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SECO-AM: AN APPROACH FOR MAINTENANCE OF IT ARCHITECTURE IN SOFTWARE ECOSYSTEMS

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For my dear grandmother Maria Luiza Pinheiro (*in memoriam*)...

I love and miss you deeply.

Para minha querida avó Maria Luiza Pinheiro (*in memoriam*) ...

Eu amo e sinto sua falta profundamente.

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SECO-AM: UMA ABORDAGEM PARA MANUTENÇÃO DA ARQUITETURA DE TI EM ECOSSISTEMAS DE SOFTWARE

Thaiana Maria Pinheiro Lima

Março/2018

Orientadores: Cláudia Maria Lima Werner
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Programa: Engenharia de Sistemas e Computação

Organizações adquirentes ou fornecedoras de software compõem um Ecossistema de Software (ECOS). Os sistemas utilizados pela organização para alcançar seus objetivos e processos de trabalho são apoiados por tecnologias incluídas na plataforma tecnológica de seu ECOS, e.g., bancos de dados e servidores web. Modificações nessas tecnologias podem levar sistemas essenciais a ficarem sem suporte ou a perderem desempenho. É relevante que informações sobre tecnologias e seus relacionamentos sejam consideradas pelo gerente de TI. No entanto, tais informações podem estar em diferentes documentos e serem difíceis de analisar devido à falta de suporte. O objetivo deste trabalho é auxiliar a tomada de decisão na modificação da arquitetura de TI, i.e., o conjunto de tecnologias de suporte aos produtos e serviços da organização. Dois estudos exploratórios indicaram características que auxiliam na manutenção, e.g., visualização de redes do ECOS e utilização de critérios bem definidos. Nesse sentido, foram investigados fatores críticos para manutenção da arquitetura de TI por meio de um mapeamento da literatura e pesquisa de opinião com especialistas. Uma abordagem que apoia esta comparação e análise foi desenvolvida, observando a estrutura da rede que representa o ECOS da organização. Um protótipo implementando as principais características da abordagem foi desenvolvido e um estudo de viabilidade foi executado, obtendo *feedback* positivo sobre a relevância da abordagem e dos recursos do protótipo.

Abstract of Dissertation presented to COPPE/UFRJ as a partial fulfillment of the requirements for the degree of Master of Science (M.Sc.)

SECO-AM: AN APPROACH FOR MAINTENANCE OF IT ARCHITECTURE IN SOFTWARE ECOSYSTEMS

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March/2018

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Software acquirer or supplier organizations compose a Software Ecosystem (SECO). The systems used by an organization to achieve its objectives and work processes are supported by technologies included in the SECO's technology platform, e.g., databases and web servers. Modifications on these technologies can lead to essential systems becoming unsupported or losing performance. Thus, IT managers should consider information about technologies and their relationships. Such information may be spread in different documents and difficult to analyze due to the lack of support. The purpose of this research is to assist IT managers and architects in making decisions regarding the IT architecture modification, i.e., the set of technologies supporting products and services adopted by an organization. Two exploratory studies have indicated features to assist in maintenance, e.g., visualization of SECO networks and use of well-defined criteria. From those studies, we investigated critical factors for maintaining the IT architecture through a literature mapping and an expert opinion survey. As a result, we developed an approach to support technology assessment and analysis by looking at the network structure that represents the organization's SECO. A prototype implementing the key features of the proposed approach was developed. We evaluated both approach and prototype based on a feasibility study, obtaining positive feedback on the approach's relevance and prototype's resources.

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Abbreviations

API	Application Programming Interface
BPMN	Business Process Model and Notation
COTS	Commercial Off-The-Shelf
GOTS	Government Off-The-Shelf
GQM	Goal-Question-Metric
ISO	International Organization for Standardization
IEC	International Electrotechnical Commission
ISV	Independent Software Vendor
IT	Information Technology
ICSOB	International Conference on Software Business
IWSECO	International Workshop on Software Ecosystems
FD	Full Development
LOC	Lines Of Code
MOTS	Modifiable Off-The-Shelf
MPS	Melhoria de Processo de Software (Software Process Improvement)
OSE	Open Software Ecosystem
PR	PageRank
RQ	Research Question
SECO	Software Ecosystem
SSN	Software Supply Network
WEA	Workshop on Ecosystem Architectures
WDES	Workshop on Distributed Software Development, Software Ecosystems and Systems-of-Systems

Chapter 1 – Introduction

This chapter aims to present the context, motivation, and problem addressed in this research. In addition, we explain the goals and the methodology adopted to achieve those goals, as well as the research structure.

