in the platform evolution (e.g., new resource, code blocks, pre and post conditions etc.). For example, StatSVN was used to collect and analyze *Brechó* platform data, e.g., source code time line, packages and files per change, developers contribution (commits history), activities per hour, per day or per week etc. This can help the licenses definition. This information is exemplified in Figure 2.10.

**Activity 4**: *apply translucence to platform' interfaces* aims to contribute to coordination and communication mechanisms and to avoid information overload, e.g., each actor has access to an abstraction level and knowledge type according to his/her role. In parallel, security and reliability should be preserved. For example, LENS/REUSE can mine *Brechó* code to visualize impacts of a given component or developer on the platform. CATALDO & HERBSLEB (2010) suggest a strategy to do it: to make information elements explicit through *tags* in architectural descriptions and *javadoc* in source code. Information visualization is an exciting topic in the SECO context (YIER, 2012). In addition, three concepts were identified: (i) *clopenness*: suggests that a software-intensive system is always both open and closed, and the system as a whole determines how the parts behave (MOLDER et al., 2011); (ii) *mashups*: applications that combine resources (e.g., data, code) from different services in the web into an integrated experience (SALMINEN & MIKKONEN, 2012); and (iii) *multi-homing*: several competing SECO platforms exist in the same market and developers offers the same products over time (HYRYNSALMI et al., 2012).



Number of Developers: 13

| Author | Author Id | Changes | Lines of Code | Lines per Change |
|---|---|---|---|---|
| marinho | marinho | 2866 (51.2%) | 64983 (44.1%) | 22.6 |
| eduardo | eduardo | 517 (9.2%) | 27838 (18.9%) | 53.8 |
| alexrd | alexrd | 680 (12.2%) | 25795 (17.5%) | 37.9 |
| murta | murta | 110 (2.0%) | 11685 (7.9%) | 106.2 |
| marlon | marlon | 170 (3.0%) | 5162 (3.5%) | 30.3 |
| paulacibele | paulacibele | 210 (3.8%) | 5130 (3.5%) | 24.4 |
| mlopes | mlopes | 111 (2.0%) | 3292 (2.2%) | 29.6 |
| luizgus | luizgus | 28 (0.5%) | 2193 (1.5%) | 78.3 |
| ronaldo | ronaldo | 24 (0.4%) | 1162 (0.8%) | 48.4 |
| hualinchang | hualinchang | 36 (0.6%) | 57 (0.0%) | 1.5 |
| gustavo | gustavo | 755 (13.5%) | 35 (0.0%) | 0.0 |
| rps | rps | 3 (0.1%) | 0 (0.0%) | 0.0 |
| Unknown | Unknown | 85 (1.5%) | 0 (0.0%) | 0.0 |
| | Totals | 5595 (100.0%) | 147332 (100.0%) | 26.3 |



Figure 2.10. Analysis of *Brechó* platform: LoC per change and contributions by developers (on the left side); activity type (modifying/adding) and flow (per hour/day) (on the right side)

### *2.3.2. Transactional Dimension*

The second dimension focuses on the knowledge (SECO element) and refers to the SSN and SECO levels (internal and external view). In this context, *knowledge* is the set of artifacts, resources and information that flows from/to the organization, subject to self-regulation mechanisms. First of all, some activities help one to identify and manage SECO elements based on the ‘ecosystem’ metaphor, such as energy source, energy and materials flow, and health (explained in the following). Next, GQM (Goal-Question-Metric) approach (BASILI et al., 1999) is suggested to guide the specification of sustainability and diversity information as SECO health measures. These measures can support the modeling of a framework to the SECO monitoring, comprising SECO aspects and strategies, e.g., using value chains (YU & DENG, 2011). According to the previous analysis performed in (BARBOSA et al., 2013), the transactional dimension highlights three challenging areas for SE in the SECO context: SECO modeling, co-innovation and business. This dimension was published in (SANTOS & WERNER, 2011d). Steps and activities of this dimension are shown in Figure 2.11.

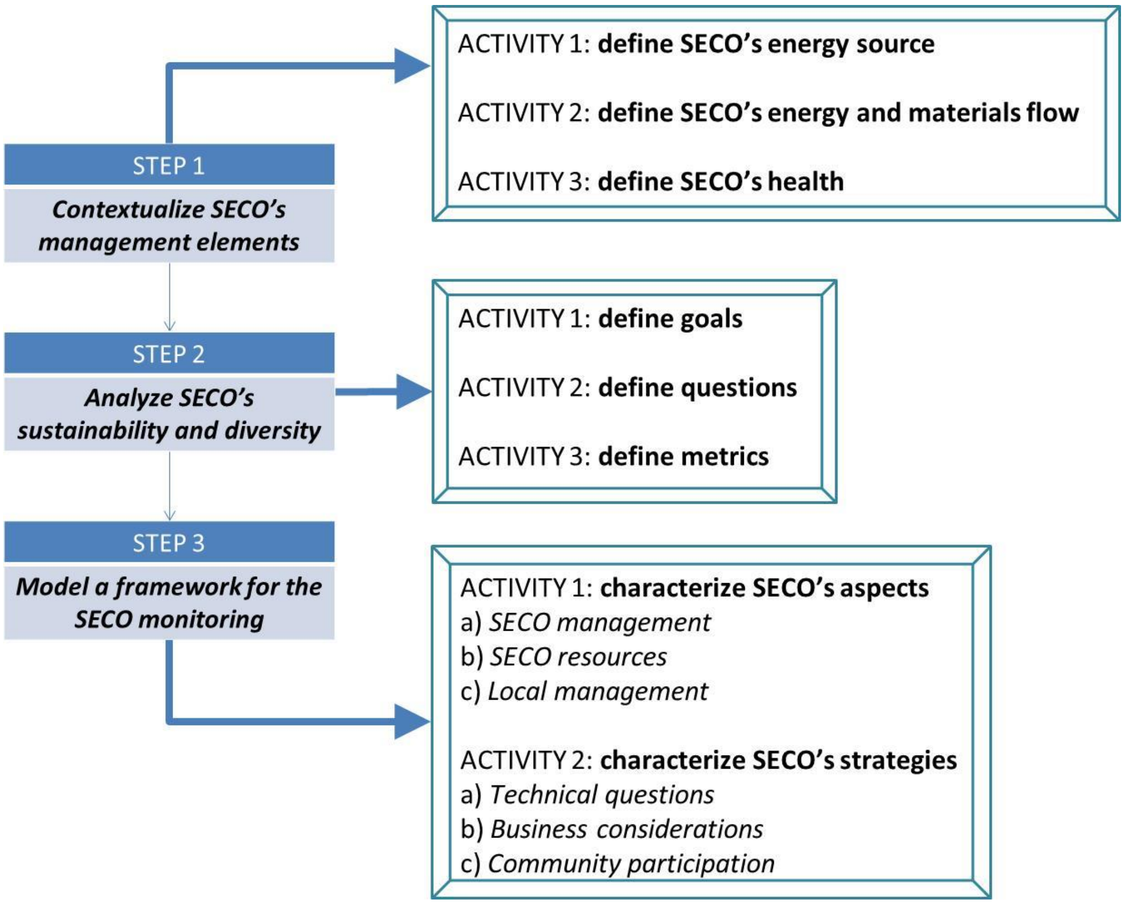



Figure 2.11. Transactional dimension of *ReuseECOS '3+1'* Framework

**Step 1**: *contextualize SECO's management elements* helps IT management teams to identify element's behaviors and characteristics in the SECO context, based on concepts derived from other ecosystems (natural, business, and social). It can make the understanding of a SECO lifecycle easier:

> ***Activity 1***: *define SECO's energy source* aims to identify a similar element to the *flora* responsible for producing primary energy through the photosynthesis in natural ecosystems; in other words, keystone's internal actors. For instance, in the LENS/REUSE SECO, PhD students are responsible for managing the platforms, according with their experience (knowledge) and relationship (social network).
>
> ***Activity 2***: *define SECO's energy and materials flow* aims to identify a similar element to the *food chain* in natural ecosystems; in other words, the SECO value

chain (SANTOS & WERNER, 2010). Both models are used to investigate and treat assumptions in daily decision-making processes (BIFFL et al., 2006). For example, *Brechó*-VCM was derived from *Brechó* platform and extended it with mechanisms to support a value chain in component markets (Figure 2.12). MCGREGOR (2010) and YU & DENG (2011) classify value chains into: (i) *classic*: usually seen in proprietary SECOs where transaction costs are applied between keystone and external partners; and (ii) *open*: usually seen in open SECOs where niche players share value to the platform (knowledge transfer).

***Activity 3***: *define SECO's health* aims to identify a similar element to *nutrients recycling process* in natural ecosystems; in other words, the knowledge flow from SECO artifacts, resources, information and actors. For example, *Brechó* platform presents the following flow: (i) a new keystone member or niche player is trained; (ii) this actor develops a pilot project to know the technology and the SECO where he/she will belong to; (iii) he/she exchanges experiences with other members so to establish his/her goal and an action plan (e.g., developing a new platform's component); (iv) his/her activities often generate value when knowledge is shared within the SECO; and (v) he/she externalizes knowledge to other SECOs through scientific papers and reports.

**Step 2.1**: *analyze SECO's sustainability* helps IT management teams to check if the SECO can increase or maintain its platforms and community over longer periods of time so as to survive when inherent changes affect the population, e.g., new products from competitors cause migrations of users, developers etc. The critical SECO element is the *keystone's actions*. DHUNGANA et al. (2010) proposed the following parameters to perform this step:

1. **How are the finite resources or reservoir treated?**
   Characterize architecture, code, time, resources, users etc.
2. **How does the population control happen?**
   Characterize the incentives to buy, use or extend a platform product.
3. **What are the types of interaction among stakeholders?**
   Characterize collaboration and competition within the SECO.
4. **What is the process of energy transfer?**
   Characterize knowledge exchange within the SECO.
5. **What is the base for defining processes?**
   Characterize market economic cycles and technological advances.
6. **How is the process of adaptation?**
   Characterize stakeholders' response to accept, reject, or learn to like a SECO.

For example, a partial analysis of *Brechó* platform produced the following results:

1. It has just two developers and a manager to maintain the platform. There are no immediate resources to support other agents who want to contribute to it.
2. The platform is versioned and controlled based on a trunk-branches-tags structure, so it is viable to control its extensions.
3. The actors can collaborate with each other to create value in the SECO in the context of an academic platform development.
4. Knowledge flow happens through mail lists and internal workshops to report the activities developed on top of the platform.

5. It adopts an agile-like development process, focused on coding and documenting via *javadoc* and some class diagrams.
6. Although it has a great industrial potential, *Brechó* platform is part of a research project and its adoption is uncertain, considering the technical support over time. Usually, newcomers interested in software reuse contact LENS/REUSE SECO's members to develop projects over an existing platform (not from scratch).

**Step 2.2**: *analyze SECO's diversity* helps IT management teams to check if the SECO has opportunities to compensate the eventual loss of stakeholders after catastrophes that affect the SECO, e.g., actions plans and situated actions. An advantage of a SECO is the fact that when an actor leaves the SSN, the knowledge remains in the SECO, differently from nutrients in natural ecosystems. The critical element is the *platform domain*. POPP (2011; 2012) introduces the *hybrid business models* that can be used to leverage diversity: *business vs. rewards models*: where several notions of value co-exist in harmony; and *community vs. commercial open source*: where different opportunities can be explored throughout the open source development. DHUNGANA et al. (2010) proposed the following parameters to perform this step:

1. **What is diversity to the SECO?**
   Characterize the diversity of users and developers' communities.
2. **Why is diversity important to the SECO?**
   Characterize how to create value from the platform (horizontal market).
3. **How does diversity help the SECO?**
   Characterize the exploration of new areas when a niche becomes obsolete.
4. **How can the diversity be ensured in the SECO?**
   Characterize the support to different technologies, and domains and users as well.
5. **Otherwise, why does it happen?**
   Characterize competitive advantage degradation which reduces/kill communities.

For example, a partial analysis of *Brechó* platform produced the following results:

1. It has a very small community of co-localized developers and some unknown users sometimes acting as influencers (*followers*);
2. A new distribution (*Brechó*-VCM) extended the original platform with mechanisms to support a value chain. However, there was no discussion about the process of opening its architecture to an open source community.
3. Few tools support reuse management processes like *Brechó* (SANTOS et al., 2010b). Therefore, as the Brazilian Software Quality Model (MPS)[10] requires software reuse process based on ISO 12207, *Brechó* has opportunity to grow up;
4. Since *Brechó* considers the concept of 'components' as a general reusable software asset, it can support several domains and knowledge areas (niches);
5. *Brechó*'s technologies were obsolete (refactoring is required); there was neither policy for external development or licensing, nor complete documentation; internal developers community was volatile; and no business strategy existed to explore scenarios in large scale.

**Step 3**: *model a framework for the SECO monitoring* helps IT management teams to characterize aspects and strategies to monitor SECO platform and community. Figure

[10] MPS Model. Available at: <http://www.softex.br/mpsbr/mps/>. In Portuguese.

2.12 and Figure 2.13 highlight some *Brechó*-VCM platform's elements to exemplify this step:

***Activity 1***: *characterize SECO's aspects* aims to perform three tasks: (a) *SECO management*: define platform properties like security, adaptability, market variability, health, competition, productivity and resources management. For example, *Brechó*-VCM has a reference repository with modules to support analysis of a historical database; (b) *SECO resources*: define knowledge properties like types of documentation, agreements, artifacts and licenses etc. For example, *Brechó*-VCM has mechanisms to support the SECO internal view to help actors to understand their roles (producer and consumer); and (c) *local management*: define focal properties to provide feedback to the SECO platform. For example, *Brechó*-VCM supports integration with local repositories.

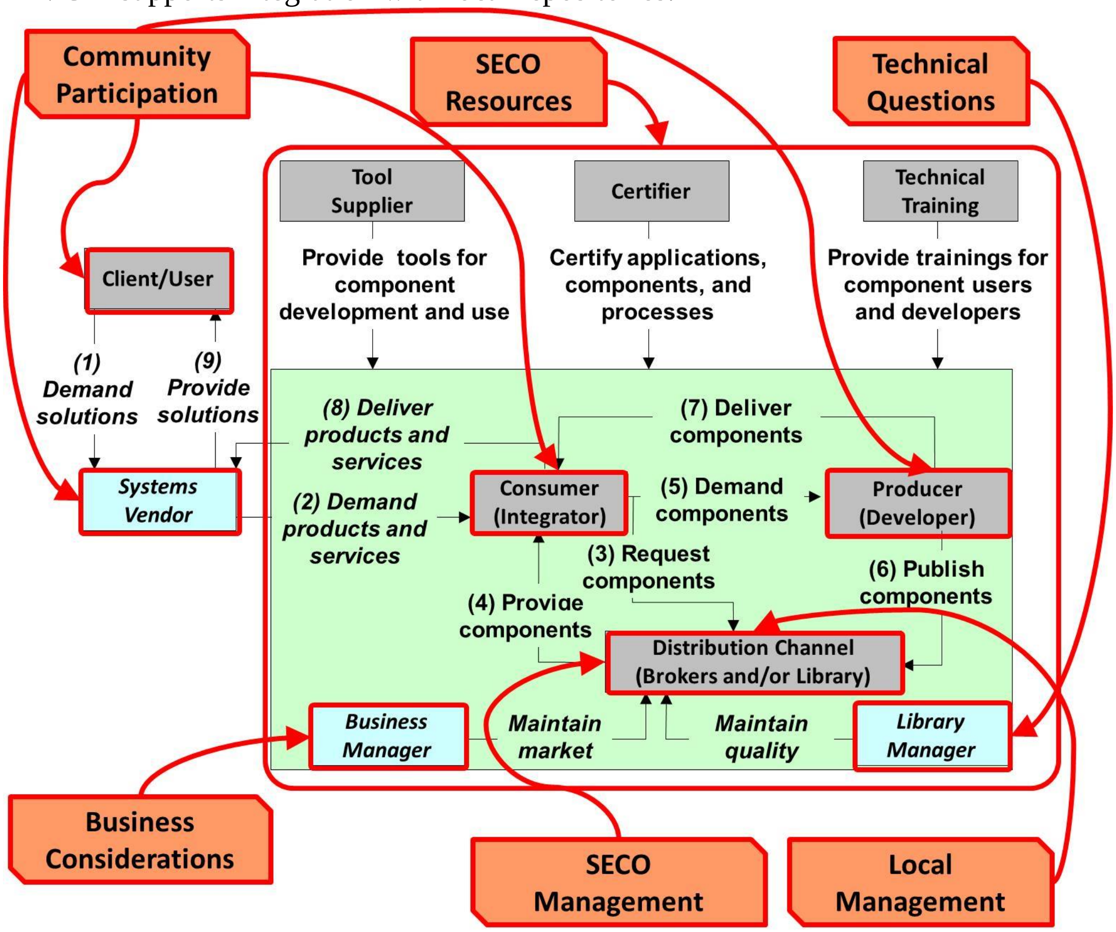



Figure 2.12. *Brechó*-VCM's value chain with marks to identify monitoring elements. Source: (SANTOS & WERNER, 2011d)

***Activity 2***: *characterize SECO's strategies* aims to perform three tasks: (a) *technical questions*: define the platform and products' quality manager who is responsible for evaluating components developed by external actors. For example, *Brechó*-VCM supports library manager's activities with a mechanism to control the platform's contributions (extensions); (b) *business considerations*: define the platform and products' business manager who is responsible for caring of the SECO economics. For example, *Brechó*-VCM supports business managers' activities with mechanisms to visualize value chain information; and (c) *community* *participation*: define platform and products' stakeholders who are responsible for interacting and sharing profits or benefits in the SECO. For example, *Brechó*-VCM supports different actors' roles in the software development in the SECO context, e.g., suppliers and acquirers.

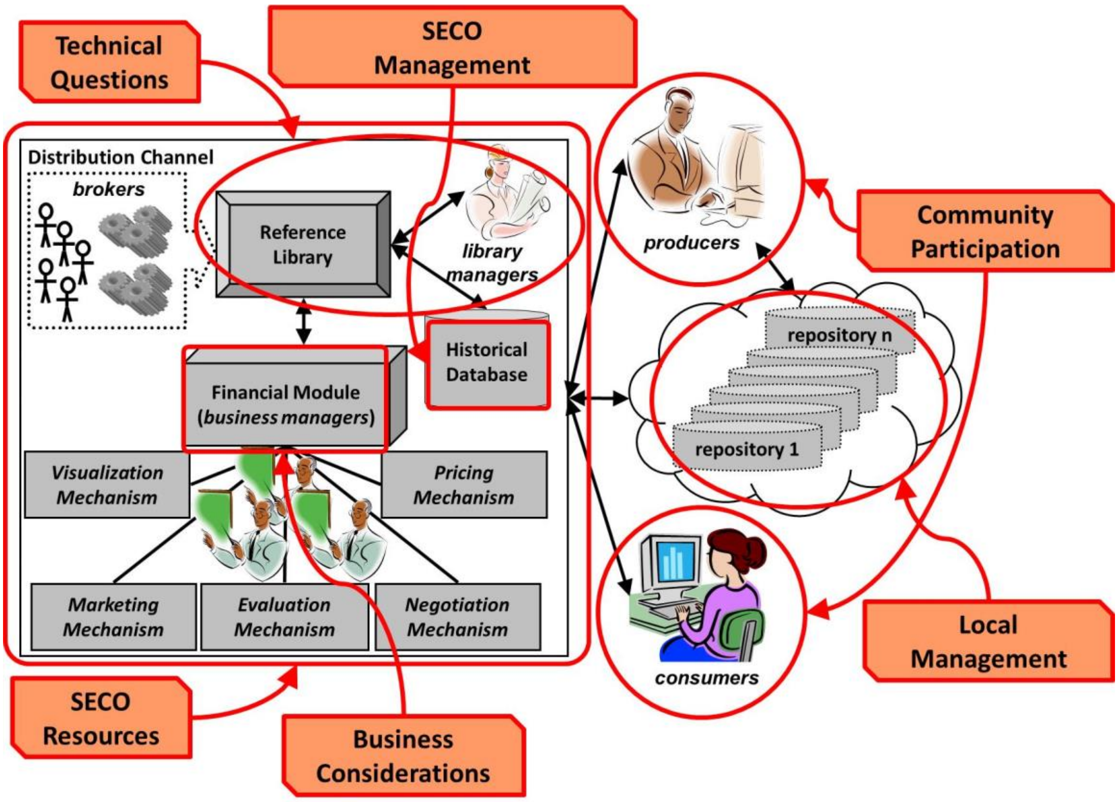



Figure 2.13. *Brechó*-VCM platform's model with marks to identify monitoring elements. Source: (SANTOS & WERNER, 2011d)

### *2.3.3. Social Dimension*

The third dimension focuses on the stakeholders (SECO element) and refers to the SSN and SECO levels (internal and external view). *Stakeholders* are defined as the actors who interact within a SECO, e.g., suppliers, acquirers, end-users, developers etc. As such, this dimension aims to understand how the actor-artifact network affects the SECO over time, also known as socio-technical network. First of all, SECO's network elements are modeled based on the types of relationships among actors and artifacts. Next, an environment to support such a network should be characterized through social resources. Mechanisms to report network indicators are then included, e.g., interaction, reputation and recommendation degrees. According to the previous analysis performed in (BARBOSA et al., 2013), the social dimension highlights one challenging area for SE in the SECO context: open source. This dimension was published in (SANTOS &

WERNER, 2012a). Steps and activities of this dimension are shown in Figure 2.14 and described next.

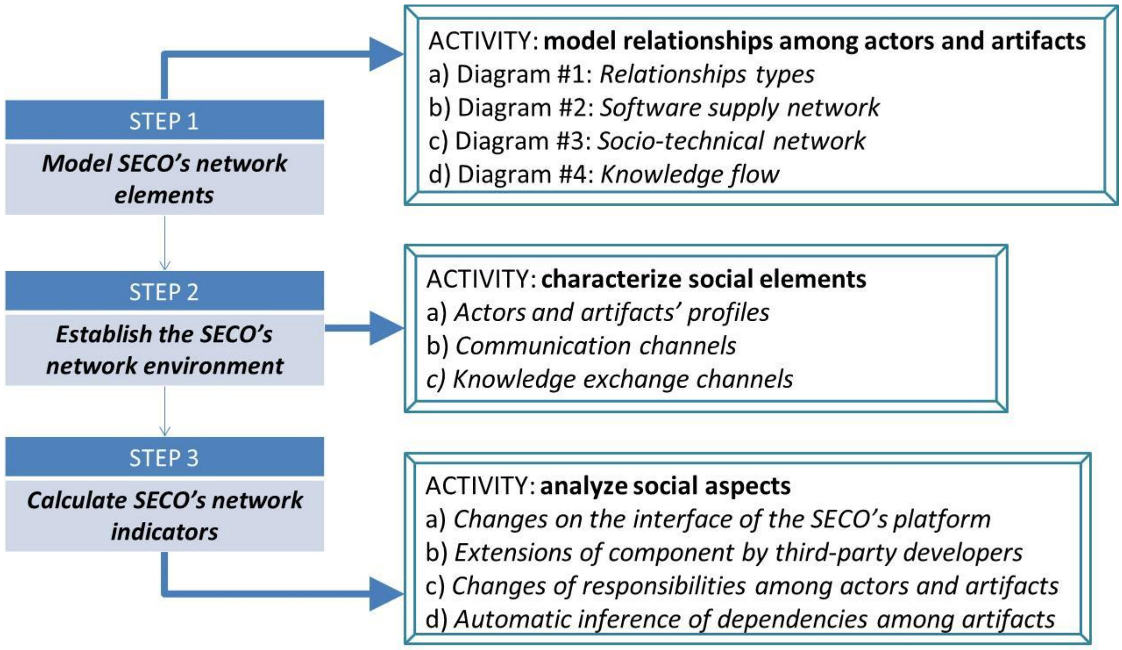



Figure 2.14. Social dimension of *ReuseECOS '3+1'* Framework

**Step 1**: *model SECO's network elements* requests IT management teams to identify some SECO social information through drafting some diagrams: (a) *relationships types*: map the main existing relationships within a SECO, e.g., 'owned by', 'interested in', 'depends on', and 'member of' (SEICHTER et al., 2010); (b) *SSN*: map ISV and the main suppliers and customers, as well as software products and services they exchange (BOUCHARAS et al., 2009); (c) *socio-technical network*: map SECO actors and artifacts as 'nodes' and their relationships as 'edges' based on Graph Theory (CAPURUÇO & CAPRETZ, 2010; MENS & GOEMINNE, 2011); and (d) *knowledge flow*: map information, resources and artifacts exchanged within a SECO into a conceptual model (SEICHTER et al., 2010). This activity is important to describe all the stakeholders involved in the network, and also the knowledge regarding the code, architecture, tests, requirements transferred within the SECO. Any model should be updated according to the community and platform data in order to reflect the SECO current status. Visualization techniques have been applied in this regard (YIER, 2012). In the case of LENS/REUSE SECO, there is no model describing the different networks; only UML class and component diagrams describe some knowledge related to the platforms' architectures.

**Step 2**: *establish the SECO's network environment* requests from IT management teams to characterize an environment (infrastructure) to support the SECO's network (SEICHTER et al., 2010), considering the following social elements that leverage different types of interaction (Table 2.5): (a) *actors and artifacts' profiles*: relevant information about SECO stakeholders and knowledge, e.g., ID, role, location etc.; (b) *communication channels*: social resources that help actors and artifacts to interact, e.g., *wall* for users and developers' comments, *new feeds* for code reviews or new releases of an artifact, *suggestions* of the actor's potential relationships or artifacts of interest, and *messaging* for personal communication; and (c) *knowledge exchange channels*: management resources that aid actors and artifacts to drive SECO results, e.g., *data* *sharing* for managing knowledge, *teaming* for supporting collaborative work, and *searching* for finding actors and artifacts in the SECO. An important goal is to know how to retain knowledge even if some event happens inside or outside the SECO. *Brechó* community uses several social resources, e.g., Yahoo Groups, SVN, Bugzilla.

Table 2.5. Types of interaction among actors and artifacts within a SECO.
Sources: (SEICHTER et al., 2010; SANTOS et al., 2014a)

| INTERACTION | DESCRIPTION |
|---|---|
| *Actor → Actor* | Actors can communicate through publications, data sharing, messages, and within groups or communities. Suggestions, evaluations, assessments, and comments can affect an actor's reputation or the SECO's social status. |
| *Actor → Knowledge* | Actors can interact with artifacts as they interact with others in a social network site. As such, actors can classify and write comments about the change of an artifact's status, enriching it with public information and contributing to modify other interactions with users, developers, suppliers, or owners. |
| *Knowledge→ Actor* | Due to the view of artifacts as 'first-class citizen', changes in the artifact's status are visible in new feeds and messages to the actors who are connected to it via software repositories, version control or bug tracker systems. |
| *Knowledge→ Knowledge* | This type of interaction can be leverage through the information publicizing and the automatic tracks among artifacts. |

**Step 3**: *calculate SECO's network indicators* requests from IT management teams to identify from which network data an organization should extract information to support SECO sustainability. CAPURUÇO & CAPRETZ (2010) point out two variables: *time* and *context*. Time 'frozen' information related to a specific moment of the SECO lifecycle, and context 'frozen' information about a specific context in which a SECO knowledge is being analyzed. Therefore, the socio-technical network allows to capture the interactions among actors and artifacts to answer some questions like "who are the key technologies supporting the platform kernel?", or "who is becoming a dominator in a SECO?". Qualitative and quantitative data can support other social indicators, such as reputation, utility, promotion, and contribution degrees. It can be useful to infer relationships or affinities (proximities) among actors and artifacts. The impacts of such analyses may affect decisions related to: (a) changes on the interface of the SECO's platform; (b) extensions of component by third-party developers; (c) changes of responsibilities among actors and artifacts, and (d) automatic inference of dependencies among artifacts. For example, the use of StatSVN tool allows LENS/REUSE managers to visualize interactions between an actor (developer) and an artifact (piece of code) of *Brechó* platform, including: level of activity developed over the platform packages, percentage of modifications/evolutions and their impacts on the source code, and artifacts modified during the last commits done in the SVN repository, as shown in Figure *2.15*.

### *2.3.4. Engineering and Management Dimension*

The fourth dimension aims to combine the three dimensions presented in the previous sections through their relationships. Relation #1 (*motivating the platform development and evolution*) is in between the technical and transactional dimensions and focuses on understanding the impacts of the SECO external view (suppliers) over ecosystem sustainability, e.g., considering different contributions models such as COTS, outsourcing and globalization (BOSCH & BOSCH-SIJTSEMA, 2010). Relation #2 (*contributing to the platform establishment*) is in between the technical and social dimensions and focuses on understanding the impacts of the SECO socio-technical network (community) over platform stability, e.g., mining software repositories to analyze technology dependency (MENS & GOEMINNE 2011). Finally, relation #3 (*mapping value propositions and realizations*) is in between the transactional and social dimensions and focuses on understanding the impacts of the SECO internal view (community) over organization performance, e.g., leveraging the satisfaction of sharing business objectives (YU & DENG, 2011). This dimension was published in (SANTOS & WERNER, 2012b).


Figure 2.15. Information on the interaction between an actor and artifacts in *Brechó* platform

As shown in Figure 2.16, three tools are required to support the three relations of the engineering and management dimension. Tool #1 is the *software development environment*, i.e., an extension of an IDE to support software processes to collect and visualize SECO measures, e.g., *architectural properties* (modularity and transparence), *business indicators* (sustainability and diversity) and *community participation* (interaction and recommendation). Tool #2 is a *SECO platform repository*, an extension of a catalog (component repository) with business and quality mechanisms to perform *market analysis* (e.g., offerings, new niches, and technology analysis), *business objectives satisfaction* and *software pricing*. Finally, tool #3 is a *socio-technical network* site, an extension of a social network site to include software artifacts and combine SECO internal and external views to analyze *network dependencies* on objectives, technologies, suppliers, and software applications.

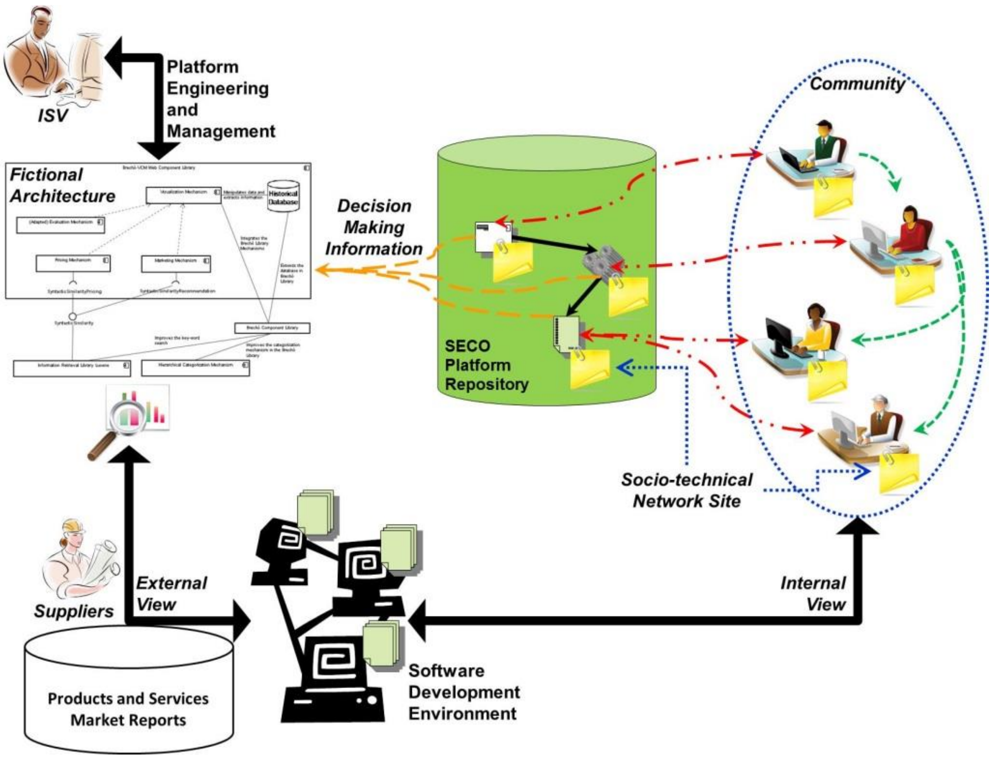



Figure 2.16. Engineering and management dimension of *ReuseECOS '3+1'* Framework

As one can observe, the fourth dimension integrates all the dimensions towards an infrastructure to aid SE in the SECO context. For example: the software development environment can be supported by an IDE like Eclipse[11] extended with some plug-ins to visualize different SECO measures; the SECO platform repository can be supported by a component repository also extended with some plug-ins to collect and analyze information from the marketplace, like *Brechó* (SANTOS, 2010); finally, the socio-technical network site can be supported by a social network site like Facebook, or a content management system like Joomla[12] or Noosfero[13], with some plug-ins to analyze

[11] Eclipse IDE. Available at <https://eclipse.org/>.
[12] Joomla, Content Management System. Available at <http://www.joomla.org>.
[13] Noosfero, Web Platform for Social/Solidarity Economy Networks. Available at <http://noosfero.org/>.

network properties, trends and scenarios, for example, based on a software product for exploring and manipulating networks like *Gephi*[14].

## 2.4 Discussion and Challenges

After releasing the first version of *ReuseECOS '3+1'* framework, we performed a collaborative work with other SECO research groups (Utrecht University and Federal University of Pernambuco) in which we strengthen our results (SANTOS et al., 2012c). In other words, we discussed the framework's dimensions, steps and activities in the context of the findings of a systematic mapping study published by BARBOSA & ALVES (2011). The final product was a more consistent roadmap of the SECO field, detailed in (BARBOSA et al., 2013). The main conclusions were: (1) many authors argued that the field is young and that many challenges are still open; (2) research methods that have been applied are those of a young research field: case studies, literature surveys, and exploratory theory building work; and (3) there is a widespread belief that SECOs represent a relevant field of study and the term "software ecosystem" is increasingly added to calls for contributions at workshops, conferences and journals' special issues.

The scope of SECOs dictates that the concepts around the objective of study is formed and intimately related to software; otherwise, it could be classified as *digital ecosystems*[15], or even generic business ecosystems. Additionally, more research should be addressed to provide a more cohesive set of classification of SECO stakeholders (SANTOS et al., 2012c). A further analysis of BARBOSA & ALVES (2011) indicated factors that leverage a FOSS ecosystem: recognition from peers, sense of community, sense of code ownership, feedback from others, learning, financial reward, engagement with new technologies, and altruistic intentions such as utilitarianism. On the other hand, since SECO has focused on large software-intensive systems as discussed in Section 1.2, this concept is not formally applied to Brazilian platforms yet, although the

[14] Gephi, Interactive Exploration Platform for Networks. Available at <http://gephi.github.io/>.

[15] Digital ecosystem is the dynamic and synergetic complex of digital communities consisting of interconnected, interrelated and interdependent digital species situated in a digital environment that interact as a functional unit and are linked together through actions, information and transaction flows (HADZIC & DILLON, 2008).

e-gov domain represents a rich real scenario, e.g., Brazilian Public Software (BPS) Portal[16], as pointed out by MANIKAS & HANSEN (2013).

From this perspective, according to BARBOSA et al. (2013), some future directions and challenges were identified for SECO research:

- *Open Source Ecosystems*: most authors have discussed the mining of software repositories and exploration of FOSS ecosystems, in which some challenges can be identified. Rich SE knowledge is hidden in such repositories, giving rise to questions like how relationships are formed between developers and how APIs to 3rd-party components are used;
- *Governance*: the main question here is what the best strategies are for survival in any ecosystem, in any role, whether the object of study is a developer, a community, or an ISV (supplier or acquirer). An interesting question refers to how actors can achieve and maintain a healthy position in a SECO;
- *Analysis*: models, visualizations, and large datasets are useful, but without proper tools and strategies for SECOs it is impossible to carry out an analysis of certain elements. Questions like whether high connectivity within a SECO increases business success, and how knowledge can be used to empower the ecosystem are relevant here;
- *Openness*: every SECO needs to have some degree of openness to enable platform extenders and suppliers to further employ platform features in their domains. An important question is how openness affects/influences the success of business, where there appears to be a trade-off between the entry barriers and number of parties willing to participate in the SECO;
- *Quality*: the quality concern is not SECO specific, but the way in which quality can be measured certainly is. Rating and quality measurement systems can help to report on the overall quality experience. A general question is how a SECO delivers a high quality experience to customers and what measures a participant can take to increase this quality;
- *Software Architecture*: the main question is how SECO architectures can be designed to meet the perspectives of the supplier (the architecture

[16] Brazilian Public Software Portal. Available at <https://softwarepublico.gov.br/social/>.

needs to be open, learnable, usable, consistent etc.) and acquirer (the platform needs to be evolvable, maintainable, span several domains etc.). Several patterns and architectural styles need to be studied, and software transparency emerges as a challenge (LEITE & CAPPELLI, 2010).

We observed that these challenges can be classified into two perspectives, according to the fourth dimension of *ReuseECOS '3+1'* framework, as shown in Figure 2.17. The first three challenges address *management issues* of SECOs, mostly related to the business dimension. In turn, the last three challenges involve *monitoring* (*engineering*) *issues*, mostly related to technical dimension. Whether in a supplier's or acquirer's SECO, relation #1 (*motivating the platform development and evolution*) puts business objectives and technologies together. As such, IT management teams face difficulties in making decisions in the SECO context considering that internal and external elements can affect the platform. In other words, different, unpredictable events may happen, e.g., a big supplier declares bankruptcy, or releases a new version of an important technology but with no integration to previous libraries. An acquirer might have applications based on that supplier's technology and such event may require urgent IT investments due to technology dependency and critical impacts on the organization's businesses short/long-term (ALBERT et al., 2013).

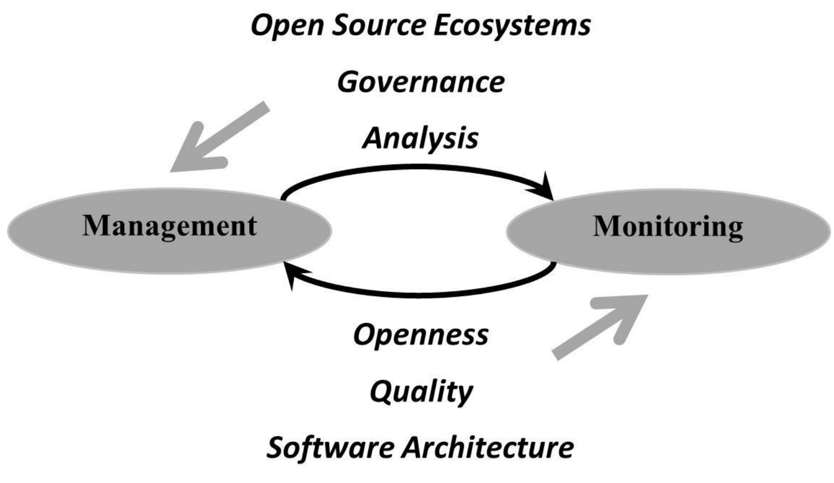



Figure 2.17. SECO Challenges.
Source: (BARBOSA et al., 2013)

Therefore, SANTOS et al. (2012c) pointed out two additional challenges for SECOs in Brazil: (1) "*what are the most attractive strategies in the global software development?*" – it is important to map strong and weak aspects of SECO platforms in order to define and automate a framework for management and monitoring of SECO platforms in a global and local perspective; and (2) “*how to explore SECOs in the Brazilian software industry?*” – it is important to model the Brazilian platforms’ SSNs, e.g., *SPB Portal* (project repository) and *Lua* (programming language), as well as those developed by small and medium enterprises (SMEs) or created within public organizations (acquirers) in order to identify their particularities when compared to well-known global SECO platforms. Investigating these challenges involves researching on SECO governance and analysis issues, as previously explained in this chapter (SANTOS, 2014).

Since managing and monitoring a SECO seem to affect IT management activities, step 3 of the framework’s business dimension pointed out some critical elements, based on the work of DHUNGANA et al. (2010). These authors proposed a framework for sustainable SECO management comprising three main elements as shown in Figure 2.18: (1) *ecosystem resources* and *local management*: each individual participant (e.g., application, technology, supplier, organizational unit etc.) contributes to the sustainability of a SECO by adhering to the fundamental laws which govern the ecosystem; (2) *ecosystem perspectives*: technical issues, business considerations, and community participation contribute to the SECO management by reinforcing existing actors and artifacts in a socio-technical network; and (3) *monitoring parameters*: frequent feedback from the ecosystem contributes to the SECO monitoring by analyzing some characteristics or changes that can affect the platform.

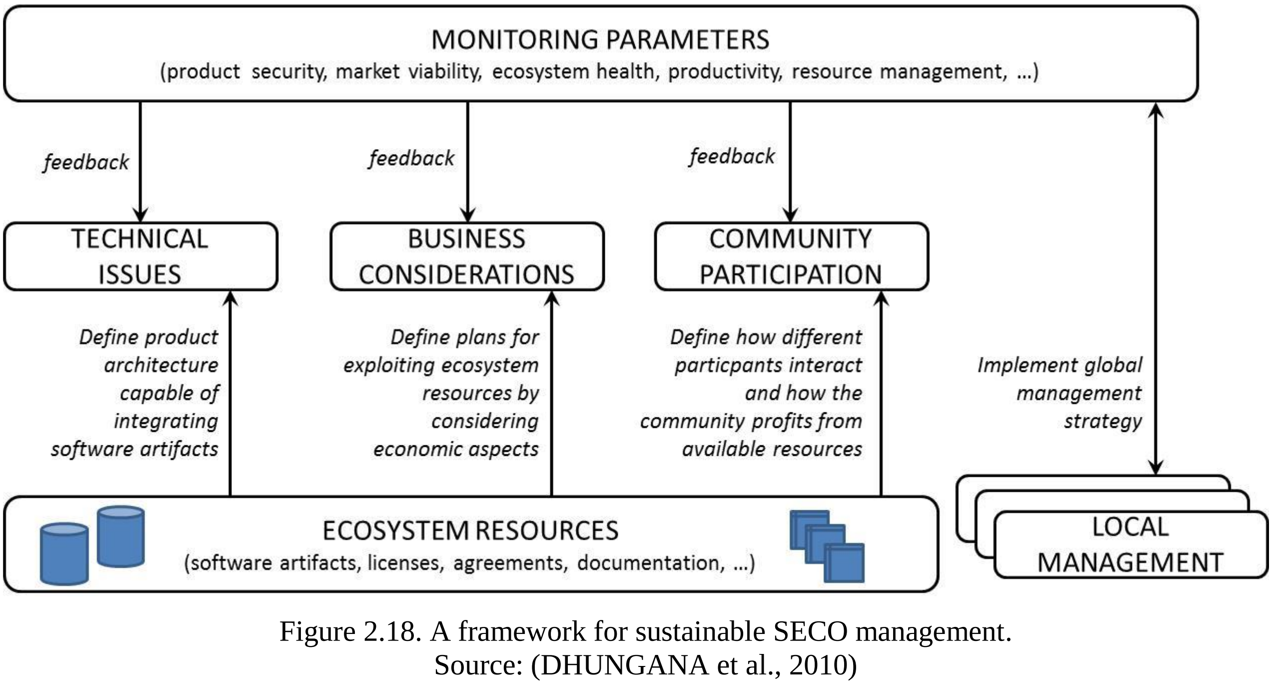



Figure 2.18. A framework for sustainable SECO management.
Source: (DHUNGANA et al., 2010)

At this point, we can observe that decision-making processes face some challenges in the SECO context since many different dimensions and elements should be considered. For example, an acquirer's IT management team must select, adopt and maintain applications and technologies that serve as tools to support the activities of employees and produce artifacts to achieve business objectives. However, such teams perform these activities with spreadsheet analysis and distributed documents, and seek market information produced by IT advisory companies (e.g., Gartner). This approach uses only external information to support IT management activities, disregarding information inherent to the acquirer's ecosystem resources. In other words, organizations lack a structured software asset base to analyze SECO indicators, especially those related to the 'hidden effects' of decisions in IT management activities.

DHUNGANA et al. (2010) corroborate decision-making challenges when stated that an ecosystem may need to be repaired (or regulation may need to be applied) after they are already functional. Motivated by our discussion regarding the RQ1, we have decided to investigate what are the most relevant mechanisms for the SECO platform management to support IT management activities, as pointed by the three elements identified by DHUNGANA et al. (2010). Finally, we can conclude that it is favorable to perform SECO research, once the domain is new and explorative, theories can be discovered, and scientific vehicles are interested in ecosystem work (BARBOSA et al., 2013). Moreover, the use of high quality datasets and established empirical research methods are important considering that the topic is maturing and theoretical foundations need to be defined.

When returning to RQ1 (*What are the SECO dimensions and key concepts that allow researchers to analyze an organization's platform?*), **technical**, **transactional** (business), **social**, and **engineering & management** are the main dimensions to be considered to SECO analysis in the software development process. In turn, **governance**, **sustainability**, **socialization**, and **acquisition** emerged as the respective key concepts extracted from each dimension, as presented in *ReuseECOS '3+1'* framework. This result motivated us to investigate SECO elements related to each key concept in order to aid software engineers to explore SECO perspective in their daily activities, more specifically considering SECO management and monitoring – the two sides of SECO challenges for the software industry.

## 2.5 Conclusion

In this chapter, we provided an overview of SECO and identified challenges faced by an acquirer performing IT management activities in this context. Firstly, we introduced SECO as a metaphor to tackle the so-called nontechnical challenges of SE research and practice. Its roots in SPL and Software Reuse, as well as different approaches to classify SECO elements were discussed in order to support the understanding of the notion of “ecosystem” in SE. We then investigated the SECO literature in order to propose a framework aiming to answer RQ1. A discussion on future directions and challenges for SECOs were also performed, pointing out critical elements for an acquirer’s IT management in the SECO context.

The overview provided in this chapter allows us to observe that the use of the SECO metaphor in the SE research community is still in its first steps, although an increasing number of publications in traditional conferences and journals indicates its valuable role in providing insightful solutions for the software development in the global industry (MANIKAS & HANSEN, 2013). The novelty of the SECO approach is to consider the dynamic, uncontrolled interplay between internal and external actors and artifacts that contributes to maintain a common technological platform (JANSEN et al., 2009c). As observed, *technical*, *transactional*, *social*, and *engineering & management* are the main dimensions to be considered to SECO analysis in the software development process, and *governance*, *sustainability*, *socialization*, and *acquisition* are the respective key concepts of each dimension, as presented in *ReuseECOS ‘3+1’* framework.

As such, software development in the SECO context needs to take into account business and social elements along with technical ones (SANTOS & WERNER, 2011b). However, the lack of analytical models and real-world case studies brings difficulties to consolidate a body of knowledge on the topic (HANSSEN & DYBÅ, 2012; SANTOS, 2014). On the other hand, many complexity management problems in SE have proved resistant to purely conventional analytical solutions due to difficulties in applying them in the real scenarios (CLARKE et al., 2002). We exemplified such barriers on the maintenance of a well-organized software asset base to analyze SECO indicators throughout the IT management activities. Such research opportunity gaps motivated us to investigate SECO elements related to each key concept in order to aid software engineers to explore SECO perspective in their daily activities, more specifically considering SECO management and monitoring. At first, we decided to explore the most relevant mechanisms for SECO platform management to support IT management activities, i.e., governance and socialization (Chapter 3).

# Chapter 3 – SECO Management

*Innovations in technology, planning, and reuse procedures were broadly seen in the 80s. However, few software producing organizations explored these innovations effectively. So, this period shows very simplified, non-validated prototypes serving as reuse support systems. We hope experiences in different domains can make technologies, strategies and reuse procedures concrete, creating opportunities to new approaches as well.*

Werner (1992)

## 3.1 Introduction

Since the treatment of economic aspects is a challenge for the Software Engineering (SE) community, IT management activities play an important role (ALBERT, 2014). For example, IT management supports organizations' businesses through the use of software developed by (or acquired from) suppliers. Software can be applications (to manage organizational information for business purpose), or supporting technologies and infrastructures (e.g., programming languages, operating systems, databases etc.). In this context, suppliers and acquirers can establish relationships through contracts of purchasing products and consulting. As discussed in Chapter 2, such relationships, involved organizations, and information exchanged among the parties (e.g., products, licenses etc.) are considered elements of a software ecosystem (SECO). All of these elements can be considered SECO assets and require governance since the way they are organized and evolved affects IT architecture over time (NIEMANN, 2006).

Based on application/technology maturity and organizational roadmap, acquirers establish a software-intensive system to support their processes, train professionals and produce artifacts to achieve their business objectives. In the last years, acquirers had difficulties in dealing with the market dynamics due to the industry globalization and the effects of an interconnected software supply network (JANSEN et al., 2009c). Actors, roles and relationships create a socio-technical network that can affect decision-making throughout IT management activities (LIMA et al., 2015). Currently, there are IT advisory companies, such as Gartner, Forrester and ThoughtWorks, whose business is to monitor the IT market in order to “advice” organizations with reports based on large-scale surveys (ALBERT et al., 2013). The goal is to support customers (in the case, acquirers) in decisions that are appropriate to their business objectives. As such, two forces were observed in the SECO context, as identified in our framework in Section 2.3, i.e., governance in a top-down way and socialization in a bottom-up way.

However, similar to component repository barriers, suppliers commonly lack a structured catalog or software asset base to explicitly support decision-making over the IT management activities (MANIKAS & HANSEN, 2013). In other words, information is usually unstructured and confined in the ‘minds’ of a small group of high experienced employees (JANSEN & CUSUMANO, 2012). This is critical for IT management, especially when new demands and solutions should be analyzed to prepare acquisition rounds (FREITAS & ALBUQUERQUE, 2014). Besides, IT advisory companies provide an external view and miss the internal view of the organization’s SECO. Other initiatives like ISO/IEC 19770-1[17] (Software Asset Management – SAM – Processes) have tried to help organizations to manage their software assets, satisfy governance requirements and ensure effective support to IT management. It is not the objective of SAM to cover processes or activities related to how IT management decisions are made, e.g., to replace a reference database, to acquire a cloud storage service, or even how to contract suppliers.

The objective of this chapter is to provide an overview of SECO management and identify how it affects an acquirer performing IT management activities, motivated by the discussions on the results of our first research question (RQ) in Section 2.4. Firstly, we present SECO management concepts identified in the step 3 of the *ReuseECOS ‘3+1’* framework’ business dimension (Section 2.3.2). We discuss SECO governance elements in Section 3.2 and SECO socialization elements in Section 3.3. Then, we present the results of two surveys with experts in order to evaluate those elements and answer RQ2 – *What are the most relevant mechanisms for SECO platform management?* Based on the results, we discuss a challenging area for IT management teams in the context of SECO in Section 3.4. Finally, we conclude the chapter in Section 3.5 with the motivation for investigating related activities in real scenarios.

[17] ISO/IEC19770-1 – Information Technology – Software Asset Management (SAM) – Part 1: Processes. Available at <http://www.iso.org/iso/catalogue_detail?csnumber=33908>.

## 3.2 Governance

According to ZACHMAN (1997), the key for managing changes and complexity is architecture, i.e., if something gets too complicated to remember all of its pieces at the same time, it means that it must be broken down. As such, the author defined Enterprise Architecture (EA) as relevant, descriptive representations to describe an enterprise so as to produce plans that attend management requirements, and that are maintained over their useful life, focusing on the IT organizational scenario and including information about strategy, business, application systems, infrastructure components, and projects (NIEMANN, 2006). However, as a typical document management issue, an important challenge is to represent and maintain architectural components and their relationships. Such a problem inspired governance frameworks, which were introduced to support organizations to drive results (ALBERT et al., 2013). In the IT context, a governance framework consists of a model that comprises a set of assumptions, concepts, values and practices regarding the organizational structure, the relationship among the components involved in different daily activities, and how resources are managed and monitored to achieve the goals defined by the organization (ALBERT et al., 2012).