1.1 Context

Software acquiring organizations generally have an IT to plan and establish which technologies they adopt or standardize to support their applications (i.e., software products and services). IT architecture is a list of technologies to be used as standard within the organization (ROSS, 2013), often classified according to a category (technology categories used by the organization, such as database, programming language, among others). In addition, IT architecture contributes to meet organizational business demands through a set of technical decisions (WEILS & ROSS, 2004). Architecture modifications may involve adopting a new technology, removing part of the architecture, or replacing technologies an organization already uses. Changes in such architecture are not trivial as they affect the development or acquisition of new applications that must be adherent to IT architecture, e.g., new software development projects should use existing technological standard according to the IT architecture.

In addition, they may reflect on development team's training needs regarding the new technology, aversion to changes and switching licensing costs, or even applications that depend on discontinued technology (LAGERSTRÖM et al., 2014). Because of rapid technological evolution, organizations frequently need to update and reevaluate their IT architecture. Evaluating the technology in relation to pre-established, manageable, and well-structured criteria provides greater transparency to the process, as the IT managers and architects should be able to check/audit the adopted criteria. In (LAGERSTRÖM et al., 2014), one of the most successful actions pointed out by companies is to use a well-defined procedure for IT acquisition. Part of the definition of that procedure is to establish evaluation criteria for technology selection (SHAFIA et al., 2015).

Hence, an organizational platform is maintained through sustaining a set of technologies employed by an organization's teams. The context in which decisions regarding platform maintenance becomes more complex as third parties have greater influence in the organization, and its boundaries become more blurred due to relationships with external organization and developers. Such context reflects Software Ecosystem (SECO) problems since they handle internal and external parties. SECO consists of a set of actors, software artifacts, a common technological platform, and their relationships (JANSEN et al., 2009). A keystone is the central organization in a SECO. Part of the elements a keystone controls is the set of technologies used to maintain a SECO platform based on its architecture. The keystone's IT management team is responsible for maintaining the SECO's applications and their supporting technologies according to business (or community) and technical needs.

1.2 Motivation

The problem of choosing which technology to introduce, discontinue, or replace in the platform architecture affects software governance and development process. A keystone may disrupt its network, loose players and break dependencies. However, a right choice can improve relationships and reduce costs with training and licensing, for example. In order to choose a given technology, IT managers and architects need to understand what requirements and quality attributes should be addressed. Often, they make decisions together as an IT management team.

As a result, the organization would have a minimum set of criteria to be used in the technology selection activity. A difficulty faced by an IT architect is that quality attributes are not always clearly specified in the requirements, or even sufficiently captured by requirements engineering teams (GORTON, 2011). Exploring SECO literature, it was noticed a lack of studies that investigate the context of selecting technologies to acquire or discontinue, considering an organization's SECO. It is aggravated by the common sense that practitioners often lack a formal procedure for acquiring or removing technologies, or even for analyzing the impact this procedure may have on other applications an organization uses.

1.3 Problem

Forming and sustaining a SECO is a challenge that includes more than technical problems: organizational and business concerns are also defiant (SADI & YU, 2015). Maintaining a platform is one of the existing activities for sustaining a SECO, since this context aggravates the problem of identifying, obtaining, and analyzing data that influence IT architecture maintenance. In addition, it is also necessary to know what impact such change brings to the organization's SECO in terms of critical issues, such as costs, integration problems, technology dependencies, and different types of license. The problem addressed in this research refers to the identification of critical factors for evaluating candidate technologies in SECO.

Revisiting an organization's IT architecture is necessary to maintain the technological platform. Moreover, it is a particular challenge considering that a SECO involves elements that interact outside the organization scope, e.g., applications, technologies, internal and external developers, suppliers, and users. There are critical factors for the maintenance of an IT architecture, from organizational or technical nature, not identified or used together in the SECO context. Those critical factors often are not clear as to their description, possible qualities, and analysis. Each critical factor may be specified in attributes so that it is better comprehended through many perspectives of the same critical factor. Those attributes are sub characteristics tied to a critical factor.