Given that architecture is also a governance discipline, the Control Objectives for Information and related Technology (COBIT) is an IT governance framework, for example, and EA for IT (IT Architecture) consists of a description of the fundamental design of the IT components and their relationships, as a way to reach the organization's business objectives (NIEMANN, 2006). As such, IT architecture involves *system architecture* (platforms; support levels; and infrastructure components) and *applications architecture* (application systems and subsystems; logical and technical components; and data), while EA uses IT architecture to support *business architecture* (business objectives and strategies; requirements and constraints; and business processes and components). In this context, business objectives are usually stated in terms of revenue, profit, profitability, and return on investment (KESTI, 2013). An organization should have clear business objectives in order to employ its IT architecture components (software products and services) to achieve them; otherwise its capacity to survive and compete will become a major challenge (ELMORSHIDY, 2013).

In the SECO context, ABREU et al. (2014) state that the IT (or even software) architecture is extended to become a "SECO architecture". MANIKAS & HANSEN (2013) define SECO architecture as a structure (or structures) of a SECO in terms of elements and their properties, as well as the relationships among them. SECO elements consist of actors, systems and system components, while relationships include software architecture-related relationships (technical network) and actor-related relationships (social network). Some architectural challenges are reinforced in the SECO context (BOSCH, 2010): (i) *stability*: once an organization is providing a platform, interfaces should evolve in a predictable fashion and with time for adjustments; otherwise, it can damage customers' business objectives; (ii) *simplicity*: integration at each of the levels of data, workflow, and user interface integration should be designed to minimize the complexity of the final solution; (iii) *security and reliability*: architecture should be designed to reduce defective and malicious external code and vulnerabilities; and (iv) *evolution*: the scope of the platform needs to be frequently adjusted upwards to incorporate functionalities based on the community's emerging demands, but also slim down the platform through re-architecting it to replace proprietary code with either COTS or open source components.

In such a turbulent and competitive business environment, organizations want to have a clear notion of which markets it participates, as well as the technologies that support its applications within these markets; the tools that support these technologies; the produced assets regarding its business objectives; and the network of suppliers, competitors and customers (including their relationships). All this knowledge is scattered through a mass of confused information, but it should help organizations to achieve objectives, optimize the use of resources and lead to increasing profitability (ALBERT et al., 2013). In this regard, BAARS & JANSEN (2012) introduced the concept of "SECO governance" as organization's procedures and processes to help controlling, changing or maintaining its current and future position in a SECO on all different SECO levels, as discussed in Section 2.2.2. They also propose a SECO governance framework that relies on surveys with organizations to understand how they maintain or change their position in a SECO, and also how other players are evolving. The framework supports suppliers that have difficulties in knowing how to measure, compare, and analyze their governance policy in SECOs.

According to ALBERT et al. (2013), suppliers cannot provide standards, platforms or technology to support the ecosystem without insights on governance, i.e., they cannot perform as SECO keystones. From the SECO level of the three-tier perspective model (Section 2.2.2), JANSEN et al. (2009a) specify the internal and external SECO views. The internal view of a SECO model comprises characteristics such as size, types of actors, roles, connectedness etc., which define the scope of a SECO. However, SECOs are identified to the outside world through external characteristics from which organizations have insights over the SECO's boundaries, considering its main properties, opportunities and threats. For an acquirer, the external view helps to realize the notion of a SECO based on the boundaries (Figure 3.1):

- *Market*: a SECO can be based on a specific market, e.g., Enterprise Resource Planning (ERP) or automation market. This view shows niche players developing and delivering similar products and services, but with different maturity and price. So, it is a critical view for acquirers;
- *Technology*: SECOs can be centered on specific technologies, e.g., a programming language (Java), or a protocol (SOAP or IPv6). This view helps an acquirer to monitor technology dependency. Such assets are organized into categories with a well-defined function;
- *Software infrastructure*: SECOs can arise from specific software applications, e.g., Eclipse, Microsoft CRM, or Ruby on Rails. Platforms functionalities can be included, modified or extended with components, or via Application Programming Interface. Applications usually depend on technologies;
- *Organization*: SECOs can be defined by a producing or consuming organization. Microsoft, Google, or SAP are suppliers and usually orchestrate SECO around their applications. On the other hand, Globo, Petrobrás, or Ministry of Education are acquirers where the platform is the asset base.

From the acquirer's perspective, maintaining data of the software asset base is indispensable for getting success in IT management in the SECO context. Some questions may arise, e.g., how applications/technologies are acquired, discontinued and/or maintained over time. According to NIEMANN (2006), such questions involve thinking about future (architecture of) asset base (*TO-BE*) against the current one (*AS-*

*IS*). Therefore, migration procedures, sequence plans or architecture roadmaps could be used as inputs for the IT management teams' decisions. Unfortunately, IT document management problem still represents an obstacle to SECO management, since usually there is no structured inventory (BOSCH & BOSCH-SIJTSEMA, 2009; WERNER et al., 2009; CHRISTENSEN et al., 2014).

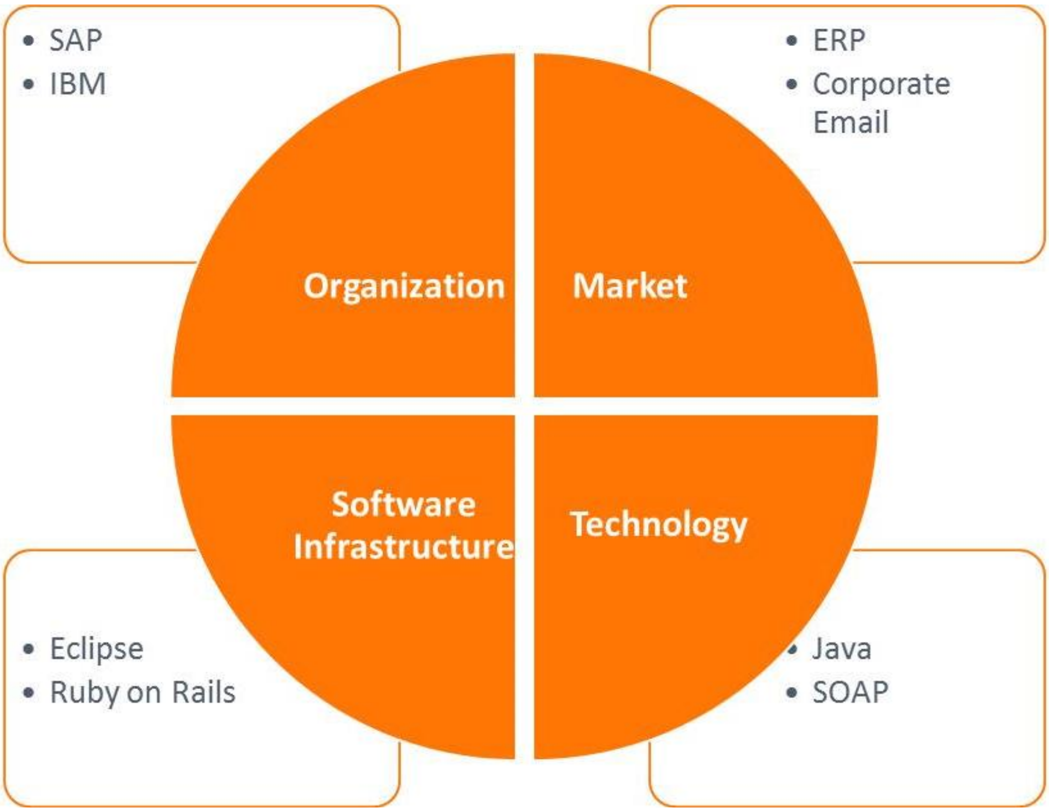



Figure 3.1. External view of a SECO

### *3.2.1. Governance Elements*

An important governance notion is the concept of *building blocks*, i.e., a package of functionalities defined to meet business needs that can be reused or integrated with others (TOGAF, 2013). Initially, building blocks can be specified with name and description, as a software demand, known as *architectural building blocks*. They can be replaced by a software application selected after an acquisition round, named *solution building blocks*. Despite the demands and candidate applications that are daily analyzed, an acquirer needs to manage its current suppliers, software applications and supporting technologies towards the satisfaction of business objectives (WERNER & SANTOS, 2015). Consequently, governance elements need to help an acquirer to keep the software asset base aligned with organization's businesses throughout the IT management activities, staining the SECO architecture (JANSEN & CUSUMANO, 2012).

Table 3.1. SECO governance elements. Source: (ALBERT et al., 2012)

| SECO Governance Element | Description |
|---|---|
| *B1. Organizational Changes* | The organizational structures based on functions, locations, sectors or matrixes sometimes add extra complexity and IT management activities become slow. Repetitive tasks should be automated, but traditional operation mindset may be difficult to change, e.g., due to political issues. |
| *B2. Maturity Models* | Some maturity models such as international CMMI and Brazilian MPS define some processes for supporting IT management activities. For example, reuse management and acquisition involve some activities that support analysis of demands and solutions using a software asset base. |
| *B3. Roles and Responsibilities* | In the SECO scenario, roles need to be defined in order to cope with upcoming challenges. Besides the acquirers and suppliers, other existing roles are: component producers (e.g., plug-in providers), consumers (e.g., value-added resellers), and asset base managers (IT management team). |
| *B4. Best Practices* | Some practices should be published to support the asset base maintenance and evolution. For example, evaluate impacts on existing applications when selecting demands, or analyze to which extent the acquirer's applications are depending upon an obsolete technology. |
| *B5. Metrics Model* | Metrics should be used to guarantee that the acquirer is driving results. Some common metrics are: return on investment, application/technology reuse level, technology concentration, business objective satisfaction, organizational unit collaboration degree etc. |
| *B6. Behavioral Impacts* | It is tightly related with 'organizational changes'. Since the maintenance of an asset base is an ongoing work, IT management teams need to attend some training and be rewarded on improvements they obtain when exploring the SECO context and their benefits, e.g., reuse. |
| *B7. Architecture Lifecycle* | This item refers to a metaprocess to define the governance lifecycle and includes: planning (to establish needs and evaluation), definition (to propose principles, processes, structures, and roles), training (to inform stakeholders), and measurement (to collect and analyze metrics). |
| *B8. Roadmap* | Governance implies in a strategy aligned with business expectation, even with the benefits of managing SECOs, e.g., how concrete the return on investment is. Some goals can be establish, such as "select demands that reduce the impact on existing applications". |
| *B9. Policy Catalog* | It is the main way to reach expected goals, including policies and guidelines related to the other elements. Only a central catalog with terms, processes, responsibilities, and technologies can help an acquirer to satisfy its objectives. |
| *B10. Component Lifecycle* | Asset base pieces (objectives, applications, technologies) are planned, designed, versioned, published, retrieved, maintained, and discontinued. The number of acquired or contracted *licenses* is checked in each phase, involving many actors (e.g., IT management team selecting demands). |

Inspired by the service-oriented architecture (SOA) scenario, we performed an investigation on the governance elements for SECO management, where the components to be governed are business objectives, applications and technologies (ALBERT et al., 2012). The goal was to evaluate governance mechanisms that ensure asset base integrity and adaptability over time. Additionally, we aimed to identify relevant elements to aid IT management activities in the SECO context. The generic governance model for SOA developed by NIEMANN et al. (2008) was used as input to do so. Table 3.1 presents the results we obtained after adapting 10 elements to the SECO context. We evaluate these elements through a survey with experts from academia and industry, discussed in Section 3.2.2.

### *3.2.2. Survey with Experts*

From the governance elements pointed out in Section 3.2.1, we planned and executed an empirical study with experts in order to evaluate the importance of each element of a governance framework for SECO architecture components. Using the Goal-Question-Metric (GQM) method (BASILI et al., 1999), this survey had:

**the objective to** analyze elements extended from a SOA governance framework
**with the purpose of** organizing a governance framework for SECO architecture
**with respect to** the evaluation of importance of the identified elements
**in the point of view of** experts in SOA, CBSE[18] and Reuse (SECO)
**in the context of** SE researchers and practitioners

#### *3.2.2.1. Planning*

The study was descriptive, i.e., we intended to identify opinions and extra information on the SECO context in order to verify how governance is applied in practice. The study was applied in a non-supervised way, i.e., participants were not assisted when they answered the questionnaire. The population involved SE researchers and practitioners who worked with SOA, CBSE and Reuse (SECO). Non probabilistic sampling was chosen since participants were invited (or recommended by experts) from the study conducted by SOFTEX (2007) and from the program committee of the Brazilian Symposium on Components, Architectures and Software Reuse (SBCARS) 2008-2011[19]. A first round was run in February and March, 2012, with 165 experts, also

[18] Component-Based Software Engineering (SZYPERSKY et al., 2002).
[19] SBCARS' past editions. Available at <http://cbsoft.org/sbcars2015/history?lang=en>.

including experts from the program committee of the Brazilian Symposium on Information Systems (SBSI)[20]. They were included because they work with scenario analysis, decision-making processes, organizational strategies and software platforms. This sample was reduced to 121 after removing invalid emails and unavailable experts.

The questionnaire we sent to the participants via Google platform and had two sections: (1) eight questions to characterize participant's background; and (2) ten questions (items) to evaluate SECO governance elements (Section 3.2.1), i.e., participants were requested to weigh each element shown in Table 3.1 using a ten-point scale from 0 (no importance) to 10 (very important), besides an extra question to provide general feedback. Only eight out of 121 invitees answered the questionnaire (6.6%), spending an average of 6.15 minutes. We observed a misunderstanding of the study objective. Then, we reviewed the study planning, included some details on the concept of 'governance framework', and adjusted the questions and the sample. Participants of SBSI were removed to focus on the SECO context and more practitioners were included.

#### *3.2.2.2. Execution*

We executed the study in May 2012, when 22 out of 82 invitees answered the questionnaire (26.82%). The invitees were those that did not take part in the pilot study, from SBCARS' program committee, SOFTEX' experts, and also practitioners from companies in the State of Rio de Janeiro. The participants spent an average time of 13 minutes: (i) 13 participants had Phd degree, 1had Master degree, 6 had Specialization degree, and 2 had Bachelor degree; (ii) 13 worked in public organizations, 7 in private organizations and 2 in semi-public organizations; (iii) 12 worked in universities or research centers, 4 were component developers, 3 worked for software suppliers, 1 was an acquirer, 1 represented a public organization who produces components and 1 was a public organization who acquires components; (iv) 19 participants were from Southeast and 3 from South of Brazil; (v) 13 have applied SOA or CBSE for at least 20 years (Figure 3.2); (vi) most of the participants worked with Architecture (14), Programming (13), Requirements (10), and Project Management (9).

[20] SBSI's past editions. Available at <http://www.portal.inf.ufg.br/sbsi2015/en/historico>.

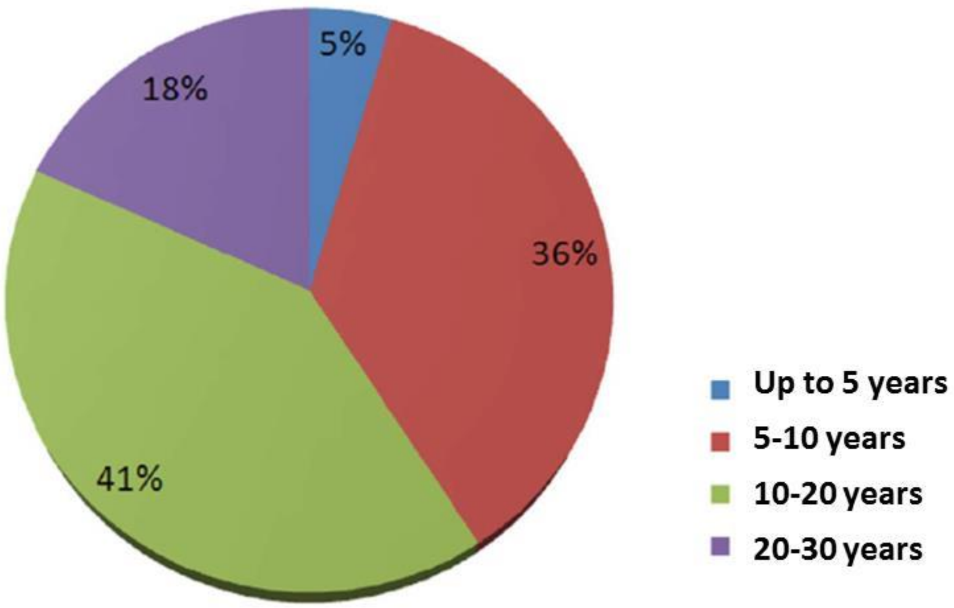



Figure 3.2. Distribution of experience in SOA, CBSE and Reuse (SECO)

*3.2.2.3. Analysis*

Considering the answers related to the second section of the questionnaire, we applied statistics to create boxplots as shown in Figure 3.3. Boxplots are useful instruments to analyze variation when different points of view should be evaluated at the same time. As observed in Figure 3.3 and Table 3.2, there is a trend to accept all the governance elements, especially B3, B10, B4 and B6, because their median have the greatest values in the dataset and their interquartile range is short. Next, B5 and B1 obtained interquartile range 3 and 3.5, and median 9 and 8, respectively. Finally, B7, B8, B2 and B9 obtained interquartile range between 4 and 4.5, and median between 8 and 8.5.

Figure 3.4 shows that researchers were the most rigorous in evaluating the governance elements since the interquartile range for each item was shorter than those analyzed by practitioners: B3, B4, B6 and B10 obtained median 9; B1, B2, B5 and B9 obtained median 8; and B7 and B8 obtained median 7. On the other hand, Figure 3.5 aggregates answers from practitioners, who recognized most of the governance elements as highly important: B3, B4, B5 and B10 obtained median 10; B6, B7 and B8 obtained median 9; and B1, B2, and B9 obtained median 8. Considering the interquartile ranges, researchers' evaluation does not converge as practitioners' does. B7 (Architecture Lifecycle), for example, obtained large range (Min: 0, Max: 10, Interquartile: 4, Median: 9) for the researchers' dataset, and short range (Min: 8, Max: 10, Interquartile: 2, Median: 9) for the practitioners' dataset. Maybe participants did not understand this concept very well.

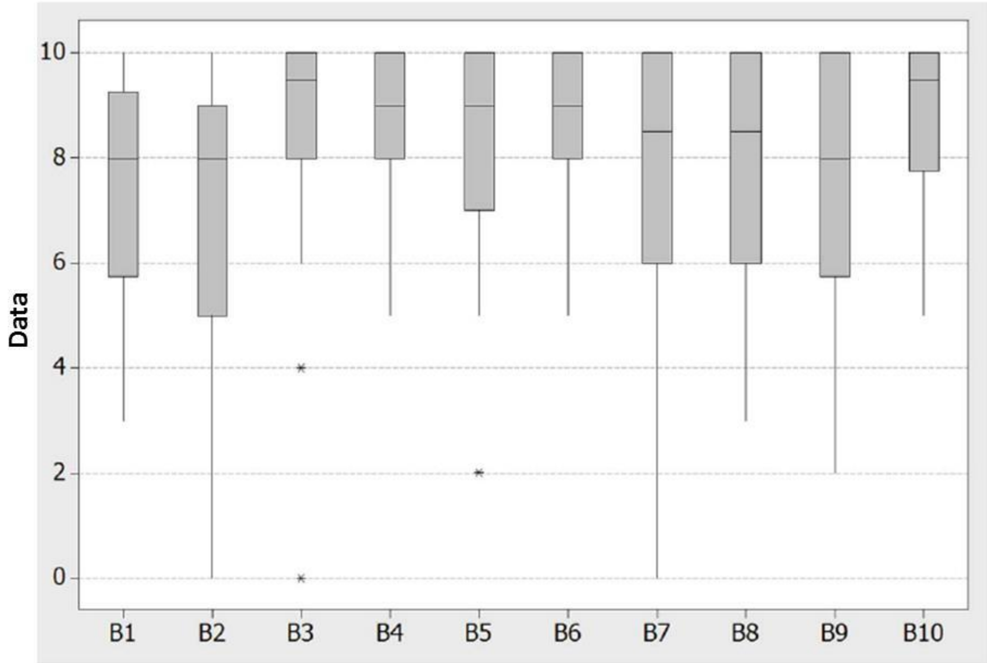



Figure 3.3. Boxplots with answers provided in the second section of the questionnaire

Table 3.2. Ranking of SECO governance elements

| Question | Recommendation | | |
|---|---|---|---|
| | Governance Element | Median | Interquartile |
| B3 | Roles and Responsibilities | 9.5 | 2 |
| B10 | Component Lifecycle | 9.5 | 2.25 |
| B4 | Best Practices | 9 | 2 |
| B6 | Behavioral Impacts | 9 | 2 |
| B5 | Metrics Model | 9 | 3 |
| B7 | Architecture Lifecycle | 8.5 | 4 |
| B8 | Roadmap | 8.5 | 4 |
| B1 | Organizational Changes | 8 | 3.5 |
| B2 | Maturity Models | 8 | 4 |
| B9 | Policy Catalog | 8 | 4.25 |

Considering only median, B3 (Roles and Responsibilities) and B10 (Component Lifecycle) obtained the best scores, as shown in Figure 3.3. Such elements reveal what is strongly relevant for SECO governance: how organizations make important decisions related to IT management (e.g., acquisition), how they determine stakeholders (roles), and how to evaluate results (responsibilities). Any initiative needs to be balanced since low governance degree causes negative effects, e.g., excessive freedom, lack of planning, lack of work visibility, difficulties in measuring production or delivery time etc. On the other hand, high governance degree generates slow processes even within the same team, or due to the number of non-relevant tasks involved in the organization's production process (NIEMANN, 2006). Additionally, no element was rejected.

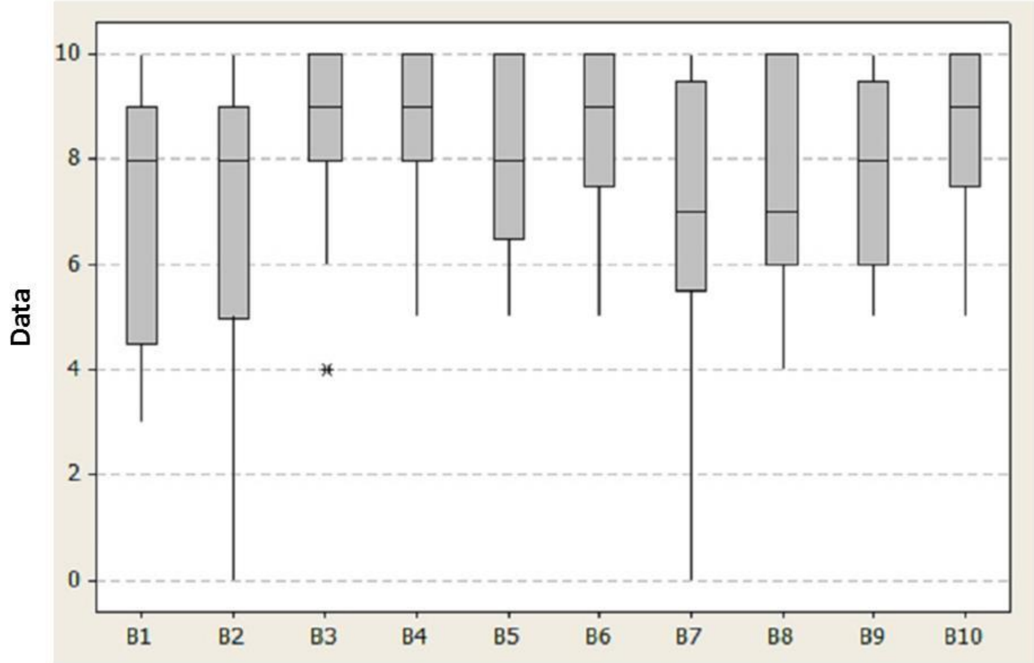



Figure 3.4. Boxplots with answers provided in the second section of the questionnaire (researchers)

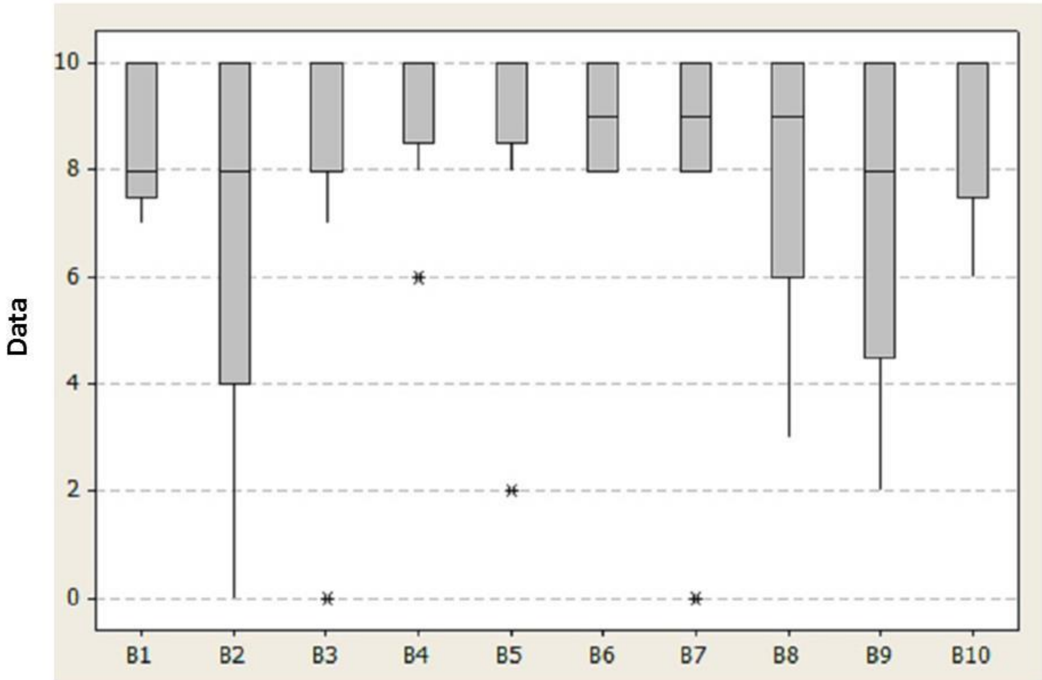



Figure 3.5. Boxplots with answers provided in the second section of the questionnaire (practitioners)

#### *3.2.2.4. Discussion*

Participants agree on the importance of B1 (Organizational Changes) ($8^{th}$), but they mentioned that its *magnitude* might create some barriers to implement a governance framework. Such process is as significant as its impact on the organizational structure, then participants suggested that changes should be implemented gradually to minimize negative effects on the organizational culture. It may be caused due to the participants' profile. Participants argued that B2 (Maturity Models) ($9^{th}$) can help the organization since this element underlies all development processes. Maturity is intrinsic to the existing process and provides feedback on its effectiveness. On the other hand, B3 (Roles and Responsibilities) ($1^{st}$) is relatively easy to understand but difficult to implement due to different profiles and attitudes within an organization. Despite this consensual opinion, they agreed that any IT initiative requires such element to reach organizational expectations. B4 (Best Practices) ($3^{rd}$) was pointed by participants as critical to aid IT management teams to explore the benefits of SECO governance.

Regarding B5 (Metrics Model) ($5^{th}$), one participant stated that "*there is no (positive or negative) evaluation without measurement and thus decision-making can be a difficult task*". In turn, another participant mentioned that metrics model could be postponed to later stages of governance. On B6 (Behavioral Impacts) ($4^{th}$), an expert highlighted that employees need incentives to maintain, use and evolve the asset base as a reference repository for supporting decisions and application's reuse. This is important to realize time and cost savings as well as quality improvement. Regarding B7 (Architecture Lifecycle) ($6^{th}$), one participant stated that this element should be integrated to the projects' lifecycle.

An expert mentioned that "*there are two types of need in a company whose main business is not IT: business needs, and IT needs that indirectly contribute to the business objectives, but aiming to improve quality of delivered applications*" for B8 (Roadmap) ($7^{th}$). Another participant endorsed the relevance of a roadmap since most organizations would prefer a gradual implementation of a governance framework to get the expertise to do so. According to one participant, B9 (Policy Catalog) ($10^{th}$) is an attempt to define a minimum quality standard for governing SECO components, i.e., objectives, applications and technologies. Finally, for B10 (*Component Lifecycle*) ($2^{nd}$), one participant highlighted the importance of getting updated information on the SECO components to support decision analysis. When returning to RQ2 (*What are the most relevant mechanisms for SECO platform management?*), **roles** and **responsibilities**, and **component lifecycle** are the most relevant governance mechanisms for SECO platform management. It was also a motivation to investigate SECO socialization elements, as discussed in Section 3.3.

*3.2.2.5. Threats to Validity*

Threats to validity include: (i) lack of weighing answers provided by the participants according to their knowledge/background in the topic (researchers/ practitioners, academic degree, experience etc.): we analyzed datasets of researchers and practitioners separately aiming to minimize this risk; (ii) participants' interpretation: they answered the questionnaire with assistance; we decided to analyze median and interquartile range through boxplots in order to better extract information from the dataset and understand the participants' point of view; and (iii) representativeness, since we sent the questionnaire to less than a hundred researchers and practitioners, and obtained around two dozen participants: after the first round, we invited practitioners aiming to get more effective participants, totalizing 26.82%. It is not novel since some studies discuss difficulties in having high participation in surveys (SMITH et al., 2013).

## 3.3 Socialization and Sustainability

In general, networks are used to map elements and their relationships. *Social networks* represent the relations among people, such as communication, cooperation, or even virtual friendship. People share information through those relationships. On the other hand, there are artifacts being produced and exchanged via purchase, downloads, collaborations etc., forming a *technical network*. Currently, the information exchanged and overall interactions among actors tend to be focused on the artifact (PETTERSSON et al., 2010), due to staff turnover and maintenance of organizational knowledge. Thus, fostering visibility and relevance of software artifacts (e.g., applications and technologies) is a growing trend (SANTANA & WERNER, 2013). SECO emphasizes that artifacts flow through the actors' relationships, as well as from/to the platform. So, it is possible to build up a socio-technical network to represent the SECO structure.

The emerging network belongs to both social and technical perspectives, i.e., dealing with relationships between actors and artifacts. Social networks platforms like websites are frequently used to support those networks. The impact of such platforms motivates organizations and communities to promote interactions through groups and profile pages (both personal and commercial), directly related to their specific goals (BOYD & ELLISON, 2007). As discussed in Section 2.2.2, socialization depends on sustainability, i.e., a property identified in the SECO level perspective related to other intrinsic properties: health (supply network level) and evolvability (organizational level). Sustainability is critical in an age when the global software industry experiences the transition from the internals of an organization towards an external environment, where technical network complexities as well as social and business challenges take place (OLSSON & BOSCH, 2015). A sustainable SECO requires capability to distinguish among different SECOs in which they operate (DITTRICH, 2014), e.g., when an acquirer is selecting and combining software solutions from different SECOs.

An analysis of the asset base can aid to tackle this challenge despite the IT document management issues mentioned in Section 3.2. However, the organization tends to trust in reports produced by IT advisory companies (formal external view), or in tacit knowledge of the IT management team (informal internal view), as concluded by ALBERT (2014). In fact, with no inventory, it will take a great effort to achieve success in analyzing a SECO platform since data possibly need to be collected manually. For example, existing software applications and their costs, licenses and users; lists of demands and candidate applications; business objectives which reflect organization units' needs; technologies that support the reference IT architecture; and suppliers who provide the organization with software solutions. These data are useful to help organizations analyzing different scenarios in decision-making (SANTOS, 2014).

In this scenario where data and information are not well preserved (FRANÇA et al., 2015) and long-term thinking in the software-intensive system design is a real-world concern (BECKER, 2014), an emerging research about social SE and sustainability takes place (PENZENSTADLER et al., 2012). According to BECKER (2014), the lack of sustainability in SE is clearly observed in the trade-off between short-term interests and long-term benefits, and it manifests as symptoms coined by SE researchers and practitioners: software aging (PARNAS, 1994), the digital dark ages (KUNY, 1998), and technical debt (KRUCHTEN et al., 2012). All of these terms take budget planning time horizon into account (BECKER, 2014), and help us to get the general notion of sustainability *as the capacity of meeting the current needs without compromising the ability of future generations to satisfy their own needs* (UNITED NATIONS, 1987). It is understood on dimensions: *social* (to preserve communities), *individual* (to preserve human capital), *environmental* (to preserve natural resources), *economic* (to preserve added value), and *technical* (to preserve information systems).

SE researchers and practitioners who were/are interested in sustainability created a document for initiating a conversation between the different communities aiming at addressing the challenges of developing sustainable software systems (VENTERS et al., 2015). Such document was known as *The Karlskrona Manifesto for Sustainability Design*, in which sustainability design in the context of software systems consists of the process of designing systems with sustainability as a primary concern, based on a commitment to some principles (BECKER et al., 2015). The main motivation of this manifesto was to make clear the fact that SE designers need to feel responsible for the long-term effects of their designs, since their underlying decisions cause changes and shape the environment. Thus, an initial set of principles and commitments were proposed to help researchers and practitioners to better understand sustainability (BECKER et al., 2015):

- *Sustainability is systemic*. As a non-isolated property, sustainability requires a transdisciplinary common ground to think about a system;
- *Sustainability has multiple dimensions*. Abovementioned dimensions are indispensable to realize the sustainability nature in any given situation;
- *Sustainability transcends multiple disciplines*. Several disciplines are addressing the challenges of sustainability from multiple perspectives;
- *Sustainability is a concern independent of the purpose of the system*. It means that sustainability is a crosscutting concern so as to be considered even if it is not the primary focus of the system under design;
- *Sustainability applies to both a system and its wider contexts*. The sustainability of the system and how it affects sustainability of the wider system of which it will be part should be considered in system design;
- *Sustainability requires action on multiple levels*. Some interventions may have more leverage on a system than others. So, opportunity costs should

be considered in any sustainability action, at other levels, as they can offer more effective forms of intervention;

- *System visibility is a necessary precondition and enabler for sustainability design*. The system's status and context should be visible at many levels of abstraction and perspectives in order to enable participation and informed responsible choice;
- *Sustainability requires long-term thinking*. Benefits and impacts on multiple timescales need to be explicitly considered so as to include longer-term indicators in assessment and decisions, e.g., when preparing acquisition rounds;
- *It is possible to meet the needs of future generations without sacrificing the prosperity of the current generation*. Innovation can help to identify and enact choices that benefit both present and future by decoupling needs in different timeframes and moving away from the language of conflict and the trade-off mindset.

In the context of sustainability in SECO, DITTRICH (2014) states that the development processes change when developing software *for* and *in* a SECO, respectively referring to suppliers and acquirers. In this regard, SANTOS et al. (2012a) extend the concept of SECO lifecycle described in Section 2.2.2 to include the effect of the social dimension as defined in sustainability (Figure 3.6). The online crowds model (RUSS, 2007) was used to do such extension. This model is based on the fact that it is fundamental to understand the effect of the social contagion process in the formation of online crowds. After combining SECO lifecycle and online crowds model, the process of SECO community formation through social networking were proposed, divided into four stages (SANTOS et al., 2014a):

1. *Initiation*: creation of a social network site on the scope of organizational level (acquirer) towards reaching supply network level, aiming at: (1) establishing a market relation with all the stakeholders; (2) adding value to the relationship with organizational units, suppliers, customers, and external developers through communication and collaboration mechanisms; and (3) expanding capabilities (marketing, support, and IT decisions based on networking). Similarly, stakeholders can create profiles or web pages in the social network site and add value to their

relationships, which include direct relations with the acquirer. The most important factor is the creation of valuable content to attract members of existing social networks of other SECOs;

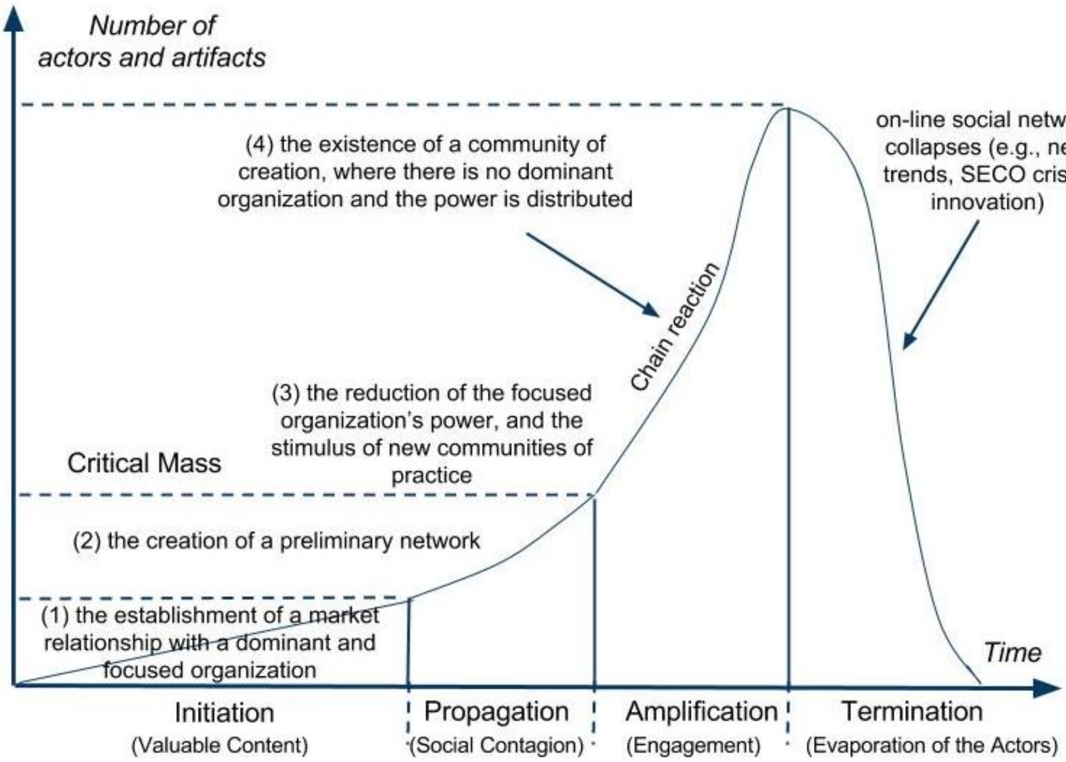



Figure 3.6. SECO social lifecycle.
Source: (SANTOS et al., 2014a)

2. *Propagation*: social contagion happens through the entry of new actors and artifacts. A preliminary network of acquirer's actors with common interests gives rise to: (1) participation of any person with a profile, or any artifact with a web page maintained by organizational units or suppliers; (2) publication of contents, comments, and communities forums (group formation); (3) stimulus to new members take part of the SECO; (4) reduction of the acquirer's power due to the SECO self-regulation; and (5) dominance of the super spreaders (market trend setters), opinion leaders and pioneers who push for innovation. At this stage, 'critical mass' is reached, similarly to a nuclear chain reaction of colliding neutrons, or infectious diseases where a virus spreads through the exposure with others;
3. *Amplification*: establishment of a self-organizing structure of the supply network level towards reaching the SECO level, and maintenance of a

community engaged with (and based on) a network of actors and artifacts. At this stage, the main focus is on the frequent stimulus to the communities or supply chain partnerships, completely integrated with the acquirer through licensing. Power gradually becomes distributed with the advantage of being supported by the SECO social network site. Members can use all the functions and resources for communication, collaboration, recommendation and marketing (e.g., publicizing and interaction);

4. *Termination*: an online social network supporting a SECO usually ends up due to the ecosystem's saturation, platform' replacement, or because new markets and trends arise after population migrations or technology maturations – a perfect time to leverage innovative solutions and create new SECO product or platform (COSTA et al., 2013). The novelty can produce an "evaporation" of the network members, possibly as a result of a termination or a SECO break off.

### *3.3.1. Socialization Elements*

In order to support sustainable platforms, we performed an investigation on the socialization elements for SECO management, where the actors are acquirers (and their units) and suppliers, and the artifacts are applications and technologies (LIMA et al., 2014). The goal was to gather resources and mechanisms to ensure asset base sustainability over time. Technical resources are commonly found in component repositories as mentioned in Section 3.2. However, these repositories often lack social resources. Additionally, we aimed to identify relevant elements to aid IT management activities in the SECO context. The social elements described in steps 1 and 2 of the *ReuseECOS '3+1'* framework's social dimension were used as the input (Section 2.3.3). Table 3.3 presents the results we obtained after adapting social elements to the SECO context. We evaluated these elements through a survey with experts from academia and industry, discussed in Section 3.3.2. The sources used for specifying the set of socio-technical elements to be evaluated are the following:

- The work about social networks presented in (SEICHTER et al., 2010). This paper considers social resources and interactions not only among actors, but also considering artifacts. Example of socio-technical element extracted from this source: "the use of a profile page for users";

- The analysis of the Brazilian Public Software Portal (BPS)[21], maintained by the Brazilian Government. This is a catalog of open source projects available at a web portal organized by communities that allows to obtain, discuss and evaluate products and projects. Examples of socio-technical element extracted from this source: “chat and community management”;
- Items proposed in (LIMA et al., 2014). This paper identifies resources that are not covered by related work (social networks, technical networks and similar work from the previous sources). It focuses on resources and mechanisms for social networks in IT management. Example of socio-technical element extracted from this source: “suggestion of demands”.

Table 3.3. SECO socialization elements. Source: (LIMA et al., 2014)

| **SECO Socialization Element** | **Description** |
|---|---|
| *S1. Collaboration* | Set of practices and tools to support stakeholders’ interaction within a SECO, and explore profile data and group formation. It includes versioning, issue tracker, demand management etc. |
| *S2. Reward System* | Criteria to evaluate an actor (with a given role) and also artifacts (applications and technologies). It stimulates acquirer’s units to engage in IT management activities (e.g., demand registering). |
| *S3. Suggestions* | Recommendation based from actors’ activities within a SECO. It aims to connect actors with common interests, leveraging the sense of community and cooperative work. |
| *S4. Search* | Function to browse and retrieve information from SECO actors and artifacts. It also includes data extracted from forums, documents, demands, software repositories etc. |
| *S5. Communication* | Central mechanism for supporting public and private messaging, including a channel for stakeholders’ negotiation strategies. It is critical to maintain a collaborative environment. |
| *S6. Network Mining* | Resource to aid IT management teams to identify urgent demands as well as application dependencies. Some related mechanisms are clustering, tag cloud, trend topics and similarity. |
| *S7. Graph Data Modeling* | Support for socio-technical network representation where nodes are actors/artifacts and edges are relations. It serves to calculate network indicators, e.g., actor’s importance or dependency level. |

### *3.3.2. Survey with Experts*

From the socialization elements pointed out in Section 3.3.1, we planned and executed an empirical study with experts in order to evaluate the relevance of each

[21] SPB – Brazilian Public Software Portal. Available at: <https://portal.softwarepublico.gov.br/social/>

element of a socio-technical network for SECO analysis, as reported in (LIMA et al., 2015). Using the GQM method (BASILI et al., 1999), this survey had:

**the objective to** analyze socio-technical elements
**with the purpose of** organizing a socialization framework for SECO analysis
**with respect to** the evaluation of relevance of the identified elements
**in the point of view of** experts in collaborative systems,
distributed development and SECO
**in the context of** SE researchers and practitioners

### *3.3.2.1. Planning*

The survey consists of a questionnaire sent via Google platform and composed by two types of questions: (i) *characterizing questions*, for collecting participant's profile; and (ii) *relevance degree*, for the assessment of socialization elements for SECOs, where 35 socio-technical resources were derived from seven socialization elements described in Table 3.3, as explained in (LIMA et al., 2014), also including an open field for general comments. The estimated response time was 25 minutes. We previously ran a pilot study with four participants to evaluate and improve the first version of the questionnaire as regards its structure, questions and instructions. After some adjustments, we emailed the survey to potential participants from our sample. Participants were chosen from personal indications and also from the program committees of two academic events in Brazil: WDDS/WDES (Workshop on Distributed Software Development, Software Ecosystems and Systems-of-Systems) 2013-2014[22]; and SBSC (Brazilian Symposium on Collaborative Systems) 2011-2013[23].

This survey was initially planned to collect and analyze information on socio-technical resources for SECO in the Brazilian scenario, motivated by the fact that BPS Portal is one of the Top 5 SECOs appearing in the literature and practice (MANIKAS & HANSEN, 2013). Considering the goal of capturing the relevance of each resource to a SECO platform, we used a five-point scale according to the following: *no importance*, *neutral*, *some importance*, *important*, and *very important*. Besides, participants were asked to qualify their experience degree regarding three areas: social networks analysis

[22] WDDS/WDES' previous editions. Available at <http://wdes2015.icmc.usp.br/Edition_en>.
[23] SBSC. Available at <http://www.ihc2015.unifacs.br/index.php/English/edicoes-anteriores1-ingles>.

and mining; SECO; and portals for managing contents and communities. These data were useful to allow us to perform some analysis of participants' profiles against the socio-technical resources' relevance.

### *3.3.2.2. Execution*

The survey was run from November 6th, 2014 to December 15th, 2014. We sent 99 invitations and 35 invitees responded the survey. The response rate (35.35%) is considered positive in studies like this, i.e., on-line surveys (NULTY, 2008). Table 3.4 and Figure 3.7 summarize data regarding participants' profile, i.e., personal experience and knowledge in the areas of interest. Most participants had some experience in the survey's areas. They have significant experience and mostly work at *public* and *academic* sectors. Figure 3.8 presents the reported distribution of roles based on some multiple-choice options, but also considering others as informed by participants. The number of participants for each role is also shown.

Table 3.4. Participants' profile

| Item | Result | | |
|---|---|---|---|
| Workplace | Public Companies | 25 | 71.4% |
| | Private Companies | 3 | 8.6% |
| | Both | 7 | 20.0% |
| | Academy | 27 | 77.1% |
| | Industry | 2 | 5.7% |
| | Both | 6 | 17.2% |
| Experience on IT/software sector | 0-5 years | 3 | 8.6% |
| | 5-10 years | 5 | 14.3% |
| | 10-15 years | 9 | 25.7% |
| | 15-20 years | 10 | 28.6% |
| | 20 years or above | 8 | 22.8% |
| Academic Degree | Bachelor degree | 2 | 5.7% |
| | Master degree | 12 | 34.3% |
| | Doctoral degree | 21 | 60.0% |

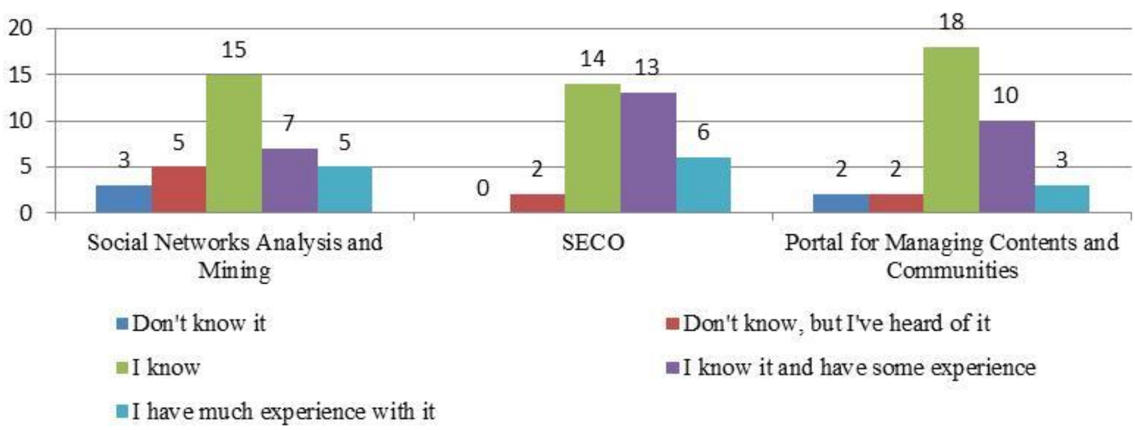



Figure 3.7. Participant's knowledge regarding the survey areas

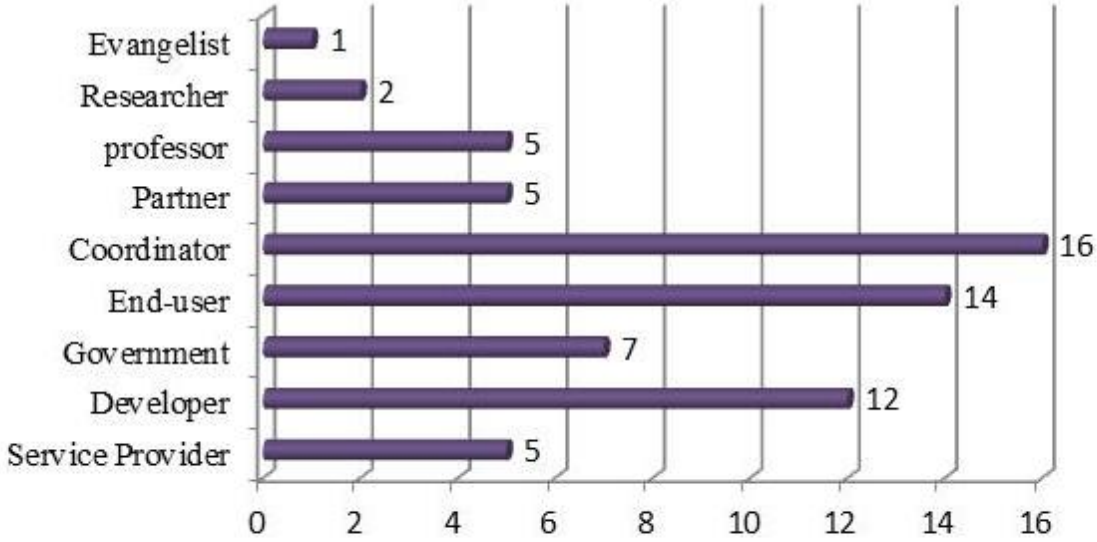



Figure 3.8. Participants' roles

It is possible to observe that several participants chose multiple roles. The only role with no representation was "Software Sector". Three roles were included: *Researcher*, *Evangelist*, and *Professor*. According to the participant that considers himself an "Evangelist", this role consists of an organizational actor responsible for training and maintaining the SECO developers' community (FONTÃO et al., 2015b).

#### *3.3.2.3. Analysis*

Once the survey execution was completed and the data were collected, some tasks to extract information were established. A formal methodology was not used, but the following steps were performed to analyze the dataset: (1) Data transformation and formatting; (2) Responses distribution; (3) "Resource-Resource" Correlation; and (4) "Specific Profile-Resource" Relations. Most of the answers were analyzed through choosing specific roles and artifacts manipulated by participants within a SECO. So, it was necessary to format the answers into a corresponding numeric scale. The Spearman correlation algorithm for calculating a correlation coefficient for ordinal scales was applied according to the relevance degree of all the socio-technical resources (*n* to *n*).

In order to calculate correlations, two tools were used: regular spreadsheets (Microsoft Excel) and *Action*[24]. *Action* is a statistics software integrated to Excel that uses data to generate many statistical analyses and graphics. *Action* was chosen because it is free and supports the Spearman correlation. For analyzing "specific profile-

[24] Action Portal. Available at <http://www.portalaction.com.br/>.

resources” relations, a subset was used, selecting the responses according to a specific participant’s profile. We defined other questions aligned with the survey’s goals to explore the results of the study, some of them related to SECO’s demand, since one goal was to understand how socialization can support the SECO’s members over time, as mentioned by several participants in the questionnaire’s open field:

Q1. Are community’s demands necessary and relevant resources in a SECO?

Q2. What are the most correlated socio-technical resources?

Q3. What are the most correlated socio-technical resources to community’s demands?

Q4. What are the most relevant socio-technical resources in the opinion of the most experienced participants?

Q5. What are the most relevant resources in the opinion of the more knowledgeable participants, regarding the survey’s areas?

Q6. What are the most relevant socio-technical resources in general?