For public companies, this problem has even more restrictions, such as adherence to governmental norms and standards, current legislation, electronic procurement process with less control over technology selection processes, and budget. Private organizations usually have more freedom to choose technologies and applications. However, both types of organizations face the problem of lacking indications to guide technologies' modification to maintain IT architecture (and how to collect them).

1.4 Objectives

This work aims to develop an approach to support the IT management team on maintaining an organizational platform based on IT architecture through technology selection process and impact analysis regarding the organization's arrangement and strategy, from the SECO perspective. There are alternatives for representing a SECO network, e.g., Software Supply Networks (SSN), Graphs Theory, and i* modeling, although only SSN is specifically designed for SECO (SADI & YU, 2015).

It is necessary to analyze the sociotechnical network based on a modeling representation, which characterizes relationships within a SECO so that an IT manager/architect can clearly decide which technology is more beneficial to the organization at the time of selection (for acquisition, modification or discontinuation), or in a near future. The objective is not to be limited by a specific SECO environment, such as mobile or cloud, but to have a broad range so that it benefits IT managers and architects in different domains.

The specific goals to address problems and needs described in this chapter are:

- Identification and validation of critical factors and their attributes for selecting technologies, providing an auditable, explicit, and general evaluation criteria based on a literature mapping study1 and a survey with experts;
- Analysis of an acquisition process in order to adapt it for technology selection and SECO concerns;
- Use of graphs as a SECO representation and analysis method;
- An approach for comprising the goals presented above (solution); and
- A tool support for implementing the proposed solution.

1.5 Research Methodology

This research followed the methodology shown in Figure 1.1. Literature mapping and survey studies sustained the solution's conception and a feasibility study were used as procedures for evaluating the proposed solution and the supporting tool.

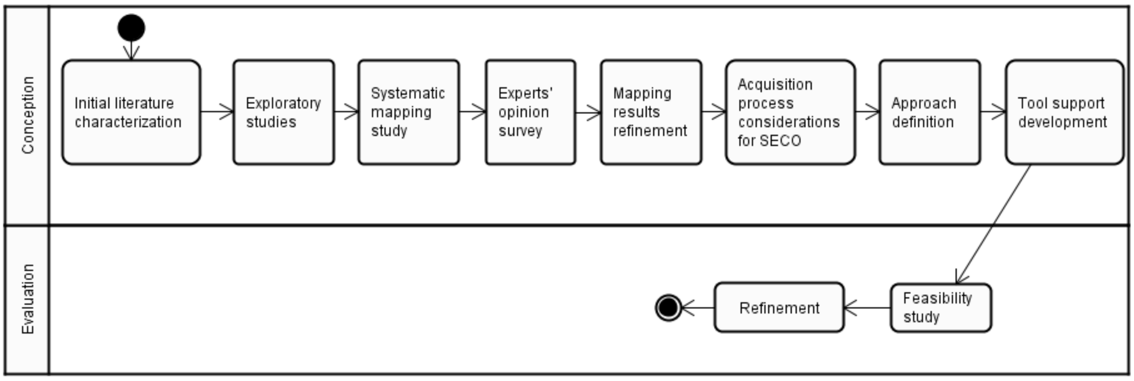

Figure 1.1. Research methodology

Each activity from Figure 1.1 is described as follows:

- **Initial literature characterization**: In this phase, the literature on SECO was studied and some research challenges were identified, mainly covering the

[1] Systematic Mapping Study: A mapping study gathers a list of research papers in a topic. This type of literature review mainly focuses on structuring a research area. Hence, it offers a general idea of the research area scope. Besides, it also aids the determination of research gaps and tendencies (PETERSON et al., 2015).

following topics: technology selection, quality measures for the SECO context, SECO health, software product quality, and SECO characteristics and classification;

- **Exploratory studies**: Two previous studies were conducted and some lessons were observed from their results. Some resources were investigated to be used in SECO. In addition, sociotechnical networks were used in the SECO monitoring, indicating positive effect on supporting this activity;
- **Systematic mapping study:** The author of this Master thesis took part of a PhD student's mapping study regarding SECO architectures at the same research group. We participated in reading studies resulting from the search string. The mapping study was executed for characterizing SECO attributes related to SECO architecture (and its elements, e.g., platform and technology). This mapping study was executed again for this research to update the results to include as many 2016 publications as possible;
- **Experts' opinion survey:** Based on the literature mapping results, a survey was conducted to obtain SECO and IT architecture experts' opinions on the identified attributes;
- **Mapping results refinement:** Opinions collected from the survey supported the results' refinement; some attributes were removed, included, or moved to another critical factor;
- **Acquisition process considerations for SECO:** The acquisition process presented in the Brazilian Software Process Improvement Model – called MPS (SOFTEX, 2013) – was analyzed and observations were extracted to cover SECO particularities. MPS is a set of guidelines aiming to improve Brazilian software processes based on CMMI's and ISO's recommendations;
- **Approach definition**: This activity aimed to define an approach for implementing the proposed acquisition process considering SECO concerns as well as the results obtained from exploratory and survey studies. Based on the proposal solution, an approach design was defined and specified;
- **Tool support development:** A tool support was developed after adapting an existing reusable components library, called Brechó-EcoSys (SANTOS & WERNER, 2011), based on Java and graph algorithm APIs. This tool has functionalities that allow it to build a representation for the SECO network

structure, e.g., registering applications, technologies (candidates or not) and dependencies as library's components. This network is analyzed before and after choosing a given technology so that it is possible to assess any related impact on the SECO;

- **Feasibility study**: A evaluation was performed with the proposal of evaluating the tool support to assess its feasibility and also the approach's contribution, as well as to collect suggestions of improvements on its functionalities and usability; and
- **Refinement**: After analyzing the results of the feasibility study, the proposed approach was refined and the tool's functionalities modified to better suit the practitioners' context.

1.6 Organization

This Master thesis is organized in eight chapters. In this chapter, the context of this work is presented, as well as the motivation and problem this research addresses. Objectives are defined and the methodology to reach those objectives is explained.

Chapter 2 presents a discussion on the main topics of this research that serve as background to develop an approach for supporting the problems described in Chapter 1. Furthermore, the SECO literature is discussed, key concepts and representation are presented, and technology management based on technology selection in SECO platform is explored.

Chapter 3 describes two exploratory studies where it was possible to better understand some resources and analysis that can be applied to a SECO context. Those resources are based on the social network theory and help SECO actors to find information and artifacts they are searching for in a component library. The negotiation decision process between a software artifact's seller and buyer was explored. From those studies, it was possible to realize many challenges when handling software artifacts in a SECO, e.g., difficulty of finding information about the artifact that is not provided by known suppliers; importance of having a sense of the community opinion; and lack of sociotechnical resources to support users to communicate among them and with the keystone.

Chapter 4 explores the planning, execution, and analysis of a literature mapping study. This study aims to collect data on how a technology can be assessed to be adopted or discontinued from the SECO literature and considering the architecture perspective. The main finding is a list of criteria that serves as a baseline for technology comparison based on literature rather than having different criteria for each decision-maker.

Chapter 5 evaluates the results described in Chapter 4 based on a survey with experts on SECO and IT architecture. The list of criteria was adapted from the experts' recommendations, adding, removing, and changing criteria to another critical factor.

Chapter 6 describes the proposed approach to reach the objectives presented in Chapter 1. The approach aims to support an IT management team to maintain the set of technologies that sustains a SECO platform. Lessons from the exploratory studies were used to benefit the approach with both social and technical features, as well as the results from Chapter 5 with the refined set of criteria. In addition, a tool support was developed and described in this chapter.

Chapter 7 explains how the proposed approach and tool support were evaluated. A feasibility study was conducted with a large organization's IT management team members. Data from a large software development project was used and those professionals executed pre-established tasks and answered a questionnaire. Based on the results, the proposed approach was refined.

Chapter 8 concludes this Master thesis with some final considerations. Contributions to the state of the art and to IT practitioners are discussed, as well as the research limitations. Future work is also presented in this chapter.

Chapter 2 – Background

To address the problem exposed in Chapter 1, this chapter presents the main areas that ground the search for a solution and other topics addressed in this work. Concepts about software ecosystems (SECO), technology selection and platform maintenance based on IT management are essential to the development of an approach to support SECO platform maintenance.

2.1 Introduction

Software acquiring organizations use a variety of processes to organize and select software products and services from the market to develop, acquire, or sell IT solutions to their clients in accordance with the organization's strategic objectives. These processes influence other organization's dimensions, e.g., political, economic, and technical. The acquisition process particularly affects a software organization's technological architecture (i.e., standard listing of specific technologies to be used in the organization) because such process helps adoption/discontinuity of technologies that support the organization's software products. This is hard to handle when it includes supporting technologies, e.g., database management system, virtual machines, over which other applications are executed.