*3.3.2.4. Discussion*

The main findings of the survey are discussed in this section. For each socio-technical resource, a distribution of answers is presented (Figure 3.9). In general, the only resource evaluated as being not so important, compared to the others, is the “User Profile Page”. This would be useful as information for others who are interested in the user reputation, or needs to find other data regarding a specific user. The best evaluations were for “Artifacts Versioning”, “Environment to Report Problems” and “Artifact Forum”. This may indicate the need for a sort of ‘place’ to discuss SECO demands and help users, as well as to control artifacts’ versions. None of the resources had the majority of votes as “No importance” or “Neutral”. For the other items, 21 were considered as “Important” and 13 items as “Very Important”.

The survey also collected data on how participants exchange information within the SECO by asking the types of artifacts they manipulate and the activities they execute. Figure 3.10 displays the types of artifacts handled by the participants and also the number of votes. From six options, the majority of participant’s votes (31 votes meaning 88.57% of the 35 participants) works with “Software Applications”. It is possible to observe that artifacts such as “Documents” and “Evaluations” are not handled so much. However, they are important to support software development. They also might be used to choose a component from the SECO, when participants are looking for evaluation and documentation. Perhaps, it happens due to the lack of appropriate support for organizing those types of artifacts.

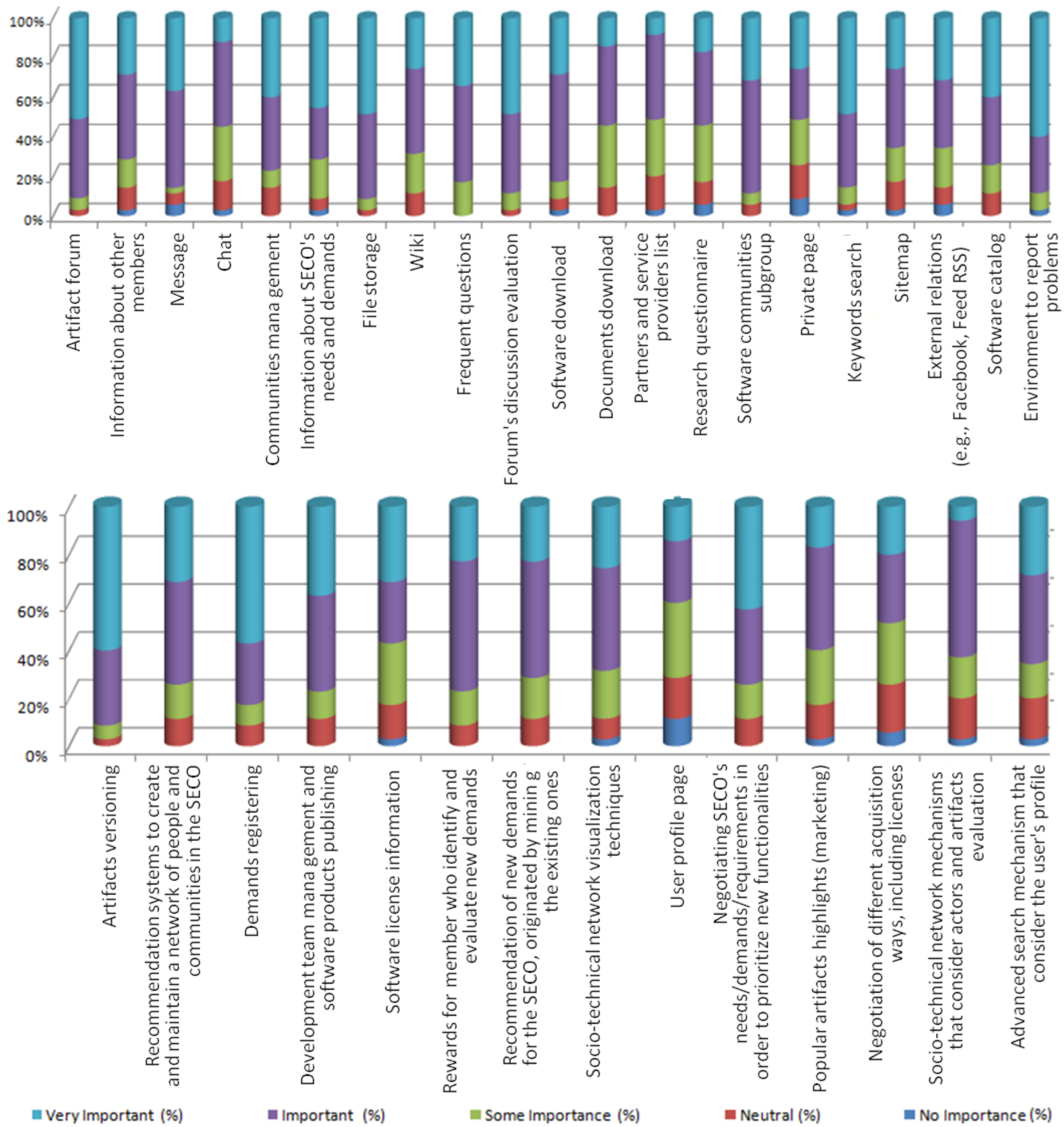



Figure 3.9. Distribution of participants' answers per socio-technical resource

It was questioned about what sort of activities the actors performed within the different SECOs they participated. Most of the participants use a SECO platform for downloading software, and attending or reading forums, though it is not possible to ensure that those are only end-users, since each participant might choose many activities from the list. Aside from the Evangelist's suggestion (only one vote), most activities stay on the range from 8 to 12 votes, as displayed in Figure 3.11.

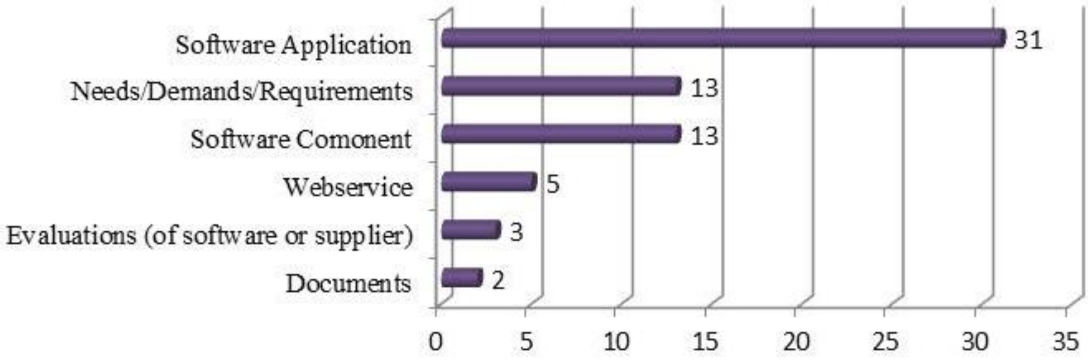



Figure 3.10. Artifacts manipulated by participants in a SECO

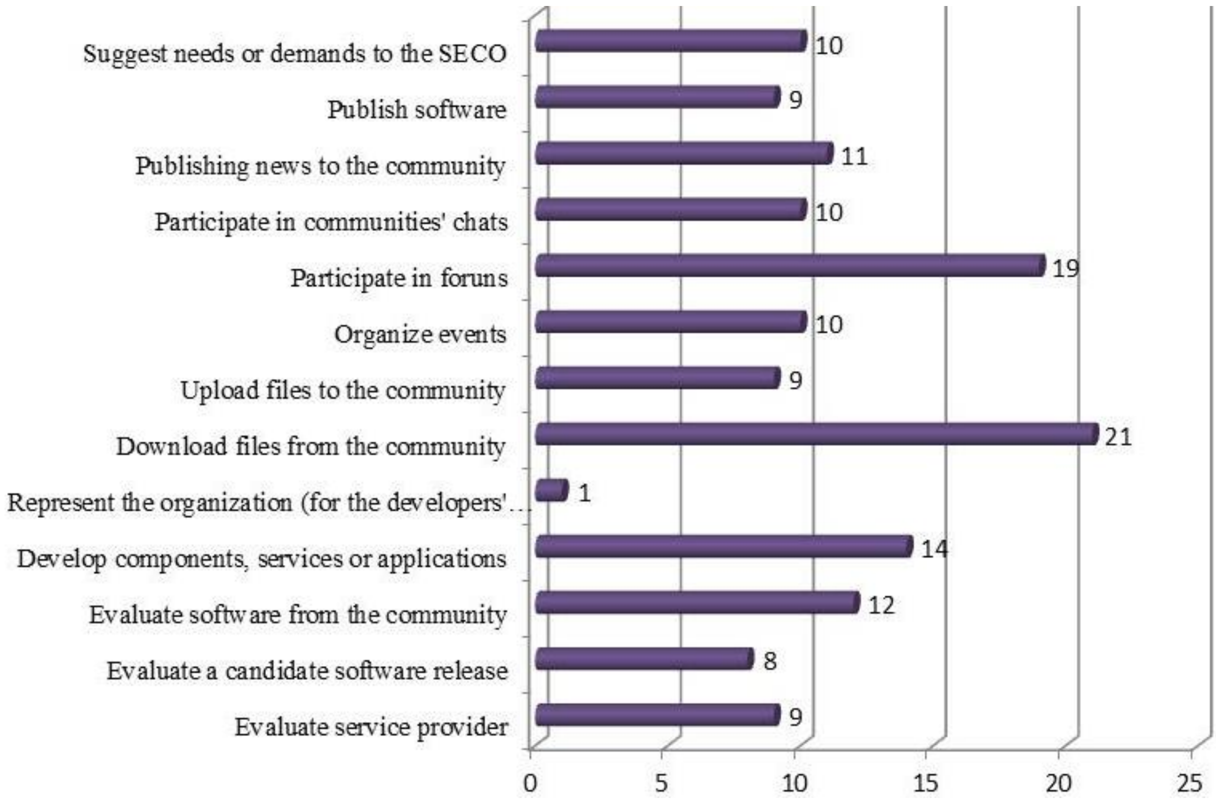



Figure 3.11. Activities performed by participants within a SECO

For Q1, resources containing the word "demand" were selected, resulting in the following socio-technical resources: (**A**) information about SECO's needs and demands; (**B**) negotiating SECO's needs/demands/requirements in order to prioritize new functionalities; (**C**) recommendation of new demands for SECO, originated by mining the existing ones; (**D**) rewards for members who identify and evaluate new demands; and (**E**) demands registering. These five socio-technical resources directly relate to community's demands and are important to foster innovation in a SECO (MANIKAS, 2016). Figure 3.12 illustrates the participants' votes regarding each resource (the percentile is shown beside the bar in the left hand side). None of them got "No importance". In fact, for these resources, the highest concentration of responses was on "Important" and "Very Important".

For *A*, *B* and *E*, the majority of participants judged them to be "Very Important" (A: 45.4%, B: 42.9% and E: 57.1%). For *C* and *D*, the responses were "Important" (C: 48.6% and D: 54.3%). For Q2, a correlation matrix was generated from the Spearman correlation algorithm through *Action* software; and results are shown in Figure 3.13. The function works by assigning a correlation from -1 to +1 for each pair of resources. The highest scores for a positive correlation coefficient regarding each resource are described in Table 3.5 (ordered by the highest correlation). The resources marked with **(1)** were extracted from (SEICHTER et al., 2010), **(2)** were observed in (ALVES & PESSOA, 2010), **(3)** adapted from the SECO's socio-technical approach proposed in (LIMA et al., 2014), and **(4)** for the ones suggested after running the pilot survey (see Section 3.3.2.1).

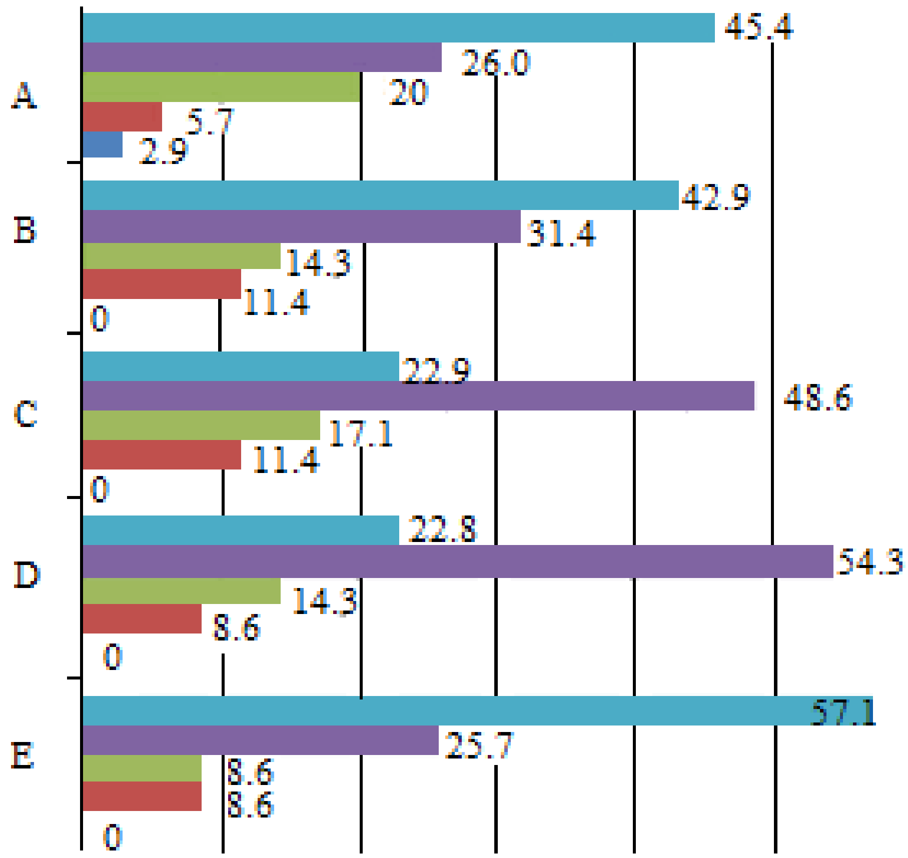



Figure 3.12. Socio-technical resources versus demands

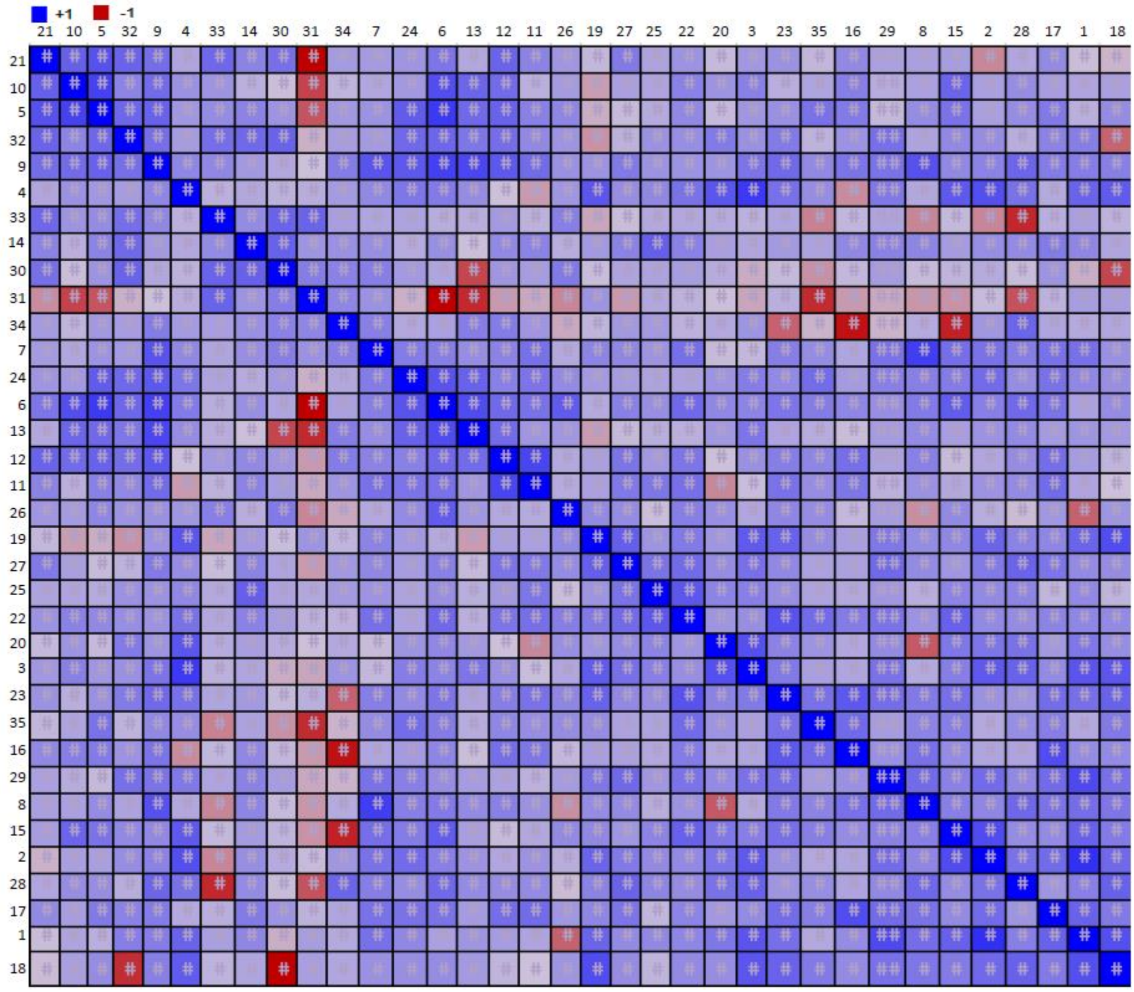



Figure 3.13. Socio-technical resources correlation matrix

Figure 3.13 shows in each cell the correlation values of the corresponding row and column using a color range that varies from dark red (strong negative correlation), over white (no correlation), to dark blue (strong positive correlation). In our analysis, if two socio-technical resources, *A* and *B*, have strong positive correlations (i.e., responses for *A* also happen for *B*), the proportion is shown by the range between -1 and +1 (from red to blue). It means that the majority of participants who voted for the most relevant resources in the first column also voted in the same way for some resources in the second column. It should be useful to identify groups of similar opinion regarding some socialization mechanisms. For example: the participants who voted for the positive relevance of “Software license information” (*ID 1*) also voted positively for “Negotiation of different acquisition ways, including licenses” (*ID 2*). We can find out that it is important to have available information about *ID 2* in a SECO. By analyzing each row, it is possible to see correlations, such as the relation between “Chat” (*ID 5*) and "Subgroup" (*ID 6*). Perhaps, a chat to communicate in a subgroup of a community or team might be useful.

Table 3.5. Highest correlation for each socio-technical resource

| ID | Resource | Resource with highest correlation |
|---|---|---|
| 1 | Software license information[3] | Negotiation of different acquisition ways, including licenses (0.753) |
| 2 | Negotiation of different acquisition ways, including licenses[3] | Software license information (0.753) |
| 3 | Development team management and software products publishing[3] | Information about SECO's needs and demands (0.705) |
| 4 | Information about SECO's needs and demands[2] | Development team management and software products publishing (0.705) |
| 5 | Chat[2] | Subgroup (0.703) |
| 6 | Subgroup[2] | Chat (0.703) |
| 7 | Partners and service providers list[2] | User profile page (0.682) |
| 8 | User profile page[1] | Partners and service providers list (0.682) |
| 9 | Information about other members[2] | Research questionnaire (0.663) |
| 10 | Message[2] | Chat (0.661) |
| 11 | Sitemap[2] | Keyword search (0.644) |
| 12 | Keywords search [2] | Sitemap (0.644) |
| 13 | Private page[1] | Information about other members (0.636) |
| 14 | Socio-technical network visualization techniques[3] | Software license information (0.617) |
| 15 | Negotiating SECO's needs/demands/requirements in order to prioritize new functionalities[3] | Negotiation of different acquisition ways, including licenses (0.608) |
| 16 | Forum's discussion evaluation[3] | Advanced search mechanism that consider the user's profile (0.603) |
| 17 | Advanced search mechanism that consider the user's profile[3] | Forum's discussion evaluation (0.603) |
| 18 | Highlighted artifacts[3] | Software catalog (0.602) |
| 19 | Software catalog[2] | Highlighted artifacts (0.601) |
| 20 | Recommendation systems to create and maintain a network of people and communities in the SECO[3] | Development team management and software products publishing (0.585) |
| 21 | Artifact Forum[2] | Chat (0.577) |
| 22 | Demands registering[4] | Rewards for member who identify and evaluate new demands (0.573) |
| 23 | Rewards for member who identify and evaluate new demands[3] | Demands registering (0.573) |
| 24 | Research questionnaire[2] | Subgroup (0.563) |
| 25 | Artifacts versioning[4] | Demands registering (0.547) |
| 26 | External relations (e.g., Facebook, Feed RSS)[2] | Subgroup (0.525) |
| 27 | Environment to report problems[4] | Software catalog (0.509) |
| 28 | Wiki[2] | Artifacts versioning (0.508) |
| 29 | Socio-technical network mechanisms that consider actors and artifacts evaluation[3] | Highlighted artifacts (0.499) |
| 30 | FAQ[2] | Wiki (0.498) |
| 31 | Software download[2] | File storage (0.483) |
| 32 | Communities management[1] | FAQ (0.483) |
| 33 | File storage[2] | Software download (0.483) |
| 34 | Documents download[2] | Socio-technical network mechanisms that consider actors and artifacts evaluation (0.474) |
| 35 | Recommendation of new demands to the SECO, originated by mining the existing ones[4] | Demands registering (0.442) |

For Q3, the highest positive coefficient of each socio-technical resource regarding demands (Q1) was extracted from Figure 3.13.

A. Information about SECO's needs and demands: *Development team management and software products publishing*;

B. Negotiating SECO's needs/demands/requirements in order to prioritize new functionalities: *User profile page*;

C. Recommendation of new demands for the SECO, originated by mining the existing ones: *Chat*;

D. Rewarding for members who identify and evaluate new demands: *Demands registering*;

E. Demands registering: *Rewards for member who identify and evaluate new demands*.

For Q4, answers from participants who had 20 or more years of experience were selected. From a total of eight participants, we extracted the most relevant options ("Very Important" and "Important"). The result filtered resources with more votes (8 and 7 votes). The majority of resources (6 out of 8) are still technical resources: "File storage"; "Software download"; "Artifacts versioning"; "Keyword search"; "Recommendation systems to create and maintain a network of people and communities in the SECO"; and "Forum's discussion evaluation". Nevertheless, participants also recognized "Environments to report problems" and "Frequent questions" as relevant resources. This fact might be a consequence of communication problems that hinder artifact's discussions which can contribute to help other actors. In addition, "Recommendation systems to create and maintain a network of people and communities in the SECO" and "Forum's discussion evaluation" are the social resources recognized by the most experienced participants as relevant as the other technical resources listed.

For Q5, all the responses from the five more knowledgeable participants were selected, considering their level of knowledge in the survey's areas (social networks analysis and mining, SECO, and portals for managing contents and communities). For each participant, it was counted "Very Important" answers. From those resources, there is one concerning "demands" and another concerning the "social side" (i.e., "Message"). The most relevant resources in their opinion were (ordered by the most relevant): "Artifacts Versioning" (5 answers); "Message" (4 answers); "Demands registering" (4 answers); "Environment to report problems" (4 answers); and "Software download" (4 answers).

Table 3.6. Most relevant socio-technical resources – VI (Very Important) and I (Important).

| Position | Resource | I (%) | VI (%) | (I + VI) (%) |
|---|---|---|---|---|
| 1st | File storage | 42.9 | 48.5 | **91.4** |
| 2nd | Artifacts versioning | 31.4 | 60.0 | **91.4** |
| 3rd | Artifact forum | 40.0 | 51.0 | **91.0** |
| 4th | Forum's discussion evaluation | 57.1 | 31.5 | **88.6** |
| 5th | Software download | 40.0 | 48.5 | **88.5** |
| 6th | Environment to report problems | 28.6 | 59.9 | **88.5** |
| 7th | Message | 49.0 | 36.8 | **85.8** |
| 8th | Keyword search | 37.1 | 48.5 | **85.6** |
| 9th | Frequent questions | 48.6 | 34.3 | **82.9** |
| 10th | Documents download | 54.3 | 28.6 | **82.9** |
| 11th | Demands registering | 25.7 | 57.1 | **82.8** |
| 12th | Rewards for member who identify and evaluate new demands | 54.3 | 25.8 | **80.1** |

For Q6, data were filtered from participants who answered "Important" and "Very Important" together (80% or more). Those can represent crucial resources for the SECO community, listed in Table 3.6. From these results, it is possible to observe that the most relevant resources are focused on demands and social networks differently from the ones that are more commonly found in the literature, such as "Keyword search" or "Documents download". They are 3rd, 4th, 11th, and 12th at Table 3.6. When returning to RQ2 (*What are the most relevant mechanisms for SECO platform management?*), **file storage**, **artifacts versioning**, and **artifact forum** are the most relevant socio-technical mechanisms for SECO platform management. Additionally, **demands registering** is also reported as important by knowledgeable participants. Together with our findings described in Section 3.2.2.4, the results show that software acquisition plays a critical role in IT management in the SECO context (Section 3.4).

### *3.3.2.5. Threats to Validity*

Threats to validity are: (1) our ad hoc observations of BPS Portal may have neglected some important socio-technical resources: we only had access to online documentation available at Internet since BPS Portal is currently being evolved to integrate collaborative tools; (2) the answers represent opinions of a sample of experts: we followed a procedure to analyze dataset based on visualization of distribution of participants' answers; (3) the invitees were Brazilians: this work consists of a first round of the survey, motivated by the fact that BPS Portal is one of the Top 5 SECOs in the literature and practice (MANIKAS & HANSEN, 2013).

## 3.4 Software Acquisition as a SECO Management Challenge

Based on the findings discussed in Sections 3.2.2.4 and 3.3.2.4, we observed that choosing which demand to prioritize and which solution to contract requires a careful analysis in order to assess the best available options (ALVES, 2005). As the SECO context also brings additional complexity to software acquisition (RIOS et al., 2013), acquirers need to analyze demands, solutions and suppliers and think in the effects of strengthening (or weakening) relationships, based on information extracted from the SECO platform. Therefore, the preparation of acquisition rounds becomes an important IT management activity since it is responsible for controlling and monitoring knowledge flow into the SECO platform (WERNER & SANTOS, 2015).

SEI (2010) defines acquisition as *the process of obtaining products or services through supplier agreements*, i.e., a documented agreement between the acquirer and supplier (e.g., contracts, licenses, and memoranda of agreement). In this context, a *supplier* is an entity that delivers software solutions being acquired. For example, an individual, partnership, company, corporation, association, or other entity having an agreement with an acquirer for the design, development, manufacture, maintenance, modification, or supply of items under the terms of an agreement. In turn, an *acquirer* is the stakeholder (individual or group) that procures a software solution from a supplier. An acquirer is affected by or is in some way accountable for the outcome of an undertaking, e.g., a business objective or a demand.

According to SEI (2010), some neglecting factors contribute for both parties' dissatisfaction after running an acquisition round: effective management, supplier selection and contracting processes, coordination of customer needs, requirements definition, technology selection procedures, and controlled requirements changes. Assuming that an acquisition round is a project, failures may be avoided if the acquirer properly prepares for, engages with, and manages suppliers and their software solutions. As such, some activities need to be executed in any acquisition round, as shown in Figure 3.14: (1) *acquisition preparation*: this activity aims to establish the acquisition needs and requirements, as well as communicate potential suppliers; (2) *supplier selection*: this activity aims to select the organization(s) responsible for developing and delivering the software solutions according to the requirements; (3) *agreement management*: this activity aims to monitor and ensure acceptable suppliers' performance according with suppliers' agreement; and (4) *customer acceptance*: this activity aims to validate the software solutions delivered by suppliers after having satisfied all acceptance criteria.

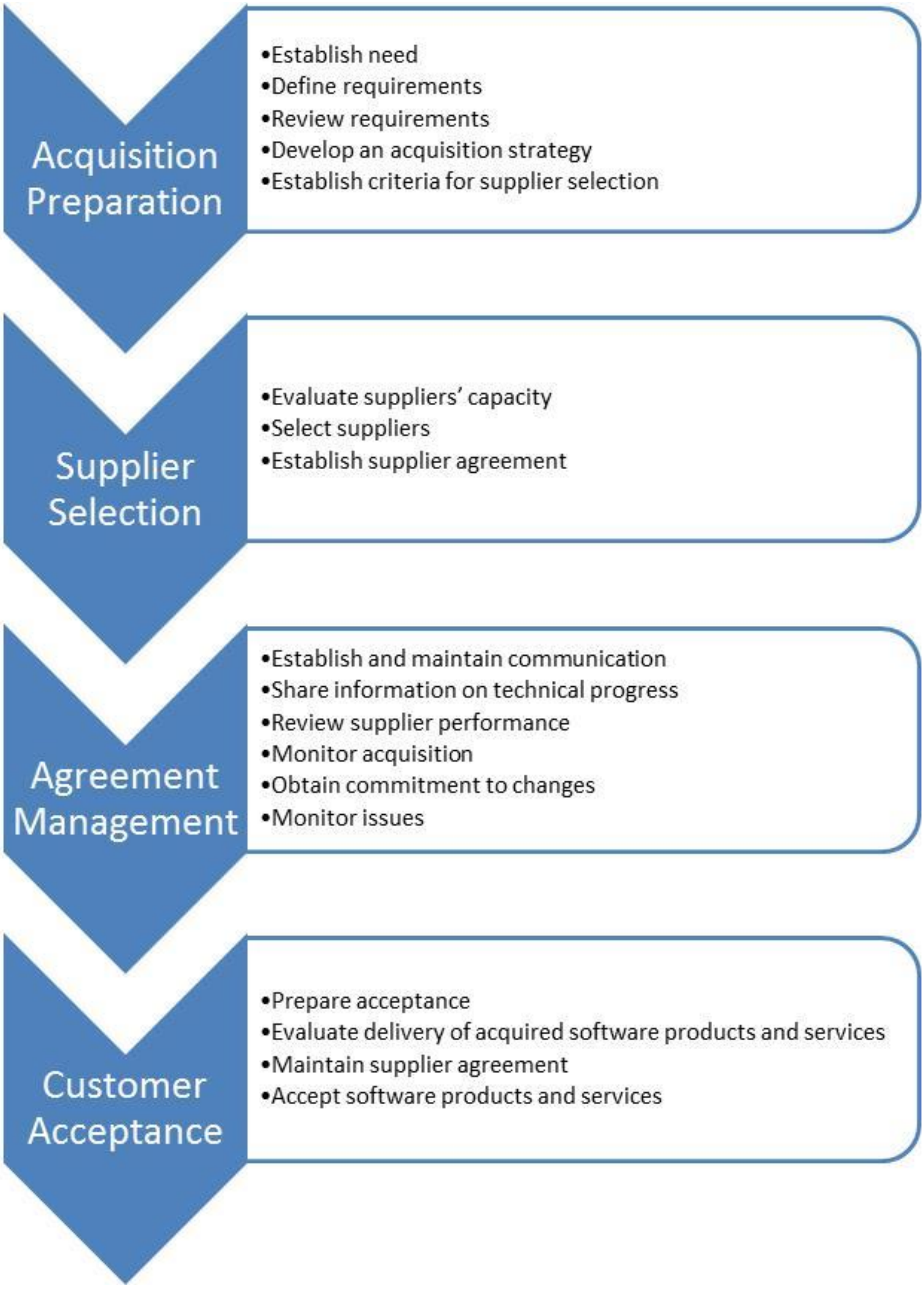



Figure 3.14. Acquisition activities and tasks.
Source: (SOFTEX, 2013)

Even intuitive, acquisition activities within the global industry are not always easily performed since some questions emerge (SANTOS & WERNER, 2012b), for example: “how to know which set of software solutions will help an acquirer reaching its business objectives?” or “will the acquired solution satisfy the organization at the end of the acquisition?”. The establishment of evaluation criteria is then critical to the acquisition success or failure (SOFTEX, 2013). Despite the typical set of criteria to evaluate candidate solutions, it is worth pointing out other factors such as SECO properties described in Section 2.2.2. Sustainability concerns detailed in Section 3.3 should be considered throughout the acquisition activities, even though they are useful when the organization is establishing criteria for analyzing demands and solutions, and evaluating their capacities to satisfy business objectives and constraints (RIOS et al., 2013). As a result, supplier agreements can include sustainability concerns in order to contribute to the health of the SECO platform, since the contracts are not the same as in the past (DITTRICH, 2014).

A direct result of this situation is that IT management teams must have the skills to measure the technical aspect of software solutions and have the competence to assess more subjective issues such as the adequacy of supplier relationship (ALVES, 2005). In this regard, SECO scenario introduces new elements from the three-dimensional view, i.e., technical, transactional and social (SANTOS & WERNER, 2011b). As such, IT management teams are requested to make tradeoffs between candidate solutions and business objectives, anticipating changes in technology, and predicting how products will integrate with the platform (BRERETON et al., 2002). ALVES (2002) points out issues that organizations need to be able to handle supplier dependency and requirement flexibility. Therefore, analyzing the supply network can be an effective way for acquirers to obtain global competitive advantage and survive in an unstable market (FARBEY & FINKELSTEIN, 2001).

However, other factors have impacts on software acquisition. Firstly, the *size of the organization*: small to medium organizations tend to keep the process slim and seek free software, while large organizations are driven by IT strategic plans pursuing competitive advantage, monitoring risks and thinking about intellectual property issues (DANESHGAR et al., 2013). Secondly, the *nature of the organization*: private organizations are mostly profit-oriented and seek strong, stable suppliers to establish tight relationships, while public organizations are driven by bidding, legal processes and cannot negotiate with suppliers (CRUZ et al., 2010). Finally, the *type of the organization*: hybrid organizations have different approaches, i.e., bespoke software or base it on a package (“make-or-buy”), while pure acquirer organizations use bidding processes to pursue COTS components or outsource development (CORTELLESSA et al., 2008a). These factors still remain in the SECO context, but another factor takes place, i.e., the *class of organization’s decisions*: traditional, ecosystem-neutral setting in which cost is the primary driver for every decision, while there exists an ecosystem-based setting in which decisions take into account the best choices for the organization’s overall sustainability over time.

## 3.5 Conclusion

In this chapter, we provided an overview of SECO management and identified how it affects an acquirer performing IT management activities. We presented SECO management concepts regarding governance and socialization elements, as well as the results of two surveys with experts that were conducted to evaluate those elements and answer RQ2. As observed, *roles*, *responsibilities*, and *component lifecycle* were the most relevant governance mechanisms for SECO platform management. In turn, *file storage*, *artifacts versioning*, and *artifact forum* were the most relevant socio-technical mechanisms.

Additionally, *demands registering* was reported as important by participants and a critical element for a sustainable SECO. Based on the results, we discuss software acquisition as a challenging area for IT management in the context of SECO. More specifically in the preparation phase, acquirers should use information of the SECO platform (asset base) to support their decisions in the organizational context. Despite the well-known barrier of maintaining structured knowledge base within the organization, such research opportunities gaps motivated us to investigate what health indicators are critical to SECO monitoring in IT management in the light of real scenarios (Chapter 4).

# Chapter 4 – Observational Studies

*The appearance of the appropriate technology movement has widened the scope of socio-technical studies by bringing in the question of choice of technology in a new way. The appropriate technology is that which best fits the total circumstances which are the case: those indirectly as well as those directly affected, the long-term as well as the short-term, and the physical in addition to the social environment.*

Trist (1981)

## 4.1 Introduction

Software Engineering (SE) area has directly supported software industry through methods, techniques and tools to develop interconnected, large-scale software-intensive systems in a rapid speed of deployment and evolution (BOSCH, 2009a). According to BOEHM (2006), the main goal of SE is to create products that add value to the society. The way different stakeholders' interests and expectations are communicated is critical for the manner they are understood, affecting how solutions meet their needs (FRICKER, 2009). Moreover, large-scale software development process is complicated, expensive, slow, and unpredictable (PAECH et al., 2005). As such, researchers and practitioners need to cope with the economic and social issues in SE (SANTOS et al., 2012c). In this context, some points can be highlighted (SANTOS & WERNER, 2013):

- software development requires to carefully think about the platforms and socio-technical networks: connectivity and dependency relationships increasingly affect IT management decisions (BARBOSA et al., 2013);
- business success no longer depends on a single organization: objective synergy and alignment are critical for the satisfaction of stakeholders' demands and for innovation in the production (SANTOS et al., 2014a).

As stated by WERNER et al. (2012), software engineers should have abilities to abstract the complexity of the whole system, which is composed by software, hardware and *peopleware* emerging in a software ecosystem (SECO). The metaphor of ecosystems in SE explores three challenging areas (MANIKAS, 2016): <u>acquisition</u>: developing and/or acquiring software to sustain an evolving organization's platform; <u>governance</u>: managing software assets to support decisions in the development processes; and socialization: analyzing socio-technical networks to monitor health and meet stakeholders' needs. Since suppliers resort to virtual integration (JANSEN et al., 2009c), an acquirer needs to analyze what application or technology enter its SECO. FRICKER (2009) pointed out that marketing requirements should define the product offering by product management; use case should align product management and users; technical specifications should align development and product managements; and system specification should align team leaders and development management.

FRICKER (2009) also points out some issues in IT management: (1) *strategic problems* derived from interests-expectations mismatching that is critical to prepare an organization to analyze demands; and (2) *tactics and methodology problems* regarding the understanding of demand-solution matching. Additionally, transitioning from traditional structures/relationships to the SECO context affects business and technical specification, and design choices (SANTOS & WERNER, 2011d). It means that IT management activities related to analyzing demand and solution are affected by SECO monitoring, since it reveals critical relationships between acquirers and suppliers (YU & DENG, 2011). The 'silent' effects of such nontechnical factors give rise to serious long rather than short-term problems, e.g., low productivity, investment loss, financial crisis, or bankruptcy – organizations trend to choose subsistence instead of sustainability.

The objective of this chapter is to investigate SECO monitoring in real scenarios in order to identify how it affects an acquirer performing IT management activities, motivated by the discussions on our second research question (RQ) in Section 3.4. Firstly, we explain the method we used to conduct observational studies (SEAMAN, 1999) in two Brazilian scenarios where different units create a SECO platform based on software acquisition (Section 4.2). In Sections 4.3 and 4.4, we characterize each case and discuss SECO monitoring in practice to answer RQ3 – *What are the most critical health indicators for SECO platform monitoring?* Section 4.5 discusses our findings, and Section 4.6 brings threats to validity. In Section 4.7, we summarize critical health indicators that impact IT management activities in the SECO context.

## 4.2 Method

At the beginning of our investigation, as discussed in Section 2.3, LENS/REUSE SECO platforms were analyzed through the *ReuseECOS '3+1'* framework and results were published in (SANTOS & WERNER, 2011bd, 2012a). The researcher took part in such academic platforms as software developer and project manager during his Master course (2007-2010). The first platform is a component and services repository to support component markets, *Brechó* (SANTOS et al., 2010a). 15 developers collaborated to maintain this SECO between 2005 and 2011 (20 until 2015), not necessarily at the same time. The second platform was a web information system to support the management of learning objects and experience reports – EduSE Portal (SANTOS et al., 2012b). Four developers collaborated to maintain this SECO between 2009 and 2011, not necessarily at the same time, and another laboratory took part of it (Software Engineering Lab at Federal University of Lavras).

Data regarding technical, transactional and social dimensions of SECO came up with acquisition, governance and socialization concerns. Data were also analyzed to characterize both platforms. We observed some issues regarding software development activities within a SECO, especially because social information is important to allow stakeholders to collaborate, e.g., interaction, utility, reputation, promotion, recommendation, and contribution (SANTOS & WERNER, 2012a). This is quite critical in IT management activities, e.g., demand and solution analysis (SANTOS & WERNER, 2013). Moreover, we observed that the adoption of new software within a SECO faces some barriers, such as market penetration and acceptance, and technology maturity (SANTOS & WERNER, 2011d).

After understanding the basics for SECO analysis (Chapter 2) and the most relevant mechanisms for SECO management (Chapter 3), we decided to perform two observational studies to identify the most critical health indicators for SECO platform monitoring in IT management activities, as reported in (SANTOS et al., 2016a). Using the Goal-Question-Metric (GQM) method (BASILI et al., 1999), these studies had:

**the objective to** analyze IT management activities (demand/solution analysis)
**with the purpose of** characterizing SECO monitoring
**with respect to** the identification critical health indicators
**in the point of view of** IT management teams
**in the context of** real scenarios

That type of study allowed us to capture firsthand behaviors and interactions that might not be noticed otherwise (SEAMAN, 1999). An observational study (or participant observation) refers to a research that involves social interaction between the researcher (observer or investigator) and informants in the milieu of the latter, during which data are systematically and unobtrusively collected (TAYLOR & BOGDAN, 1984). We selected two Brazilian scenarios to perform our observational studies. In both cases, the researcher was engaged in some activities while participants were being observed, although this is not mandatory for observational studies (SEAMAN, 1999).

Some reasons to conduct a qualitative research in our context are suggested by HANCOCK et al. (2009): (i) it studies behavior in natural settings, usually without manipulation of variables; (ii) it focuses on reporting experiences or data which cannot be adequately expressed numerically; (iii) it focuses on how informants can have different ways of looking at reality; (iv) it focuses on description and interpretation, and it can lead to an evaluation of an organizational process; (v) it considers complexity by incorporating real-world context; and (vi) it uses a flexible methodology. In SECO field, researchers have adopted qualitative research to observe real situations, mostly using data from free open source software (FOSS) SECOs to do so, as reported by a systematic literature review (MANIKAS & HANSEN, 2013).

Both observational studies followed some recommendations adapted from (SEAMAN, 1999), as seen in Table 4.1. The researcher was guided by three questions regarding SECO challenging areas (MANIKAS, 2016) that helped us to observe both cases throughout the studies' activities that were conducted at different times. For each study, the researcher attended project meetings (sessions) in a specific timeframe with different stakeholders. For example, users, clients, requirements engineers, software architects, developers, test engineers, suppliers, project managers, and IT consultants. Moreover, the researcher wrote down all observations he could, i.e., impressions, opinions and thoughts in a notebook. An example of meeting's notes is shown in Figure 4.1. After each observational study, the researcher organized the data collected in the sessions to classify and analyze relevant information into the following categories:

(Q1) **Acquisition**: How is demand and solution analysis performed by the acquirer?

(Q2) **Governance**: How is the asset base used to support IT management activities?

(Q3) **Socialization**: How is supply network used to support IT management activities?

Table 4.1. Recommendations on observational studies (SEAMAN, 1999)

| SITUATION | RECOMMENDATION |
|---|---|
| *much of software development activities are implicit and some key-stakeholders keep important information in their mind* | *Communication* is the best resource for a researcher to observe the IT management activities, taking part of project meetings and requesting short meetings. |
| *informants can think they are being observed throughout the study activities* | *Notes* are the best resources for a researcher to register "normal" behavior of informants, and project meetings should be as unobtrusive as possible. |
| *notes are often visible to some informants throughout the study activities* | *Attention* is the best advice for a researcher to keep his/her notes confidential and has freedom to write down his/her own impressions, opinions and thoughts (notes can be shared with informants in the triangulation phase). |
| *different meetings and sessions can freely happen throughout the study activities* | *Emails* are the best resources for a researcher to gather information on meetings dates and times since he/she is trying to attend them as lifelike as possible. |
| *different issues are usually discussed in a project meeting beyond the initial outline* | *Text marks* are the best resources for a researcher to highlight relevant information since he/she should write down observations as much as he/she can. |

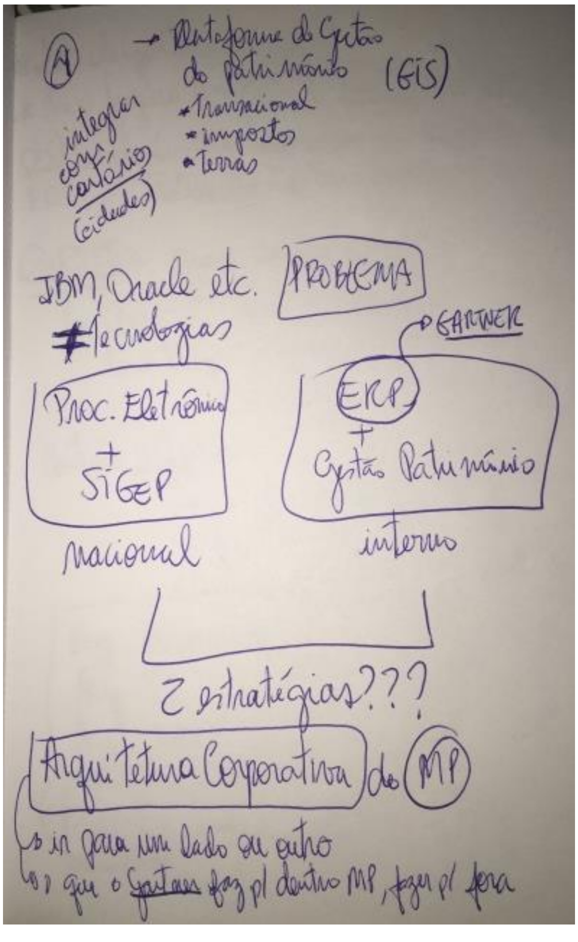



Figure 4.1. Example of meeting notes (in Portuguese).

## 4.3 Case 1

The *Observational Study 1* was conducted between July 2010 and December 2012 through monthly project meetings (two hours each). Detailed information on this study is presented in (SANTOS et al., 2013a). It refers to *Case 1* in which the researcher took part as project manager and also requirements engineer. In this scenario, the acquirer was represented by a consortium of ten research laboratories (universities or scientific foundations) within Rio de Janeiro State, joining approximately a hundred researchers. This consortium consists of a scientific SECO[25] in the public policy domain. The IT management activities referred to acquire a content management system and some components to support a scientific ecosystem focused on knowledge sharing and collaboration (SANTOS et al., 2010c). Five candidate software solutions (i.e., a software product and some components) were analyzed (SANTOS et al., 2012d). Stakeholders with diverse background took part of this consortium, such as geographers, social scientists, architects, life science researchers, managers, computer scientists, and software engineers.

### *4.3.1. Characterization*

The consortium was created over the first semester of 2010. The first goal was to develop a central platform (web portal) to help the laboratories to share their research artifacts (e.g., videos, interviews, news, books, articles, thesis etc.) and to enhance their collaborative initiatives through communication and coordination mechanisms. In this scenario, three roles were identified: (i) *producers*: students, researchers and professors who are responsible for developing, publishing and maintaining research artifacts within the scientific SECO; (ii) *consumers*: students, researchers and professors who are responsible for downloading, evaluating and (re)using research artifacts within the scientific ecosystem; and (iii) *repository managers*: IT management team responsible for managing the quality of research artifacts and for supporting the platform (portal and plug-ins management). Such roles interact though a process of production-management-consumption (ALMEIDA et al., 2007), as shown in Figure 4.2.

[25] A scientific SECO consists of an ecosystem centered in the scientific software products and in the groups that developed them. It is usually supported by research agency founding and involves researchers with cross-disciplinary skills (MONTEITH et al., 2014).

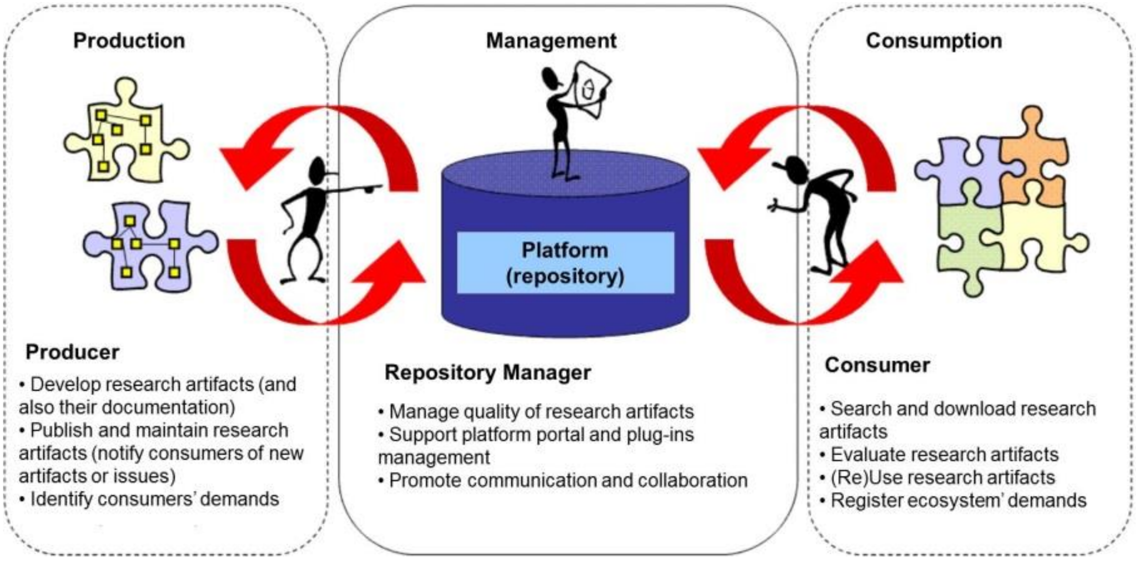



Figure 4.2. Process of production-management-consumption of the scientific ecosystem. Adapted from (ALMEIDA et al., 2007)

According to repository managers, after initial meetings, it was clear that all the laboratories were trying to create a scientific SECO. A closed network should be strengthened before opening it up to allow other organizations to participate in (e.g., libraries, governmental institutions, investors etc.). Figure 4.3 shows a model for the scientific SECO adapted from (JANSEN et al., 2009a). The platform should allow a laboratory (*LabX*) to use research artifacts produced by other laboratories (*Lab1*, *Lab2* and *Lab3*) and also develop and publish its own artifacts to others (*Lab3* and *Lab4*). On the other hand, *LabX* is part of the closed network and can be seen as an actor of the scientific SECO. Finally, this ecosystem is actually part of a set of different, interrelated ecosystems, that comes up from diverse national and/or international contexts and different domains (areas of knowledge).

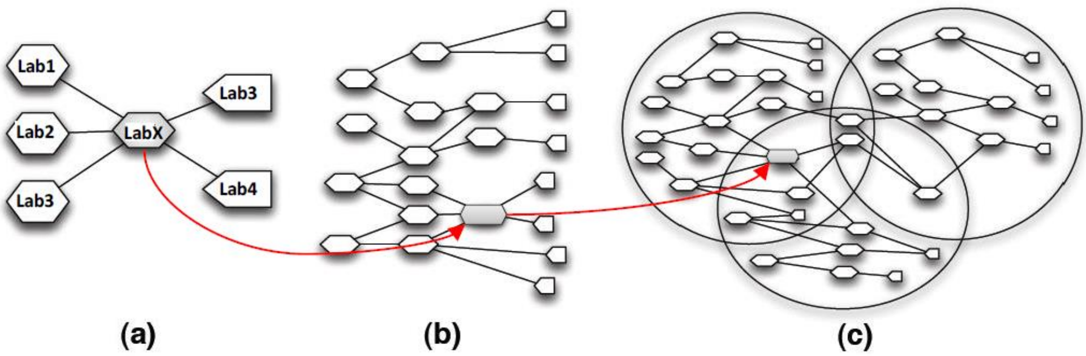



Figure 4.3. Scope levels of the scientific ecosystem based on SECO notation. Source: (SANTOS et al., 2013a)

In September 2010, an IT management team was created to manage demands for the development or acquisition of the platform's components (software applications). This committee was formed by one member of each laboratory and also by six software engineers from the Software Reuse Lab of COPPE/UFRJ. An IT architect, a project manager, a web designer, two requirements engineering interns and a testing engineering intern composed this technical team. From September 2010 to June 2011, monthly seminars were promoted to identify demands and develop a prototype. All laboratories explained their needs aiming to help the IT management team to specify the platform's components and also get the commitment of the ecosystem's members. The main components identified and prioritized during the seminars sessions were: (i) communication management (support to users, laboratories, news, and links); (ii) authentication/security; (iii) events and conferences support; (iv) component repository storage, publishing, search and retrieval mechanisms (for all types of scientific artifacts, e.g., videos, audios, texts, databases); and (iv) accounting management.