Those technologies are not isolated within their institutional boundaries (especially in a SECO) and generate a sociotechnical network that can aid to decide whether to insert/remove technologies into/from the organization's platform. When choosing to acquire a supporting technology, an organization is also choosing to which SECO it will be integrated. To achieve better results in selecting such technologies, a large set of information is needed regarding technology dependencies and their relationships with other software products and services, as well as data on SECO elements, e.g., licenses, number of actors using the technology, etc. This information may be spread throughout the organizational sectors and the underlying network, or they may not have registered indications where the technology modification could affect the organization, such as costs or the need for training.

This chapter is structured as follows: Section 2.2 presents the main concepts from SECO literature used to for the background for this research; Section 2.3 discuss some aspects of SECO platform maintenance and the role technologies have in the platform; Section 2.4 present steps necessary for software and technology's acquisition; and Section 2.5 concludes the chapter.

2.2 Software Ecosystem

Once an organization ‘opens’ its platform beyond organizational boundaries by making them available under a common technological platform and interacting with external actors, a SECO is formed (BOSCH, 2009). In addition, an organization reaches external partners exchanging technical artifacts, creating value and connections (such as dependencies). Thus, a SECO encompasses not only the organization and its products, but also other organizations (e.g., partners and suppliers) based on a SECO common technological platform.

2.2.1. Definitions

A systematic literature review (MANIKAS & HANSEN, 2013) gathered different definitions from the SECO literature, as reproduced in Table 2.1. From those definitions, MANIKAS & HANSEN (2013) identified three essential concepts: Business (expressed as 'set of business' or 'community of users'), Common Software (expressed as common technological platform), and Connecting Relationships.

Table 2.1. Definitions for SECO. Source: (MANIKAS & HANSEN, 2013)

Authors	Definition
MESSERSCHMITT & SZYPERSKI (2003)	“a software ecosystem refers to a collection of software products that have some given degree of symbiotic relationships.”
JANSEN et al. (2009) (most cited definition)	“We define a software ecosystem as a set of businesses functioning as a unit and interacting with a shared market for software and services, together with the relationships among them. These relationships are frequently under-pinned by a common technological platform or market and operate through the exchange of information, resources and artifacts.”
BOSCH (2009)	“A software ecosystem consists of the set of software solutions that enable, support and automate the activities and transactions by the actors in the associated social or business ecosystem and the organizations that provide these solutions.”
BOSCH AND BOSCH-SIJTSEMA (2010a; 2010b)	“A software ecosystem consists of a software platform, a set of internal and external developers and a community of domain experts in service to a community of users that compose relevant solution elements to satisfy their needs.”
LUNGU et al. (2010)	“A software ecosystem is a collection of software projects which are developed and evolve together in the same environment.”

From this compilation, it is noticed that the concepts have different dimensions at the same time, i.e., social, business, and technical. Relationships and communities are features that differentiate SECO from traditional environments, as they have concerns about external partners and developers outside an organization.

2.2.2. Constituent Elements

SECO is essentially formed by relationships. There is a set of elements that configure a SECO as they form relationships: a common technological platform to support software development, e.g., Java platform supporting development of applications in Android SECO; actors inside and outside an organization, e.g., user, technology's suppliers, and external and internal developers; and SECO assets, e.g., developed applications, documentation, videos, pattern specification, software components etc.

The **common technological platform** comprises the core software technology on which a SECO is built and maintained (MANIKAS & HANSEN, 2013), e.g., Eclipse, Windows, and SAP. A real example is the iPhone environment where the actors are Apple, users, internal and external developers; and iOS is the core software technology, i.e., the common technological platform on which the applications are built.

An **actor** (LIMA et al., 2014) can play a variety of roles, e.g., a company (or other types of organizations), a company's sector, end user, supplier, client, and a project team. Depending on the relationship being analyzed, the same actor may play a distinct role, e.g., an actor may be a component supplier and an application end-user within the same SECO. There are many types of actors. Figure 2.1 illustrates three types of actors' roles extracted from the literature (LIMA et al., 2013; 2014).

Niche players are actors who are internal to an organization and can perform a variety of activities, e.g., selling, purchasing, and developing. They are classified into different types according to their activities. Actors that work outside the organization are labelled as external actors and may change the platform by developing on their own, e.g., developing a mobile application for only later submit it to the marketplace or unofficial means of distribution. Nonetheless, that may happen under the organization demand, e.g., an organization hires an independent development and provides requirements. The actors that heavily influence a SECO are known as hubs. The main hubs are keystone (wants the SECO to grow) and dominator (wants the SECO to fail), e.g., in Android SECO, Google is the keystone and Apple is the dominator.

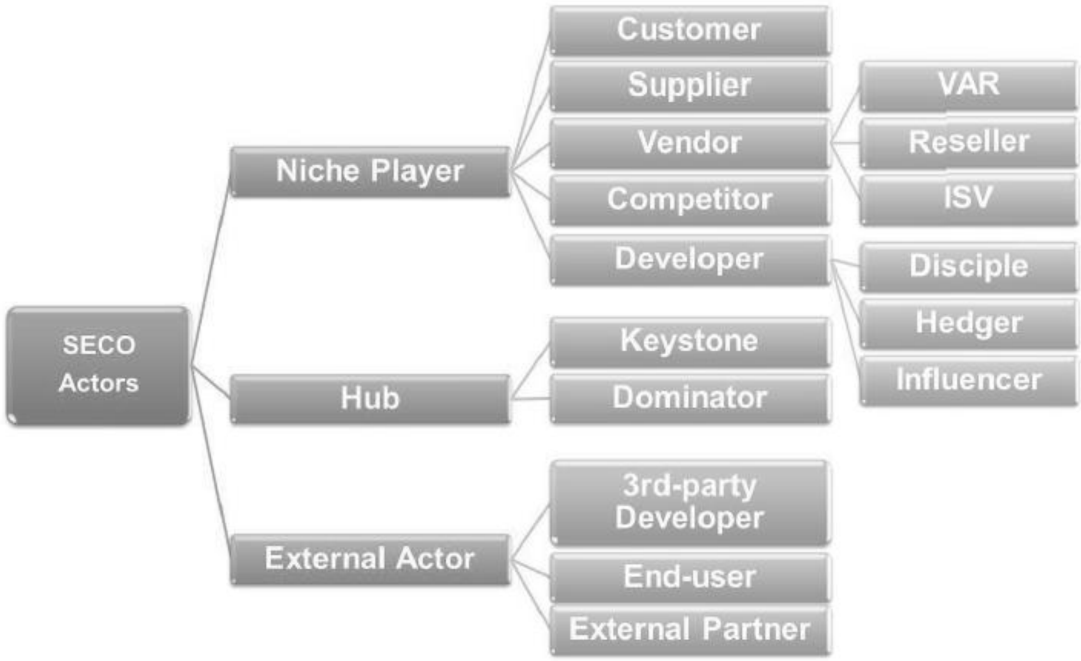

Figure 2.1. Types of actor's roles in a SECO

Software assets are artifacts produced/acquired and stored by an organization (ADAMS & GOVEKAR, 2012). In the scope of this work, SECO assets (LIMA et al., 2014) comprise SECO products, such as software assets (components, services, and applications) and needs (demands or software requirements). A SECO platform can be supported by a software asset library, responsible for managing the SECO's lifecycle. Software assets can be considered reusable assets. These reusable assets can be created within the organization, brought from outside the organization or even from the SECO.

2.2.3. SECO Characterization

There are many ways to characterize a SECO. MANIKAS (2016) uses the structure initially presented in (CHRISTENSEN et al., 2014) as starting point: organizational, business, and software. Organizational structure reveals characteristics of *orchestration*, distinguishing how to govern and arrange a SECO: Monarchy, Federal, Collective, and Anarchy. Business structure explores *value creation*, similar to how open a SECO is: Proprietary, Open Source, and Hybrid. Software structure is a technical perspective as it refers to the variety of common *technologies* shared within a SECO: Platform, Protocol, Standard, and Infrastructure.

BOSCH (2009b) suggests a taxonomy for SECO in two dimensions: platform type (Desktop, Web, and Mobile) and platform category (Operating Systems, Application, and End-user Programming) as shown in Table 2.2. This taxonomy is to some extent difficult to use nowadays; for example, the same software may be multiplatform working on web and mobile, e.g., Google services, or it may have a version for each platform, e.g., Office Desktop, Office 360, and Office Mobile.