In February 2011, the IT management team was asked to decide whether the consortium should configure/use FOSS solution, buy COTS software, or develop/extend a platform from scratch or using the component-based paradigm. After analyzing the list of platform's functions, five candidate solutions were identified: (i) configure and deploy a web portal based on Joomla[26] platform with plug-ins to meet the ecosystem's demands; (ii) configure and deploy a web portal based on Moodle[27] platform, which is broadly supporting communities in the learning domain; (iii) configure and deploy a web portal based on Sakai[28] platform, which is also supporting communities in the learning domain; (iv) extend a Software Reuse Lab platform named EduSE Portal (SANTOS et al., 2011) with plug-ins to meet the ecosystem's demands; or (v) contract a supplier to develop a web portal based on well-known frameworks/technologies supported by the IT management team.

After a seminar in March 2011, Joomla was chosen as the supporting technology. However, software engineers of the IT management team faced some difficulties in meeting users' demands with such technologies. In a seminar in April

[26] Joomla – A Content Management System which enables users to build Web sites and powerful online applications. Available at <http://www.joomla.org>.
[27] Moodle – An Open Source Community Based Tools for Learning. Available at <http://moodle.org>.
[28] Sakai – An Open Source Learning Management System that provides a flexible and feature-rich environment for teaching, learning, research, and collaboration. Available at <http://sakaiproject.org/>.

2011, some ecosystem's members started criticizing the graphical user interfaces of the communication management component. This situation motivated the IT management team to realign stakeholders' expectations and consortium's interests. Therefore, it decided to develop a requirements specification in order to aid decision-making. In June 2011, the committee finally ended up the first version of a formal requirements specification, which included the following sections: problem definition, platform scope, software and hardware interfaces, platform's functionalities, list of users, data dictionary, functional and non-functional requirements lists, use cases, and mockups.

Considering the specificities of its ecosystem's platform, the consortium voted for the development of a web portal based on well-known frameworks and Java technology, which is supported by the IT management team. A supplier was selected by its expertise in developing community and content management portals. The platform development started in July 2011. Three main players took part in the iterative-incremental development process: (i) *supplier*: external organization responsible for coding and evolving the platform, and for integrating web design templates; (ii) *IT management team*, representing the *acquirer*: responsible for performing four activities, i.e., project management, web design, requirements management, and testing; and (iii) *laboratories' members*: responsible for validating functionalities implemented in the platform. The requirements specification had been evolved throughout the development of the platform, which was concluded in December 2012 (1.5 year).

The platform was finally released and deployed in January 2013. Some remaining issues were fixed in the first semester of 2013 when laboratories' members started publishing and downloading research artifacts and platform's plugin-ins. The IT committee was redefined since software development activities related to the platform's kernel were not required after it was running. After three years of tightly collaborative activities within the emerging ecosystem, other laboratories started contributing to the opening network. In addition, a new platform focused on public policy in education was derived from the scientific SECO. This new platform tried to follow the same trajectory of the previous one and components (plug-ins and extensions) were developed to meet specific demands of the new domain. This platform is still under development.

### *4.3.2. Analysis*

Regarding the IT management activities performed by the consortium, *Case 1* allowed us to observe two main challenges: *communication* and *autonomy*. Since ecosystem's members worked in different geographic locations and had different backgrounds, it was very hard to make convergent decisions on the components to be acquired. The senior researcher who managed the consortium then explicitly stimulated at least one member of each laboratory to attend the monthly seminars, especially in the first year – when the platform was created. Moreover, different backgrounds make the requirements communication very difficult, even when coping with software development terms, e.g., 'web design' (software engineers) *versus* 'visual identity' (social science researchers). As such, another responsibility of the IT management team was not only to align stakeholders' expectations but also respect their expertise, preserve their autonomy, and bring them into the development process to make them feel as critical players (decision makers).

On the *acquisition* perspective (Q1), *Case 1* allowed us to observe two main challenges: *future demands* and *inter-organizational validation*. Demand analysis still remains a critical issue in IT management (FREITAS & ALBUQUERQUE, 2014). This implies that deciding which demands are currently more valuable for the most important stakeholders is not a simple task, especially if the software project is cancelled. Sometimes it was very difficult to convince some ecosystem's members that some demands would translate into non-useful functionalities, e.g., integrating a chat mechanism into the platform considering that most members use well-known chats (Gtalk, Skype, Facebook Messenger etc.). It means that the platform evolution should prioritize what was really important to leverage the scientific SECO. The IT management team also faced barriers in orchestrating validation activities because different ecosystem's members had different perceptions of functionalities. However, it can be very positive for verification activities (functional testing) since different types of users had contributed to test the platform's components and identified/reported software bugs, interface mismatching etc.

On the *governance* perspective (Q2), *Case 1* allowed us to observe two main challenges: *solution analysis* and *user recommendations*. When the IT management team performed a feasibility study to decide on the platform development strategy, it was clear that most of the ecosystem' members strongly recommended checking market reports about "content and community management systems". Some traditional IT advisory companies like Gartner[29], Forrester[30] and ThoughtWorks[31] produce reports on technology maturity and trends. Following market indicators, the IT management ended up developing the platform based on component-based frameworks and technologies (Java, HSQLDB, JSF2, Richfaces 4, EJB 3.1). Another relevant criterion was to seek user ratings (i.e., evaluations and suggestions) regarding each candidate solution. To do so, software engineers collected strengthens and weaknesses of existing web portals that support similar ecosystems.

On the *socialization* perspective (Q3), *Case 1* allowed us to observe two main challenges: *development with reuse* and *hybrid development process*. After failing attempts to configure Joomla to support the SECO demands, the IT management team decided to develop a structured requirements specification in order to concretely coordinate the set of demands. The decision on the development of the platform kernel through contracting a supplier was driven to frameworks and technologies that improve time-to-market as mentioned before. As such, existing mechanisms were reused and integrated over the platform development. In parallel, an iterative-incremental development process was adopted, combining some practices, e.g., useful items of requirements specification (use cases), prototyping, 4-week iterations, biweekly project's meetings with the supplier and IT committee, monthly consortium's seminars with the ecosystem's members etc. This was critical to align stakeholders' expectations, change priorities, get feedback, measure project's performance, and adjust plans.

## 4.4 Case 2

The *Observational Study 2* was conducted between May 2013 and April 2014 through semester (2013) and monthly (2014) project meetings. Detailed information on this study is presented in (SILVA et al., 2014). It refers to *Case 2* in which the researcher took part as process engineer. In this scenario, the acquirer was represented by a consortium of dozens of departments within Distrito Federal State, joining approximately a hundred practitioners. This organization consists of a governmental

[29] Technology Research – Gartner Inc. Available at <http://www.gartner.com/>.
[30] Forrester Research Inc. Available at <https://www.forrester.com/>.
[31] ThoughtWorks Inc. – Technology Radar. Available at <http://www.thoughtworks.com/radar/>.

SECO[32] in the public management domain. The IT management activities referred to acquire applications and technologies to create a governmental SECO to support public management focused on improving participatory democracy. Several software solutions (mostly web information systems) are weekly analyzed aiming to support an e-gov environment (RODRIGUES et al., 2013). A process to support the ecosystem was mapped and modeled based on agile development for large corporations. Stakeholders with diverse roles took part in this consortium, such as managers, directors, coordinators, suppliers, consultants, clients, end-users, and computer scientists.

### *4.4.1. Characterization*

In 2012, the IT management team decided to spend efforts to understand how the software process was daily performed. This team realized that the organization was adopting an agile approach over the unified process often implemented in public corporations, producing a hybrid process. Then, the organization decided to model such dynamic, “organic” software process aiming to share process knowledge and practices as well as to collectively maintain it over time. In May 2013, the first project meeting focused on analyzing previous process modeling initiatives based on Business Process Model and Notation[33] (BPMN). It was observed that the process was not as dynamic as they wished, and most stakeholders had no idea on how to get it or use it in practice. The main stakeholders were identified: (i) *Systems Sector* (SS): responsible for analyzing, selecting, prioritizing, managing, and concluding demands requested by the organization, acting as *project managers*; (ii) *Business Areas*: departments or sectors within the organization responsible for demanding software solutions, acting as *clients*; and (iii) *Suppliers*: organizations responsible for developing solutions or selling COTS software that are/will be managed by the Systems Sector.

After some political issues related to reprioritization of investments, a second project meeting was performed in October 2013 aiming at exploring ways to sustain the hybrid software process focused on software artifacts. In that occasion, the IT management team and the process engineer together discussed how SECO modeling and analysis might help the organization to better understand the software process. As a

[32] A governmental SECO consists of an ecosystem centered in management information systems and in the network of business units and suppliers that developed them. It is usually supported by public founding and involves system analysts and business managers (RODRIGUES et al., 2013).
[33] OMG – BPMN. Available at <http://www.bpmn.org/>.

consequence, the Systems Sector's coordinator proposed a strategy and also a roadmap to get first useful results of software process modelling. Initially, Systems Sector's analysts and the process engineer investigated and studied approaches for agile-driven, hybrid process modeling over three months, keeping a monthly videoconference meeting. Between January and April 2014, monthly one-week observational sessions were then performed, starting with a workshop on process definition and modeling (January). The workshop produced a conceptual map and an initial model based on Software & Systems Process Engineering Metamodel[34] (SPEM), Eclipse Process Framework[35] (EPF), and Disciplined Agile Delivery process framework[36] (DAD).

Besides the workshop in January 2014, some sections of the observational study were conducted in the context of diverse software projects' meetings involving clients, suppliers, project managers, consultants etc. until April 2014. Some records are presented in Table 4.2 and Table 4.3.

The top ten observations collected from the sessions are presented below:

1) The organization recognizes some areas of interest, i.e., the *management of software process*, *application portfolio*, *acquisition* (*monitoring contracts*), and *IT services*, as identified in the workshop discussions;
2) The organization requires support in SE education and training in order to identify effective ways of *disseminating and institutionalizing its software process*;
3) The Systems Sector is driven by frequent releases, shortening time-to-market and agile practices, sometimes leading many geographically distributed suppliers and facing *collaboration challenges*;
4) The System Sector maintained a *reference IT architecture* as a set of applications and technologies organized into categories (taxonomy), guided by market and IT advisory companies;
5) The acquisition process is supported by a diagnosis phase that is part of the software process, which aims to perform a feasibility study to decide whether *make, buy or reuse* software solutions;

[34] OMG – SPEM. Available at <http://www.omg.org/spec/SPEM/2.0/>.
[35] EPF Project. Available at <http://www.eclipse.org/epf/>.
[36] DAD Framework. Available at <http://www.disciplinedagiledelivery.com/>.

6) The organization had faced *reprioritization decisions* over time, e.g., some on-going projects may be canceled. Then, demand selection and prioritization is crucial to earn value early;
7) The organization has a structural role within a governmental SECO and has tried to reduce acquisition costs and sustain solutions through collaborative software projects, but it had also faced *political issues*;
8) The organization had no clear governance over applications, partners, suppliers and other SECO elements, though it frequently needs to reevaluate its application portfolio due to *scarce resources*;
9) The organization has produced triennial IT investment plan (*roadmap*) to define which software demands should be executed and which should not;
10) The System Sector has faced some barriers in running a *hybrid process* since contracts are specified in Function Points and projects are managed through an agile approach (stories, sprints, backlog etc.).

The first version of the hybrid software process was finally concluded between May and June 2014. It focused on modeling all the process elements of the System Sector (i.e., activities, roles and work items). It was quite difficult to understand and some process areas remained unexplored, such as make-buy-reuse analysis (diagnosis phase), since there was no inventory to leverage a software asset governance strategy. Reprioritization also seemed to be a recurrent situation. Moreover, the potential process line approach (WERNER & TEIXEIRA, 2011) was not explored yet. It may contribute to the dissemination and institutionalization of the process, especially because collaboration was also a challenge. So, from the first semester of 2015, the software process has been analyzed again to create a "slim" version that is effectively applied, as well as to explore the application portfolio and collaboration activities to support the SECO. The ecosystem platform and its related process are still under development.

Table 4.2. Project meetings records of *Case 2* (Part 1)

| DATE | STAKEHOLDERS | PROJECT | DISCUSSION |
|---|---|---|---|
| Jan. 13-15, 2014 | Process Engineer<br>SS Coordinator<br>Software Architect<br>3 Project Managers<br>Engineer Intern | Process Workshop (all-day) | Studies on DAD framework and how EPF/SPEM would support the software process. A process conceptual model was developed. Main concerns: audit management, acquisition, suppliers' contracts, architecture, and IT services. |
| Jan. 16, 2014 | Process Engineer<br>SS Coordinator<br>SE Consultant | Training (one hour) | Strategies to sustain the software process by contracting SE training (supplier). Main concerns: use learning management system to allow the teams to share experiences with each other. |
| Jan. 17, 2014 | Process Engineer<br>IT Director<br>SS Coordinator<br>Project Manager | Software Asset Platform (two hours) | Strategies to select technologies to support collaborative development, software asset management (including inventory), governmental SECO analysis, and agile software process. |
| Feb. 10, 2014 | Process Engineer<br>SS Coordinator<br>Project Manager<br>SE Consultant | Portfolio Management (one hour) | Strategies to support release and backlog planning, projects' prioritization, clients' commitment, configuration management, and software testing outsourcing. |
| Feb. 11, 2014 | Process Engineer<br>SS Coordinator<br>Project Manager<br>Business Area | Software Development / Acquisition (one hour) | Identifying clients' needs to support decision-making on buying or developing a purchasing system. For example: How many does it cost (functions points)? What existing solutions are available? Do other areas face the same issues? |
| Feb. 11, 2014 | Process Engineer<br>SS Coordinator<br>SE Consultant | Market Analysis (one hour) | Requesting an IT advisory company information on technologies and/or applications to support the development or acquisition of enterprise service bus, data governance, enterprise resource planning, distributed storage and distributed processing. |
| Feb. 12, 2014 | Process Engineer<br>SS Coordinator<br>2 SE Consultant | Project Management (one hour) | Strategies to support service quality and service deployment, as well as to manage external infrastructures to manipulate large data volume. Main concerns: minimum price, and delay in processing information. |
| Feb. 12, 2014 | Process Engineer<br>SS Coordinator<br>Business Area | Software Development / Acquisition (one hour) | Identifying clients' needs to support decision-making on buying or developing a business process office system. For example: How to integrate different existing subsystems? How to better migrate paper-based processes? |

Table 4.3. Project meetings records of *Case 2* (Part 2)

| DATE | STAKEHOLDERS | PROJECT | DISCUSSION |
|---|---|---|---|
| Feb. 12, 2014 | Process Engineer<br>SS Coordinator<br>Supplier | Software Development / Acquisition (one hour) | Identifying clients' needs to support decision-making on developing a strategic planning management system. Two business areas were interested in it, one of them using the current supplier's solution and another interested in use it. For example: How to coordinate different, distributed demands? Is there any other market solution? |
| Feb. 13, 2014 | Process Engineer<br>SS Coordinator<br>Business Area | Software Development / Acquisition (one hour) | Identifying clients' needs to support decision making on buying or developing an event management system. This decision had priority over the others since the main director of the organization requested it. |
| Feb. 14, 2014 | Process Engineer<br>SS Coordinator<br>Business Area | Software Process (one hour) | Strategies to adapt the software process to a specific department. Process components (roles, activities and artifacts) should be selected according to software projects' characteristics (e.g., legacy software migration). |
| Feb. 24-25, 2014 | Process Engineer<br>SS Coordinator<br>Software Architect | Software Process (two hours per day) | Strategies to support the software process internalization within the organization. Two supporting tools focused on managing software artifacts were analyzed: EPF and IBM Rational Method Composer[37]. EPF was selected. An existing DAD process library was analyzed, but it was decided to evolve an initial version built by the SS coordinator. SPEM was confirmed as the official process modeling notation. |
| Feb. 26, 2014 | Process Engineer<br>SS Coordinator<br>Business Area | Software Development / Acquisition (one hour) | Identifying clients' needs to support decision-making on selecting the official content management system (CMS) technology for e-gov domain applications. WordPress, Joomla, Plone, and Drupal were analyzed. Integration with existing systems was the main concern. |
| Feb. 27, 2014 | Process Engineer<br>SS Coordinator<br>Supplier | Software Development / Acquisition (one hour) | Regarding the strategic planning management system discussed in previous meetings, the specification strategy adopted should support future customizations by other organizational units. |

[37] IBM RMC. Available at <http://www-03.ibm.com/software/products/en/rmc>.

### *4.4.2. Analysis*

Regarding the IT management activities performed by the organization, *Case 2* allowed us to observe two main challenges: *roadmap development* and *contract monitoring*. In this context, all acquisition activities performed within the organization should be described in a triennial IT management plan consolidated with departments, institutions and sectors. Despite issues related to possible budget cuts, this document represents a high level description of the organizational demands (an important guide to the IT management). As such, all contacts should be monitored in order to check to what extent all organizational demands were being solved. However, such precise control still remains as a challenge, especially considering different clients running acquisitions rounds at the same time. Besides, since the System Sector had formal responsibility in monitoring Function Points counting, an organization specialized in doing so was hired.

On the *acquisition* perspective (Q1), *Case 2* allowed us to observe two main challenges: *process institutionalization* and *frequent reprioritization*. As mentioned before, the organization invested in hybrid software process modeling to support the System Sector to run projects. The process needed to be disseminated/institutionalized, but some barriers referred to its “overloaded” nature and difficulties to understand it still waited for solutions. As such, some stakeholders did not know how the process works and how to use it in practice. An issue related to requirements management was the frequent reprioritization of project portfolio due to budget cuts or specific interests, mainly in political transition situations. Demand selection and prioritization is affected and affect the organizational roadmap and the software project as well. So, the System Sector coped with these issues by applying agile practices.

On the *governance* perspective (Q2), *Case 2* allowed us to observe two main challenges: *mature technology*, and *education and training*. Similar to *Case 1*, the organization looked at market reports produced by IT advisory companies to justify some IT management decisions. In one session, a conference call between the System Sector’s coordinator and a famous IT advisory company’s analyst was performed to decide on the technology to support an enterprise service bus, for example. Another issue observed throughout the sessions was the demand for education and training in some relevant SE disciplines in the organizational context. This problem happened due to the high turnover that also affects process dissemination and institutionalization.

On the *socialization* perspective (Q3), *Case 2* allowed us to observe two main challenges: *reference architecture* and *hybrid development process*. In order to sustain all the solutions produced over time, the System Sector decided to define a reference IT architecture, i.e., a set of standard/adopted technologies grouped by categories. It makes software maintenance easy and reduces the learning curve bypassing the high turnover; however, this strategy required an IT architect team to be able to sustain and evolve it. As such, the organization started observing a network of technology suppliers surrounding the SECO because demands' specifications should consider technology constraints established in the reference architecture and 'unrequired' dependencies. Finally, the hybrid process needed to support demand coordination, including activities related to the organizational scenario (e.g., project management) but also to the ecosystem scenario (e.g., partner selection).

## 4.5 Discussion

In this section, we summarize our findings, as shown in Table 4.4. In *Case 1*, we observed some problems related to communication among stakeholders during the IT management activities regarding the acquisition preparation, which was collaborative and iterative. A possible reason is that they had different backgrounds and strategic decisions were initially based on monthly seminars with no requirement specification document at the beginning. Moreover, IT management team faced challenges in classifying current and future business objectives due to the lack of synergy. Market reports and user ratings on content management systems available on the Internet were taken into consideration to choose mature supporting technologies. In this specific scenario, the organization preferred to choose a closer supplier to develop a customized portal than an existing COTS solution.

In *Case 2*, we observed that the software process defined by the IT management team aims at centralizing acquisition but some business areas disturb it. In other words, short-term goals affect shared business objectives and cause frequent reprioritizations. Therefore, business areas prefer to pursuit specific software solutions rather than analyze their problems and feed organization's objectives. The same legal issues and the use of IT advisory company’s market reports found in *Case 1* apply. A particularity of this case is the priority of selecting Brazilian public software, as well as FOSS solutions. Finally, this organization gets in trouble due to some dependencies on certain suppliers, e.g., high costs and poor support.

Table 4.4. Summary of data collected throughout the sessions of each industrial case

| | **Case 1** | **Case 2** |
|---|---|---|
| **IT Management (general observations)** | Stakeholders worked in different geographic locations and had diverse backgrounds. Then, collaborative, nonsystematic specification was used to guide the acquisition preparation. | The organization developed a triannual roadmap consolidated with its departments and mostly focused on monitoring supplier agreements. |
| **Acquisition (Q1)** | An IT management team had biweekly meetings to prioritize shared business objectives, e.g., which of them should be postponed. | An IT management team had weekly meetings to coordinate shared business objectives into an informal portfolio that often faces reprioritizations. Organization mostly focused short-term goals. |
| **Governance (Q2)** | The consortium selected the top mature FOSS solutions from specific forums on the Internet to conduct a feasibility study. | The organization contracted an IT advisory company to obtain IT recommendations on the most appropriate technologies. Public, FOSS solutions were preferable. |
| **Socialization (Q3)** | In this specific case, the consortium decided to outsource the solution development. A supplier was chosen based on its background and previous collaboration/experience. | The organization mostly contracted software factories based on bidding processes driven by the minimum as the key factor. Formal requirements specification was not used as a key factor as it used to be. |

Considering the SECO management issues discussed in Chapter 3, we observed that there is an emerging concern with sustainability in SE, then acquisition preparation needs to take into account other criteria than available budget and requirement specification, as well as long-term rather than short-term IT management. In summary, regarding the elements that affect SECO platform sustainability, the main observations performed in our studies helped us to collect data to answer “*what are the most critical health indicators for SECO platform monitoring?*” are:

- *analysis of the decision space*: acquirers commonly do not know how to formally cope with several demands from its units at the same time. An inhibitor is the poor knowledge management that depends on many elements, such as suppliers, existing applications and adopted technologies, producing obstacles to analyze acquisition impacts;
- *business objective synergy*: applications are normally acquired taking into account specific demands. Acquisition preparation is still a great

challenge since each organizational unit has its own goals in its particular roadmap, producing obstacles to leverage socialization;

- *technology dependency*: market information on applications and technologies capabilities is not so useful as the only indication, though organizations hire IT advisory companies to guide their IT management decisions. Organizations often neglect the software asset base since they have no virtual catalog or inventory, producing obstacles to the governance of the SECO platform architecture;
- *supplier dependency*: similar applications are acquired from either third-parties or commercial suppliers or resellers. A purely cost-based, short-term approach is not so useful from now on, because business, long-term information of the relationships within the supply network may be left out, producing obstacles to the SECO sustainability.

## 4.6 Threats to Validity

Threats to validity include: (i) we have reported direct observations as the primary data collection method (nonsystematic analysis): we complemented them by collecting data from direct verifying IT management documents, e.g., triennial roadmap, request for proposal, demands' specifications etc.; also, two researchers analyzed the cases and solved any conflict of observation together; (ii) impressions, opinions and thoughts were subjectively reported in both cases: at least two researchers attended each meeting to reduce misunderstandings; notes written down during each meeting was sent to the respective IT management team for approval and then merged to a single description (triangulation); and (iii) conclusions are limited to the cases' scenarios: in *Case 2*, for example, the organization is responsible for IT standardization and regulatory processes applied to other public organizations; therefore, the System Sector works with different scenarios and serves as a laboratory to explore process, methods and technologies to be adopted by the government IT.

## 4.7 Conclusion

In this chapter, we investigated SECO monitoring in real scenarios in order to identify how it affects an acquirer performing IT management activities. We presented the results of two observational studies conducted in Brazilian scenarios where different units create a SECO platform based on software acquisition. We characterize each case and discuss SECO monitoring in practice to answer RQ3. As observed, *analysis of the decision space*, *business objective synergy*, and *technology/supplier dependency* were the most critical health indicators for SECO platform monitoring in IT management activities. Additionally, demand and solution analysis seems to be very important for acquisition preparation and for maintaining a sustainable SECO.

Although selection and prioritization activities have been investigated in the SE area (ALVES, 2005; BAKER et al., 2006; CORTELLESSA et al., 2008b; FREITAS & ALBUQUERQUE, 2014), two challenges for acquires' IT management still remain: (1) *IT architectural matching taking into account supplier and technology dependencies over time* (LAGERSTRÖM et al., 2014); and (2) *multiple selections of software applications to help customers satisfy their business objectives* (FINKELSTEIN, 2014). According to BAKER et al. (2006), from the set of candidate components (in this case, demands and solutions), the IT management team should search for a subset that balances these competing, conflicting concerns as better as possible.

As observed, IT management teams had regular meetings to deliberate on those components based on their expertise and IT market recommendations, sometimes including spreadsheets and distributed documents. This reality brought acquisition preparation to play a critical role in the SECO context (PMI, 2014). Also, IT management teams considered requirement specifications and available budget as criteria to analyze demands and solutions since a structured asset base is missing, neglecting the 'hidden effects' of their long-term decisions. In an acquirer's point of view, such effects refer to a proper known as *diversity*, i.e., how sustainable the SECO platform is over inherent changes like technology obsolescence and business evolution. Such current industry challenges motivated us to investigate how SECO perspective can aid IT management teams to perform their daily activities within a supply network, more specifically demand and solution analysis. Then, we proposed a solution approach in Chapter 5.

# Chapter 5 – *SECO2M* Approach

*A recurring user-organization desire is to have technology that adapts to people rather than vice versa. This is increasingly reflected in users' product selection activities, with evaluation criteria increasingly emphasizing product usability and value added vs. a previous heavy emphasis on product features and purchase costs. Such trends ultimately will affect producers' product and process priorities, marketing strategies, and competitive survival.*

Boehm (2006)

## 5.1 Introduction

According to LAGERSTRÖM et al. (2014), current business environments are continuously evolving. Organizations have invested in a massive adoption and use of software applications and technologies to support a wide range of business processes and then enhance competitive advantage (GROOT et al., 2012). However, the number of those components has increasingly grown, being more and more interdependent. As a consequence, suppliers have established tight relationships aiming to create networks of influence and interoperability (JANSEN et al., 2009c). In parallel, an evolving business environment contributes to changes in organizational processes, affecting business objectives and demands. For example, choosing the appropriate application to be acquired from a pool of candidate solutions requires balancing the immediate needs of an organization against those of the future (ZHANG et al., 2010).

As a result, software development activities have concerned with the software supply network (HANSSEN & DYBÅ, 2013). BOEHM (2006) previously claimed that the change in the global market requires higher levels of agility in business processes, whereas their supporting systems are simultaneously becoming ever more software-intensive. According to SANTOS et al. (2014c), research topics have arisen in the Software Engineering (SE) field to address such large, complex systems that are created and maintained over a plethora of 'nontechnical' elements. For example, in the software ecosystem's (SECO) context, platform evolution depends on the community's emerging demands and contributions (FRICKER, 2009).

As an emerging research topic, SECO has motivated a growing community that is interested in those SE issues (SEREBRENIK & MENS, 2015). The main concern is the dynamic software industry where SECO management and monitoring affect the IT management activities (DHUNGANA et al., 2010; BOSCH, 2012). However, a strong inhibitor to make this concept effectively understandable and useful to practitioners is the complexity to perform SECO analysis (SANTOS, 2014). In other words, such a confusing scenario creates barriers to research advances (JANSEN et al., 2015), and practitioners are to a greater extent adopting 'ad hoc' SECO elements to create strategies to survive within the global industry (PICHLIS et al., 2014; VALENÇA et al., 2014). As such, despite the initial advances in SECO research, few analytical models, case studies with real data, and integrated tool support exist (MANIKAS, 2016).

JANSEN et al. (2015) argue that SECO modeling is important to provide insights from representations and allow analyzing and comparing 'static' ecosystems, based on key concepts (organizations, relationships and flows) and existing methods (socio-technical network and software supply network). In turn, SANTOS & WERNER (2012b) state that SECO analysis is important to provide different players with supporting information for decision-making. For example, impacts of demands and candidate solution over the existing software applications and technologies; changes on technology/supplier dependency levels; and objective satisfaction levels over the acquisition rounds (SANTOS & WERNER, 2010; ALBERT et al., 2013; LIMA et al., 2015). Despite the IT advisory companies' recommendations, such decision-making issues still exist since acquirers lack a structured asset base (SANTOS et al., 2013b).

For an acquirer, it is critical to manage and monitor the software asset base, i.e., the network of objectives, applications, technologies, and suppliers; otherwise, market disturbances can affect organization's surveillance (ULKUNIEMI & SEPPÄNEN, 2004). However, organizational knowledge is usually spread in distributed documents and employees' minds, also poorly documented or maintained, and this reality obstructs SECO management and monitoring (WERNER et al., 2009). A strategy to work with this reality is to understand IT management activities from asset base by analyzing historical data through technical, business and social mechanisms (SANTOS et al., 2010a). These mechanisms are important to provide precise information to decision-making (FINKELSTEIN, 2013; 2014) even with the difficulties related to market uncertainty (PICHLIS et al., 2014).

The objective of this chapter is to propose an approach for managing and monitoring SECO to support IT management activities, more specifically demand and solution analysis, motivated by the results of our first three research questions (RQs). Firstly, we present an overview of our proposal in Section 5.2, including details on the requirements, strategy, and conceptual model. We discuss the SECO management and monitoring mechanisms and infrastructure in Sections 5.3 and 5.4. Related work is presented in Section 5.5. Finally, we conclude the chapter in Section 5.6 with the motivation for investigating our last RQ on the use of our approach in a real scenario.

## 5.2 *SECO2M* Overview

The studies performed throughout the research activities allowed us to conclude that acquirers need an approach to maintain their SECO platforms sustainable over time (SANTOS et al., 2016a), mainly when a multiple selection of demands and software solutions are guided by architectural and business concerns (ALVES, 2005). In order to help acquirers to realize how SECO perspective can aid IT management activities, we propose an approach for **SECO M**anagement and **M**onitoring, named *SECO2M*. This approach was inspired on the elements of the generic framework for sustainable SECO management proposed by DHUNGANA et al. (2010) (Section 2.4). Such framework brings up three SECO elements: ecosystem resources and local management; ecosystems perspectives; and monitoring parameters. However, *SECO2M* specifically focuses on helping IT management teams to perform demand and solution analysis based on the visualization of information regarding the SECO platform sustainability.

In this context, the acquirer's software asset base is seen as the SECO platform and then an environment should be defined and modeled to support SECO management with governance and socialization mechanisms, as discussed in Chapter 3. Additionally, the platform should be analyzed and maintained as an organizational instrument to support SECO monitoring with health indicators, e.g., technology dependency and objective synergy, as pointed out in the end of Chapter 4. The main contribution of *SECO2M* is to aid IT management teams to better prepare acquisition rounds, i.e., to aid IT managers and architects to analyze organizational demands and candidate solutions. The novelty is to consider not only the traditional paradigm in which cost is the primary driver, but also to introduce an ecosystem setting driven by sustainability in which acquirers look at the 'hidden effects' of IT management teams' decisions over time.

*SECO2M* was developed based on the SECO elements identified from our first three RQs, which were stated as requirements (R0 to R10) for a SECO management and monitoring approach (Table 5.1*).* Regarding RQ1 (*What are the SECO dimensions and key concepts that allow researchers to analyze an organization's platform*), R0 was derived as the elementary requirement: *support SECO management and monitoring*. Next, RQ2 (*What are the most relevant mechanisms for SECO platform management?*) derived six requirements to address the top two governance elements (*management of roles and responsibilities, and component lifecycle*), and also the top four socialization elements (*management of file storage, artifact versioning, artifact forum, and demand registering*). Finally, RQ3 (*What are the most critical health indicators for SECO platform monitoring?*) allowed us to derive the last four requirements related to the acquisition preparation challenge (*analysis of the decision space: demands/solutions*) and the health indicators identified in real cases (*monitoring of business objective synergy*, *technology dependency*, *and supplier dependency*).

Table 5.1. SECO elements that affect IT management activities (extracted from our RQs), stated as requirements of *SECO2M*

| **Source** | **ID** | **Description** |
|---|---|---|
| **RQ1** | R0 | Support SECO management and monitoring |
| **RQ2** | R1 | Manage roles and responsibilities for SECO governance |
| | R2 | Manage component lifecycle for SECO governance |
| | R3 | Manage file storage for SECO socialization |
| | R4 | Manage artifact versioning for SECO socialization |
| | R5 | Manage artifact forum for SECO socialization |
| | R6 | Manage demand registering for SECO socialization |
| **RQ3** | R7 | Support analysis of the decision space: demands/solutions |
| | R8 | Monitor business objective synergy |
| | R9 | Monitor technology dependency |
| | R10 | Monitor supplier dependency |

### 5.2.1. *Strategy*

*SECO2M* is an approach centered in a *SECO platform*. Similar to a component repository[38], the SECO platform works as a broker and plays an important role: to serve as an organization's virtual inventory enriched with SECO management and monitoring mechanisms to aid IT management activities. In the traditional scenario, the IT management team acts as the organization's broker. In other words, the IT management team centralizes the main relationships with the other SECO elements (nodes). Relationships are seen as underlying connections, keeping *actors* as 'first-class citizens' (Figure 5.1):

- knowledge is mostly tacit, usually unstructured and confined in the minds of a small group of experienced employees;
- organization frequently adopts technologies based on recommendations from IT advisory companies (external view);
- organization is not clearly aware of how tight or loose and/or dangerous or fruitful relationships with suppliers can be;
- requirement specifications and available budget serve as key criteria to analyze organizational units' demands; and
- there is no software inventory or catalog, then information is hidden in spreadsheets and distributed documents.

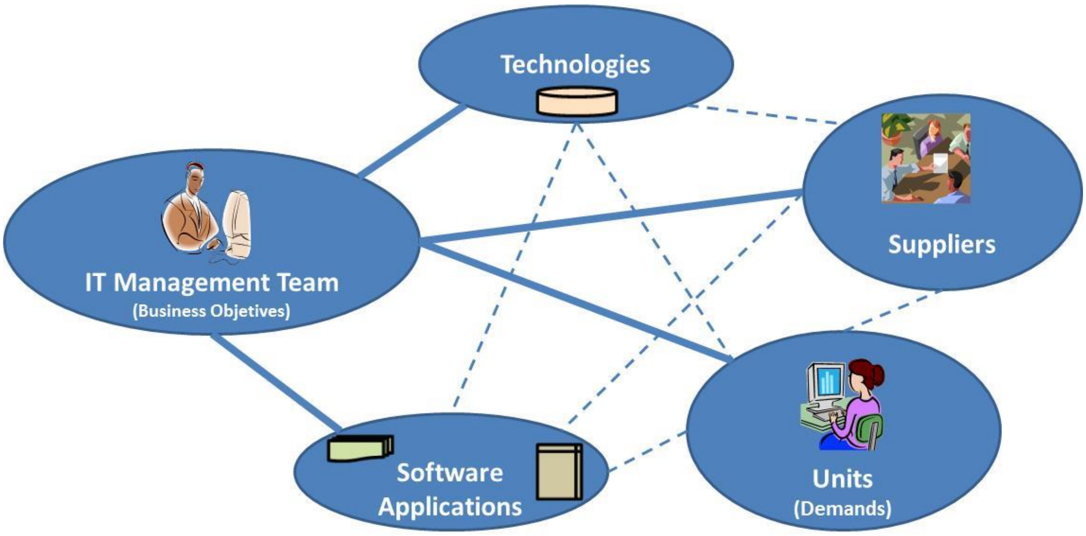



Figure 5.1. Traditional IT management scenario.
Adapted from (SANTOS et al., 2014a)

[38] A component repository is a database prepared to store and retrieve components, i.e., any artifact produced or used throughout software development processes (SZYPERSKI et al., 2002).

On the other hand, the IT management scenario in the SECO context with *SECO2M* is shown in Figure 5.2. As such, the SECO platform supports relationships between actors and artifacts within the ecosystem in order to create an environment where each of them can contribute to long-term ecosystem sustainability. According to SCHILLING (2008), that central entity is indispensable for retaining organizational knowledge and leveraging business innovation. In other works, an acquirer can be able to answer some questions like: *Are the software applications aligned with different organization's business objectives, helping it to drive results? Which candidate applications better fit to the technologies currently adopted in the IT architecture? And is the organization's IT management team aware of its suppliers and/or technology dependency?* SECO platform serves as a hub for the relationships amongst the nodes, promoting *artifacts* as 'first-class citizens' (SEICHTER et al., 2010):

- knowledge is mostly explicit and the organization' businesses are not so dependent upon employees, especially because high turnover;
- organization adopts technologies based on information obtained from the asset base (internal view) and also from market reports (external view);
- organization has become even more aware of how tight or loose and/or dangerous or fruitful relationships with suppliers can be;
- SECO platform health as well as requirement specifications and budget serve as criteria to analyze organizational units' demands;  and
- there is a software inventory or catalog, where information is stored and available to support decision-making.

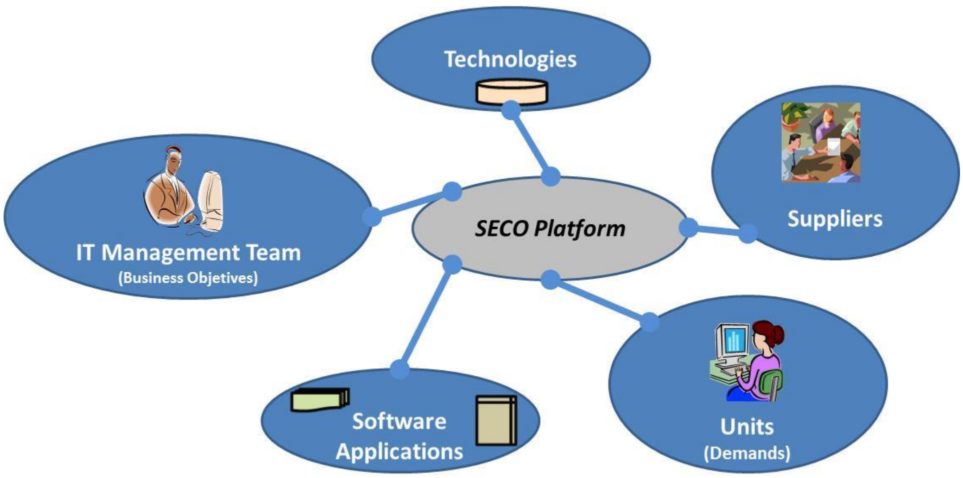



Figure 5.2. IT management scenario in the SECO context with *SECO2M*.
Adapted from (SANTOS et al., 2014a)

According to CLARKE et al. (2002), complexity management problems like those faced in the traditional IT management have proved resistant to analytical solutions, since perfect solutions are impossible or impractical. Thus, the traditional scenario still remains in the software industry, despite the research community efforts to propose practical solutions (BAARS & JANSEN, 2012; ALBERT et al., 2013; MANIKAS et al., 2015). One reason is the fact that IT management activities like demand and solution analysis are usually characterized by competing and interrelated objectives/constraints, which are critical for balancing interests when any parameter is changed, although sometimes they are poorly specified (CORTELLESSA et al., 2008b).

In addition, software-intensive systems accumulate Technical Debt (TD) when short-term goals are traded for long-term goals, e.g., quick-and-dirty implementation to reach a release date versus a well-refactored implementation that supports the long-term health of the project (LI et al., 2015). However, similar to other engineering disciplines, SE is typically concerned with near optimal solutions or those within a defined acceptable tolerance, after evaluating and comparing candidates (HARMAN & JONES, 2001). For instance, it may be difficult to know how to select a demand or a candidate solution with low coupling and high cohesion, but it is relatively easy to decide whether a specific design is more coupled than another (CLARKE et al., 2002).

Under these circumstances, we highlighted two factors (SANTOS & WERNER, 2010): (1) it is preferable to explore information management and visualization to allow IT managers and architects to perform activities and make decisions rather than propose analytical solutions or automation (except when exploring large amounts of data and/or solutions); and (2) it is critical to make decisions thinking in long-term goals traded for short-term goals due to the 'hidden effects' of IT management teams' decisions over time (nontechnical issues). In *SECO2M*, two challenges for IT management are explored: (1) *IT architectural matching taking into account supplier and technology dependency over time* (LAGERSTRÖM et al., 2014); and (2) *multiple selections of software applications to help customers satisfy their different business objectives* (FINKELSTEIN, 2014). As such, to play as a broker, we state that a platform should incorporate the elements pointed out as requirements for managing and monitoring SECO, as presented in Table 5.1.

### *5.2.2. Conceptual Model*

After proposing an approach to help suppliers to play in a component marketplace in our previous work (SANTOS, 2010), we concluded that an acquirers' support was missing in the SECO context. In (SANTOS, 2010), the top three elements observed in a survey with experts regarding suppliers' needs were: (A) to develop strategies to treat *nontechnical issues* in component-based SE (e.g., marketing, visualization, negotiation, pricing and evaluation); (B) to analyze the *components supply* from Internet-based distribution channels with search, retrieval, storage, comprehension, and quality support; and (C) to define *the concept of 'value'* for components considering stakeholders' perspectives as well as different facets, i.e., not only costs and profits, but also benefits, needs, risks, flexibilities, requirements etc.

In turn, *SECO2M* aims to offer a conceptual and technological support for an acquirer to define and manage elements that affect IT management activities, as well as monitor and analyze information that is useful for demand and solution analysis, attending SECO element *R0*. In the opposite perspective, suppliers' *nontechnical issues*, *component supply*, and *concept of 'value'* that also affect acquirers' IT management activities are respectively addressed by SECO three-tier perspective model (Section 2.2.2): acquirers' *governance and socialization* (organizational level or ISV), *demand and solution analysis* (software supply network level or SSN), and *ecosystem monitoring* (SECO level). Based on these statements, *SECO2M* was also developed to help acquirer to understand the SECO elements, as well as to treat the so-called 'nontechnical' issues of the global industry (SANTOS, 2013ab).

*SECO2M* tries to combine both internal and external SECO views, i.e., data from the organization and its current relationships (ISV and SSN levels) with data from the possible, future relationships (SECO level). In this context, the approach directly involves an environment for managing and monitoring such elements: (i) a network of suppliers and organizational units providing and consuming applications to satisfy the acquirer's objectives, on high level; and (ii) a network of existing and candidate applications being supported by technologies adopted by the acquirer, on low level. A minimum body of knowledge on the SECO definition was required to characterize both the internal and external views, as explained in Section 3.2. Then, *SECO2M* comprises four paired modules as shown in Figure 5.3: *definition* & *management*, and *monitoring* & *analysis*. Figure 5.4 presents a complete picture of the environment, explained next.

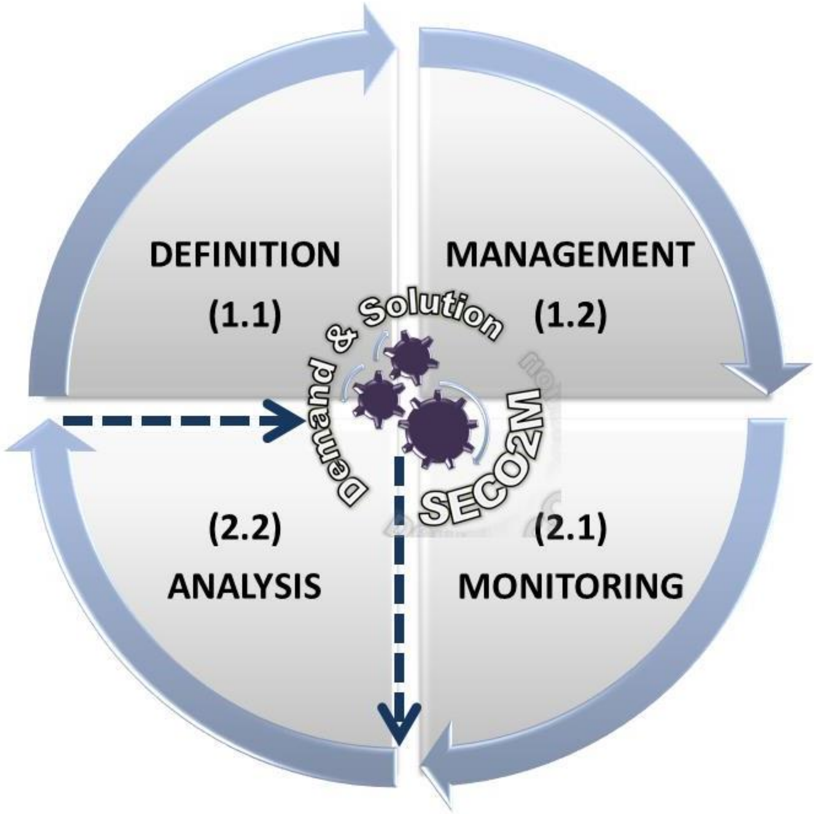



Figure 5.3. Overview of *SECO2M* modules

The first two modules (1.2 and 1.3) consist of SECO definition from the perspective of an acquirer performing IT management activities, and management of SECO governance and socialization elements based on mechanisms integrated to the platform. The first resulted in a conceptual model derived from *ReuseECOS '3+1'* framework (Section 2.3) – an important instrument to help IT management teams to properly understand SECO key concepts and relations (WERNER, 2009). The second resulted in an extension of a software asset base to support both the SECO internal and external views with mechanisms identified in Chapter 3, attending requirements *R1* to *R6* (SANTOS et al., 2013b; ALBERT, 2014; LIMA, 2015). This module comprises SECO platform components, i.e., acquirer's objectives, applications, and technologies, and SECO actors (organizational units and end-users). Mechanisms were proposed to aid IT management activities in the SECO context, handling technical, business and community information – SECO perspectives described in (DHUNGANA et al., 2010).

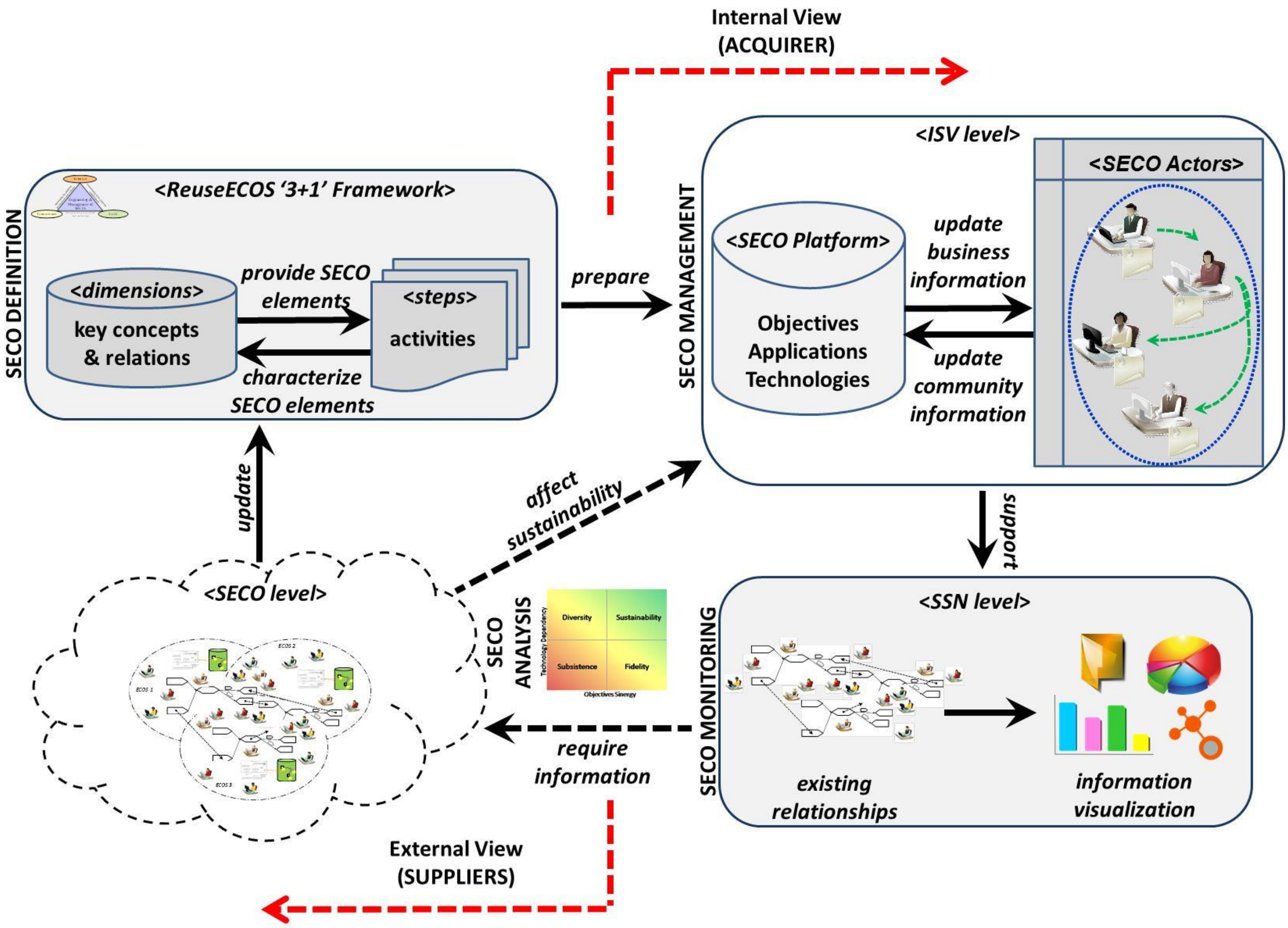



Figure 5.4. *SECO2M* conceptual model

The second two modules (2.1 and 2.2) consist of SECO monitoring from an acquirer performing IT management activities; and SECO analysis based on mechanisms integrated to the platform. The first resulted in an analytical model derived from SECO health indicators to aid an IT management team to understand information related to the platform sustainability (SANTOS & WERNER, 2013). The second resulted in an extension of a software product for exploring and manipulating networks to support demand and solution analysis with mechanisms identified in Chapter 4, attending requirements *R7* to *R10* (SANTOS et al., 2016ab). This module collects and uses data from both the internal and external SECO views. Mechanisms were proposed to aid IT management activities in the SECO context, handling relationships among actors and artifacts to visualize information related to technology/supplier dependency and business objective synergy. As such, this module requires historical data, as well as understanding of IT management decisions. The following sections provide details on all modules and supporting infrastructure.

## 5.3 SECO Definition & Management

As concluded in Chapter 2, SECO management is critical for IT management activities since the lack of analytical models and real-world case studies brings difficulties to consolidate a body of knowledge on ecosystems. Moreover, SECO management comprises two forces, as identified in our framework in Section 2.3, i.e., governance in a top-down way and socialization in a bottom-up way. The results obtained in two surveys conducted to investigate these forces in IT management activities reported the six most critical elements to be considered in our approach. Here, we present the first two modules of *SECO2M*, i.e., definition and management.

### *5.3.1. Model*

As introduced in Section 5.2.2, *SECO2M* aims to support the SECO definition & management based on enriching a platform with *mechanisms* to collect and maintain technical, business and community information. In Figure 5.5, SECO elements are modeled based on the key concepts and relations extracted from step 3 of the *ReuseECOS '3+1'* framework's business dimension (Section 2.3.2), the framework proposed by DHUNGANA et al. (2010) (Section 2.4) and the SECO elements discussed in Chapters 3 and 4. The *acquirer* represents a software consuming organization with software asset base. Such platform has the same structure of a traditional component repository used to catalog acquired *licenses* of a version (*application release*) of an *application*. A license consists of the acquisition agreement, as explained in Section 3.4. In addition, applications' releases can be grouped into software packages or kits (*software configuration*) to be associated with actors' *roles*.

A *user* is an employee who is benefited from the applications' functionalities if he/she were given any license of such applications. Users work in an *organizational unit* from which *community information* is provided, i.e., *demands*. Demands help the organization to satisfy *business objectives* and affect some application releases, for example, when existing applications need to be integrated with new ones (integration issues). As such, an acquisition agreement is firmed with a *supplier* in such a way that users are allowed to use application release' licenses. These elements are analyzed in the context of the *business information*. As regards the *technical information*, an application is supported by a *technology* or, in other words, a given application release depends on a *technology release* to run, so as to compose the SECO platform architecture. Finally, a technology release has a kind of evaluation degree based on experts' opinions and market's trends, i.e., the *maturity analysis*. This information is critical to the platform architecture since applications running over legacy or obsolete technologies can compromise organization's businesses (production) and then threat the SECO platform sustainability over time (ALBERT et al., 2013).

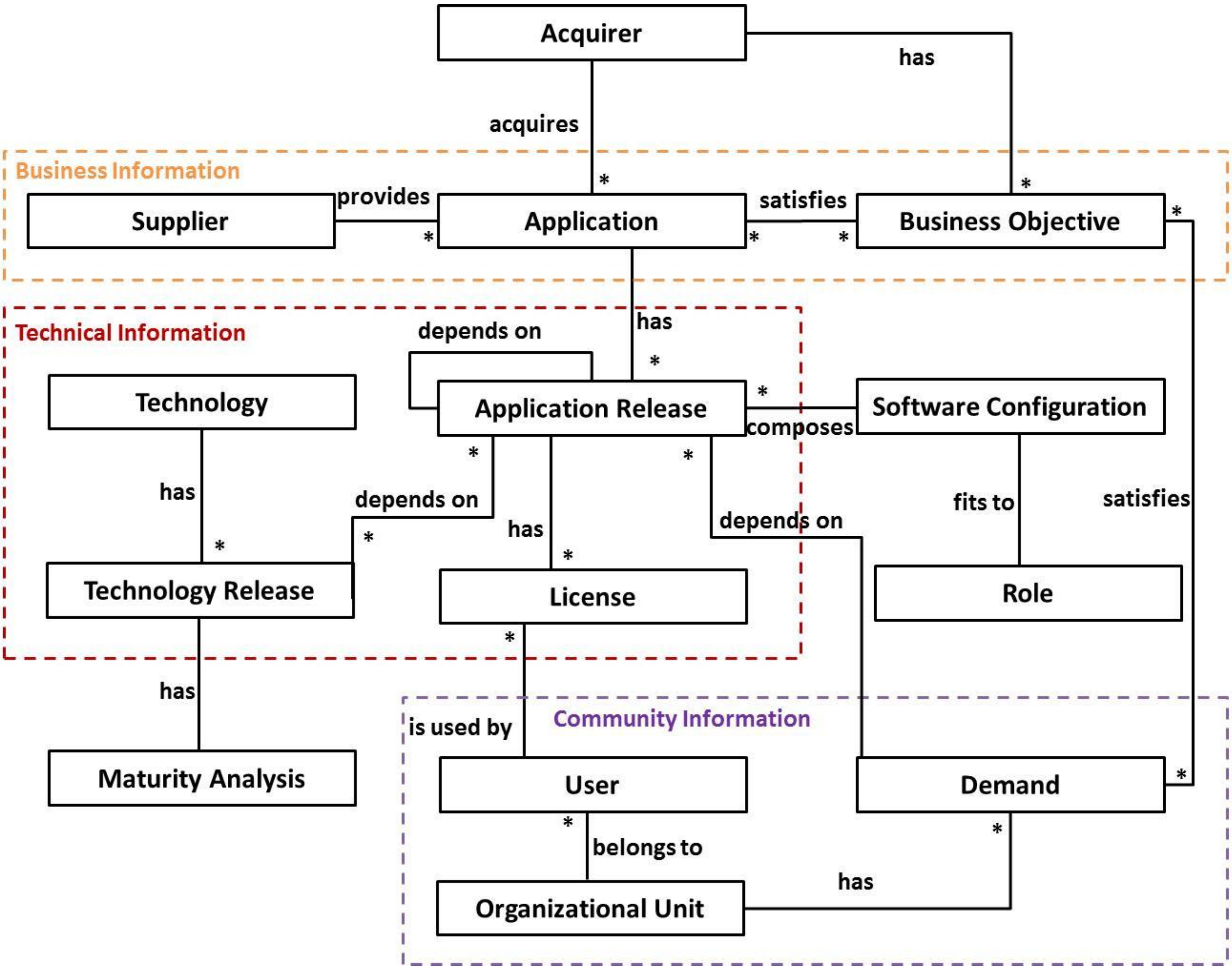



Figure 5.5. *SECO2M* elements

In order to analyze the *SECO2M* elements, some mechanisms were proposed, as shown in Figure 5.6. The goal is to extract information both from the SECO internal and external views. In other words, an acquirer should store and organize data related to the SECO elements that will be manipulated to produce views that support supplier management. Thus, an acquirer needs to provide data regarding components into some categories (i.e., business objectives, applications, and technologies), and demands. In parallel, data should be collected from the software market, i.e., candidate applications to be included into the SECO platform, and maturity analysis reports regarding demands, applications, and technologies.

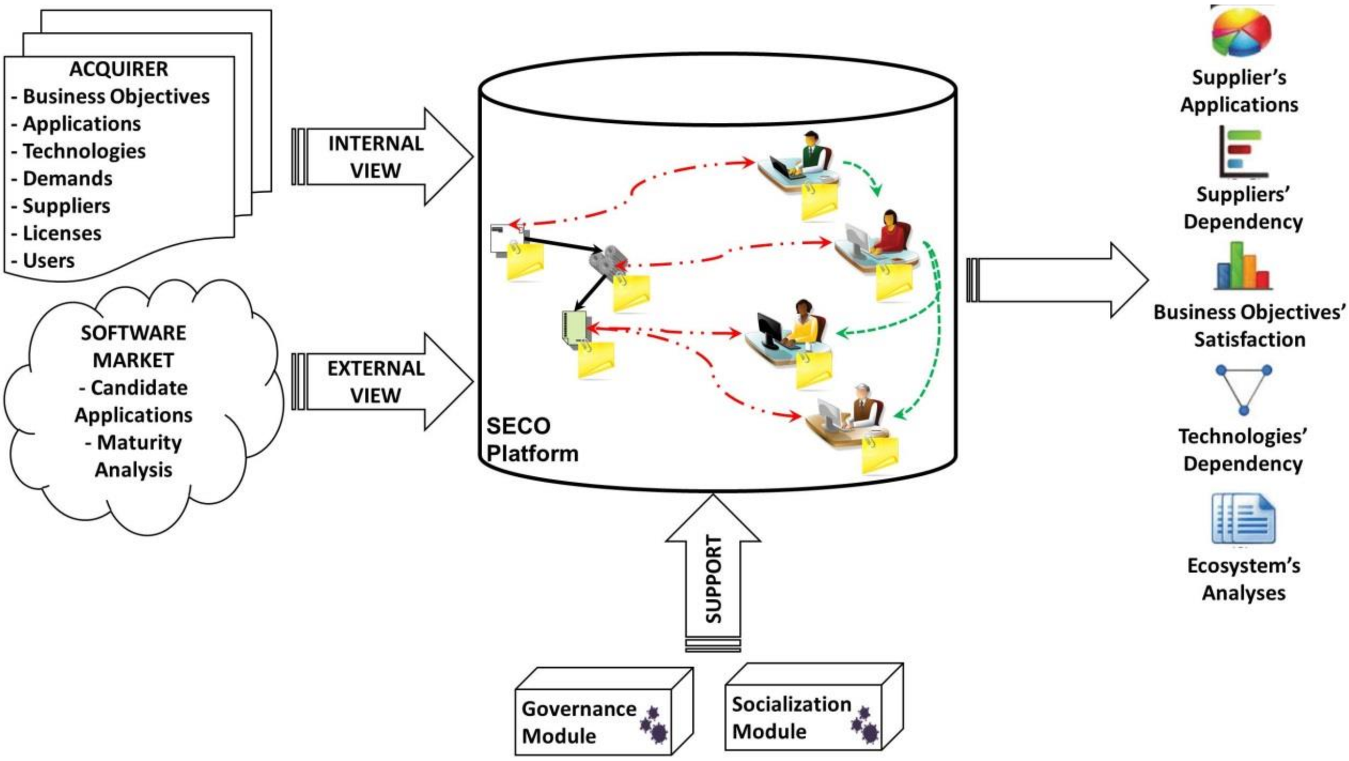



Figure 5.6. *SECO2M* mechanisms

From a SECO platform prepared for data registration search and retrieval, some SECO management information can be summarized and visualized through charts or documents: (a) *supplier's applications*: distribution of releases per supplier; (b) *supplier's dependency*: number of supplier's licenses over total number of licenses; (c) *business objectives' satisfaction*: number of licenses that satisfies a given objective over the total number of licenses; (d) *technologies' dependency*: number of technology's licenses over the total number of licenses; and (e) *ecosystem's analyses*: demands', applications' or technologies' maturity analysis reports that justify IT management decisions, e.g., technology reevaluation, or demand selection and prioritization. Finally, Table 5.2 summarizes the information extracted from the SECO platform, detailed in (SANTOS et al., 2011d; 2012a; ALBERT et al., 2013; RIOS, 2013; ABREU et al., 2014; LIMA et al., 2014; BARBOSA et al., 2015). The governance and socialization modules that support the SECO management are detailed in the following sections.

Table 5.2. Information extracted from the SECO platform in *SECO2M*.

| DATA | INFORMATION |
|---|---|
| *Objective Synergy* | Set of demands/applications that are satisfying a business objective. |
| *Application Dependency* | Set of technologies that are supporting an application. |
| *Supplier Concentration* | Distribution of licenses acquired from a given supplier. |
| *Technology Category* | Distribution of technologies within a category. |
| *User Satisfaction* | Set of applications that are benefiting a user in a given moment. |
| *Production Rate* | Distribution of applications that drive results in a given moment. |
| *Candidate Application* | License, cost and supplier of an application that fits to a demand. |
| *Maturity Analysis* | Applications or technologies recommended by market analysis. |

### *5.3.2. SECOGov Module*

In order to incorporate governance critical elements to a SECO platform and support an acquirer to choose, adopt and maintain applications/technologies over time, a Master thesis was developed in the context of this PhD research (ALBERT, 2014). An approach named *SECOGov* (**SECO Gov**ernance) was proposed. The approach helps an acquirer to understand the market in which it operates and map its relationships, manage licenses, and visualize the evolution of IT architecture. It is essential to record how applications and technologies, labeled *software assets*, are added, deleted, or maintained. Considering the lack of research that combines market data with data obtained from the acquirer's asset base, *SECOGov* was built upon SECO governance and software asset management mechanisms to support IT architect's activities.

*SECOGov* treats SECO requirement R1 (*Manage roles and responsibilities for SECO governance*) and R2 (*Manage component lifecycle for SECO governance*). As such, the approach combines mechanisms for managing software assets, known as components (*intra-organizational view*), and for tracking the evolution of markets, suppliers, technologies and applications (*inter-organizational view*). The intra-organizational view consists of the first four mechanisms, and the last three refer to the inter-organizational view:

1. *Manage Software Taxonomy*: the organization must be able to organize and maintain the most appropriate software categories to catalog their software assets. For example, Operating System, Programming Language, Database, Server, and Business Applications;
2. *Manage Software Architecture*: this mechanism allows an acquirer to define which software assets are standardized for each category. Therefore, it is possible to quickly find what asset is standard for a given

technology, or whether the organization already has assets for a specific technology; e.g., Microsoft Office 2013 for Windows 8 (software asset) is the standard for Office Application Package (category);

3. *Manage Software Configuration*: this mechanism allows an acquirer to define which assets compose a configuration that meets a profile or role within the organization. For example, the *administrative* configuration contains Windows 8, MS Office 2013, Adobe Reader XI, and Skype;
4. *Manage Software Licenses*: This mechanism consists of two sub-activities: manage the quantity and the variety of license types; and assign/release licenses to/from users. Thus, the following questions are answered more efficiently and effectively: (i) what assets are used by a specific user or unit in daily activities? (ii) what is the number of licenses available for units or that are in use? and (iii) how many (and what kind of) results are being produced from the use of a particular asset in order to track the return on investment of acquisition?;
5. *Monitor SECOs*: this mechanism allows an acquirer to monitor the information on the ecosystems that an organization participates (or want to attend). This information is provided in reports of IT advisory companies. For example, benefit rate, maturity, time for adoption, and recommendation for adoption of a certain application or technology;
6. *Analyze Technologies Maturity*: this mechanism allows an acquirer to analyze the SECO platform architecture when comparing information regarding the maturity of different technologies or markets;
7. *Select Product or Technology*: this mechanism allows an acquirer to specify requirements of software application/technology to be acquired. It also suggests the execution of tests based on questionnaires, reports and proofs of concept to evaluate such requirements as well as the definition of purchasing or hiring services.

Figure 5.7 provides an overview of *SECOGov* roles, mechanism and outputs. The approach involves the following roles (*R1*): (a) *IT Architect*: responsible for ensuring that the SECO platform contains the necessary information for the IT management team's decisions; (b) *Collaborator*: requests software installation or uninstallation; (c) *IT Infrastructure Analyst*: answers software requests, and manages the types of licenses and default software configuration settings; (d) *IT Manager*: requires maturity analysis of software and make acquisition decisions over time; and (e) *Supplier*: manufacturer/ distributor of software acquired by the organization.

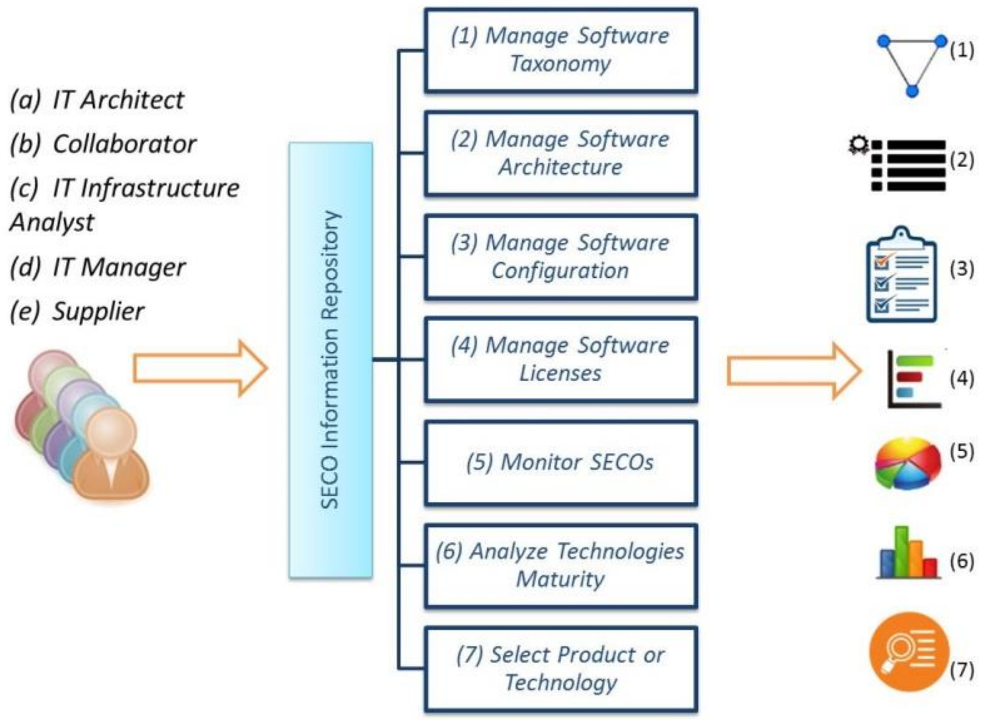



Figure 5.7. Overview of *SECOGov*

*SECOGov* requires a repository with storage, search, retrieval, documentation, publishing, and classification functions to explore and maintain the SECO platform data. The approach's mechanisms were implemented as a *Brechó Library* extension. *Brechó* is a web information system to support reuse management (WERNER et al., 2009). The concept of 'component' is flexible, allowing its use in different contexts. Thus, a software asset is represented as a component in *Brechó*. It is used to control the component lifecycle (*R2*), where the IT Architect role has an administrator profile in *Brechó* (*supervisor*). Figure 5.8 shows the simplified diagram of the *Brechó* extension. The original library entities are arranged on the right side and new entities are on the left side:

- *Category*: enables to organize the acquirer's software assets (e.g., Office Bundled Application Software, Database Management System etc.);
- *Component*: is the entity conceptually stored in the library; in the *SECOGov* context, software assets (e.g., Microsoft Office);

- *Distribution*: represents a set of asset's features that meet specific users' groups (e.g., Microsoft Office for Windows, Microsoft Office for iOS);
- *Release*: represents the set of the artifacts' versions of a software asset at a given time (*R4*) (e.g., Microsoft Office 2013 for Windows);
- *Package*: allows grouping software assets' artifacts according to a target audience (*R3*) (e.g., Microsoft Office 2013 installation files for iOS);
- *Service*: enables an asset's release to be offered as web services (e.g., image collection online service for Microsoft Office 2013 for Windows);
- *License*: allows the definition of packages' and services' rights and obligations (e.g., individual license, floating license etc.);
- *Analysis*: enables to register SECO information that justifies the existence of categories and/or the adoption of assets (e.g., document "Analysis of Office Suites Evolution");
- *Configuration*: allows an acquirer to group software assets to provide users with software tools (e.g., "Configuration for Project Manager", which includes Microsoft Project, Office, Subversion);
- *SECOGov Component*: dynamic form that concentrates SECO relevant information to be filled for each software asset.

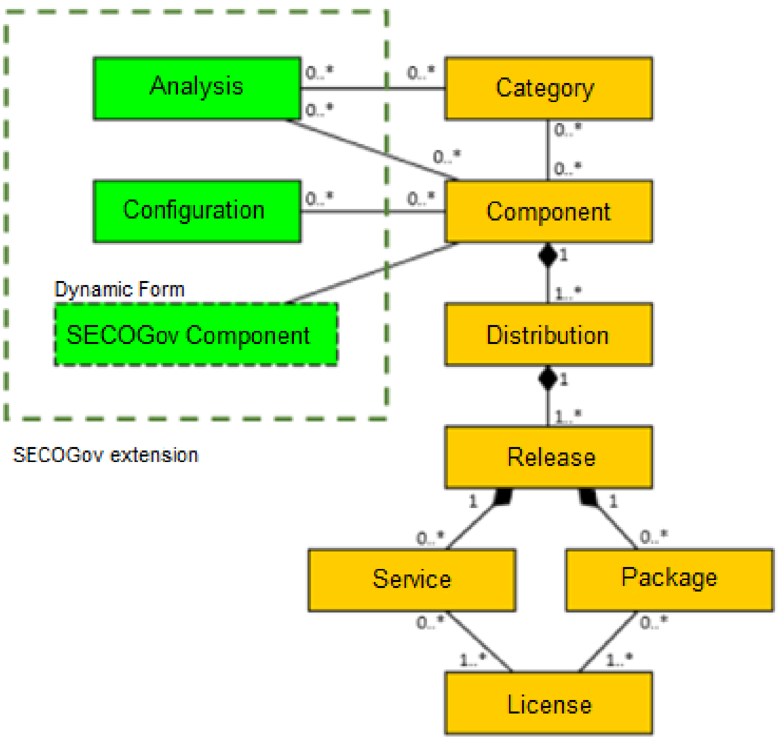



Figure 5.8. *SECOGov* elements in *Brechó* Library

Figure 5.9 shows the list of applications and technologies previously registered in *Brechó*. As we can observe, several assets' data are collected, e.g., name, status (accepted, under evaluation or rejected), vendor (supplier), nature (acquired or developed), category, distributions, and consumers (users). On the right side, we can see a menu with governance mechanisms such as components' control (status), categories' administration (taxonomy), licenses types, software configurations, SECO analyses, SECO graphs (e.g., level of supplier and technology dependency), and application and technology evaluation.

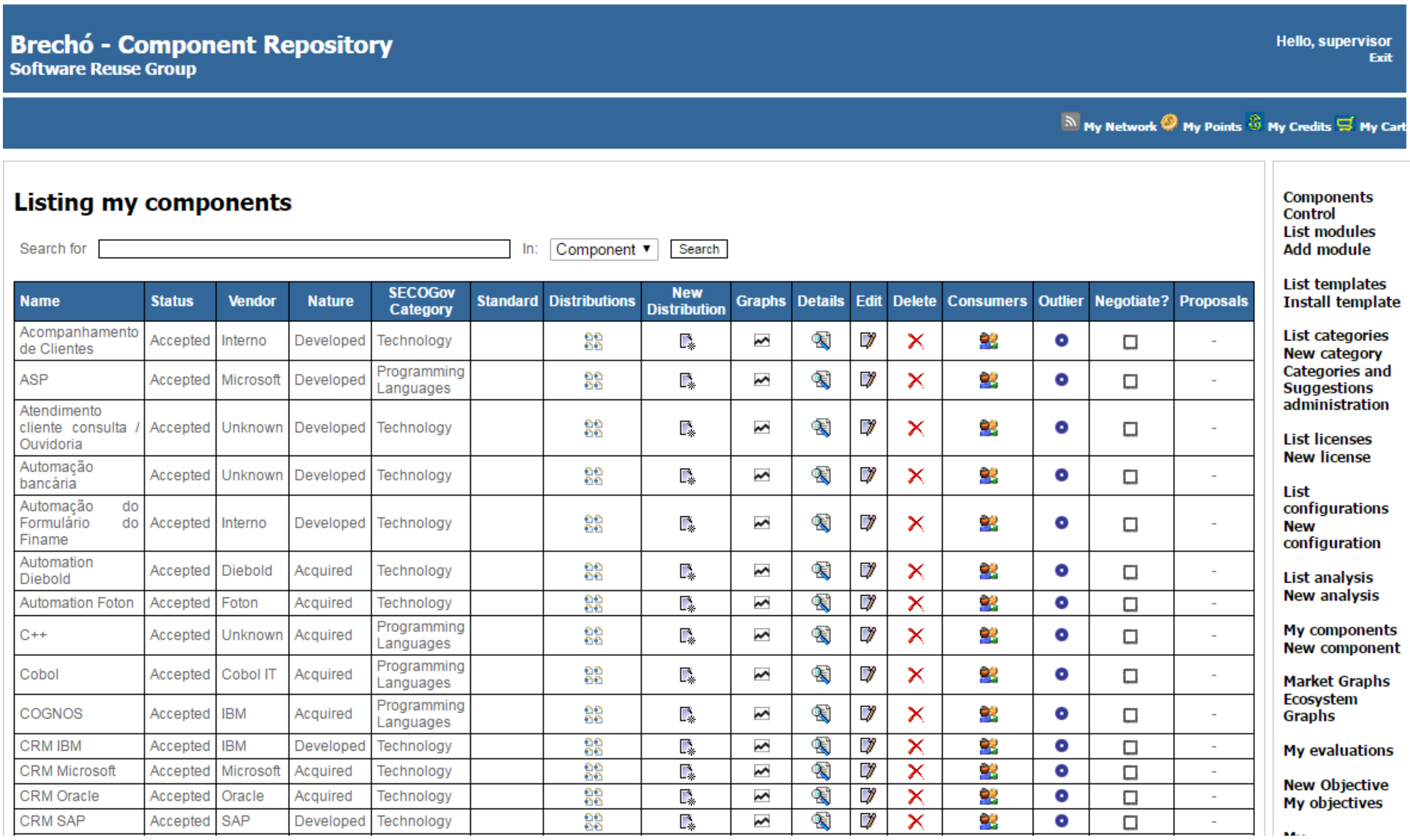



Figure 5.9. Applications and technologies of a given acquirer stored in *Brechó* Library with *SECOGov* module

An evaluation of *SECOGov* mechanisms and infrastructure was performed with 16 software engineers working in IT architecture sector of a large organization in the energy segment in order to assess its ease of use and utility. The amount of hits, the effectiveness and efficiency of the participants to perform the proposed IT architecture activities were higher with the tool arrangement in the selected and applied context. However, time and perceived accuracy of the answers provided for such those activities were not significantly different when compared to those who did not use *SECOGov*. At the end, they observed indications that the approach is applicable to support IT architecture activities, especially monitoring and evolution of application/technology adoption. Details on such mechanisms, infrastructure and evaluation are available in (ALBERT et al., 2013; ALBERT, 2014).

#### *5.3.3. SocialSECO Module*

In order to incorporate socialization critical elements to a SECO platform and support an acquirer to satisfy objectives, stimulate collaboration, and identify demands, over time, a Bachelor monograph was developed in the context of this PhD research (LIMA, 2015). An approach named *SocialSECO* (**Social**ization in **SECO**) was proposed. The approach helps an acquirer to understand the community surrounding the SECO platform and map its relationships, manage demands and visualize the evolution of social interaction. It is essential to record how demands, also labeled as *software assets*, are added, deleted, and maintained. Considering the lack of research that combines socio-technical network with data obtained from the acquirer's asset base, *SocialSECO* was built upon SECO socialization and network analysis mechanisms to support IT management activities.

We identified some socio-technical resources as solutions for the problem of providing acquirer's asset information and a channel for acquirer's stakeholders to communicate with, as shown in Figure 5.10: *actor/artifact profile*, *artifact/team forum*, *demand registering*, *evaluation system*, *team creation*, *trend topics (tag clouds)*, and *recommendations (news feeds)*. These resources can help IT managers to be aware of SECO trends, and discussions would be of great value for the identification of new demands over time. Thus, *SocialSECO* treats SECO requirements R3 (*Manage file storage for SECO socialization*), R4 (*Manage artifact versioning for SECO socialization*), R5 (*Manage artifact forum for SECO socialization*), and R6 (*Manage demand registering for SECO socialization*).

The resource *forum* in the SECO context is organized in three sections (*R5*). The first section is used for general discussion, organized by "topics". These topics are theme-free, i.e., users that belong to organizational units can talk about an application features, ask for help, report a bug etc. This section allows a potential user to communicate with others before suggesting new demands, for example. Moreover, one can infer how active an organizational unit is and how many errors have been reported so far. Thus, a forum consists of an important source of information for collaboration and information sharing. The second section intends to gather “suggestions” from an organizational unit. Anyone who is a member of a forum can contribute with suggestions for new demands, and an IT manager is responsible for managing these suggestions. Finally, the third section allows a unit’ representative to officially *register demands* (*R6*). He/she registers these demands, or he/she can select a suggestion from the second section and make it into a demand.

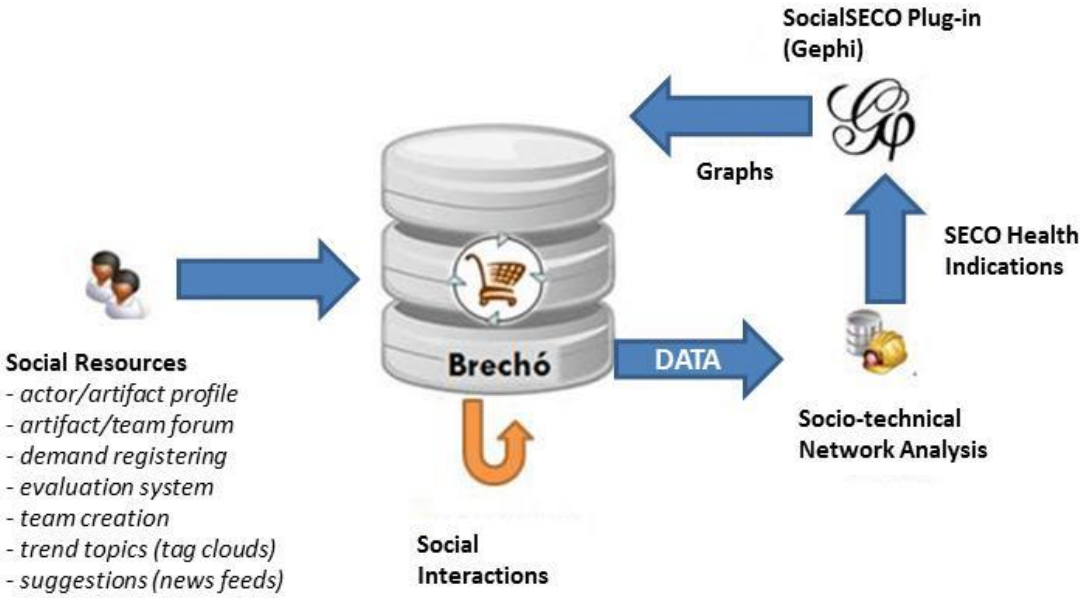



Figure 5.10. Overview of *SocialSECO*

Users can ‘follow’ a demand, triggering recommendations (news feed updates). Therefore, this resource works as a strategy for demand registering since it involves the SECO community, existing discussions, and suggested application’s features. In addition, every message in a topic, as well as suggestions, is subjected to an *evaluation system*. An actor can vote for positive (+1) or negative (-1), regarding his/her opinion for each message. An actor can collect points for registering a suggestion that has received many positive votes. These points are used to leverage the organizational unit collaborative level, as well as to reward users. Considering the evaluation system, IT managers can better understand the relevance of suggestions registered by organizational units, as well as all the demands emerging from the community. This extra information allows an IT management team to make better decisions on the demands’ selection and prioritization. With the first three social resources, potential users already have much more information about the applications before adopting it (*R3*), not only relying on the supplier's word, but on the SECO's 'word of mouth'.

Besides, actors can create *teams* and add other actors. Different types of team can be created, e.g., 'iOS users', 'Financial Sector', 'CRM extensions' etc. Teams are defined as a type of user, which means that they keep a user profile. They can request demands, publish messages in forums, and evaluate applications on behalf of the team. Every team has administrators and members, and have a forum associated with it. Users and teams can check the proportion of actions they have performed within the SECO, being a producer, a consumer, or a simple user profile. This proportion is calculated according to the actions, such as publishing, downloading, or evaluating. In turn, *tag clouds* improve the way new trends and popular information are visualized in the SECO platform. It is a direct summarization of what is being discussed and evaluated by the community. The tag cloud consists of a data mining function that uses as input forums' discussions, recommendations and demands, as well as teams' information.

SECO platform can give an actor some *recommendations* (new feed). It is based on the forums he/she participates, as well as the profiles and demands he/she follows. Recommendations refer to teams, forums and/or applications of interest, also including information about the teams that an actor participates and new releases of applications (*R4*). They aim to bring new information to an actor (motivating him/her to keep updated), and search for further information. In addition, to face the social barriers, SECO leverages the importance of groups of actors pursuing a common goal. From the team resource, actors can send requests for take part in an existing demand.

All the resources and functions related to *SocialSECO* were also implemented as a *Brechó* extension, as shown in the "My Network" panel in Figure 5.11. An evaluation of *SocialSECO*'s mechanisms and infrastructure was performed through a comparative analysis of how social resources were implemented in *Brechó* and also in a real SECO platform – the Brazilian Public Software (BPS) Portal. We observed that BPS Portal offers some resources not proposed in our implementation, e.g., wiki and integration to a project management environment. Details on such mechanisms, infrastructure and evaluation are available in (LIMA et al., 2014; LIMA, 2015).

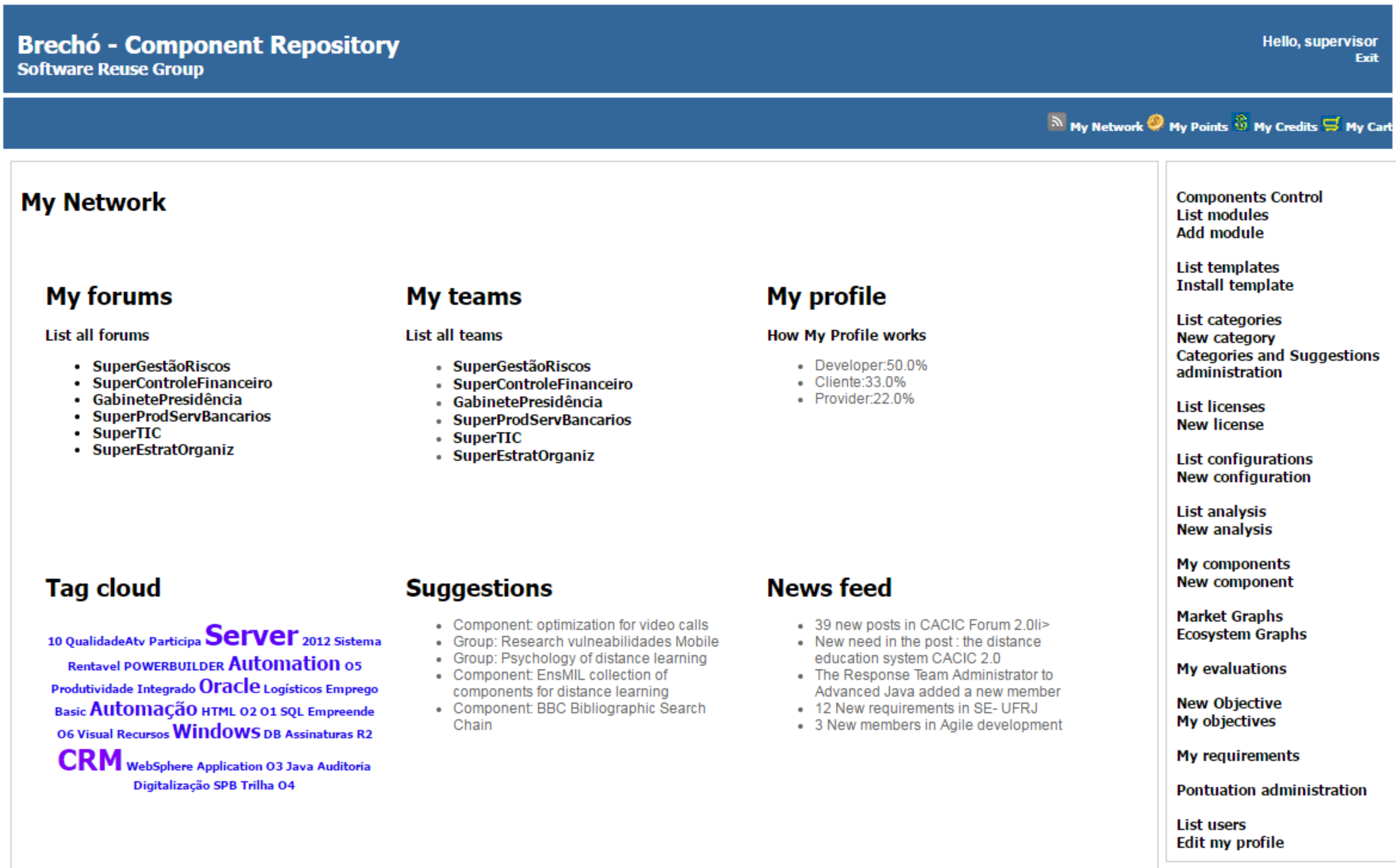



Figure 5.11. Socio-technical network of a given acquirer stored in *Brechó* Library with *SocialSECO* module

## 5.4 SECO Monitoring & Analysis

As concluded in Chapter 2, SECO monitoring is also critical for IT management activities since the lack of analytical models and real-world case studies brings difficulties to consolidate a body of knowledge on ecosystems. Similar to SECO management, we observed that SECO monitoring also comprises two forces, as presented in Chapter 4, i.e., *dependency* and *synergy*, corresponding to governance and socialization, respectively. The results obtained in two observational studies conducted to investigate these forces in IT management activities reported the four most critical elements to be considered in our approach. In this section, we present the second two modules of *SECO2M*, i.e., monitoring and analysis.

### *5.4.1. Model*

As introduced in Section 5.2.2, *SECO2M* aims to support SECO monitoring & analysis based on the enrichment of a platform with *mechanisms* to analyze relationships among actors and artifacts to visualize information related to technology/supplier dependency and business objective synergy (SECO health indicators). Such information meets the current IT management challenges discussed in Section 5.2.1. In addition, they were identified as critical indications for the SECO platform in practice, as concluded in Section 4.5. Based on our findings, we decided to explore those contrary forces to analyze the sustainability of the SECO platform in which dependency and synergy levels derive some scenarios (SANTOS et al., 2016ab). In *SECO2M*, *technology/supplier dependency level* is the number of licenses related to a given technology/supplier acquired by the organization over the total number of technologies' licenses. In turn, *business objective synergy level* is the number of licenses of all software applications (and demands) that satisfy a given objective over the total number of applications' licenses. Despite their simplicity, when analyzed together, such metrics help IT managers and architects to start realizing the impact of the SECO perspective on acquisition preparation, i.e., the 'hidden effects' of decisions.

An analogy can be used to explain dependency and synergy in the SECO context: *coupling* and *cohesion* (YOURDON & CONSTANTINE, 1979). In SE area, coupling refers to the degree of interdependence between modules, i.e., a measure of the strength of interconnection. In turn, cohesion is the degree to which the elements of a module belong together, i.e., a measure of the strength of relationship between pieces within a module. In software development, the goal is to reach low coupling and high cohesion, although there is no scenario where coupling degree is zero and cohesion degree is 100%. In *SECO2M*, we also follow this rule:

1. most applications/demands within a SECO platform commonly have tight dependencies with a small set of suppliers/technologies compared to the whole set. However, an acquirer tries to seek "low coupling", i.e., similar (and low) *technology/supplier dependency level* for all suppliers/ technologies;
2. most applications/demands often closely satisfy a small set of business objectives compared to the whole set. However, an acquirer tries to seek "high cohesion", i.e., similar (and high) *business objective synergy level* for all business objectives.

In a high level perspective, SECO health indicators are monitored and analyzed in *SECO2M* with focus on IT management activities, more specifically demand and solution analysis. In this case, a candidate application should satisfy a given demand. The acquirer's SECO platform is taken as an input, i.e., a set of software applications, as well as supporting technologies and related business objectives. Such components are organized into categories and have relationships with each other, defining the current version of SECO platform. This platform configuration is named '*AS-IS*', as explained in Section 3.2. However, several demands and solutions are frequently and concurrently selected and prioritized, than the organizations need a support for IT management decisions regarding acquisition preparation. '*WHAT-IF*' analyses over the combinations of demands and solutions are performed by IT management teams. Different from traditional criteria like requirement specifications and available budget (short-term goals), *SECO2M* introduces dependency and synergy as instruments to help practitioners to understand IT management teams' effects over time (long-term goals).

After performing some analyses of demand and candidate solutions, the IT management team observes the impacts on the technology/supplier dependency levels and also on the business objective synergy levels. As such, different SECO platform configurations can be analyzed in order to decide which of them better fit the acquirer's goals ('*TO-BE*'). Figure 5.12 summarizes the main elements of *SECO2M* monitoring & analysis. The motivation for considering '*WHAT-IF*' analysis is the fact that practitioners can think of possible scenarios, using their expertise and market reports (traditional IT management), and also technical, business and community information (IT management in the SECO context). In other words, a huge number of organizational network elements (nodes) and relationships (edges) should not be neglected; otherwise an acquirer may face serious obstacles in the global industry (JANSEN et al., 2009c). However, it is important to mention that *SECO2M* is intended to provide practitioners with a model and an infrastructure to analyze alternatives – the final decision depends on IT management team.

In a low level perspective, *SECO2M* monitoring & analysis modules collect data from the definition & management modules in order to calculate the abovementioned SECO health indicators. The five SECO platform components of an acquirer are: business objective (*OBJ*), application (*APP*), technology/supplier (*TEC*), demand (*DEM*) and candidate application (*CAN_APP*). Two measures are considered for these components: (1) **component property**: *number of licenses* for each application (SANTOS et al., 2016a); and (2) **component relationship**: *dependencies* of each application, demand or candidate application over other applications, technologies and business objectives (WERNER & SANTOS, 2015). In this case, a demand depends on the business objectives it satisfies, and on the applications it need to be integrated (e.g., to access services); and the candidate application depends on technologies. Since a candidate application (*concrete component*) satisfies a demand (*abstract component*), there is a dependency, but this relationship only exists to register the origin of an acquired application. Other useful data are stored: (1) unit cost *C* for each application's, technology's, demand's and candidate application's licenses, due to budget constraints, and (2) impact factor *W* for each business objective, according to the acquirer's business strategy, e.g., the number of benefited stakeholders (SILVA et al., 2014).

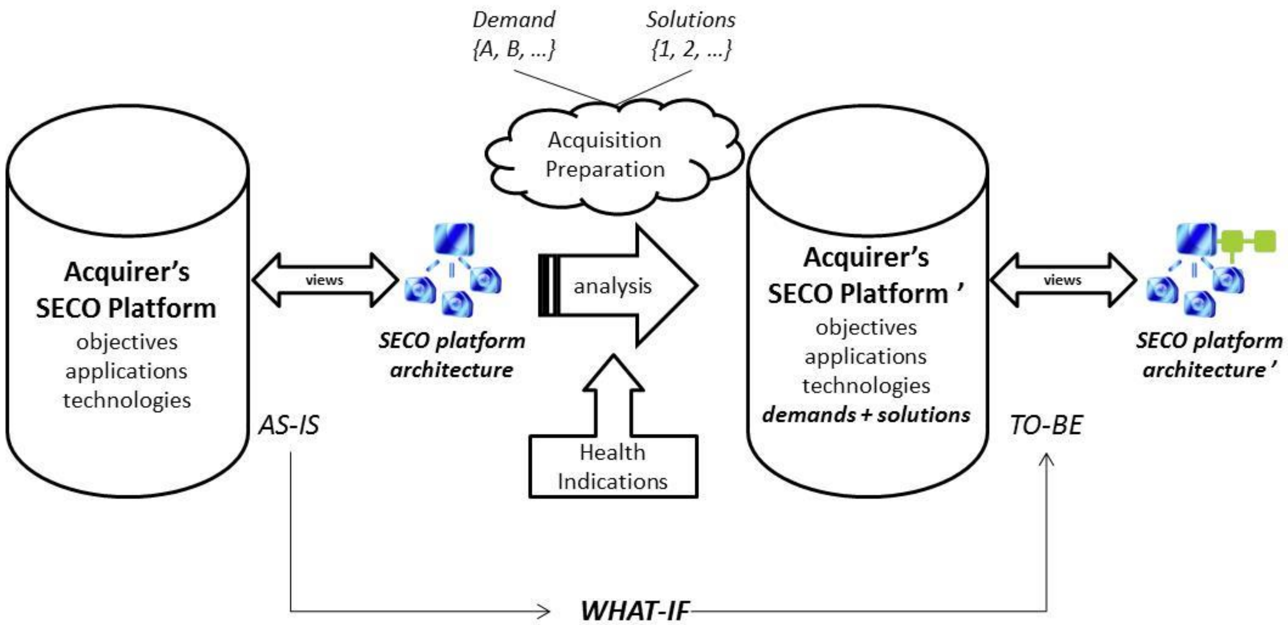



Figure 5.12. Overview of *SECO2M* monitoring

In *SECO2M*, those components and relationships are respectively represented as nodes and edges like in a graph, as shown in Figure 5.13. *SECO2M* considers three platform configurations: *AS-IS*, *WHAT-IF* and *TO-BE*. Additionally, *demand analysis* and *solution analysis* are the IT management activities that help an acquirer to move from one configuration to another, aiming to support acquisition preparation, since this activity was identified as critical for the SECO platform sustainability (Section 3.3). Firstly, the SECO platform configuration is composed of *OBJs*, *APPs* and *TECs* as well as their relationships (*AS-IS*). Then, the IT management team can analyze how the SECO platform would be after selecting some demands for investment (*WHAT-IF*). At this moment, new relationships are abstractly established with *OBJs* and *APPs*, changing the platform configuration. Based on the demands previously analyzed and selected, the IT management team can visualize how the SECO platform would be after selecting some candidate applications (*TO-BE*). Once more, new relationships are abstractly established with *TECs*, changing the platform configuration.

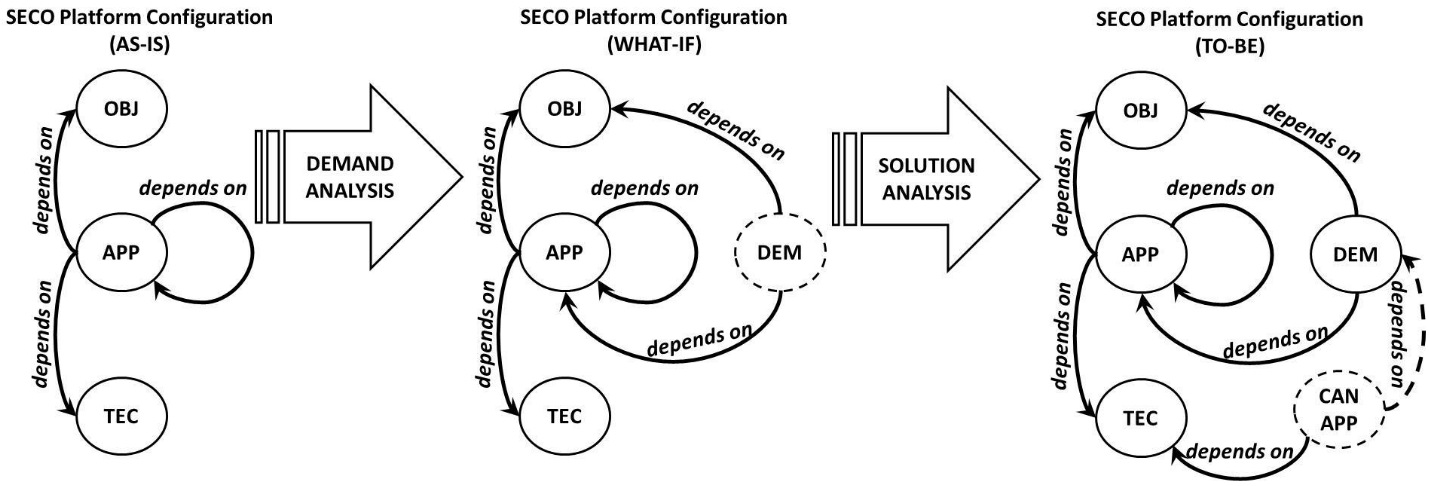



Figure 5.13. SECO platform components in *SECO2M*

Such evolving network is explored in *SECO2M* as the basis for calculating SECO health indicators from technology/supplier dependency (*TECDEP*) and business objective synergy (*OBJSYN*). We used a graph-based strategy to obtain each component importance based on the measures previously mentioned: *number of licenses* and *dependencies*. To do so, we investigated Graph Theory in order to select an algorithm that fitted to our problem, i.e., analyze demands and solutions considering existing objectives, applications, and technologies. Since the most important *TECs* and *OBJs* are those that have more applications that depend direct and indirectly on them, and also whose applications have a higher number of licenses, we represented our graphs as shown in Figure 5.14. In these graphs, *APPs*' numbers of licenses (*LIC*) are used to weigh their relationships with *OBJs* and *TECs*.

After investigating some graph algorithms for relationship analysis, we selected *PageRank*, or PR (PAGE et al., 1999). PR is an algorithm developed by Google that addresses the link-based object ranking problem, assigning numerical ranks to pages based on backlink counts and also on ranks of pages that provided such backlinks. PR considers a model in which a user starts at a website and randomly follows links from the page he/she is currently in (a new webpage may be opened occasionally in another ‘walk’). Therefore, *PR(x)* is the probability of a webpage *x* being visited on a particular random walk. Considering a simplified version, let *R(u)* be the rank of a page *u* and $B_u$ the set of pages pointing *u* directly. For each page *v* in $B_u$, calculate *R(v)*. Since the link of a page that points to few pages is more relevant than the link of another page that points to several, $N_v$ is used as the number of out links from *v* and *R(u)* is defined as:

$$R(u) = \sum_{v \in B_u} \frac{R(v)}{N_v}$$

In *SECO2M*, we adapted the simplified version of PR algorithm to fit our problem: (1) each SECO platform component corresponds to a page (graph’s node); (2) each component’ relationship corresponds to a link (graph’s edge), which is weighted by the number of licenses of the dependent component (weights of pages that provided backlinks); (3) a given technology rank or objective rank can be weighted by the number of licenses (if applicable) or the impact factor (i.e., weigh of each objective), respectively; set as *1* (one), otherwise; and (4) random walk and convergence was not relevant for the scope of our problem since it is deterministic.

From these statements, *TECDEP* and *OBJSYN* are defined as follows:

$$OBJSYN(OBJ_j) \;=\; R\,(OBJ_j) \;*\; W\,(OBJ_j)$$

$$TECDEP\,(TEC_i) \;=\; R\,(TEC_i) \;*\; LIC\,(TEC_i)$$

As previously discussed, for sustainability reasons, all *TECDEPs* should have close values to maintain low levels of dependency. In other words, a sustainable SECO platform should avoid the Pareto Principle (or 80-20 rule), i.e., that 20% of technologies support 80% of acquirer’s applications. The same applies to *OBJSYNs*, except that it also should consider the maintenance of high levels of synergy, i.e., that almost 100% of acquirer’s applications aid each business objective to some extent. In a lower level, *SECO2M* states that both SECO platform health indicators can be calculated as the dispersion of the *TECDEPs* dataset and of the *OBJSYNs* dataset. As such, two health indicator parameters were derived: *technology/supplier concentration* (*TECCON*) and *business objective concentration* (*OBJCON*). The measure of dispersion, the *coefficient of variation* (*CV*), was adopted to compute *TECDEP* and *OBJSYN* datasets on a ratio scale and with non-negative values. *CV* is defined as the ration of the standard deviation (σ) to the mean (μ). *CV* shows the extent of variability in relation to the mean of the population in *SECO2M* for each dataset.

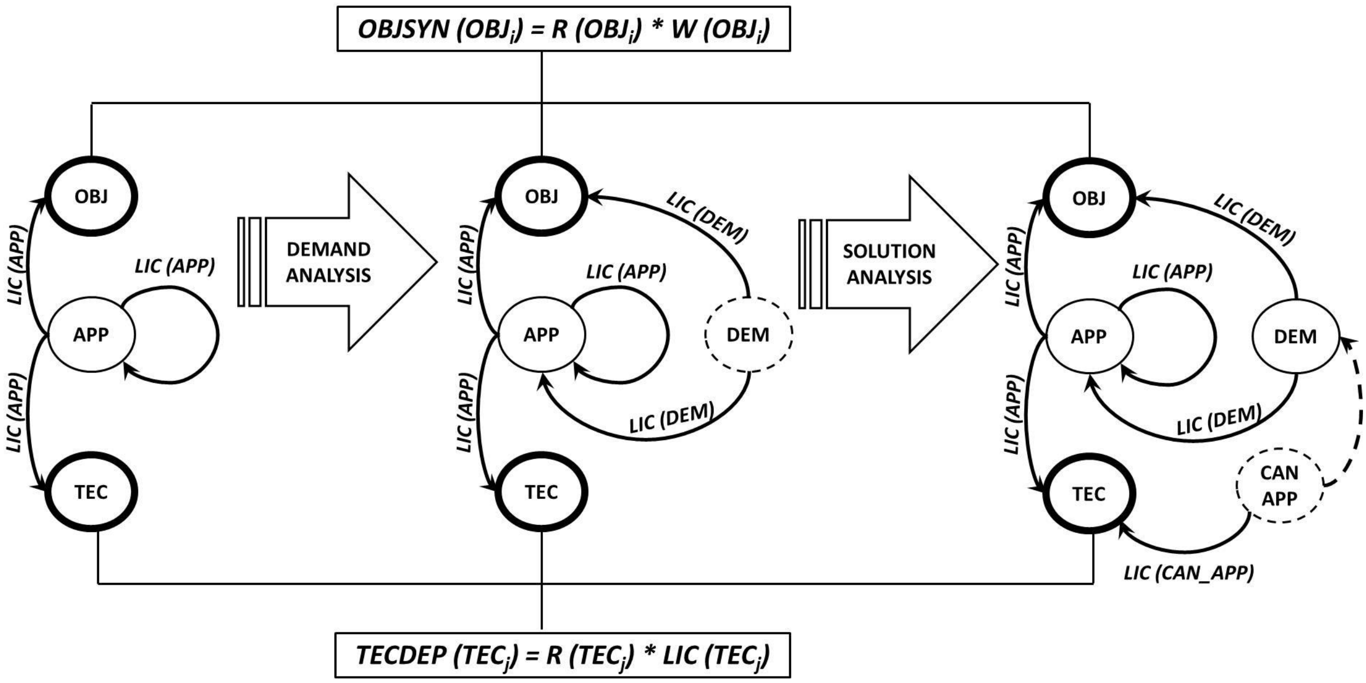



Figure 5.14. Calculation of health indicators in *SECO2M*

From these statements, *TECCON* and *OBJCON* are defined as:

$$OBJCON = CV\ (OBJSYN)$$

$$TECCON = CV\ (TECDEP)$$

*TECCON* and *OBJCON* are expressed as percentages and should be interpreted as follows: the *lesser* the value of those measures (less variation), the *greater* the sustainability of the SECO platform is. Considering an interval 0-100%, such measures allowed us to reason about different sustainability scenarios, inspired by the findings of our previous studies in SECO field (Chapters 2-4). They suggested two perspectives in which IT management teams usually perform acquisition preparation, i.e., the *sense of dependency* and the *sense of synergy*. The former perspective focuses on the ecosystem external view, i.e., how the organization realizes its dependencies on technologies and suppliers. The latter in turn focuses on the ecosystem internal view, i.e., how the organization realizes its business objectives satisfaction and alignment. As such, *SECO2M* gives rise to four scenarios that reflect the SECO platform sustainability based on demand and solution analysis, as drawn in Figure 5.15.

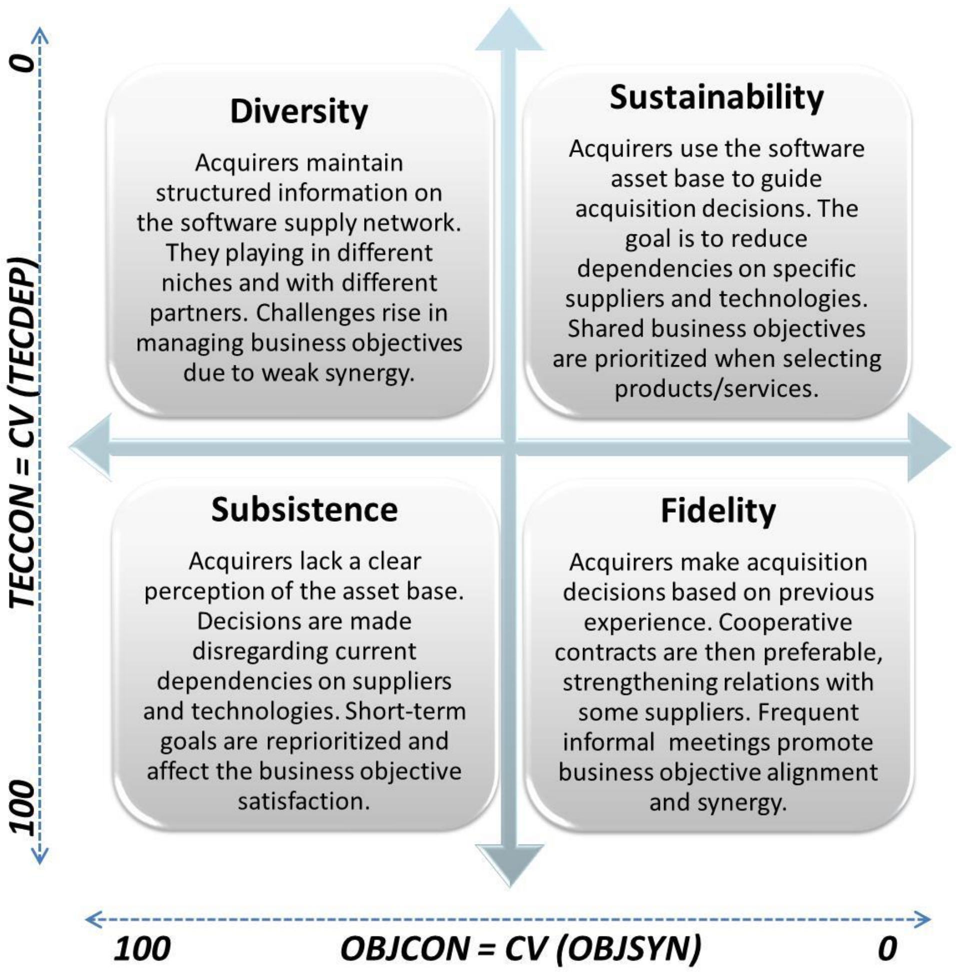



Figure 5.15. Sustainability Chart to support demand and solution analysis in *SECO2M*

**Scenario #1: Subsistence**

This scenario reflects an acquirer with low sense of dependency and synergy (*TECCON* > 50% and *OBJCON* > 50%). The main goal is to drive results (i.e., production and profits) to survive in the current market. Such organizations have an unclear perception of their SECO internal view, so they usually depend on certain suppliers/technologies (high dependency). Consequently, acquisition decisions are made disregarding a clear notion of their dependencies, focusing on short-term goals. They commonly have difficulties in maximizing business objectives satisfaction and alignment since reprioritizations are commonly experienced (low synergy).

**Scenario #2: Fidelity**

This scenario reflects an acquirer with low sense of technology (*TECCON* > 50%) and high sense of synergy (*OBJCON* < 50%). The main goal is to look at organizational unit's needs to establish supply partnerships. Similarly to what happens in the subsistence, these organizations also lack a clear perception of the SECO internal view, but they make acquisition decisions based on previous experiences with suppliers (high dependency). In this case, organization units' evaluation and users' ratings represent important feedback. In addition, they focus on short-term goals although demands often emerge from the community. Demands are selected based on IT management team meetings focused on analyzing how demands affect business objectives (high synergy).

**Scenario #3: Diversity**

This scenario reflects an acquirer with high sense of dependency (*TECCON* < 50%) and low sense of synergy (*OBJCON* > 50%). The main goal is to analyze the software supply network to expand their businesses. Differently from what happens in the subsistence, these organizations often maintain structured information of their software applications, as well as suppliers and supporting technologies. So, they try to control their dependencies in order to play safely in different niches or application domains, and with different partners (low dependency). This posture requires managing business objectives that are of high impact on the organization's businesses, sometimes requiring specific solutions as it seeks diversified domains (low synergy).

**Scenario #4: Sustainability**

This ideal scenario reflects an acquirer with high sense of dependency and synergy (*TECCON* < 50% and *OBJCON* < 50%). The main goal is to prepare acquisition decisions to sustain the SECO platform over time. Combining diversity and fidelity strengths, these organizations maintain and analyze software assets to help their IT management teams to get insights on demand and solution analysis. They try to balance dependencies on suppliers and technologies, and satisfy as much business objectives as possible with all software applications they acquired so far. In other words, IT management decisions should be driven by technical criteria (requirements specification and available budget) without losing sight of reducing undesired dependencies and increasing business synergy over time. Some barriers to lie in this scenario are the lack of techniques to treat a number of competing and interrelated objectives and constraints, and socio-economics training in SE area (BOEHM, 2006).

Finally, an IT management team can perform demand and solution analysis to get insights on how decisions can affect the SECO platform sustainability. Figure 5.16

presents how an acquirer can move through those scenarios based on platform configurations. Firstly, after analyzing some demands, the initial platform configuration ($P_0$) changes and then *TECCON* and *OBJCON* are recalculated in order to show how the selected demands modify dependency and synergy levels ($P_{DA1}$). For each demand previously included in the SECO platform, a solution can be selected, then dependency and synergy levels can be analyzed ($P_{SA1}$). The IT management team can realize the impact of multiple selections of candidate applications. In any activity, the acquirer's selections are subjected to a budget limit previously informed.

In order to support the whole SECO monitoring & analysis, we developed an extension of a software product for exploring and manipulating networks, discussed in the next section. This module supports demand and solution analysis with mechanisms identified in Chapters 3 and 4.

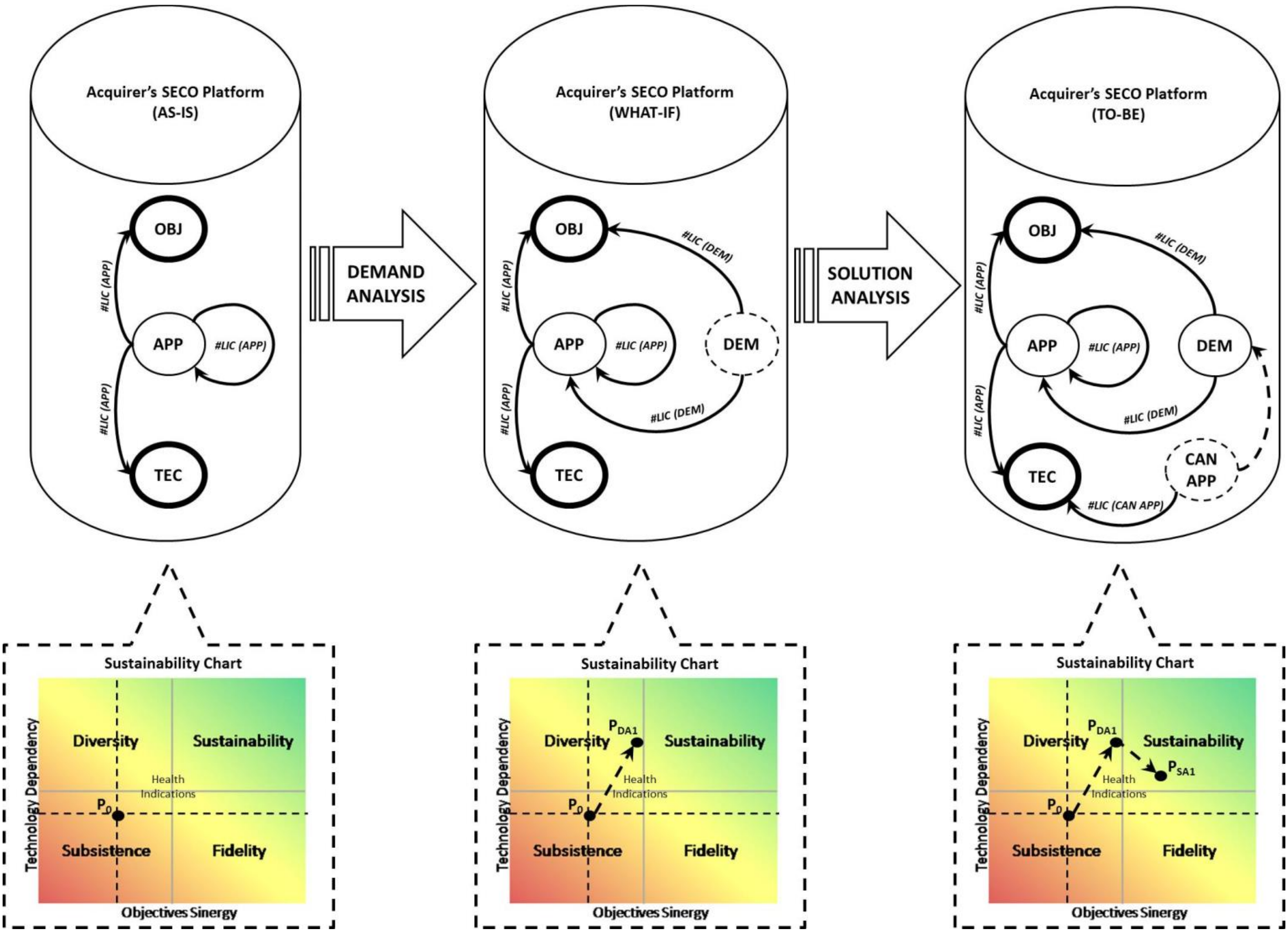



Figure 5.16. *SECO2M* analysis

### 5.4.2. SECO-DSA Module

In order to support SECO analysis in *SECO2M*, the most critical health indicators for SECO monitoring were incorporated into a SECO platform as a key contribution of this PhD research (WERNER & SANTOS, 2015; SANTOS et al., 2016a). An extension of *Brechó Library* was implemented to adapt *SECOGov* and *SocialSECO* modules (Sections 5.3.2 and 5.3.3) for SECO monitoring. In addition, a plug-in for SECO analysis was integrated to *Brechó*. This plug-in was built upon *Gephi*, a software product for exploring and manipulating networks. *Gephi* was chosen because it is a free open source software (FOSS) that allows graph modelling and visualization, and also have a rich API supporting network measures and algorithms. A detailed discussion on the different network analysis and mining tools is provided in (SANTOS & OLIVEIRA, 2013).

This module – named *SECO-DSA* (**SECO** in **D**emand and **S**olution **A**nalysis) – aims to help an acquirer to understand the relationships among actors and artifacts when visualizing information related to technology/supplier dependency and business objective synergy. *SECO-DSA* treats SECO requirement R7 (*Support analysis of the decision space: demands/solutions*) and R8-R10 (*Monitor business objective synergy, technology dependency and supplier dependency*). Along with the other modules and tools, *SECO-DSA* composes *Brechó-EcoSys*, an infrastructure for SECO management and monitoring to support IT management activities (SANTOS & WERNER, 2011c), more specifically demand and solution analysis, as shown in Figure 5.17.

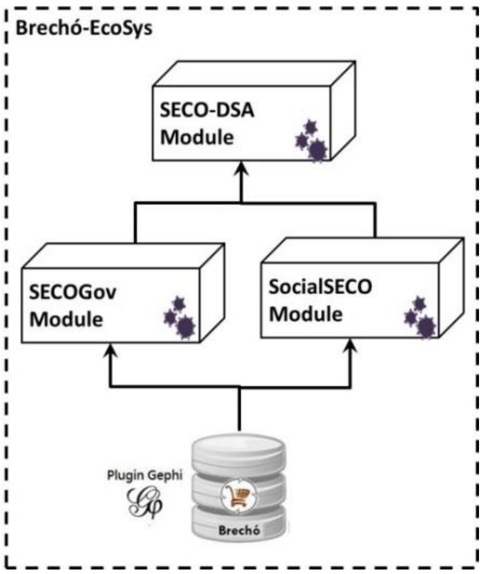



Figure 5.17. *Brechó-EcoSys* environment

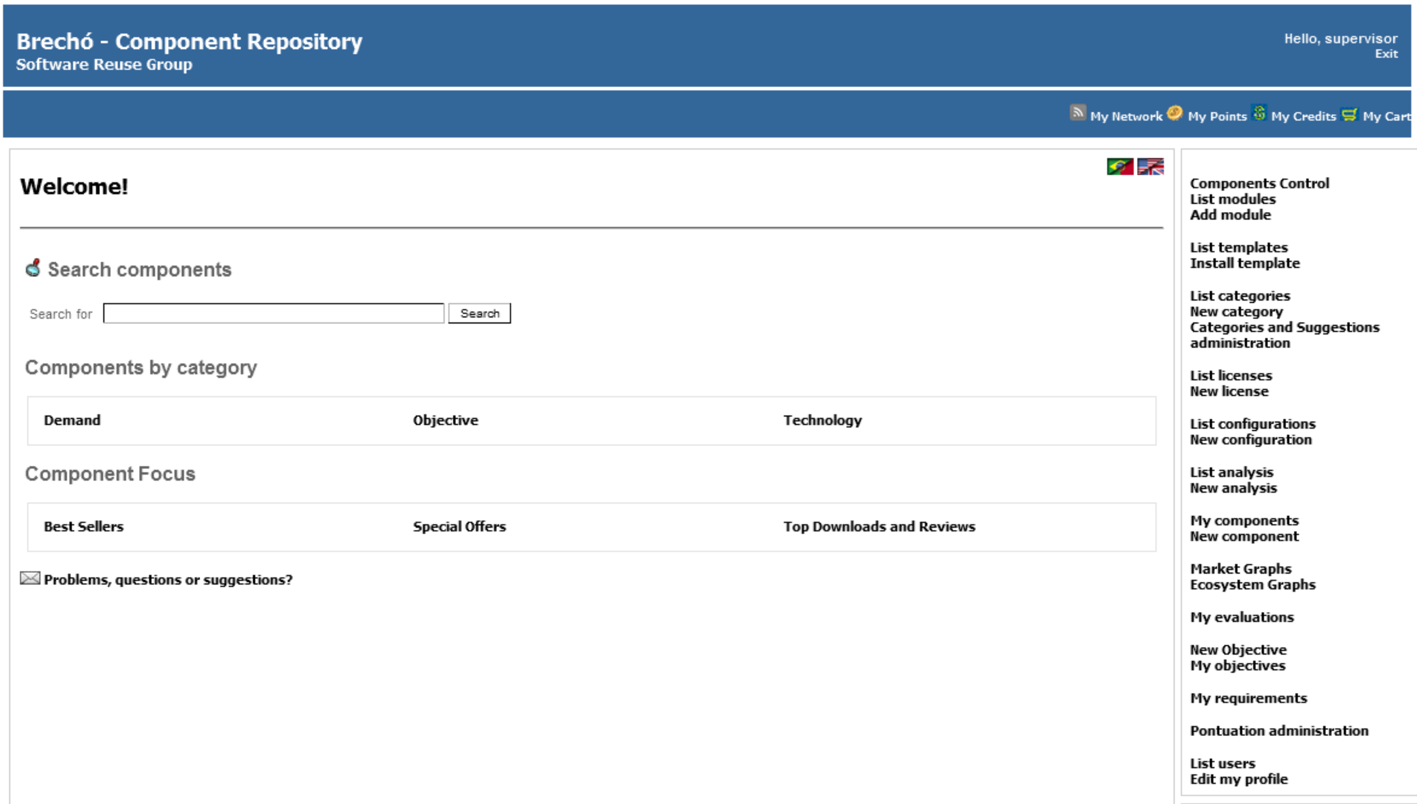



Figure 5.18. *Brechó* main screen after integrating the extension to support *Brechó-EcoSys*

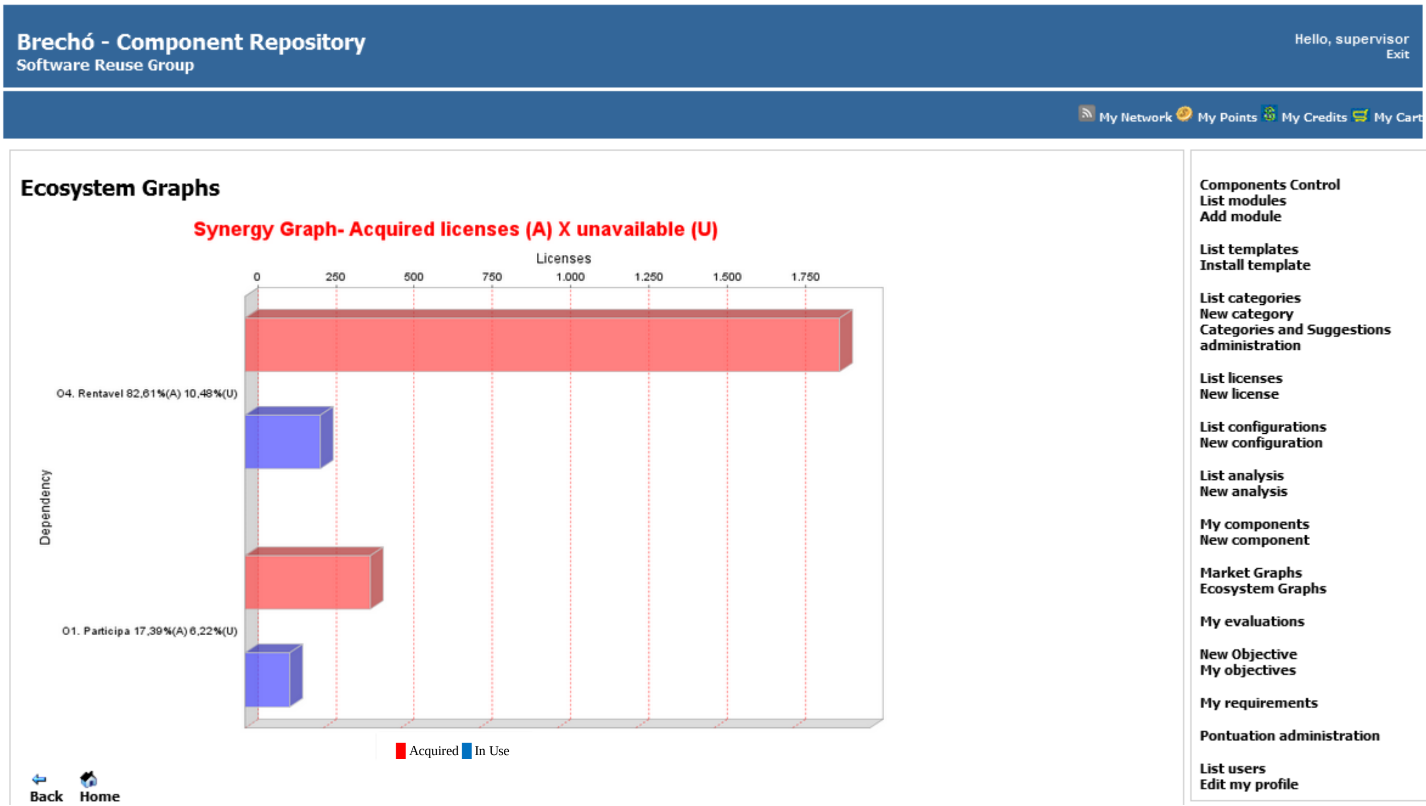



Figure 5.19. SECO graphs (synergy) in *Brechó* with *SECO-DSA* (*SECOGov*'s extension)

*Brechó-EcoSys*' main screen is shown in Figure 5.18. As observed, three categories were created to organize SECO platform components: *Demand*, *Objective* and *Technology*. Two menu options were also included by *SECO-DSA* module: *My Objectives*, where IT management team can register and manage business objectives, informing the impact factor (*W*); and *Ecosystem Graphs*, where IT management team can visualize objective synergy, technology dependency and supplier dependency levels (*R8-R10*). The first is exemplified in Figure 5.19 – an extension of the *SECOGov* module (Section 5.3.2).

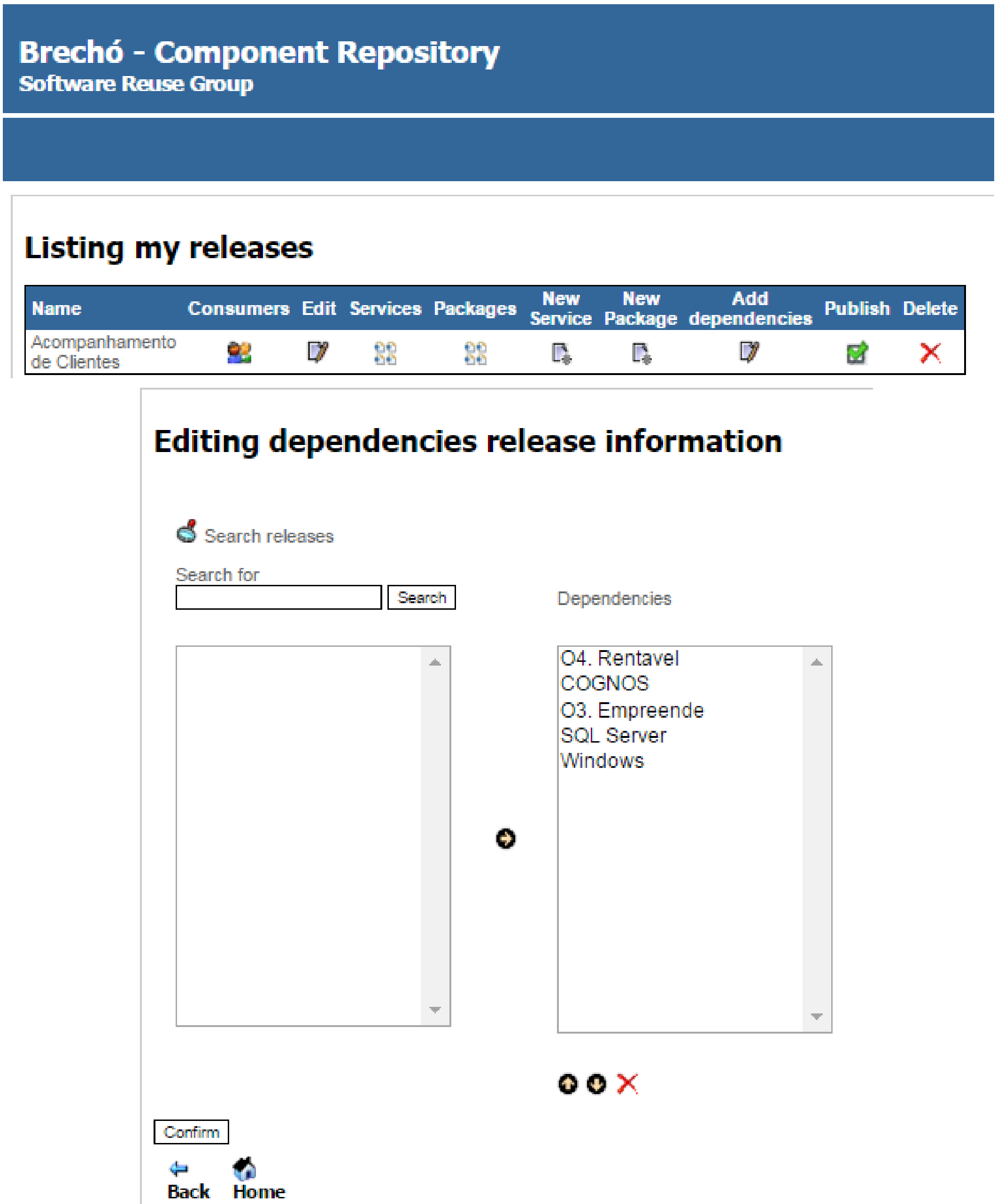



Figure 5.20. Dependency configuration screen in *Brechó* with *SECO-DSA* (*Brechó*'s extension)

The number of licenses and unit cost should be provided when a component's release (application, technology, demand or candidate application) is registered. It is performed in the "New Component" menu (Figure 5.18). In turn, the dependencies of applications, demands and candidate applications are added to the component release level (Figure 5.20). There is a mechanism for editing dependencies based on searching for existing components' releases in the platform (an extension of *Brechó*'s kernel).

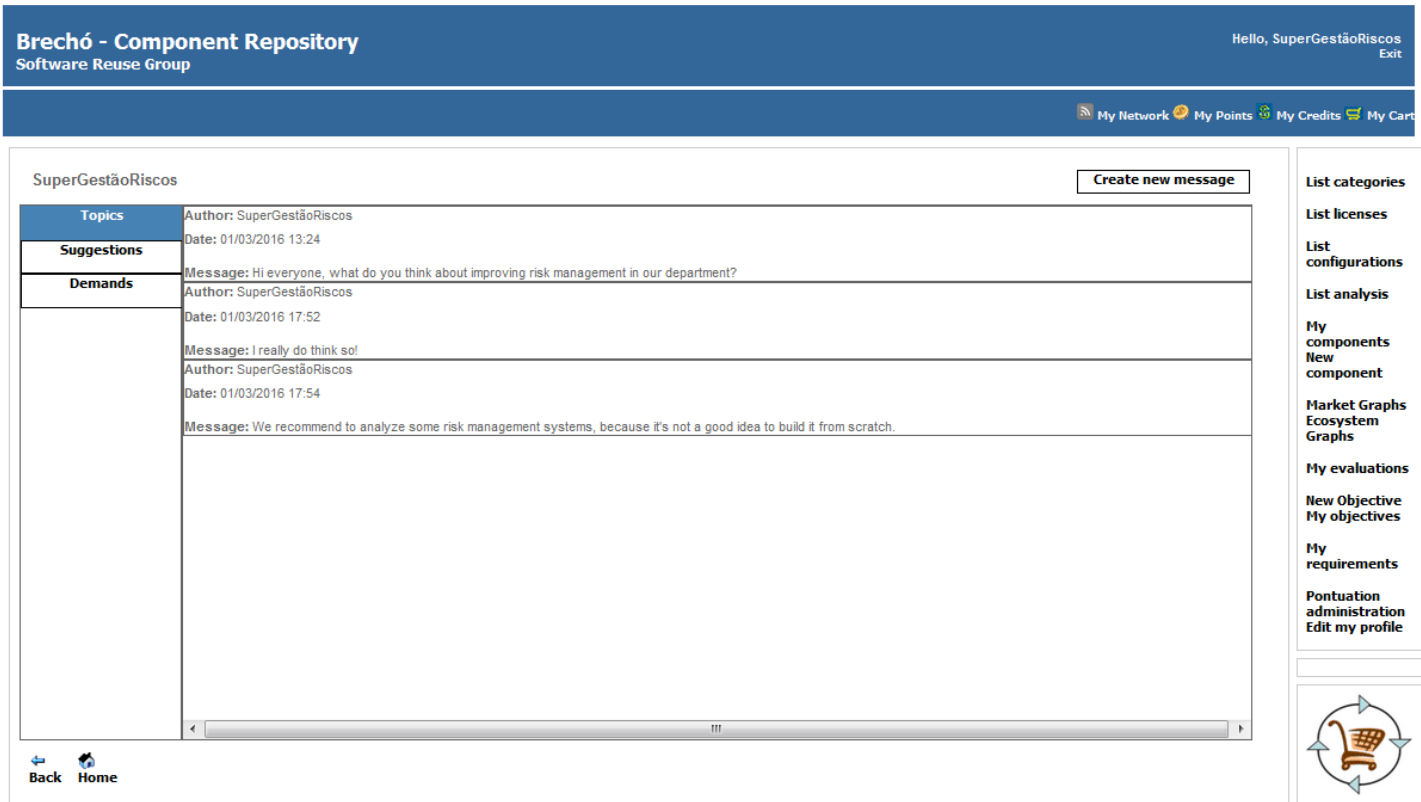



Figure 5.21. Demand management in *Brechó* with *SECO-DSA* (*SocialSECO*'s extension)

Regarding demand management, the *SocialSECO* module was extended to aid organizational units to take part of demand registering. In "My Network" (Figure 5.21), a unit's user (*team*) can register a demand as a component directly classified into the category 'Demand'. A unit's representative can register candidate applications relative to its demands in order to provide IT management team with sufficient data to perform SECO analysis. Figure 5.22 and Figure 5.23 show the *SECO-DSA* module's *Gephi* plug-in in which IT managers and/or architects can visualize relationships among SECO platform components. Information on how SECO platform sustainability is after adjustments in technology/supplier dependency and/or business objective synergy is shown. Such adjustments happen once some demands are selected (Figure 5.22), as well as when some respective candidate applications are analyzed (Figure 5.23).

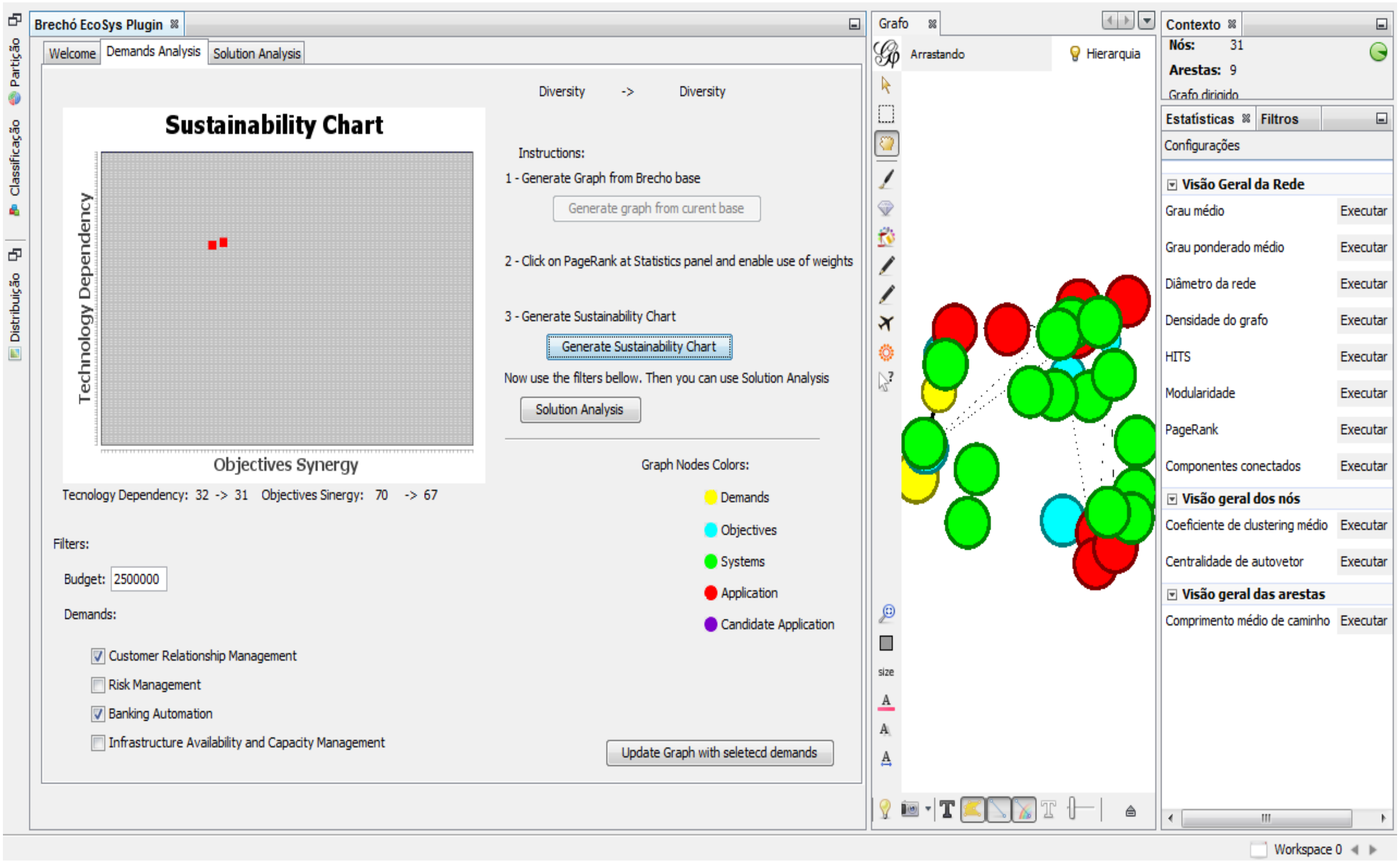



Figure 5.22. Demand analysis in *Gephi*'s plug-in integrated to *Brechó* with *SECO-DSA*

## 5.5 Related Work

In SANTOS (2014), some approaches related to *SECO2M* were identified from the initial body of knowledge provided by *ReuseECOS '3+1'* framework presented in Section 2.3. Most of them satisfy at least two SECO requirements stated in Table 5.1. BOUCHARAS et al. (2010) proposed a formal notation for modeling software products and SECO elements at the SSN level based on a UML metamodel, named Software Ecosystems Modeling (SEM). No tool is provided, SEM focuses on analyzing only direct network relationships and no social elements are treated. BERK et al. (2010) proposed a descriptive business model to evaluate key SECO characteristics in the context of SECO cases based on the ISV level, named SECO Strategy Assessment Model (SECO-SAM). A case study in the Open Design Alliance (ODA) is described and some weaknesses were observed, e.g., how to get insights from SECO-SAM without a SECO monitoring approach, and how to analyze quantitative business and social elements (health indications).

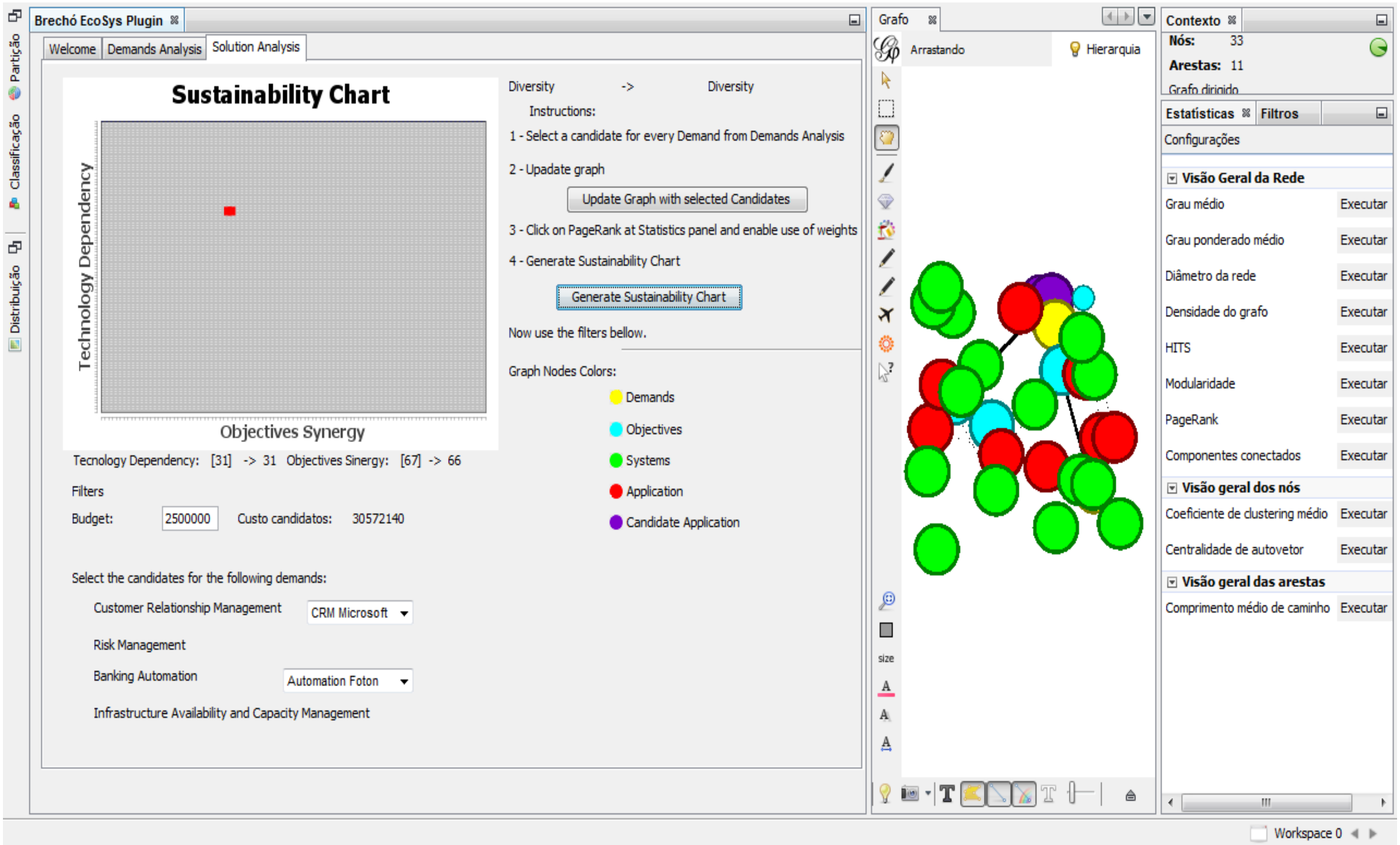



Figure 5.23. Solution analysis in *Gephi*'s plug-in integrated to *Brechó* with *SECO-DSA*

ANGEREN et al. (2011) created a relationship model based on UML to describe how a cluster of organizations can work together in a SECO. Organizational relations were identified and three SECO cases were compared (SAP, ODA, and Eclipse). However, this work partially analyzes the SECO external view and the main focus is on the business dimension, lacking relations with the underlying socio-technical network. YU & DENG (2011) identified some SECO elements and used i* models to describe dependencies among organizations, external developers and end-users, aiming to get insights from the SECO context. No repository was used to collect SECO data and no tool or evaluation was discussed. MCGREGOR (2012) proposed a method for modeling and analyzing SECOs based on a defined vocabulary and a UML profile, called STRategic Ecosystem Analysis Method (STREAM). It uses SE tools and techniques (e.g., software product line approach) to support the comprehension of SECOs. STREAM seems to be an industrial approach and the SECO external view was not investigated in a deep way.

As compared in Table 5.3, it can be observed that the related work minimally treats part of the SECO definition, management, monitoring, and analysis. None of them presented an integrated environment with an established SECO elements representation or analysis mechanisms. This reality affects the comprehension of IT management activities in the SECO context. Most of them have no support or interfaces to component repositories or socio-technical network analysis tools, except MCGREGOR (2012). A divergent terminology was observed, although none of them referred to it as a problem. Another issue is the focus on the SECO external view, hindering the analysis of the SECO internal view. *SECO2M* attends all requirements presented in Table 5.3.

Table 5.3. Related work against the SECO requirements satisfied by *SECO2M*

| | BOUCHARAS *et al.* (2009) | BERK *et al.* (2010) | ANGEREN *et al.* (2011) | YU & DENG (2011) | MCGREGOR (2010; 2012) |
|---|---|---|---|---|---|
| R0. Support SECO management and monitoring | ✘ | ⚠ | ⚠ | ⚠ | ✔ |
| R1. Manage roles and responsibilities for SECO governance | ✔ | ✔ | ✔ | ✔ | ✔ |
| R2. Manage component lifecycle for SECO governance | ⚠ | ⚠ | ⚠ | ⚠ | ✔ |
| R3. Manage file storage for SECO socialization | ✘ | ✘ | ✘ | ✘ | ⚠ |
| R4. Manage artifact versioning for SECO socialization | ✘ | ✘ | ✘ | ✘ | ⚠ |
| R5. Manage artifact forum for SECO socialization | ✘ | ✘ | ✘ | ✘ | ✘ |
| R6. Manage demand registering for SECO socialization | ✘ | ⚠ | ⚠ | ⚠ | ✘ |
| R7. Support analysis of the decision space: demands/solutions | ⚠ | ⚠ | ⚠ | ⚠ | ⚠ |
| R8. Monitor business objective synergy | ✘ | ✔ | ✔ | ⚠ | ⚠ |
| R9. Monitor technology dependency | ⚠ | ⚠ | ⚠ | ⚠ | ⚠ |
| R10. Monitor supplier dependency | ✔ | ⚠ | ✔ | ✔ | ✘ |

*where:* ✔ *= support;* ⚠ *= partially support;* ✘ *= do not support*

Regarding demand and solution selection (*SECO-DSA* module), BAKER et al. (2007) address the problem of determining the next set of candidate software components to be selected. A generic instantiation of this problem finds the IT management team considering many candidate components described in terms of *cost of acquisition* (COTS/outsourced, or bespoke) and *development time* to a single cost; *customer desirability* and *expected revenue* to a single weigh; and the *value of item*.

Despite the formulation (optimization 0-1 knapsack problem) and the application of search algorithms, the authors lack of other parameters than those observed in the traditional IT management scenario.

CORTELLESSA et al. (2008ab) introduce a framework that supports the decision whether to buy software components, or to build them in-house as an optimization problem. The framework devises a non-linear cost/quality optimization model based on decision variables that can be embedded into a Cost Benefit Analysis Method to provide decision support to architects. Although both BAKER et al. (2007) and CORTELLESSA et al. (2008ab) approaches are also applied into acquisition preparation, they lack a strategy to take into account data of the software assets to analyze possible effects of selecting a given set of components over the sustainability of the acquirer's asset base (SECO platform). For example, selecting a given set of components can contribute to increase (or decrease) either the dependency on a set of suppliers or technologies over time, or the long-term synergy of business objectives.

In conclusion, it is clear that IT management activities in the SECO context needs to take care of the platform over time, since it is the 'hearth' of the acquirer's businesses in the dynamic, global industry. It is tightly dependent on knowledge flow from/into the platform (in this case, objectives, applications, technologies, demands, and candidate applications), affecting the SECO sustainability (RIOS et al., 2013). Therefore, the first two modules of *SECO2M* support a SECO platform with governance and socialization mechanisms that maintain information on how an acquirer can manage the SECO when preparing acquisition rounds over time, as discussed in Section 5.3.1. In turn, the last two modules of *SECO2M* support a SECO platform with SECO health indication mechanisms that show information on how an acquirer can monitor the SECO, as described in Section 5.4.1. In summary, *SECO2M* focuses on supporting IT management teams to understand the 'hidden effects' of demands and solutions selection and its impacts on the SECO platform sustainability.

## 5.6 Conclusion

In this chapter, we proposed an approach for managing and monitoring SECO to support IT management activities, more specifically demand and solution analysis, motivated by the results of our first three RQs. We presented an overview of our proposal including details on the requirements, strategy, and conceptual model. SECO management and monitoring mechanisms and infrastructure were also presented in order to compose a solution for the challenges identified throughout our previous studies. As observed, demand and solution analysis seems to be very important for acquisition preparation and for maintaining a sustainable SECO, since it involves knowledge flows from/into the platform.

The software asset base is the 'hearth' of such a challenging context since it allows acquirers to take a look at internal and external views before making decisions, i.e., to consider the organization and the supply network as constituent elements that are critical for IT management towards the sustainability scenario. However, complexity management in SE has proved resistant to conventional analytical solutions, since perfect solutions are impossible or impractical – an open challenge for IT management.

After implementing our proposal into the *Brechó-EcoSys* environment, we decided to execute a feasibility study with practitioners with data from a real scenario in order to evaluate *SECO-DSA* module (Chapter 6). As such, we stated RQ4 – *Is SECO management and monitoring feasible to aid managers and/or architects to perform IT management activities, more specifically demand and solution analysis, with efficiency and effectiveness?*

# Chapter 6 – Evaluation

*The study of software engineering has always been complex and difficult. The complexity arises from technical issues, from the awkward intersection of machine and human capabilities, and from the central role of human behavior in software development (...) it is the last factor, human behavior, that software engineering empiricists are only recently beginning to address in a serious way.*

Seaman (1999)

## 6.1 Introduction

As observed in the previous studies performed in this PhD research, acquirers and suppliers establish ties on their relationships over the IT management activities through software acquisition and consulting contracts, for example (NIEMANN et al., 2008). In Software Engineering (SE), such relationships, involved organizations and information exchanged among the parties create a software ecosystem (SECO). Despite the challenges faced by suppliers on the development and evolution of applications and technologies in a competitive market (SANTOS & WERNER, 2010), acquirers face difficulties throughout the IT management activities, e.g., to analyze and select demands and applications available at the market (ALBERT, 2014, LIMA, 2015), as well as to manage and monitor the organization's software assets (SANTOS, 2014).

An obstacle faced in this context is the fact that terminology varies, few analytical models exist and real-world data is missing – a natural fact in the trajectory of an emerging topic or concern (HANSSEN & DYBÅ, 2012). For example, SANTOS (2013a) identified at least ten SECO definitions in literature. However, an increasing number of papers related to the topic has been published in literature. 231 papers from 2007 to 2014 were identified in a longitudinal literature study recently published in *The Journal of Systems and Software* (MANIKAS, 2016). Despite the several benefits of managing and monitoring SECO pointed out in Chapter 2, the current status of technical literature and the dynamic, global software industry make the 'ecosystem' metaphor difficult to understand, but largely adopted by practitioners (FORBES, 2014). As such, a body of empirical evidence is necessary to allow SE community to evaluate the 'hidden effects' of the SECO perspective in industry.

We then proposed an approach for managing and monitoring SECO to support acquirer's IT management activities, more specifically demand and solution analysis, named *SECO2M*, presented in Chapter 5. *SECO2M* was developed to integrate the SECO elements identified as results of our first three research questions (RQs), and comprises a model and an infrastructure named *Brechó-EcoSys*. In order to contribute to the SECO research and practice, a feasibility study was conducted with practitioners in a real scenario to evaluate *SECO2M*, more specifically *SECO-DSA* module and its infrastructure implemented at *Brechó-EcoSys*. The objective of this chapter is to present details on the study that was planned (Sections 6.2) and executed (Section 6.3) with 11 experts in demand and solution analysis (3 for pilot and 8 for the study itself). The goal was to answer RQ4 – *Is SECO management and monitoring feasible to aid managers and/or architects to perform IT management activities, more specifically demand and solution analysis, with efficiency and effectiveness?*. We analyze the results in Section 6.4 and threats to validity in Section 6.5. We conclude the chapter in Section 6.6.

## 6.2 Planning

This section describes the evaluation planning of our approach through a feasibility study. For the preparation of this planning, we used as an example some studies of the Reuse Software Lab (VASCONCELOS, 2007; MAGDALENO, 2013; NUNES, 2014; ALBERT, 2015) and other SE research groups at COPPE/UFRJ (TRAVASSOS et al., 2002; MAFRA & TRAVASSOS, 2006; BARRETO, 2011; SANTO, 2012). Following the approach defined by SHULL et al. (2001), this planning includes a first study to determine the feasibility of using a solution in practice. Feasibility studies try to characterize a technology in order to ensure that it actually does what it claims to do and that it is worth of extra effort to develop it. SHULL et al. (2001) state that such reviews cause the greatest changes in emerging technologies. Therefore, they have to be applied in the beginning of the evaluation process. So, feasibility studies are often conducted to evaluate a new technology or approach.

In our study, we used part of the Technology Acceptance Model (TAM) proposed by DAVIS (1993) to evaluate our approach from the tool support. TAM's evaluation is based on two concepts: (i) *perception of ease of use*; and (ii) *perception of usefulness*. This model is one of the most influential in the academic area to measure technology acceptance and has strong theoretical foundation and extensive experimental support (HU et al., 2009; HERNANDES et al., 2010; SANTO, 2012). According to POLANČIČ et al. (2010), the TAM model strengths are: (i) it focuses on specific information of technologies; (ii) its validity and reliability have been demonstrated in several researches; (iii) it is extensible; and (iv) it can be used during and after the adoption of a particular technology.

### *6.2.1. Global Objective*

The main purpose of this study is to evaluate our approach for SECO management and monitoring to support IT management activities, more specifically demands and solution analysis, in the context of a software acquirer. From this main goal, secondary goals took place over the evaluation of the infrastructure regarding ease of use and usefulness.

### *6.2.2. Study Objectives*

The study goals are defined accordingly to the Goal-Question-Metric (GQM) paradigm (BASILI et al., 1999), as described in Figure 6.1. The three goals are described in Table 6.1, Table 6.2 and Table 6.3, respectively.

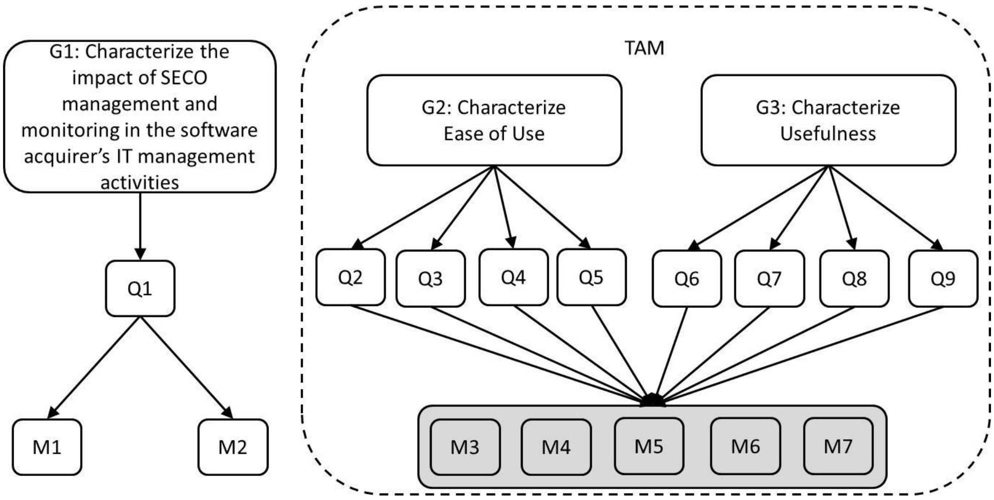



Figure 6.1. GQM model for *Brechó-EcoSys* evaluation (*SECO-DSA module*)

Table 6.1. Goal G1

| | |
|---|---|
| **Analyze** | *the SECO-DSA module and its infrastructure at Brechó-EcoSys* |
| **With the purpose of** | *characterizing* |
| **With respect to** | *the impact of SECO management and monitoring in the software acquirer's IT management activities* |
| **The point of view from** | *IT management team* |
| **In the context of** | *demand and solution analysis* |

Table 6.2. Goal G2

| | |
|---|---|
| **Analyze** | *the SECO-DSA module and its infrastructure at Brechó-EcoSys* |
| **With the purpose of** | *characterizing* |
| **With respect to** | *ease of use* |
| **The point of view from** | *IT management team* |
| **In the context of** | *demand and solution analysis* |

Table 6.3. Goal G3

| | |
|---|---|
| **Analyze** | *the SECO-DSA module and its infrastructure at Brechó-EcoSys* |
| **With the purpose of** | *characterizing* |
| **With respect to** | *usefulness* |
| **The point of view from** | *IT management team* |
| **In the context of** | *demand and solution analysis* |

### *6.2.3. Questions and Metrics*

This section presents the questions and metrics defined for this feasibility study. The main question investigated in this study is:

**Q1: Are the participants able to realize the impact of SECO management and monitoring in the software acquirer's IT management activities for demand and solution analysis, regarding effectiveness and efficiency?**

This perception is measured by the participants' answers given to the study's tasks. Therefore, the following metrics are defined as follows:

**M1: Effectiveness**

The effectiveness measures the relation between the results and the objectives. The calculation is done by the following formula:

$$Effectiveness = \frac{number\ of\ correct\ answers}{total\ number\ of\ questions}$$

**M2: Efficiency**

The efficiency measures the relation between the results and the resources. The calculation is done by the following formula:

$$Efficiency = \frac{number\ of\ correct\ answers}{time\ taken\ to\ participate}$$

Figure 6.1 shows other eight questions (Q2 to Q9) related to G2 and G3 (GQM model). These questions were formulated aiming to capture the dimensions *ease of use* and *usefulness* of our approach, as described in Table 6.4, inspired by the TAM model.

The questions related to the TAM model were based on studies performed by HERNANDES et al. (2010) and SANTO (2012). Four questions refer to the evaluation of the ease of use, and four other regard to the usefulness.

Table 6.4. Questions derived from TAM model to evaluate our approach

| Question | Description | Dimensions |
|---|---|---|
| **Q2** | Did I easily learn how to use the approach? | **Ease of use** |
| **Q3** | Did I use the approach in the way I wanted to? | |
| **Q4** | Did I understand what happened in the interaction with the tool? | |
| **Q5** | Did I easily execute the proposed tasks with the tool? | |
| **Q6** | Did I think that the approach is useful for SECO management and monitoring? | **Usefulness** |
| **Q7** | Does the approach allow me to realize how acquirer's demands and solutions depend on SECO elements, i.e., business objectives, suppliers and technologies? | |
| **Q8** | Did the approach improve my performance over the execution of the proposed tasks? | |
| **Q9** | Does the approach support IT management activities? | |

Participants answer each question with a value in an ordinal scale, as shown in Table 6.5 (values are in a descending order of value). For each question, we provided a text field for additional comments on the given answer. In addition, for each question considered in the study, there is a set of related metrics, as shown in Table 6.6. Once each question has been computed, an interpretation regarding the ease of use and usefulness of the approach can be obtained. Due to the high number of possible combinations for the configuration of each response, we chose to separate the interpretation of the ease of use and usefulness.

Table 6.5. Possible answers for the TAM model questions in a decreasing order

| Scale |
|---|
| Totally Agree |
| Agree |
| Neither agree nor disagree |
| Disagree |
| Strongly disagree |

Table 6.6. Metrics for the approach evaluation

| Metrics | Description |
|---|---|
| **M3** | Number of participants who choose "Totally Agree" |
| **M4** | Number of participants who choose "Agree" |
| **M5** | Number of participants who choose "Neither agree nor disagree" |
| **M6** | Number of participants who choose "Disagree" |
| **M7** | Number of participants who choose "Strongly disagree" |

### *6.2.4. Hypothesis*

An empirical study is generally based on one or more hypotheses. The main hypothesis is known as null hypothesis and states that there is no significant relation between the cause and the effect. The main objective of the study is then to reject the null hypothesis in favor of one or some alternative hypotheses. The decision on the rejection of a null hypothesis can be taken based on the results of its evaluation using a dataset analysis (TRAVASSOS et al., 2002).

In our study, the following hypotheses were defined:

- **Null Hypothesis** (**H01**): There is no difference in **effectiveness** between practitioners executing IT management activities for demand and solution analysis with or without the approach for SECO management and monitoring.

  **H01:** $\text{Effectiveness}_0 = \text{Effectiveness}_1$, where:

  *$Effectiveness_0$ = Effectiveness without the approach*

  *$Effectiveness_1$ = Effectiveness with the approach*

  **Alternative Hypothesis (HA1)**: Practitioners executing IT management activities for demand and solution analysis with the approach for SECO management and monitoring were more effective in their tasks than those who executed them without the approach.

  **HA1:** $\text{Effectiveness}_1 > \text{Effectiveness}_0$

- **Null Hypothesis** (**H02**): There is no difference in **efficiency** between practitioners executing IT management activities for demand and solution analysis with or without the approach for SECO management and monitoring.

  **H02:** $\text{Efficiency}_0 = \text{Efficiency}_1$, where:

  *$Efficiency_0$ = Efficiency without the approach*

  *$Efficiency_1$ = Efficiency with the approach*

  **Alternative Hypothesis (HA2)**: Practitioners executing IT management activities for demand and solution analysis with the approach for SECO management and monitoring were more efficient in their tasks than those who executed them without the approach.

  **HA2:** $\text{Efficiency}_1 > \text{Efficiency}_0$

### 6.2.5. *Context*

The context describes the conditions in which the study is conducted (TRAVASSOS et al., 2002).

#### 6.2.5.1. *Participants*

Participants were selected by convenience. They are practitioners (IT managers and architects) working in a Brazilian large banking organization. This organization plays as a software acquirer in the global industry. There is an IT management team responsible for performing activities related to demand and solution analysis. Spreadsheets and distributed documents are usually taken into consideration in meetings regularly promoted to analyze and select demands. As a strength of our approach, SECO management and monitoring mechanisms were integrated into an repository so as to improve software assets' storage, search, retrieval, classification, and analysis.

Since an experimental context very similar to the software industry reality is desirable, participants must have a managerial view even with different levels of experience in IT management and architecture. Based on information provided through the characterization form, participants should be divided into similar groups. Participants' sessions should be individually performed. There should not be any kind of compensation or reward for the participants.

#### 6.2.5.2. *Tasks*

We defined a set of ten tasks to be executed in order to explore if practitioners are able to realize the impacts of SECO management and monitoring in a software acquirer's IT management activities for demand and solution analysis. Tasks are classified into three categories according to complexity in execution, based on the work of (OLIVEIRA, 2011):

**Filtering tasks**: this category comprises simple tasks that depend on reading some information using the approach's infrastructure in order to answer some questions. If a participant is not able to execute such tasks, he/she should be removed from the analysis because this situation can affect the understanding of the tool or tasks. The specific tasks executed in the context of this category in our study were:

1. What are the business objectives registered by the organization?

2. What organizational unit is responsible for managing the demand labeled as ‘fiscal management’?
3. What programming languages are adopted in the organization’s reference IT architecture?

**Basic tasks**: this category comprises basic tasks that depend on reading some information using the approach’s infrastructure and interpreting the results to answer some questions. The tasks executed in the context of this category in our study were:

4. What technologies support the software application ‘integrated logistics support system’?
5. What business objectives are related to the demand ‘customer relationship management’?
6. What is the percentage of licenses of applications acquired or developed that are related to the business objective ‘leverage productivity’?
7. What suggestions of potential demands have been discussed by the ‘Control, Security and Risk Management Department’?

**Assimilation tasks**: this category comprises difficult, complex tasks that depend on the participant’s background to understand and interpret information related to IT management and architecture to answer some questions. The specific tasks executed in the context of this category in our study were:

8. What demands should be selected for investments if the organization decides to improve business objective synergy?
9. Considering the demands (1) ‘banking automation’ and (2) ‘customer relationship management’, what candidate market solutions should the organization select to reduce the technology/supplier dependency?
10. If the organization selects Microsoft CRM as a solution for the demand ‘customer relationship management’, what is the impact on the SECO platform sustainability? Does the platform become more sustainable, i.e., this decision reduces dependency over a small group of technologies and also improves business objective satisfaction?

Participants should not be informed about such categories in order to avoid any influence in the proposed tasks. An oracle (correct answers) was created from the real dataset of a Brazilian large banking organization for both groups of those who should use the approach, and who should not.

#### *6.2.5.3. Data*

This study focuses on analyzing information so as to observe the impact of SECO management and monitoring on the software acquirer’s asset base throughout IT management activities, more specifically demand and solution analysis. To do so, we collected real data from a Brazilian large banking organization regarding: (1) list of 21 business objectives with weights; (2) list of 100 applications, 40 technologies, five current demands and a set of 12 candidate solutions (with number of licenses, cost, and dependencies); (3) list of 20 suppliers; and (4) list of 30 organizational units. Data were structured in spreadsheets provided by an organization’s IT manager and also extracted from the organization’s public documents available at Internet. The IT manager was available for questions all the time. Finally, data were registered in the infrastructure developed to support our approach.

#### *6.2.5.4. Groups*

It is known that the sequence of tasks and the support for execution can influence the results. Thus, participants should be characterized before the execution aiming to distribute them in two homogenous groups. A group should use the approach to execute the proposed tasks, and the other should not. Participants are ranked based on a score obtained from the characterization form answers, as shown in Table 6.7. Each group should have four participants, one of them with participants classified in even positions (*G1*), and the other with those ranked in odd position (*G2*), as shown in Table 6.8. This strategy allowed us to avoid confusion factors, aggregate results and create control (and comparison) points. It helped us to analyze the effect of our approach.

Both groups should be submitted to the same ten tasks. However, in the proposed experimental design, the treatment varies (*with the approach* and *without the approach*). The participants who should not use the approach should use their daily tool support to perform IT management activities for demand and solution analysis. Information related to resources used to execute the proposed tasks should be collected to aid comparison.

Table 6.7. Criteria applied for ranking participants based on characterization form answers

| Question | Highest Score | Observations |
|---|---|---|
| **1. Academic Background** | 6 | 6: Postdoc<br>5: PhD Degree<br>4: PhD student<br>3: Master Degree<br>2: Master student<br>3: Specialization Degree<br>2: Specialization student<br>1: Bachelor Degree<br>0: Bachelor student |
| **2. Experience** | 10 | a + b |
| **a) Experience (Degree)** | 5 | Experience degree from five relevant knowledge areas for the study |
| **b) Experience (Time)** | 5 | Average time normalized from lesser and highest time informed |
| **3. Experience with Similar Tools** | 6 | Experience informed for four tools |

Table 6.8. Experimental design – groups and treatments

| Group | Execution | Participants |
|---|---|---|
| **G1** | With the approach | 2º, 4º, 6º, 8º |
| **G2** | Without the approach | 1º, 3º, 5º, 7º |

### *6.2.6. Variables*

There are two types of variables: independent and dependent. Independent variables refer to the inputs of the experimental process. Such variables have the cause that affects the result of the experimental process. Their objective is to identify the forces that influence (or can influence) the results of the execution. In turn, dependent variables refer to the outputs of the experimental process (TRAVASSOS et al., 2002). They correspond to those that we are interested in evaluating in the study execution. Such variables are defined according with goals and questions established for the study.

The *independent variable* in our study is:

- The approach used to support IT management activities for demand and solution analysis. This variable has two treatments: (a) the use of the approach for SECO management and monitoring; (b) the use of traditional IT management tools and other organizational resources.

The *dependent variables* in our study are:

- Number of correct answers for each participant;
- Time spent to execute the proposed tasks;

### *6.2.7. Instruments and Preparation*

This section defines what instruments should be applied during the evaluation and how evaluation procedure should be prepared. We prepared six instruments presented in Annex 1 (applied in Portuguese).

1. *Informed Consent Form* (Section A1.1): informs the study objective and participant's rights and responsibilities. It also informs that collected data should not be used to evaluate participants' performances, and explains confidentiality terms. This form should be sent to participants before the study execution. Each participant should return with this document;
2. *Characterization Form* (Section A1.2): allows the researcher to analyze participants' profiles and also classify them into groups. This information is also used for analysis of results;
3. *Execution Form* (Section A1.3): presents the context of the work and the ten proposed tasks. The participants are asked to play as they currently do in daily IT management team' activities within the large banking organization. This document is also used to collect answers for each task;
4. *Evaluation Form* (Section A1.4): consists of a questionnaire in which each participant should evaluate his/her experience after the study execution. Qualitative information on the study execution is collected, as well as suggestions of improvement for the approach and considerations regarding the experience in the study;
5. *SECO Background* (Section A1.5): before starting the study, participants should be submitted to a short training on the SECO dimensions and key concepts. They can use this document whenever they need it;
6. *Tool Guide* (Section A1.6): participants who should use the approach should be submitted to a short training on the infrastructure. They also can use this document whenever they need it.

### *6.2.8. Planning Validity*

As suggested by MAFRA & TRAVASSOS (2006), planning and instruments should be validated with other researchers before executing the study. Such researchers should not be interested in the study's results in order to reduce bias. In our study, the planning was validated by two researchers (chosen by convenience) who have previous experience in studies like this. In addition, a pilot study was conducted with three participants simulating both groups. Such pilot aimed to identify possible difficulties in executing the study, including the understanding of related concepts or even the infrastructure. This pilot also helped to improve the instruments and to have an idea of how long the study execution should take. It can be run with more participants if any important issue still remains.

#### *6.2.9. Interpretation and Analysis*

The results should be analyzed in both qualitative and quantitative ways. Quantitative analysis refers to effectiveness and efficacy. In turn, qualitative analysis refers to participants' satisfaction, perception of complexity and accuracy in performing the proposed tasks. The results should be analyzed based on: (a) participants' answers; (b) duration of activity; and (c) participants' feedback provided in the evaluation form.

#### *6.2.10. Pilot Study*

A first pilot study was conducted in February 2016 with two participants through individual sessions. The first participant is a postdoc and the second is a PhD student. The first participant informed medium levels of experience in SE and Social Network (4 and 3, respectively), whereas the second informed high to medium levels of experience in Demand and Solution Management, Governance, and SECO (5, 5, and 4, respectively). Both have experience in SE (4 and 10 years, respectively), although the first is a researcher in social networks (12 years) and the second is a researcher and practitioner in Demand and Solution Management (10 years). Both have experience with collaborative tools and only the second has used software asset management tools. Both are not expert in tools for SECO visualization and analysis.

After signing the informed consent form and filling the characterization form, they were given the SECO background document. Both executed the proposed tasks without the approach and filled in the evaluation form. None of them performed all the tasks and pointed them as difficult. The main problem reported was: the lack of a centralized, automatic infrastructure to help answering the tasks. They reported that most of the information required depends on different stakeholders and that SECO internal view is missing. Next, the first participant was given a tool guide document and re-executed the tasks with the approach' infrastructure. This participant had some difficulties in understanding *Brechó-EcoSys*' native terminology and graphical user interface, and also reported some bugs found during the execution.

After some improvements in the study's instruments and infrastructure, a second pilot study was conducted with one participant. This participant has a PhD degree and informed high levels of experience in SE (5), and Governance, Demand and Solution Management, and Social Networks (4 each). This participant has experience in SE (20 years), and Governance, and Demand and Solution Management (8 years), as well as with governance and software asset management tools. Firstly, the participant executed the tasks without the approach. The participant reported low accuracy in answering most of the tasks during the study execution, being partially satisfied with the results and mentioned that the tasks are time-consuming. Next, the participant re-executed the proposed tasks with the approach's infrastructure. It was pointed some benefits of the approach, such as improvements in productivity, software asset integration, SECO understanding, and IT management support. At the end, the participant informed bugs.

The participants who used the approach easily performed the filtering and basic tasks. However, they had difficulties with assimilation tasks since they had just been introduced to a new tool; thus, more time was needed to answer the questions. On the other hand, with the approach, they found information and hit more questions. We realized that the pilot studies were very important to refine the study's instruments and fix bugs found in *Brechó-EcoSys*.

## 6.3 Execution

After some adjustments, the study was conducted with 8 participants working in the IT management team of a large banking organization in February 2016. In the first step, the participants signed an informed consent form and answered the characterization form. This allowed us to distribute them into two groups of equal size, so as to balance the profile of the groups as much as possible, i.e., a group would not be "stronger" than the other, which could introduce bias in the results. In the second stage, both groups received the SECO background document. The group *G1* (with the approach) also received a short training on *Brechó-EcoSys* (about 10 minutes) and then used the tool to perform the tasks. The group *G2* (*without the approach*) used the organization’s IT management resources and knowledge (spreadsheets and documents). In the third stage, each participant evaluated the study. Participants in the first group also evaluated the ease of use and usefulness regarding the approach’s infrastructure.

## 6.4 Analysis

In this section, we analyze the data collected in our study. As such, participants’ profile and dataset analysis are discussed.

### *6.4.1. Subjects’ Profile*

In the participant’s characterization step, it was possible to identify some relevant aspects. Regarding the academic education, one participant reported to have PhD degree, one is a PhD student, 5 have Master or Specialization degree, and one is a Master student. The participants informed experience degree according to the following scale:

- 0 is “none” (no experience);
- 1 is “I studied in class or in a book” (very low experience degree);
- 2 is “I used it in some projects in the classroom” (low experience level);
- 3 is “I used it in my own projects” (average experience degree);
- 4 is “I used it in few projects in the industry” (high experience degree);
- 5 is “I used it in several industrial projects” (very high experience level).

Table 6.9 shows the participants’ experience level (degree). Most of them (85-100%) informed to have high to very high experience in SE, Governance, and Demand and Solution Management. Regarding Social Networks and SECO, the experience level was relatively low. This profile is interesting since it can help us to observe if the SECO perspective affects IT management activities for demand and solution analysis. Table 6.10 presents the participants’ experience level (time in months). This item was normalized in a 0-5 scale, as previously explained in Table 6.7. Again, most participants have been working with SE, Governance, and Demand and Solution Management for 12.12, 6.06 and 5.79 years in average, respectively.

Regarding experience with similar tools, where 0 is “I have no familiarity”, 1 is “I have some familiarity”, and 2 is “I am very familiar”, only one participant reported he/she has no familiarity with governance tools. The same happened for software asset management and collaboration tools, but with different participants. Only two participants reported that they have some familiarity with SECO visualization and analysis tools. Therefore, we understood that this sample can come up with important findings regarding how SECO management and monitoring affects IT management activities for demand and solution analysis.

Table 6.9. Participants' experience level (degree)

| SUBJECT ID | Experience (SE) | Experience (Governance) | Experience (Demand and Solution Management) | Experience (Social Networks) | Experience (SECO) |
|---|---|---|---|---|---|
| P8 | 4 | 5 | 4 | 4 | 4 |
| P3 | 5 | 4 | 5 | 4 | 1 |
| P5 | 5 | 5 | 5 | 3 | 0 |
| P4 | 5 | 5 | 4 | 2 | 2 |
| P6 | 5 | 4 | 4 | 3 | 1 |
| P2 | 5 | 4 | 4 | 1 | 1 |
| P1 | 5 | 4 | 4 | 0 | 0 |
| P7 | 2 | 4 | 4 | 3 | 0 |

Table 6.10. Participants' experience level (time)

| SUBJECT ID | Experience (SE) | Experience (Governance) | Experience (Demand and Solution Management) | Experience (Social Networks) | Experience (SECO) | Experience (AVERAGE) | Experience (NORMALIZED) |
|---|---|---|---|---|---|---|---|
| P4 | 180 | 180 | 180 | 120 | 0 | 132 | 5.0 |
| P5 | 216 | 156 | 156 | 84 | 0 | 122.4 | 4.6 |
| P6 | 300 | 48 | 12 | 24 | 6 | 78 | 3.0 |
| P3 | 120 | 48 | 84 | 12 | 0 | 52.8 | 2.0 |
| P8 | 84 | 84 | 40 | 24 | 24 | 51.2 | 1.9 |
| P2 | 180 | 18 | 36 | 12 | 6 | 50.4 | 1.9 |
| P1 | 72 | 24 | 24 | 0 | 0 | 24 | 0.9 |
| P7 | 12 | 24 | 24 | 12 | 0 | 14.4 | 0.5 |
| **AVERAGE** | 145.50 | 72.75 | 69.50 | 36.00 | 4.50 | 65.65 | 2.49 |

Finally, participants were ordered based on the values for all parameters stated in the characterization form, as shown in Table 6.12. The groups were formed based on criteria explained in Section 6.2.5.4.

Table 6.11. Participants' experience with similar tools

| SUBJECT ID | Tools (Governance) | Tools (Software Asset Management) | Tools (Collaboration) | Tools (SECO) |
|---|---|---|---|---|
| P8 | 1 | 2 | 2 | 1 |
| P5 | 2 | 2 | 2 | 0 |
| P4 | 2 | 1 | 1 | 1 |
| P6 | 1 | 1 | 2 | 0 |
| P3 | 1 | 2 | 1 | 0 |
| P1 | 2 | 1 | 0 | 0 |
| P7 | 1 | 1 | 1 | 0 |
| P2 | 0 | 0 | 2 | 0 |

Table 6.12. Participants' ranking and group formation

| SUBJECT ID | POSITION | Groups (G1/G2) |
|---|---|---|
| P5 | 1 | G2 |
| P4 | 2 | G1 |
| P6 | 3 | G2 |
| P8 | 4 | G1 |
| P3 | 5 | G2 |
| P2 | 6 | G1 |
| P1 | 7 | G2 |
| P7 | 8 | G1 |

### *6.4.2. Results*

After classifying the participants, results should be analyzed based on participants' answers, duration of activity, and participants' feedback provided in the evaluation form, as explained in Section 6.2.9. Thus, an analysis could be done to better understand the study from data collected and evaluated according to statistical resources. Measures of central tendency and dispersion were calculated from the dataset, as presented in Table 6.13. Moreover, individual point diagrams were generated to help us to visually analyze the distribution of data in each group (Figure 6.3).

Table 6.13. Measures of central tendency and dispersion for the study dataset

| | | MEASURES OF CENTRAL TENDENCY | | MEASURES OF DISPERSION | | | | |
|---|---|---|---|---|---|---|---|---|
| VARIABLE | GROUP | MEAN | MED | AMP | VAR | SD | MIN | MAX |
| *effectiveness* | G1 | 0.90 | 0.90 | 0.20 | 0.01 | 0.08 | 0.80 | 1.00 |
| | G2 | 0.53 | 0.60 | 0.50 | 0.05 | 0.22 | 0.20 | 0.70 |
| *efficiency* | G1 | 0.23 | 0.20 | 0.20 | 0.01 | 0.09 | 0.16 | 0.36 |
| | G2 | 0.25 | 0.25 | 0.20 | 0.01 | 0.11 | 0.15 | 0.35 |

In total, participants were asked to answer ten questions that covered IT management activities for demand and solution analysis, and explored SECO management and monitoring, as listed in Section 6.2.5.2. Participants who used the approach (*G1*) hit 9 questions in average, whereas those who did not use it hit 5.25 questions in average. We also analyzed the groups based on the individual point diagram for number of correct answers. We observed a difference in this number in favor of the use of our approach. *G2* had an outlier who only hit 2 questions. *G2*'s participants had difficulties in answering the questions without talking with another IT management team's member. As such, they tried to list the documents where the information probably would be found.

These barriers reinforce the importance of maintaining a software asset base with SECO management and monitoring mechanisms to aid practitioners to make decisions based on the organizational context (internal view). Thus, regarding the relation between the number of correct answers over the total number of questions, *G1*'s participants had a very high average effectiveness (0.9) when compared with *G2*'s (0.53). The individual point diagram generated for effectiveness (Figure 6.2) shows a difference in this measure in favor of the use of our approach, i.e., all the *G1*'s participants were more effective than *G2*'s ones (H01 is refused). It can indicate that our approach helps IT management teams in their daily activities.

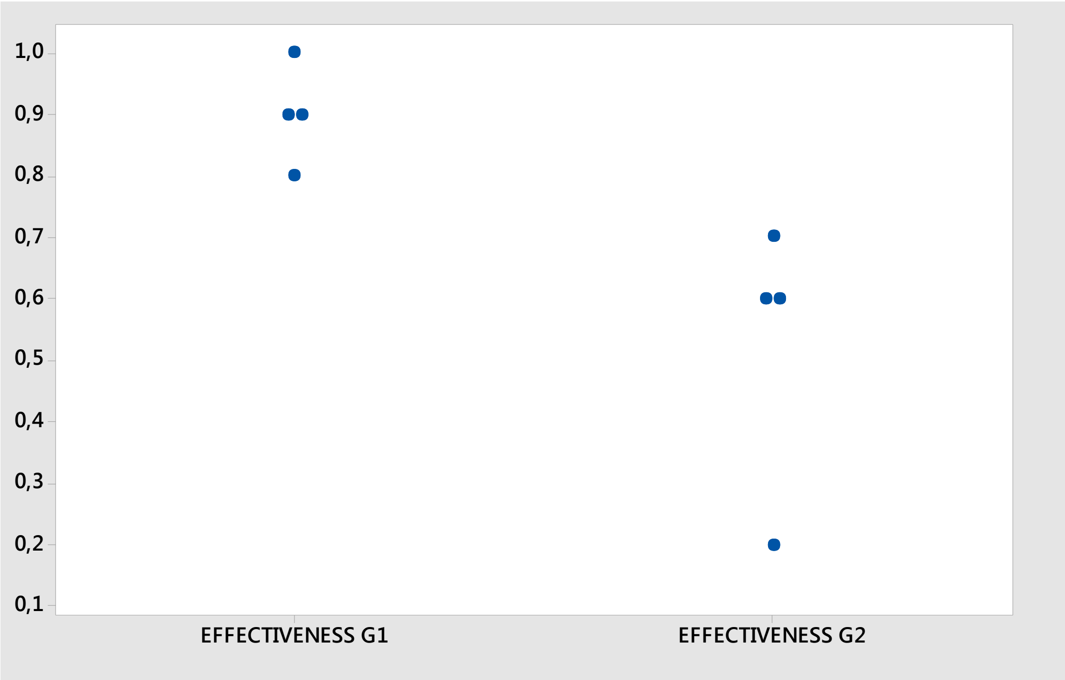



Figure 6.2. Individual point diagram for effectiveness

Participants who used the approach (*G1*) spent on average 43 minutes to perform the tasks regarding IT management, and those who did not use it spent on average 22.75 minutes. We observed such a difference in time against the use of our approach, although each group has an outlier disturbing it and *G1*'s participants spent more time in the execution. We argue that those participants had no previous knowledge about the approach and the infrastructure. On the other hand, *G2*'s participants mentioned some expressions like '*I know who can help me to get this information*', '*It should spend 35 hours to analyze these data within our organization*', '*I know there is a spreadsheet with data sources*', '*It is not possible to get it right now*', '*I need to check it with a consultant*', or '*I only can estimate it based on my experience*'.

Thus, the relation between the number of correct answers over the resources did not present a significative difference for *G1* (0.23) and *G2* (0.25) in average (H02 is not refused). This result is confirmed by the individual point diagram generated for efficiency (Figure 6.3). Despite an outlier in *G1*, the approach introduces terminology and an infrastructure that are new to the participants. In other words, even with experience in SE, Governance, and Demand and Solution Analysis, most of them had low experience level in SECO.

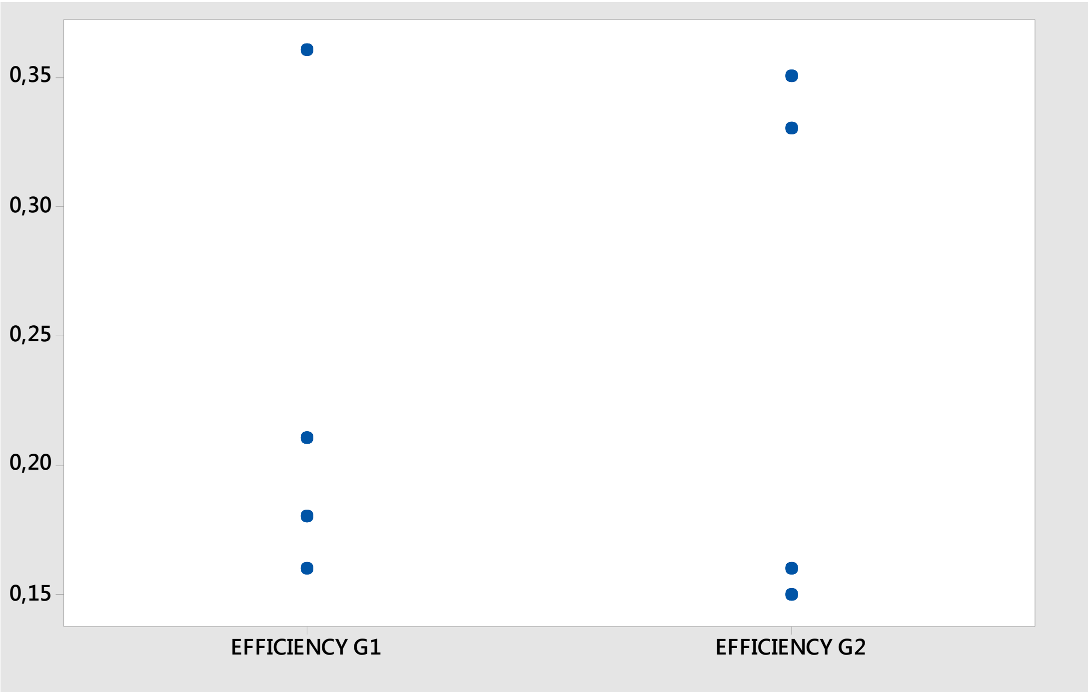



Figure 6.3. Individual point diagram for efficiency

Finally, we analyzed the evaluation questionnaire that participants filled after the execution. It was revealed that 3 (out of 4) participants had accomplished all the tasks in

*G1* and *G2*, and participants from both groups were satisfied (or partially satisfied) with the outcome of the study. All the participants agree that SECO perspective can benefit or support IT management activities. This result can motivate more research in this topic in the SE area. *G2*'s participants mentioned difficulties in performing the proposed tasks without requesting someone else. One of them explicitly said that he/she is now aware of how complex is to make decisions if other indicators than specification and budget should be taken into account. Two other participants also reinforced the importance of thinking about dependency and synergy within an acquirer.

Table 6.14. Evaluation of the study execution

| **ANSWER** | **GROUP** | **I performed the whole set of proposed tasks** | **I was satisfied with the final result** | **SECO perspective can benefit or support IT management activities** |
|---|---|---|---|---|
| *YES* | G1 | 3 | 3 | 4 |
| | G2 | 3 | 2 | 4 |
| *PARTIALLY* | G1 | 0 | 1 | 0 |
| | G2 | 0 | 2 | 0 |
| *NO* | G1 | 1 | 0 | 0 |
| | G2 | 1 | 0 | 0 |

In addition, 3 (out of 4) *G2*'s participants declared that the proposed tasks are difficult to perform even working with IT management within a software acquirer. One of them mentioned that "*a deep analysis is required regarding some answers*". The most common problems faced by that group were: terminology (P1), lack of transparency in demand selection (P3), time spent to monitor platform health indicators (P5), and difficulties in remembering indispensable information for decision-making (P6). On the other hand, 3 (out of 4) *G1*'s participants declared that those tasks were easy to perform with the approach's support. However, they pointed out some issues related to the proposed tasks: network's manipulation and analysis (P2), SECO contextualization (P4), high learning curve (P7), and information retrieval (P8).

Despite such critics, *G1*'s participants evaluated the approach's ease of use (Q2-Q5) as 'Agree' in most cases. Also, opportunities for improvements were identified, as reported in Annex B. None of them answered those questions with 'Disagree' or 'Totally Disagree'. Q4 (*Did I understand what happened in the interaction with the tool?*) was the only question that got a final evaluation degree as 'Neither Agree Non Disagree'. This might have happened because participants made recommendations on the graphical user interface. Moreover, one participant explicitly stated that

"*Considering the benefits of the tool, I am evaluating it as a possible buyer*". Regarding the approach's usefulness (Q6-Q9), most answers were set as 'Agree' or 'Totally Agree'. However, one participant disagree on Q8 (*Did the approach improved my performance over the execution of the proposed tasks?*). He/she is one of the participants with high experience level (time) and was evaluating the tool as a buyer.

Finally, participants pointed out strengths and weaknesses of the approach, as well as considerations on the support for demand and solution analysis based on the sustainability indicators. As strengths, P4 mentioned that the approach allows an IT management team to analyze different scenarios to prepare for an acquisition round, and P8 highlighted the support for managing business objectives and demands together. As weaknesses, P2 and P7 reported the high learning curve from beginners, "*though it decreases over time*" (P2). Usability aspects should be investigated as future work. When questioned on their conclusions related to business and community dimensions, they agree on the real barriers to control technology/supplier dependency. P4 claimed for the challenges of preparing acquisition plans in public organizations in Brazil. This participant also suggested strategies to manage relations between business objectives and demands, introducing a new parameter to collect information on how demands are gradually affecting business objectives over time.

## 6.5 Study Validity

Every study has issues that can impact or limit the results' validity. Such issues are known as threats to validity and are classified into four categories (WHÖLIN et al., 1999; TRAVASSOS et al., 2002): (a) *internal validity*: defines if the relation between the treatment and the result is casual and derived from influences of other uncontrolled (or even not measured) factors. Sampling, grouping, treatment application, and social aspects are concerns in this category; (b) *external validity*: defines the conditions that make it difficult to generalize results to other contexts. Participants' interaction with the treatment, location and occasion should be considered in this category; (c) *construct validity*: considers the relations between theory and observation, i.e., whether the treatment reflects the cause and the result reflects the effect. Undesirable behavior from the participants' or researcher's sides should be analyzed in this category; and (d) *conclusion validity*: refers to the conditions to make right conclusions on the relations between the treatment and the results. Statistical methods and sample size choices, as well as measures' confidentiality should be discussed in this category.

Threats to validity identified in our study are:

**Internal Validity:**

- Since this study involved more than one participant and they were classified into two groups subjected to different treatments, the greatest threat to internal validity is the relationship of the results with the selection of participants or a given scenario of interest – to reduce this risk, a participants' characterization form was applied in order to balance the group formation process;
- the exchange of information with other participants who conducted the study – to reduce this risk, the study was executed within 24 hours and we explicitly requested participants to not exchange information;
- the infrastructure can influence the results, if the participants face unexpected difficulties (e.g., slowness, server errors etc.), and the interactions with the tool can influence the way they perform the tasks – to reduce this risk, a short training session was prepared and a pilot was run to capture any confounding factor;
- the understanding of the execution form is directly influenced by the way the questions were designed, i.e., if the question was poorly worded, the study may be adversely affected – to reduce this risk, a pilot study was previously run to capture any confounding factor;
- the learning effect can manifest itself in the order the study's tasks were executed – to reduce this risk, tasks were arranged in an increasing complexity sequence and without entanglement, to not affect the thinking and the execution. Thus, the participant has the chance to understand the problem by running first with simpler tasks. It is noteworthy that the task sequence was the same in both groups;
- for the data analysis, the participants' characterization information should be used – unfortunately, it is not possible to meticulously verify that such information is correct although the research can recommend the participants to be precise in their answers.

**External Validity:**

- the study considers a mass of data related to a reality of a specific acquirer – a real dataset of an acquirer was used, participants were selected from this acquirer, and the acquirer's businesses are different from those that inspired our approach, as discussed in Chapter 4;
- it is not possible to represent all the situations of a SECO context, then studies in different organizations should be performed – unfortunately, research community commonly faces challenges in establishing many partnerships to collect real data and to evaluate proposed solutions. However, a strength of our study is the fact that we used a large dataset from a real software asset base.

**Construct Validity:**

- the selected measures might not be good indicators for the feasibility of the proposed approach – to reduce this risk, measures were chosen based on the information needed to answer the tasks, and a pilot study was previously run to capture any confounding factor;
- since participants were chosen for convenience, their behavior might reflect assumptions on the expected results for this study – to reduce this risk, we executed the study in an organization where participants have no academic or professional relationship with the researcher. A random selection was not possible, since the approach requires participants that work as IT manager/architect and have experience in industry;
- the tasks were grouped by type in order to aid data analysis and the same weight is assigned to all tasks; however, some tasks might have higher difficulty degree compared to others and this fact can influence the results – we decided to keep this setting because of the subjectivity in assessing difficulty degrees (which would introduce bias in the analysis).

**Conclusion Validity:**

- the main threat is the sample size, with a small number of participants, not being ideal from the statistical perspective – to reduce this risk, our analysis included all data collected from the participants. Unfortunately, this is a recurrent difficulty for empirical studies in SE area, especially for approaches that require industrial evaluation, as in our case. Thus, our study presents a limitation on the results, which are considered as indications (and not evidences).

## 6.6 Conclusion

In this chapter, we presented a feasibility study conducted with practitioners in a real scenario to evaluate our approach and contribute to the SECO community research and practice. Details on the study's planning and execution were discussed. A pilot was conducted with three participants at first. After refinement, the study was performed with eight participants. As a result of RQ4, the *effectiveness* to perform IT management activities for demand and solution analysis *was improved with the approach* support in the selected and applied context. However, the *efficiency was not so high with the use of the approach* since practitioners need some time to learn how to use it before being benefited from it.

After analyzing participants' answers for the proposed tasks and for the study evaluation, there is some indication that the approach is applicable for SECO management and monitoring to support IT management activities, especially demand and solution analysis. Several opportunities for improvements were identified, mainly regarding the graphical user interface. Considering usefulness, participants started being aware of the impacts of SECO perspective in their daily activities. It also reinforces the importance of the maintenance of a sustainable SECO platform.

# Chapter 7 – Conclusion

*Staying ahead means welcoming uncertainty. To overcome this challenge, companies must relearn skills and capabilities that brought them industry leadership – adopting processes that create variation, not eliminate it, and valuing flexibility over the relentless pursuit of efficiency.*

MacCormack (2013)

## 7.1 Summary

Current business environments and communities are continuously evolving. Organizations have invested in a massive adoption and use of applications and technologies to support business processes and then enhance competitive advantage (GROOT et al., 2012). However, the number of such components has increasingly grown, being more and more interdependent. In parallel, an evolving business environment contributes to changes in the organizational processes, affecting business objectives and demands. Thus, in the global industry, acquirers inevitably aim to maximize return on investment for each IT demand they prioritize and for each agreement they establish with suppliers (FARBEY & FINKELSTEIN, 2001).

Although selection and prioritization activities were investigated by researchers (ALVES, 2005; BAKER et al., 2006; CORTELLESSA et al., 2008b; FREITAS & ALBUQUERQUE, 2014), two challenges for IT management still remain: (1) IT architectural matching taking into account supplier and technology dependency (LAGERSTRÖM et al., 2014); and (2) multiple selections of applications to aid customers satisfy different business objectives (FINKELSTEIN, 2014). A crucial element in this context is the acquirer's platform, also known as the software asset base (ALBERT et al., 2013). Unfortunately, IT knowledge is commonly scattered through a mass of confusing information sources and on the minds of some critical IT managers or architects, hampering organizations to drive results and optimize use of resources, similar to obstacle to Component-Based Development (CBD).

In order to investigate such challenges, Software Engineering (SE) researchers have been exploring metaphors to understand a plethora of the natural 'nontechnical' elements surrounding the global industry (SANTOS et al., 2014c). Software ecosystem

(SECO) then came up as a topic of interest (JANSEN et al., 2009c). The main motivation is the dynamic software supply network where SECO management and monitoring affect IT management activities (DHUNGANA et al., 2010; BOSCH, 2012). However, as in any emerging, interdisciplinary topic, few analytical models, case studies with real data and integrated tool support exist (MANIKAS, 2016).

In this scenario, *SECO2M* was proposed as an approach for SECO management and monitoring to support IT management activities, more specifically demand and solution analysis. This approach was inspired on a generic framework for sustainable SECO management (DHUNGANA et al., 2010) and was developed based on 11 SECO elements identified in different studies performed so far. Mechanisms were proposed and an infrastructure was implemented from a component repository (*Brechó*) and a software for manipulating and exploring networks (*Gephi*), known as *Brechó-EcoSys*. Part of *SECO2M* (*SECO-DSA*) was evaluated through a feasibility study conducted with practitioners in a real scenario. Results provide indications of the effectiveness of the use of the approach for IT management, although efficiency still remains as a challenge.

## 7.2 Contribution

### *7.2.1. Main Contribution*

This PhD thesis contributes with: (a) the development of a framework to help researchers to better understand SECO dimensions and key concepts and to analyze organizations' platforms, based on an analytical literature review; (b) the identification of management mechanisms that are critical for IT management regarding governance and socialization in the SECO context, based on the experts' opinion; (c) the identification of monitoring indicators that are critical for IT management regarding sustainability of a platform in the SECO context, based on observational studies in real scenarios; (d) the definition of an approach for managing and monitoring SECO to support IT management activities, more specifically demand and solution analysis; and (e) the evaluation of some modules of the approach with practitioners (IT managers and architects) performing demand and solution analysis in a real scenario.

This PhD research and work provided the SE community with the following detailed contributions in the context of the treatment of economic and social issues:

- *SECO literature mapping* (Section 2.3): we organized SECO researches published in the International Workshop on Software Ecosystems (IWSECO) into a framework to support analyses of SECO platforms, named *ReuseECOS '3+1'*. The framework provides a step-by-step process to serve as an instrument to help IT management teams to characterize and analyze organizational platforms considering the SECO context. Key concepts and relations were structured in a set of steps and activities which compose each dimension based on peer-reviewing process, i.e., two researchers worked in organizing/developing the framework, and two researchers worked in verifying/validating it. The framework has served as an initial body of knowledge and was also evolved after being combined with the results of a systematic mapping study on SECO in collaboration with other universities;
- *two surveys with experts* (Sections 3.2.2 and 3.3.2): based on *ReuseECOS '3+1'*, we identified SECO management and monitoring as a critical aspect for IT management activities. For SECO management, two forces were observed: governance in a top-down way and socialization in a bottom-up way. We then performed two empirical studies (surveys) to evaluate what are the most relevant mechanisms in each case. We obtained two rankings of SECO elements that impact acquirers in the global industry, concluding that decisions related to acquisition preparation affect the SECO platform management;
- *two observational studies* (Chapter 4): also we performed two observational studies in order to identify how SECO monitoring affects acquirers performing IT management activities in real scenarios. As observed, analysis of the decision space, business objective synergy, and technology/supplier dependency were the most critical health indicators for SECO platform monitoring in IT management activities. Additionally, demand and solution analysis seems to be very important for acquisition preparation and for maintaining a sustainable SECO;
- *SECO2M conceptualization* (Chapter 5): the studies performed throughout the research activities allowed us to conclude that acquirers need an approach to maintain their SECO platforms sustainable over

time. We then defined a model to help acquirers to realize how SECO perspective can aid IT management activities, based on 11 SECO elements identified in our first three research questions (RQs). *SECO2M* is centered in a SECO platform and extends the software asset base with mechanisms for managing and monitoring SECO;

- *SECO2M tools* (Chapter 5): an infrastructure to support the proposed approach was developed as an extension of a component repository (*Brechó Library*) and as a plug-in of a free open source software (FOSS) for manipulating and exploring networks (*Gephi*). The complete infrastructure is known as *Brechó-EcoSys* and comprises works developed by researchers of the Software Reuse Lab: *SECOGov*, *SocialSECO* and *SECO-DSA*. More specifically, the last aims to help IT managers and architects to understand the relationships within a SECO and to visualize information related to technology/supplier dependency and business objective synergy;
- *feasibility study with real data and in an industrial scenario* (Chapter 6): practitioners evaluated part of the proposed approach and infrastructure (*SECO-DSA*) in a real scenario. A structured investigation protocol was developed and refined with a pilot study. It serves as a base for the SECO community to conduct studies like this since there is a lack of analytical models, case studies with real data, and integrated tool support. The effectiveness to perform IT management activities for demand and solution analysis were improved with the approach support in the selected and applied context. However, efficiency was not so high with the use of the approach since practitioners need some time to learn how to use it before being benefited from it.
- *international collaborations*: two main international collaborative work were performed during this PhD work. The first was the collaborative development of a pioneering body of knowledge of SECO research based on the evolution of a systematic mapping study, involving PESC/COPPE/UFRJ (Federal University of Rio de Janeiro), CIn/UFPE (Federal University of Pernambuco) and Utrecht University, The Netherlands. The result was a chapter published in the current reference

SECO book. The second was the academic visit to the Department of Computer Science, Software Systems Engineering Group, at University College London (UCL), under supervision of Prof. Anthony Finkelstein. This visit was supported by CAPES (Proc. No . BEX 0204/14-5). Two papers are expected from this collaboration (one of them is under the researcher's review and will be submitted to *IEEE Software*).

### *7.2.2. Secondary Contribution*

Some Bachelor and Master works were co-supervised in the context of this PhD research and work as follows:

- RIOS, L.A., 2013, "Assets Governance in Software Ecosystems at *Brechó* Library". Bachelor Monograph in Information and Computer Engineering. COPPE – Federal University of Rio de Janeiro, Rio de Janeiro, Brazil, 58p. (In Portuguese);
- ALBERT, B.E., 2014, "*SECOGov*: A Software Ecosystem Governance Model to Support IT Architecture Activities". Master Thesis in Computer Science and System Engineering. COPPE – Federal University of Rio de Janeiro, Rio de Janeiro, Brazil, 171p. (In Portuguese);
- LIMA, T.M.P., 2015, "A Social-technical Approach to Support Software Ecosystems Modeling and Analysis". Bachelor Monograph in Information and Computer Engineering. COPPE – Federal University of Rio de Janeiro, Rio de Janeiro, Brazil, 83p. (In Portuguese);
- Undergraduate students working in *Brechó* Project: BARBOSA, G.S. in 2015; ABREU, Y.J.L. in 2013; CAMPOS, B.P. in 2012; TOSTES, L.R. in 2012; CAMPBELL, I.V. in 2011; and FERNANDES, Y.V. in 2011.

### *7.2.3. Publication*

Research activities performed in this PhD produced the following publications:

- *Brechó-EcoSys infrastructure* was developed during this research in order to evolve a component repository maintained by LENS/REUSE Lab towards a SECO platform. Initial results were published in conference papers (SANTOS & WERNER, 2010; 2011c);

- *ReuseECOS '3+1' framework* was developed by the researcher (Chapter 2) and results are described in (SANTOS & WERNER, 2011bd; 2012ab). Additionally, a book chapter was published as an evolution of this framework based on a systematic mapping study, in collaboration with other universities (BARBOSA et al., 2013);
- *RPP Portal* (Chapter 2) was developed by the researcher with other students from the Software Reuse Lab and based the first observational study presented in Chapter 4. Some book chapters (SANTOS et al., 2012d; 2013a) and a conference paper (OLIVEIRA et al., 2011) were published;
- *SECO research agenda for the Brazilian software industry* was created and published in the proceedings of the *Brazilian Symposium of Software Engineering* (SANTOS et al., 2012c);
- *Governmental SECO studies* were performed by the researcher with other practitioners at COPPE/UFRJ and based the second observational study presented in Chapter 4. Conference industrial papers were published (e.g., RODRIGUES et al., 2013; SILVA et al., 2014);
- *Studies related to SECO modeling and analysis* were performed and some concepts used in our research were investigated: impacts of SECO on acquisition (RIOS et al., 2013); demand management and communication (SANTOS & WERNER, 2013); business process modeling in SECO (COSTA et al., 2013); and data-driven ecosystems (FRANÇA et al., 2015);
- *PhD proposal and refinement* was published in the proceedings of the *International Software Product Line Conference* (SANTOS, 2013b) and *International Conference on Software Engineering* (SANTOS, 2014). The goal was to discuss our research and get feedback from well-known researchers in the SE community;
- *SECOGov module* was developed by a Master student to extend *Brechó* Project with some mechanisms for SECO governance. Results were published in conference papers (ALBERT et al., 2012; 2013; ABREU et al., 2014);

- *SocialSECO module* was developed by a Bachelor student to extend *Brechó* Project with some mechanisms for SECO socialization. Results were published in journal papers (SANTOS et al., 2014a; LIMA et al., 2014; 2016) and some conference papers (SANTOS et al., 2013b; LIMA et al., 2013c; 2015; BARBOSA et al., 2015).

As a pioneering research in Brazil, this PhD work produced tutorials/courses:

- *Brazilian Symposium on Information Systems* (SANTOS et al., 2010c; SANTOS & WERNER, 2011; SANTOS & OLIVEIRA, 2013);
- *Brazilian Symposium on Computers in Education* (WERNER et al., 2010);
- *Ibero-American Conference on Software Engineering* (WERNER & SANTOS, 2012);
- *Brazilian Congress on Software: Theory and Practice* (WERNER et al., 2012);
- *Brazilian Symposium on Software Quality / Amazon Advanced School on Software Quality* (WERNER & SANTOS, 2015).

This PhD also triggered collaborative work with national researchers:

- *Co-chair* (2015) */ Steering Committee* (2015-2017) *of the Workshop on Distributed Software Development, Software Ecosystems and Systems-of-Systems* (WDES), co-located with the *Brazilian Congress on Software: Theory and Practice* (SANTOS et al., 2015);
- *Applications of SECO research in other areas*:
    - learning SECO (BORGES et al., 2011abc; CAMPOS et al., 2011; LIMA et al., 2011; 2012; SANTOS et al., 2011; 2012b; 2013c);
    - social network analysis and mining (SANTOS et al. 2012a);
    - software testing in distributed software development (MAIA et al., 2013);
    - communication in distributed software development (FARIAS JUNIOR et al., 2013);
    - systems-of-systems (SANTOS et al., 2014c);

- software quality (SANTOS et al., 2014b);
- mobile SECO (FONTÃO et al., 2014; 2015ab; 2016).

## 7.3 Limitation

Some boundaries were identified for this PhD thesis. A limitation in the literature review refers to the fact that we initially did not plan or conduct a systematic mapping study (or even a systematic literature review, if applicable). SECO literature was emerging by the time we performed our first researches in 2010. Regarding the other subjects involved in this PhD thesis – IT governance, software acquisition, social SE, sustainability –, the literature review was selective but guided by the results of the SECO literature mapping and also by the collaborations performed with the international research groups mentioned in Section 7.2.1. Besides, the interactions with other researchers in several conferences and workshops, as well as practitioners in industrial projects (2007-2015) helped us to minimize the risks of this limitation.

A limitation in the surveys with experts refers to the fact that they were conducted with Brazilian researchers and practitioners. As such, the approach developed in this PhD thesis relies on opinions that may reflect the national scenario of governance and socialization mechanisms for SECO management. Another limitation is the number of respondents which can limit the generalization. These issues were reported in sections related to the threats to validity in Chapter 3. Considering the observational studies, some limitation can be pointed out: the number of cases analyzed (two); the impossibility of attending all the IT management teams' meetings; and the subjectivity of the researcher's impressions, opinions and thoughts. However, since it is very difficult to take part in many industrial scenarios, especially due to confidentiality reasons, the proposed approach might reflect the reality we observed.

A limitation in the practice is the fact that the approach was developed based on limited resources (a literature mapping, two surveys and two observational studies). To minimize such risks, we decided to evaluate our approach with real data and practitioners in a different industrial scenario (a Brazilian large banking organization). Another limitation is the number of participants that evaluated the approach (eight divided into two groups) and the context where the study was performed (more threats to validity are presented in Section 6.5). SECO management and monitoring mechanisms evaluated in the feasibility study refers to the context of IT managements activities, more specifically demand and solution analysis. Finally, there is no support for automating and/or optimizing decision making in software acquisition.

## 7.4 Future Work

Some opportunities were identified from this PhD thesis:

- Investigation of optimization strategies to support demand selection over uncertainty based on the applications' roadmaps in the SECO context;
- Investigation of transparency in demand and solution analysis, since one participant pointed it as a barrier for managing and monitoring SECOs;
- Integration of the proposed approach model with portfolio management and acquisition processes to evaluate its impacts over time;
- Evolution of *Brechó-EcoSys* (tool) to improve ease of use and usefulness considering the participants' feedback and our observations;
- Preparation and execution of other studies with a mass of practitioners (IT managers and architects) in open source SECO platforms, in global acquirers, and in other Brazilian acquirers;
- Investigation of knowledge management strategies and frameworks to evolve *SECO2M* model with mechanisms for automating some IT management activities and improving the support for the sense of community;
- Investigation of platform architecture evolution based on theoretical foundations and practice of systems-of-systems (SoS), since an acquirer's set of software assets can be seen as a SoS;
- Investigation of how quality assurance can be used as a mechanism to identify other SECO platform health indicators to aid demand and solution analysis.

In summary, this PhD thesis started with the problem formulation supported by the literature mapping and the studies conducted to rank the most critical SECO management and monitoring elements that affect IT management activities. The solution provided by the model built upon our initial studies encompasses IT governance, socialization in SE and SECO health, named *SECO2M*, and the final focus of this work was on its monitoring & analysis module, named *SECO-DSA*, responsible for supporting demand and solution analysis. It is important to mention that *SECO2M*'s strategy is to organize the SECO internal view over a software asset base, and to explore long-term rather than short-term goals. Several research questions still remain as future research beyond the ones briefly listed in this section. Despite several limitations of this work, this researcher believes that a long road is right ahead and the topic can contribute to SE area regarding the treatment of business and social challenges discussed by the research and industrial communities.

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# Annex 1 – Evaluation Instruments

This annex presets the instruments we used throughout the feasibility study activities, as explained in Section 6.2. They were prepared and applied in Portuguese.

## A1.1 Informed Consent Form

The informed consent form informs the study objective and participant's rights and responsibilities. It informs that collected data should not be used to evaluate participants' performances, and explains confidentiality terms. This form should be sent to participants before the execution. Each participant should sign and return with this document.

| **Investigação sobre Ecossistemas de Software**<br><br>**Termo de Consentimento Livre Esclarecido** |
|---|

**OBJETIVO DO ESTUDO**

Este estudo visa realizar uma investigação sobre Ecossistemas de Software.

**IDADE**

Eu declaro ter mais de 18 (dezoito) anos de idade e concordar em participar de um estudo conduzido por Rodrigo Pereira dos Santos da COPPE/UFRJ, sob a orientação da Profa. Cláudia Maria Lima Werner.

**PROCEDIMENTO**

A pesquisa será realizada em duas etapas. Na primeira etapa, pedimos que você responda sobre sua experiência em alguns temas. Assim, caso concorde em participar do estudo, realize esta primeira etapa respondendo ao questionário enviado.

Na segunda etapa (que será agendada diretamente com você), você será convidado a realizar algumas tarefas. Você receberá orientações sobre como realizar as atividades, bem como os dados de acesso para realização do estudo.

Para participar deste estudo solicitamos a sua especial colaboração em: (1) fornecer informações sobre sua experiência; (2) permitir que os dados resultantes da sua participação sejam estudados; (3) informar o tempo gasto nas atividades; e (4) responder um questionário final com as suas impressões. Quando os dados forem coletados, seu nome será removido destes e não será utilizado em nenhum momento durante a apresentação dos resultados.

Estima-se que para realizar a primeira etapa sejam necessários cerca de 5 (cinco) minutos e que para realizar a segunda etapa seja necessária aproximadamente 30 (trinta) minutos.

**CONFIDENCIALIDADE**

Eu estou ciente de que meu nome não será divulgado em hipótese alguma. Também estou ciente de que os dados obtidos por meio deste estudo serão mantidos sob confidencialidade, e os resultados serão posteriormente apresentados de forma agregada, de modo que um participante não seja associado a um dado específico.

Da mesma forma, me comprometo a não comunicar meus resultados enquanto o estudo não for concluído, bem como manter sigilo das técnicas e documentos apresentados e que fazem parte do experimento.

**BENEFÍCIOS E LIBERDADE DE DESISTÊNCIA**

Eu entendo que, uma vez o experimento tenha terminado, os trabalhos que desenvolvi serão estudados visando entender a eficiência dos procedimentos e as técnicas que me foram ensinadas.

Os benefícios que receberei deste estudo são limitados ao aprendizado do material que é distribuído e ensinado. Também entendo que sou livre para realizar perguntas a qualquer momento, solicitar que qualquer informação relacionada à minha pessoa não seja incluída no estudo ou comunicar minha desistência de participação, sem qualquer penalidade. Por fim, declaro que participo de livre e espontânea vontade com o único intuito de contribuir para o avanço e desenvolvimento de técnicas e processos para a Engenharia de Software.

**PESQUISADOR RESPONSÁVEL**

Rodrigo Pereira dos Santos (rps@cos.ufrj.br)
Programa de Engenharia de Sistemas e Computação - COPPE/UFRJ

**PROFESSORA RESPONSÁVEL**

Profa. Cláudia Maria Lima Werner (werner@cos.ufrj.br)
Programa de Engenharia de Sistemas e Computação - COPPE/UFRJ

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Data, nome do participante e rubrica

## A1.2 Characterization Form

The characterization form allows the researcher to analyze participants' profiles and also classify them into groups. This information is also used for analysis of results.

| **Investigação sobre Ecossistemas de Software**<br><br>**Formulário de Caracterização do Participante** | |
|---|---|
| **Código do Participante:** | |

Este formulário contém algumas perguntas sobre sua experiência acadêmica e profissional.

**1. Formação Acadêmica**

( ) Pós-Doutorado
( ) Doutorado concluído
( ) Doutorado em andamento
( ) Mestrado concluído
( ) Mestrado em andamento
( ) Especialização concluída
( ) Especialização em andamento
( ) Graduação concluída
( ) Graduação em andamento

Ano de ingresso: _________ Ano de conclusão/previsão de conclusão: ________

**2. Experiência Profissional**

**a) Grau de Experiência**
Por favor, indique o seu grau de experiência nas áreas de conhecimento a seguir, com base na escala abaixo:

| **Área de Conhecimento** | **Grau de Experiência** | | | | | |
|---|---|---|---|---|---|---|
| Engenharia de Software | 0 | 1 | 2 | 3 | 4 | 5 |
| Governança de TI | 0 | 1 | 2 | 3 | 4 | 5 |
| Gestão de Demandas e Soluções | 0 | 1 | 2 | 3 | 4 | 5 |
| Redes Sociais | 0 | 1 | 2 | 3 | 4 | 5 |
| Ecossistemas de Software | 0 | 1 | 2 | 3 | 4 | 5 |

**0** = nenhum *(nunca participou de atividades deste tipo)*
**1** = estudei em aula ou em livro *(possui conhecimento teórico apenas)*
**2** = pratiquei em projetos em sala de aula *(possui conhecimento teórico aplicado apenas no contexto acadêmico)*
**3** = usei em projetos pessoais *(possui conhecimento teórico somado de experiências práticas individuais)*
**4** = usei em poucos projetos na indústria *(possui conhecimento teórico somado de poucas experiências práticas reais)*
**5** = usei em muitos projetos na indústria *(possui conhecimento teórico somado de muitas experiências práticas reais)*

**b) Tempo de Experiência**

Por favor, detalhe sua resposta. Inclua o número de meses de experiência para cada uma das áreas de conhecimento.

| Área de Conhecimento | Tempo de Experiência (Meses) |
|---|---|
| Engenharia de Software | |
| Governança de TI | |
| Gestão de Demandas e Soluções | |
| Redes Sociais | |
| Ecossistemas de Software | |

## 3. Experiência com Ferramentas Similares

Esta seção será utilizada para compreender quão familiar você está com os tipos de ferramentas que serão utilizadas no estudo. Por favor, indique o seu grau de experiência seguindo a escala abaixo:

| Ferramenta | Grau de Experiência | | |
|---|---|---|---|
| Ferramentas de governança de TI | 0 | 1 | 2 |
| Ferramentas de gestão de ativos de software | 0 | 1 | 2 |
| Ferramentas de colaboração (redes sociais, fórum, lista, comunidade) | 0 | 1 | 2 |
| Ferramentas de visualização e análise de ecossistemas de software | 0 | 1 | 2 |

**0** = Eu não tenho familiaridade com este tipo de ferramenta.
**1** =Eu tenho alguma familiaridade com este tipo de ferramenta.
**2** = Eu tenho muita familiaridade com este tipo de ferramenta.
**Comentários:**

*Desde já, agradecemos a sua colaboração.*

Rodrigo Pereira dos Santos
Cláudia Maria Lima Werner

## A1.3 Execution Form

The execution form presents the context of the work and the proposed tasks. The participants are asked to play as they currently do in daily IT management team' activities within the large banking organization. This document is also used to collect answers for each task.

| **Investigação sobre Ecossistemas de Software**<br><br>**Formulário de Execução do Estudo** | |
|---|---|
| **Data:** | |
| **Código do Participante:** | |

**CONTEXTUALIZAÇÃO**
Você é um dos analistas de sistemas da sua organização, atuando na gestão de TI no seu dia a dia, mais especificamente na análise de demandas e soluções. Sua organização possui uma variedade de atividades executadas, visando atender aos seus objetivos de negócio. Para tanto, ela prescinde de software do tipo aplicação (e.g., CRM, automação). As aplicações, por sua vez, dependem de outras aplicações e de tecnologia de suporte (e.g., Java, Windows, DB2). Aplicações e tecnologias funcionando como 'componentes arquiteturais' em conjunto com os objetivos de negócio da organização, formando a arquitetura empresarial. A configuração desta arquitetura é alterada a cada nova demanda aprovada ou aplicação adquirida.
Como analista de sistemas atuante na equipe de gestão de TI, a sua tarefa principal é registrar e analisar todas as demanda solicitadas pelas diversas áreas de negócio da organização (unidades organizacionais), bem como avaliar software prospectado, desenvolvido ou comprado, incluindo seus fornecedores. Por meio destes registros, você realiza análises de dependência da empresa em relação a determinado fornecedor ou tecnologia, bem como da satisfação de objetivos de negócio a partir das suas aplicações. De acordo com estas características, é possível perceber que, sem um mínimo de organização, rapidamente o controle sobre estas informações pode se perder, deixando a organização à mercê das análises apresentadas pelas equipes de vendas dos fornecedores ao negligenciar o contexto interno.

**INSTRUÇÕES**
Para a execução desta atividade, siga as instruções abaixo.

- Resolva as tarefas do formulário **na ordem em que elas são apresentadas**.
- Registre o **horário de início** e o **horário de término** de cada atividade sempre que solicitado. Se for gasto algum tempo no entendimento do modelo antes das atividades, este tempo não deve ser contabilizado.
- **Caso não consiga determinar a resposta, mas tenha uma medida de quanto tempo levaria para executá-la, por favor, responda com o valor em questão e com a palavra "estimativa" entre parêntesis e some as estimativas ao horário de término.**

**TAREFAS**
Por favor, responda as seguintes questões:

| TEMPO | |
|---|---|
| **INÍCIO:** | |
| **TÉRMINO:** | |

A1) QUAIS SÃO OS OBJETIVOS DE NEGÓCIO REGISTRADOS PELA ORGANIZAÇÃO?
PERCEPÇÃO = ___ (0 - 10)

A2) QUE UNIDADE ORGANIZACIONAL É RESPONSÁVEL PELA DEMANDA DE AQUISIÇÃO DE SOLUÇÃO FISCAL E DE GESTÃO TRIBUTÁRIA ("Fiscal Management")?
PERCEPÇÃO = ___ (0 - 10)

A3) QUAIS SÃO AS TECNOLOGIAS REFERENTES ÀS LINGUAGENS DE PROGRAMAÇÃO ADOTADAS PELA ORGANIZAÇÃO?
PERCEPÇÃO = ___ (0 - 10)

A4) QUAIS SÃO AS TECNOLOGIAS QUE DÃO SUPORTE À APLICAÇÃO SISTEMA INTEGRADO DE RECURSOS LOGÍSTICOS?
PERCEPÇÃO = ___ (0 - 10)

A5) QUE OBJETIVOS ESTRATÉGICOS ESTÃO RELACIONADOS COM A DEMANDA CRM ("Customer Relationship Management")?
PERCEPÇÃO = ___ (0 - 10)

A6) QUAL O PERCENTUAL DE LICENÇAS DE SOFTWARE ADQUIRIDO OU DESENVOLVIDO QUE ESTÁ RELACIONADO DE ALGUMA FORMA COM O OBJETIVO ESTRATÉGICO 'AUMENTAR PRODUTIVIDADE'?
PERCEPÇÃO = ___ (0 - 10)

A7) QUE SUGESTÕES DE POTENCIAIS DEMANDAS ESTÃO SENDO DISCUTIDAS PELA SUPERINTENDÊNCIA DE CONTROLES INTERNOS, SEGURANÇA E GESTÃO DE RISCOS ("SuperGestãoRiscos")?
PERCEPÇÃO = ___ (0 - 10)

A8) QUAIS DEMANDAS DEVERIAM SER SELECIONADAS PARA INVESTIMENTO, CASO SE OPTE POR OBTER ALGUMA MELHORA NO GRAU DE SINERGIA DOS OBJETIVOS DE NEGÓCIO DA ORGANIZAÇÃO?
PERCEPÇÃO = ___ (0 - 10)

A9) PARA AS DEMANDAS DE AQUISIÇÃO DE (1) AUTOMAÇÃO ("Banking Automation") E (2) CRM ("Customer Relationship Management"), QUE SOLUÇÕES DE MERCADO SELECIONADAS REDUZIRIAM O GRAU DE DEPENDÊNCIA DE TECNOLOGIAS DA ORGANIZAÇÃO?
PERCEPÇÃO = ___ (0 - 10)

A10) AO SELECIONAR MICROSOFT CRM COMO SOLUÇÃO PARA A DEMANDA DE AQUISIÇÃO DE CRM ("Customer Relationship Management"), QUAL O IMPACTO GERADO SOBRE A SITUAÇÃO DO ECOSSISTEMA DA EMPRESA? QUER DIZER, A ORGANIZAÇÃO SE TORNA MAIS SUSTENTÁVEL, I.E., MENOS DEPENDENTE DE CERTAS TECNOLOGIAS EM RELAÇÃO DE OUTRAS E MAIS EQUILIBRADA NA SATISFAÇÃO DE SEUS OBJETIVOS DE NEGÓCIO?
PERCEPÇÃO = ___ (0 - 10)

*Obrigado pela sua colaboração.*

Rodrigo Pereira dos Santos
Cláudia Maria Lima Werner

## A1.4 Evaluation Form

The evaluation form consists of a questionnaire in which each participant should evaluate his/her study. Qualitative information on the study execution is collected, as well as suggestions of improvement for the approach and considerations regarding the experience in the study. There are two versions: one for those who should use the approach and another for those who should not.

### A1.4.1. Evaluation Form without the Approach

| **Investigação sobre Ecossistemas de Software**<br><br>**Formulário de Avaliação do Estudo** | |
|---|---|
| **Data:** | |
| **Código do Participante:** | |

Prezado(a) participante,
Esta é a última parte do estudo. O objetivo deste questionário é obter informações adicionais e a sua percepção sobre o estudo, a partir das respostas às questões listadas a seguir:

**1) Você conseguiu efetivamente <u>realizar</u> todas as tarefas propostas?**

( ) Sim ( ) Não

**Comentários:**

**2) Você ficou <u>satisfeito</u> com o resultado final das tarefas?**

( ) Sim ( ) Parcialmente ( ) Não

**Comentários:**

**3) No seu ponto de vista, a <u>visão de Ecossistemas de Software pode beneficiar ou apoiar atividadesde Gestão de TI, mais especificamente análise de demandas e soluções</u>?**

( ) Sim ( ) Parcialmente ( ) Não

**Comentários:**

**4) Qual o grau de dificuldade na realização das tarefas?**
( ) A execução das tarefas é muito difícil
( ) A execução das tarefas é difícil
( ) A execução das tarefas é fácil
( ) A execução das tarefas é muito fácil
**Comentários:**

**5) Qual a maior dificuldade encontrada na realização das tarefas?**
**Comentários:**

**6) Este espaço é reservado para quaisquer comentários adicionais (dificuldades, críticas e/ou sugestões) a respeito do estudo executado. Contamos com sua contribuição para que o trabalho seja aprimorado.**
**Comentários:**

*Novamente, gostaríamos de agradecer pela sua disponibilidade e participação neste estudo.*

Rodrigo Pereira Santos
Cláudia Maria Lima Werner

## A1.4.2. Evaluation Form with the Approach

| **Investigação sobre Ecossistemas de Software**<br><br>**Formulário de Avaliação do Estudo** | |
|---|---|
| **Data:** | |
| **Código do Participante:** | |

Prezado(a) participante,
Esta é a última parte do estudo. O objetivo deste questionário é obter informações adicionais e a sua percepção sobre o estudo, a partir das respostas às questões listadas a seguir:

**1) Você conseguiu efetivamente <u>realizar</u> todas as tarefas propostas?**

( ) Sim ( ) Não

**Comentários:**

**2) Você ficou <u>satisfeito</u> com o resultado final das tarefas?**

( ) Sim ( ) Parcialmente ( ) Não

**Comentários:**

**3) No seu ponto de vista, <u>é possível perceber como atividadesde Gestão de TI, mais especificamente análise de demandas e soluções, podem ser beneficiadas pela visão de Ecossistemas de Software</u> usando as informações apresentadas?**

( ) Sim ( ) Parcialmente ( ) Não

**Comentários:**

**4) Em que <u>tipo de empresa</u> você considera que a abordagem utilizada poderia agregar maior valor?**

( ) Empresa pequena
( ) Microempresa (Receita menor ou igual a R$ 2,4 milhões)
( ) Pequena empresa (Receita maior que R$ 2,4 milhões e menor ou igual a R$ 16 milhões)
( ) Média empresa (Receita maior que R$ 16 milhões e menor ou igual a R$ 90 milhões)
( ) Média-grande empresa (Receita maior que R$ 90 milhões e menor ou igual a R$ 300 milhões)
( ) Grande empresa (Receita maior que R$ 300 milhões)
**Comentários:**

**5) Qual o <u>grau de dificuldade</u> na realização das tarefas?**

( ) A execução das tarefas é muito difícil
( ) A execução das tarefas é difícil
( ) A execução das tarefas é fácil
( ) A execução das tarefas é muito fácil

**Comentários:**

**6) Qual a <u>maior dificuldade</u> encontrada na realização das tarefas?**

**Comentários:**

**7) Ferramenta *Brechó-EcoSys***

Por favor, indique o seu grau de concordância com as afirmações colocadas na tabela abaixo:

| Afirmação | Discordo totalmente | Discordo | Não concordo nem discordo | Concordo | Concordo totalmente |
|---|---|---|---|---|---|
| Foi fácil aprender a usar a EcoSys? | | | | | |
| Consegui utilizar a EcoSys da forma que eu queria? | | | | | |
| Entendi o que acontecia na minha interação com a EcoSys? | | | | | |
| Foi fácil executar as tarefas com o uso da EcoSys? | | | | | |
| Considero a EcoSys útil para gerenciamento e monitoramento de ecossistemas de software? | | | | | |
| A EcoSys permite perceber como as demandas e soluções da organização consumidora se relacionam a elementos do ecossistema de software (objetivos, fornecedores e tecnologias)? | | | | | |
| O uso da EcoSys melhorou o meu desempenho durante a execução das tarefas? | | | | | |
| A EcoSys apoia atividades de gestão de TI? | | | | | |

**Comentários:**

**8) Quais as funcionalidades da ferramenta *Brechó-EcoSys*que foram mais úteis na realização das tarefas?**
**Comentários:**

**9) De acordo com sua opinião, liste os aspectos positivos da utilização da ferramenta *Brechó-EcoSys*.**
**Comentários:**

**10) De acordo com sua opinião, liste os aspectos negativos da utilização da ferramenta *Brechó-EcoSys*.**
**Comentários:**

**11) Você possui alguma sugestão para melhoria da ferramenta *Brechó-EcoSys*? Em caso positivo, por favor, especifique-a(s).**

( ) Sim ( ) Não

**Comentários:**

**12) Quais conclusões ou observações você pode extrair sobre o grau de dependência tecnológica entre a empresa consumidora e as empresas fornecedoras?**
**Comentários:**

**13) Quais conclusões ou observações você pode extrair sobre o grau de sinergia de objetivos de negócio entre a empresa consumidora e suas demandas e soluções?**
**Comentários:**

**14) Este espaço é reservado para quaisquer comentários adicionais (dificuldades, críticas e/ou sugestões) a respeito do estudo executado. Contamos com sua contribuição para que o trabalho seja aprimorado.**
**Comentários:**

*Novamente, gostaríamos de agradecer pela sua disponibilidade e participação neste estudo.*

Rodrigo Pereira Santos
Cláudia Maria Lima Werner

## A1.5 Software Ecosystem Background

A palavra ecossistema foi utilizada pela primeira vez no ano de 1935, pelo ecólogo inglês Arthur George Tansley. Em seu artigo, Tansley discute o uso do termo “bioma” para definir o conjunto complexo de seres que habitam uma região e introduz o termo ecossistema, para que fosse considerada uma maior complexidade nas pesquisas desta área. Estas se concentravam somente no estudo dos componentes orgânicos, considerando-os a parte mais importante e desprezando os componentes inorgânicos, componentes físicos da região. Foi já no século XXI que os termos ecossistema e software se encontraram pela primeira vez. Mais precisamente em 2003, Messerschmitt e Szyperski lançaram o livro “Software Ecosystem: Understanding na Indispensable Technology and Industry”. Um dos exemplos é que um único computador de mesa, que geralmente vem com um conjunto padrão de software, pode atender às necessidades de alguns tipos de usuários. Esse conjunto de software poderia, por exemplo, vir deum único fornecedor, como a Apple, Microsoft, ou Oracle, ou mesclar componentes, produtos e serviços de diferentes plataformas e criados por diferentes desenvolvedores. Este pequeno exemplo destaca que uma rede de produção de software aparece e impacta o desenvolvimento de software, seja para empresas consumidoras ou produtoras de software e serviços.

Nesta pesquisa, o enfoque será agregar os estudos sobre Ecossistemas de Software com a visão da empresa consumidora de software, de como ela trata o software comprado ou desenvolvido internamente, bem como de como ela toma decisões de novas aquisições de software pensando na continuidade de suas operações e na sua capacidade de atender ao mercado. Organizações consumidoras enfrentam desafios em lidar com a gestão de TI em um mercado dinâmico onde a dependência de fornecedores e de tecnologias podem afetar o funcionamento das organizações que os adquiriram. A falta de gerenciamento das demandas de software pode impactar a sinergia dos objetivos da organização consumidora, de tal modo que as demandas selecionadas possam viabilizara aquisição de produtos que não contribuem para o negócio da organização como um todo, por exemplo. Esses fatores trazem complexidade adicional às tarefas das organizações consumidoras de analisar demandas e soluções rumo a uma gestão de TI sustentável, isto é, que apoie às suas atividades fim ao mesmo tempo em que equilibra a sua dependência externa e promove a satisfação dos seus objetivos. Os processos que uma organização consumidora utiliza para adquirir produtos visando apoiar suas atividades podem ser mais complexos quando se trata de uma empresa pública ou que seja obrigada a seguir normas sobre licitações e contratos, como a lei federal brasileira 8666 de 1993.

Uma organização consumidora típica possui estabelecido um conjunto de ferramentas (aplicações e tecnologias) para apoiar os seus processos e profissionais, e produz artefatos (utilizando esta estrutura) para atingir seus objetivos de negócio. Frente às contínuas demandas de software, a organização se vê em uma constante situação de análise de soluções em relação aos objetivos de negócio e à arquitetura tecnológica e do impacto que isto causará em seu orçamento e sustentabilidade. Algumas perguntas típicas tratariam aspectos como:

- Que aplicações vão sofrer impactos ao atender uma determinada demanda? Haverá recursos (humano, financeiro etc.) disponíveis para cobrir integrações, interfaces etc.?
- Que conjuntos de ferramentas apoiam determinado objetivo de negócio? Essas ferramentas são realmente indispensáveis aos negócios da empresa, ou parte delas poderia ser descontinuada?
- Qual o impacto de selecionar uma aplicação que requer uma dada tecnologia em detrimento de outra? A organização consegue continuar funcionando caso haja algum problema com alguma tecnologia de sua arquitetura?

Frente a isso, uma organização consumidora se prepara para os tipos de eventos citados ao se manter atualizada em relação aos acontecimentos do mundo ao seu redor. Atualmente, existem institutos de pesquisa e recomendação de TI, como Gartner e Forrester, que dedicam seus esforços a acompanhar este mercado. Eles funcionam como “conselheiros de TI” das organizações e seus “conselhos” são produzidos na forma de relatórios e gráficos gerados por processos de pesquisa. A metodologia do Gartner, por exemplo, é constituída a partir do refinamento de cenários de mercado; da condução de *surveys* com usuários de TI, fornecedores, investidores, profissionais da indústria e acadêmicos; de análises de padrões que emergem dos mercados; e do posicionamento técnico e mercadológico. O objetivo destes institutos é entregar uma visão para apoiar os clientes em decisões adequadas aos seus objetivos estratégicos.

Frequentemente, as análises feitas por esses institutos indicam uma orientação mais complexa do que “pule fora disto”, “invista naquilo” ou “esta é a melhor ferramenta para o seu problema”. Assim sendo, as organizações consumidoras precisariam ainda manter uma gestão de TI em um nível adequado, que fornecesse a visão da TI instalada na empresa e das demandas de suas diferentes unidades. Promover a comunicação e alinhamento entre as suas unidades organizacionais também seria útil para a troca de experiências e informações valiosas para uma análise de demandas que privilegie aquelas que promovam colaboração interna. A partir dessa visão e das informações da base de ativos de software, também conhecido como inventário ou catálogo de software, as organizações poderiam tentar antever ou minimizar os impactos de eventos como o anúncio de descontinuidade de determinada tecnologia ou a sensação de falta de sinergia entre o parque tecnológico e os objetivos de negócio, além de identificar oportunidades de aprimoramento dos negócios a partir de evoluções tecnológicas.

Percebe-se, portanto, que esta discussão transcende os limites da organização, seja ela consumidora ou fornecedora de software. As organizações envolvidas, suas relações e as informações trocadas entre elas são consideradas elementos de **ECOS (Ecossistemas de Software)**. Jansen et al. (2009c) definem um ECOS como um conjunto de atores funcionando como uma unidade e interagindo em um mercado compartilhado de software e serviços, centrados por uma plataforma tecnológica. Por sua vez, Bosch (2009b) considera um ECOS como um conjunto de soluções de software (i.e., plataforma) que apoiam e automatizam atividades e transações entre atores que estão associados a um ecossistema social ou de negócio. Do ponto de vista da organização consumidora que deseja gerenciar e monitorar a sua plataforma tecnológica, no caso, organizar e analisar a sua base de ativos de software e alinhá-la com seus objetivos de negócio e suas demandas, alguns questionamentos aparecem:

- Como avaliar se um ECOS contém as ferramentas e redes de fornecedores mais adequadas às suas demandas e objetivos de negócio?
- Como gerar e extrair o máximo de valor dos relacionamentos entre as partes do ECOS, sejam com fornecedores/ferramentas, ou entre as suas unidades?
- Como saber o momento de mudar de fornecedores ou alterar a sua plataforma tecnológica considerando o ECOS construído ao redor da organização?

Para melhorar a compreensão das recentes evoluções tecnológicas, a dinâmica das redes sociais e de novos modelos de comércio na internet, pesquisadores de ECOS têm se valido de analogias com Ecossistemas Biológicos a fim de fazer análises e comparar classificações e métodos das duas áreas, e.g., avaliar a sustentabilidade do ecossistema. Estes estudos têm se multiplicado nos últimos anos e as vantagens desta percepção e de novos métodos derivados delas estão sendo colocadas à prova a cada novo resultado divulgado. Explorando mais profundamente o assunto, Jansen et al. (2009c) especificam as fronteiras internas e externas de ECOS. A visão interna de um modelo de ECOS contém características como tamanho, tipos de atores, papéis, conexões etc. que definem a dinâmica e a identidade de um ECOS. Entre esses elementos, está a saúde do ECOS, i.e., a capacidade do EOS sobreviver frente a perturbações internas e externas, por exemplo, descontinuidade de uma tecnologia ou bancarrota de um fornecedor.

No entanto, um ECOS tem características externas que os identificam para o mundo exterior. Essas características permitem que outras organizações possam ter *insights* sobre os limites do ECOS, considerando suas principais características, potenciais oportunidades e análise de ameaças. Esta visão agrega valor de forma imediata para uma organização consumidora, a perspectiva externa em ECOS traz os seguintes limites:

| | |
|---|---|
| **Mercado** | ECOS podem ser centrados em mercados específicos, como o de Enterprise Resource Planning (ERP) ou o mercado de automação industrial. Esta perspectiva evidencia participantes que desenvolvem e fornecem produtos semelhantes, mas com diferente maturidade e preço, definidos como competidores. Sendo assim, esta visão fundamental para os consumidores. |
| **Tecnologia** | ECOS podem ser baseados em tecnologias específicas, tais como a linguagem de programação Java, ou um protocolo como SOAP ou IPv6. Esta perspectiva destaca ativos observáveis com aplicação definida. Esses ativos estão correlacionados e são organizados por taxonomias. |
| **Plataforma** | ECOS podem ser criados em torno de aplicações específicas, tais como a plataforma Eclipse, plataforma Microsoft CRM ou framework Ruby on Rails. Plataformas são caracterizadas por suas funcionalidades que pode ser estendidas com componentes ou via *Application Programming Interface* (API). As aplicações normalmente implementam tecnologias, ou dependem destas para cumprirem sua função. |
| **Organização** | ECOS também podem ser definidos em torno de uma organização, seja ela fornecedora ou consumidora de software. Entre as fornecedoras, estão Microsoft, Google ou SAP, com papel de orquestradoras de ecossistemas formados em torno de plataformas. Por outro lado, grandes organizações como Globo, Petrobrás ou Ministério da Educação atuam como consumidoras, cuja plataforma é formada pela sua base de ativos de software. |

## A1.6 Tool Guide

A biblioteca ***Brechó*** compõe o Projeto *Brechó* (*BRECHÓ*, 2010), desenvolvido pelo Grupo de Reutilização de Software da COPPE/UFRJ, que visa pesquisar tópicos relacionados a repositórios e à indústria de componentes e serviços. A biblioteca *Brechó* consiste em um sistema de informação web (repositório) com uma base de dados de componentes e serviços, produtores e consumidores, e conta com mecanismos de armazenamento, documentação, publicação, busca e recuperação. Esta biblioteca utiliza um conceito flexível de componente, que inclui todos os artefatos produzidos no desenvolvimento (processo, modelos, manuais, código fonte, binário, testes etc.) e, assim, permite diferentes conjuntos de artefatos empacotados ou disponibilizados como serviços (quando possível), atrelados a licenças personalizadas e configuráveis. A estrutura de documentação é fundamentada em categorias e formulários dinâmicos e configuráveis a elas associados, que favorecem a construção da documentação de componentes na forma de um mosaico, uma vez que estes podem pertencer a várias categorias ao mesmo tempo (SANTOS, 2010).

A biblioteca é organizada internamente em cinco níveis, sendo o primeiro denominado **Componente**, no qual os artefatos armazenados são representados conceitualmente. O segundo nível é **Distribuição**, que representa o conjunto de funcionalidades relacionadas aos artefatos armazenados, que podem ser obtidas pelos usuários. O terceiro nível é **Release**, que representa, temporalmente, as diferentes versões que um componente pode ter na biblioteca. No quarto nível estão **Pacotes e Serviços**, sendo Pacote responsável por possibilitar o agrupamento de diversos artefatos para atender a necessidade de um usuário, e Serviço, que possibilita a reutilização de uma *release* como serviços Web. Por fim, no último nível, tem-se **Licença**, que define os direitos e deveres sobre um artefato ao obtê-lo (Marinho et al., 2009).

A biblioteca *Brechó* recebeu extensões para acomodar as funcionalidades desenhadas na abordagem ***Brechó-EcoSys*** para atender ao gerenciamento e monitoramento de ECOS. Foram mapeadas classes de objetos entre ECOS e a *Brechó* estendida pela abordagem:

| ***Elementos de ECOS*** | ***Implementação na Brechó-EcoSys*** |
|---|---|
| Unidades Organizacionais | Usuários “time” |
| Redes Sociais | Painel “minhas redes” |
| Arquitetura Empresarial | Categorias “objetivos”, “demandas” e “tecnologias” |
| Objetivo, Demanda, Tecnologia | Componente/Distribuição/*Release*/Pacote ou Serviço |
| Saúde | Monitor de Sustentabilidade |

Apresentam-se algumas telas para facilitar a utilização das funções de **Gerenciamento de ECOS**, para apoiar a definição e modelagem de ECOScomo extensão da ferramenta *Brechó*, e de **Monitoramento de ECOS**, para apoiar a análise de redes como plug-in da ferramenta *Gephi*. A Figura 1 apresenta a tela principal da ferramenta *Brechó*, com o menu à direita que permite acessar às funcionalidades. A Figura 2 apresenta a tela com informações extraídas do ECOS da organização consumidora, com destaque para as informações de gestão de TI considerando a dependência de fornecedor e de tecnologia, bem como sinergia dos objetivos. A Figura 3 apresenta a tela dos mecanismos sociais de apoio à identificação de demandas pelas unidades organizacionais.

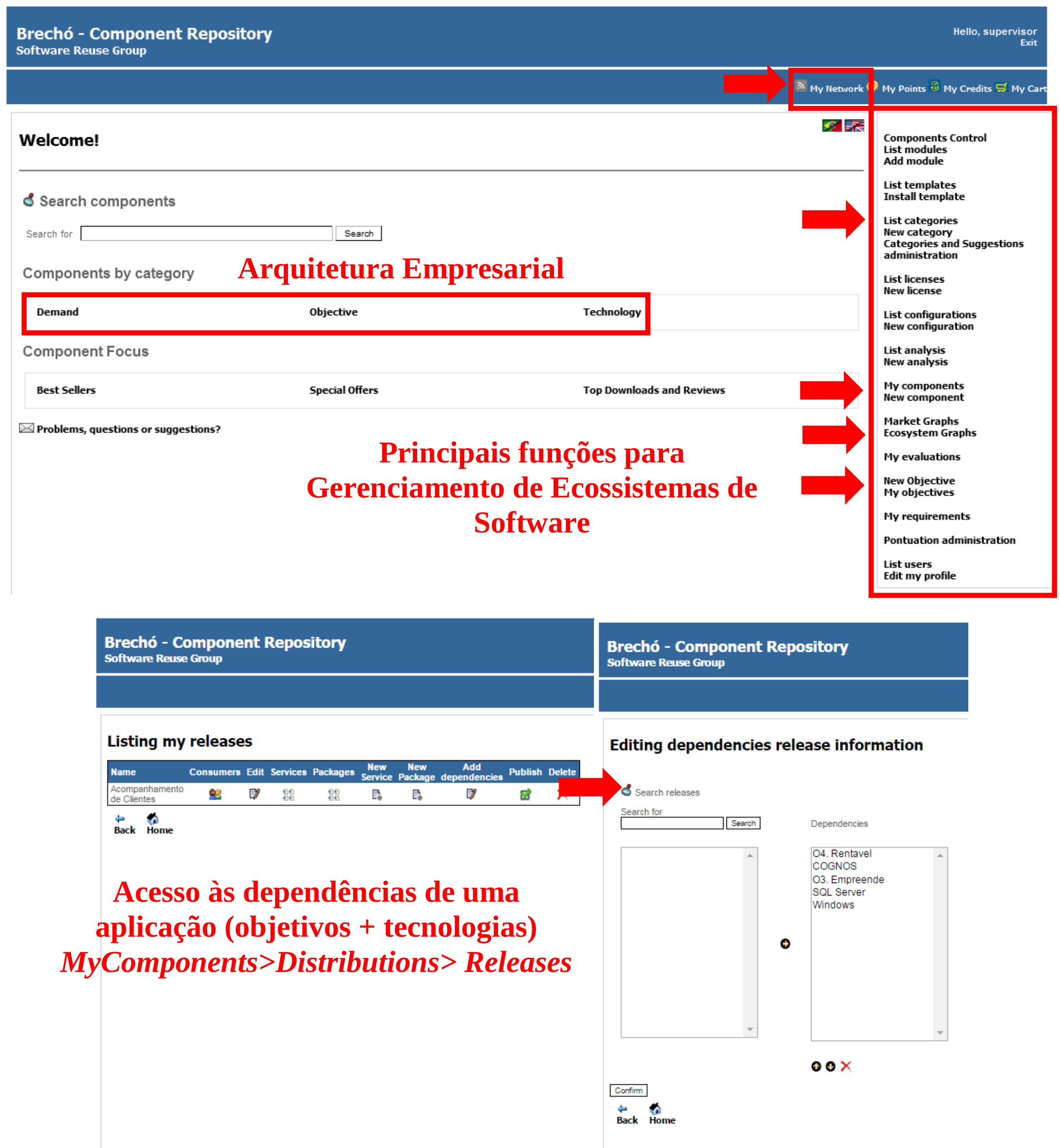


Figura 1. Tela inicial da *Brechó* estendida com menu de funcionalidades de gerenciamento do ECOS.

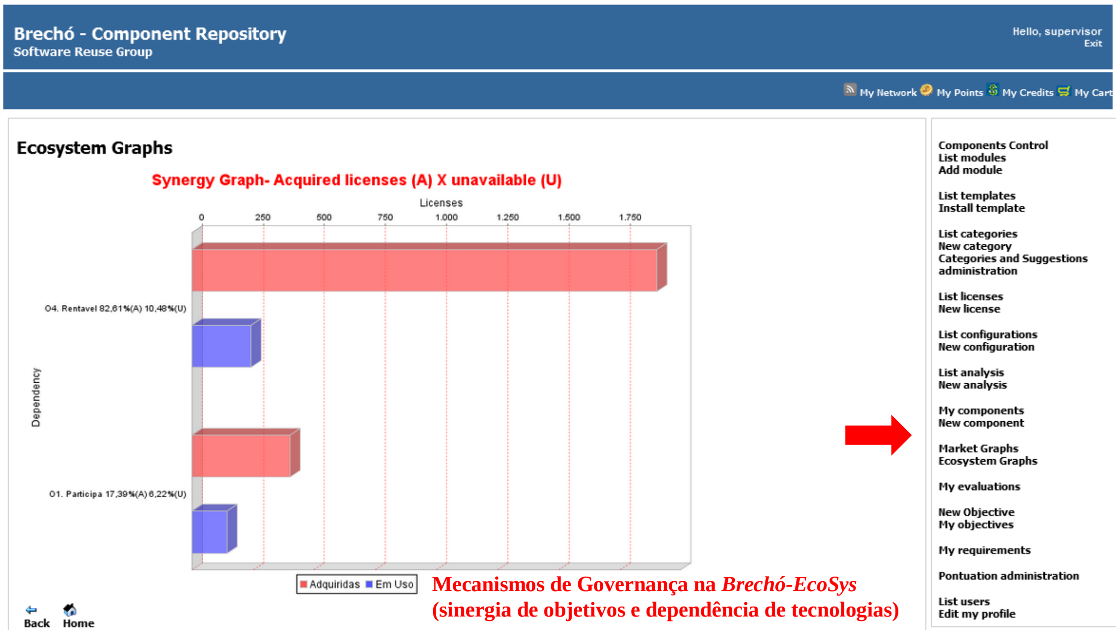


Figura 2. Tela de análise técnica de ECOS.

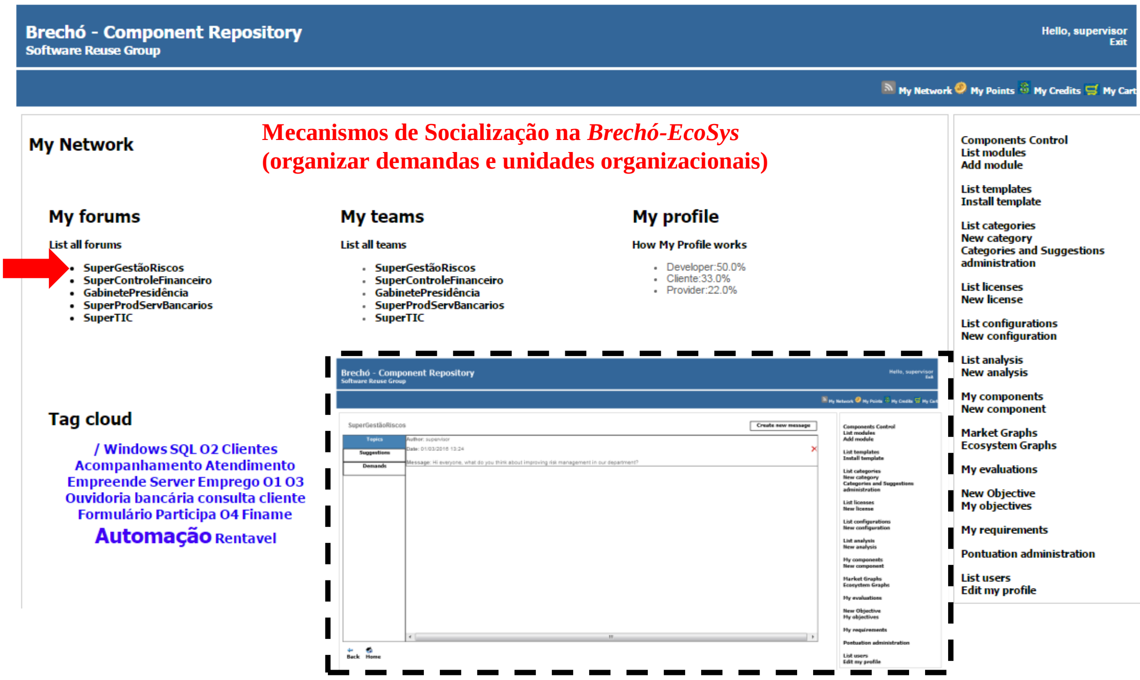


Figura 3. Tela de análise social no ECOS.

A Figura 4 apresenta a tela principal da ferramenta *Gephi* com o plug-in para análise da rede dos componentes da arquitetura empresarial com funções para monitoramento do ECOS e para a seleção de demandas e de soluções.

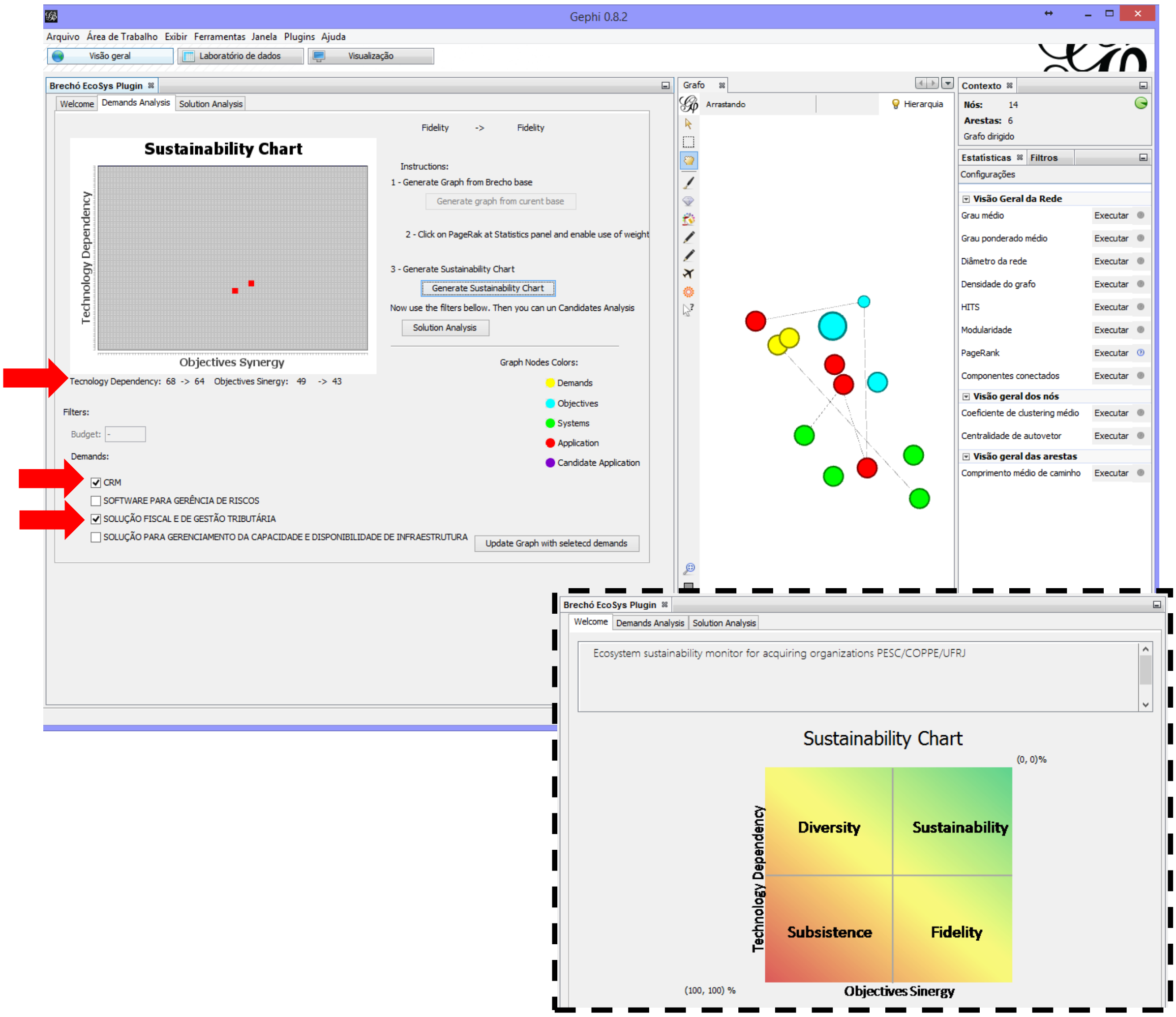


Figura 4. Tela inicial do *Gephi* estendido com menu de funcionalidades de monitoramento do ECOS.

# Annex 2 – Collected Data

As described in the study planning in Chapter 6, from the characterization data, participants were divided into two groups. The first group (*G1*) used the approach for executing the proposed tasks. Results were registered as shown in Table A2.1. The evaluation of the study is presented in Table A2.2.

Table A2.1. Results of tasks performed by *G1*'s participants

GROUP G1 - RESULTS

| ID | Time | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | Correct | Efficiency | Effectiveness | PA 1 | PA 2 | PA 3 | PA 4 | PA 5 | PA 6 | PA 7 | PA 8 | PA 9 | PA 10 | PA Average | Efficiency with weights | Effectiveness with weights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **P2** | 47 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 10 | 0,21 | 1,00 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 7 | 6 | 10 | 9,3 | 1,98 | 9,3 |
| **P4** | 55 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 9 | 0,16 | 0,90 | 10 | 10 | 5 | 3 | 9 | 7 | 10 | 9 | 2 | 5 | 7 | 1,15 | 6,3 |
| **P7** | 25 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | **0** | 9 | 0,36 | 0,90 | 8 | 9 | 8 | 8 | 6 | 8 | 8 | 7 | 7 | 5 | 7,4 | 2,66 | 6,66 |
| **P8** | 45 | 1 | 1 | 1 | **0** | 0 | 1 | 1 | 1 | 1 | 1 | 8 | 0,18 | 0,80 | 8 | 9 | 10 | 9 | 6 | 8 | 10 | 10 | 10 | 10 | 9 | 1,60 | 7,2 |

Table A2.2. Results of study evaluation performed by *G1*’s participants

EVALUATION - GROUP G1

| ID | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7a | Q7b | Q7c | Q7d | Q7e | Q7f | Q7g | Q7h | Q8 | Q9 | Q10 | Q11 | Q12 | Q13 | Q14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P2 | Y | y | y | LC | E | Graphic manipulation. | A | A | A | A | A | TA | A | TA | Graphic Manipulation. | Useful information for decision-making; compile different aspects | Low difficult degree but decreasing after some tasks. | | High dependency level. | Demands and solutions should be aligned with business objetives so as to leverage the business objetive's synergy. | |
| P4 | Y | P | Y | LC | E | I spoke a lot, simple questions, it's missing some contextualization, and I had an appointment later. | A | NAND | TA | A | A | A | D | A | Graphic Visualization to better realize my tasks (analysis). | Play with scenarios (create and simulate) | Lacking usability (intuition in Brechó) and big expectations (Gephi). | Yes, provided in other answers. | Public companies in Brazil (law 8666) make it hard to make decisions over applications licenses. Technology degree should consider integration issues (high platform vs low platform) to prioritize strategic planning | How to realize the relations among objetives? | |
| P7 | N | Y | Y | LC | E | High learning curve, many information. | A | NAND | A | A | A | A | NAND | A | Sustainability analysis. | Usability. | Time. | No. | | | |
| P8 | Y | Y | Y | ML | D | It was difficut to find the information I needed. | A | A | A | NAND | A | TA | A | TA | Demand and objective control. | Manage organizational demands and strategic objetives | Usability. | Yes. Usability. | Dependency degree is a real problem. It's hard to solve. | There is a dependency between business objectives and solution demands. | Usability. |
| | | | | | | | | | | | | | | | | | | | | | |
| Y | 3 | 3 | 4 | | | M3 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 2 | | | | | | | |
| N | 1 | 0 | 0 | | | M4 | 4 | 2 | 3 | 3 | 4 | 2 | 2 | 2 | | | | | | | |
| P | 0 | 1 | 0 | | | M5 | 0 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | | | | | | | |
| | | | | | | M6 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | | | | | | | |
| | | | | Very Difficult | 0 | M7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | | |
| | | | | Difficult | 1 | TA | | | | | | | | | | | | | | | |
| | | | | Easy | 3 | A | A | | A | A | A | A | A | A | | | | | | | |
| | | | | Very Easy | 0 | NAND | | NAND | | | | | | | | | | | | | |
| | | | | | | D | | | | | | | | | | | | | | | |
| | | | LC | 3 | | TD | | | | | | | | | | | | | | | |
| | | | ML | 1 | | | | | | | | | | | | | | | | | |
| | | | MC | 0 | | | | | | | | | | | | | | | | | |
| | | | PE | 0 | | | | | | | | | | | | | | | | | |
| | | | MI | 0 | | | | | | | | | | | | | | | | | |
| | | | SC | 0 | | | | | | | | | | | | | | | | | |

The second group (*G2*) did not use the approach for executing the proposed tasks. Results were registered as shown in Table A2.3. The evaluation of the study is presented in Table A2.4.

Table A2.3. Results of tasks performed by *G2*'s participants

**GROUP G2 - RESULTS**

| ID | Time | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | Correct | Efficiency | Effectiveness | PA 1 | PA 2 | PA 3 | PA 4 | PA 5 | PA 6 | PA 7 | PA 8 | PA 9 | PA 10 | PA Average | Efficiency with weights | Effectiveness with weights |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 | 18 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 6 | 0,33 | 0,6 | 9 | 6 | 9 | 7 | 0 | 7 | 5 | 8 | 0 | 0 | 5,1 | 1,70 | 3,06 |
| P3 | 43 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 7 | 0,16 | 0,7 | 10 | 5 | 7 | 5 | 5 | 9 | 7 | 10 | 7 | 7 | 7,2 | 1,17 | 5,04 |
| P5 | 13 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 2 | 0,15 | 0,2 | 10 | 10 | 10 | 10 | 10 | 7 | 10 | 10 | 0 | 7 | 8,4 | 1,29 | 1,68 |
| P6 | 17 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 6 | 0,35 | 0,6 | 4 | 8 | 10 | 9 | 9 | 4 | 6 | 7 | 9 | 9 | 7,5 | 2,65 | 4,5 |

Table A2.4. Results of study evaluation performed by *G2*'s participants

**EVALUATION - GROUP G2**

| ID | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 |
|---|---|---|---|---|---|---|
| P1 | Y | P | Y, Understanding this synergy helps the organization to reach objectives based on right IT efforts. | E | Terminology | |
| P3 | Y | Y | Y | D | There is a lack of transparency regarding demands selection and prioritization inside the organization. | |
| P5 | Y | P, I wasn't sure of some answers. | Y | D, a deep analysis is required regarding some answers. | Many tasks are time consuming. | The subject is highly important and relevant for an organization. |
| P6 | N, it's very hard to get this kind of information without requesting someone else. | Y, I am now aware of how difficult is to acquire software considering the organizational environment. | Y, it introduces a new perspective of long term thinking. | D | It was difficult to remember indispensable information for decision making. | |
| | | | | | | |
| Y | 3 | 2 | 4 | | | |
| N | 1 | 0 | 0 | | | |
| P | 0 | 2 | 0 | | | |
| | | | | | | |
| | | | VD | 0 | | |
| | | | D | 3 | | |
| | | | E | 1 | | |
| | | | VE | 0 | | |