Bosch's taxonomy was important since it defined frontiers for researching in those specific SECO classes, although platforms are not so separate anymore; they are still important concepts and give visibility to emerging SECO such as Mobile. At the time it was proposed, there was no example that fitted the category Application in Mobile platform, or End-user Programming in Mobile platform, according to BOSCH (2009). Currently, MS Excel (previously categorized as Desktop and End-user programming) has a mobile version as most of MS Office applications have.

Table 2.2. SECO Taxonomy. Source: (BOSCH, 2009)

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 in 2009
End-User Programing	MS Excel, VHDL, Mathematica	Google's mashup editor MS PopFly, Yahoo! Pipes	None in 2009

Another way to distinguish different SECO is through their dimensions as described in ReuseECOS '3+1' Framework (SANTOS & WERNER, 2012). This framework comprises the following SECO dimensions: Technical, Business (or Transactional), Social, and Engineering & Management, as shown in Figure 2.2. Those dimensions are to some extent related to the main groups proposed by MANIKAS (2016): Software Engineering, Business and Management, and Relationships.

The Technical Dimension represents concerns about SECO platform that encompasses elements, such as a common market, common technological platform, and technologies. From MANIKAS's groups, Software Engineering is the closest one to the Technical Dimension, since it covers software and its infrastructure (platform).

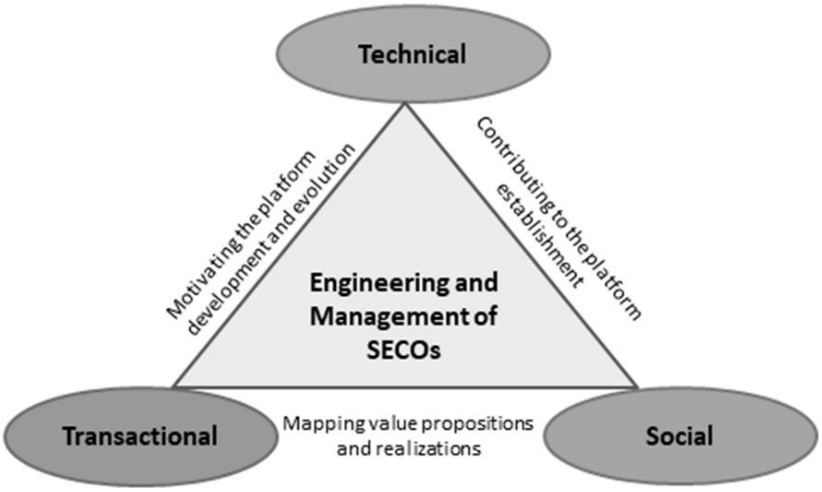

Figure 2.2. ReuseECOS '3+1' Framework. Source: (SANTOS & WERNER, 2012)

The Social Dimension covers actors (people that somehow interact with the SECO) and their relationships. This dimension is similar to the MANIKAS' group known as Relationships. It comprises the community and social network derived from the set of interactions within a SECO.

The Transactional Dimension refers to knowledge and strategy and it is similar to the MANIKAS' group known as Business and Management (since organizational elements are part of it). Engineering and Management Dimension comprises interactions among other dimensions similarly to Business and Management group, because both aim at monitoring a SECO.

Those SECO dimensions can be observed in several levels of development. A SECO can be characterized by looking in which stage of lifecycle it is. Considering that natural ecosystems background has inspired SECO concepts, a SECO also has properties, such as health, sustainability, and diversity (DHUNGANA et al., 2010). A healthy SECO can extend its lifecycle, keeping clients and consumers satisfied, enhancing software quality, and keeping the community active.

SECO health is simply translated to how well it attracts new actors and artifacts, although there are indications to specify this property. Sustainability is measured by the ecosystem ability to maintain or expand its community (DHUNGANA et al., 2010). Diversity grows according to how many different actors' roles an ecosystem has. In the ecosystem lifecycle, IANSITI & LEVIEN (2004) propose the following measures for determining health: (1) *robustness* measures how the ecosystem recovers from disturbances in its structure or network; (2) *productivity* measures the level of activity; and (3) *niche creation* refers to the ability of creating opportunities for (new) members.

Robustness can be indicated by some characteristics such as number of non-active projects or network connectivity before and after a disturbance. Productivity can be measured by the amount of software products and services produced within the SECO platform, or lines of code included or changed over a period. Niche creation can be conveyed through the diversity of contributors and projects, i.e., number of different roles and projects created within the ecosystem.

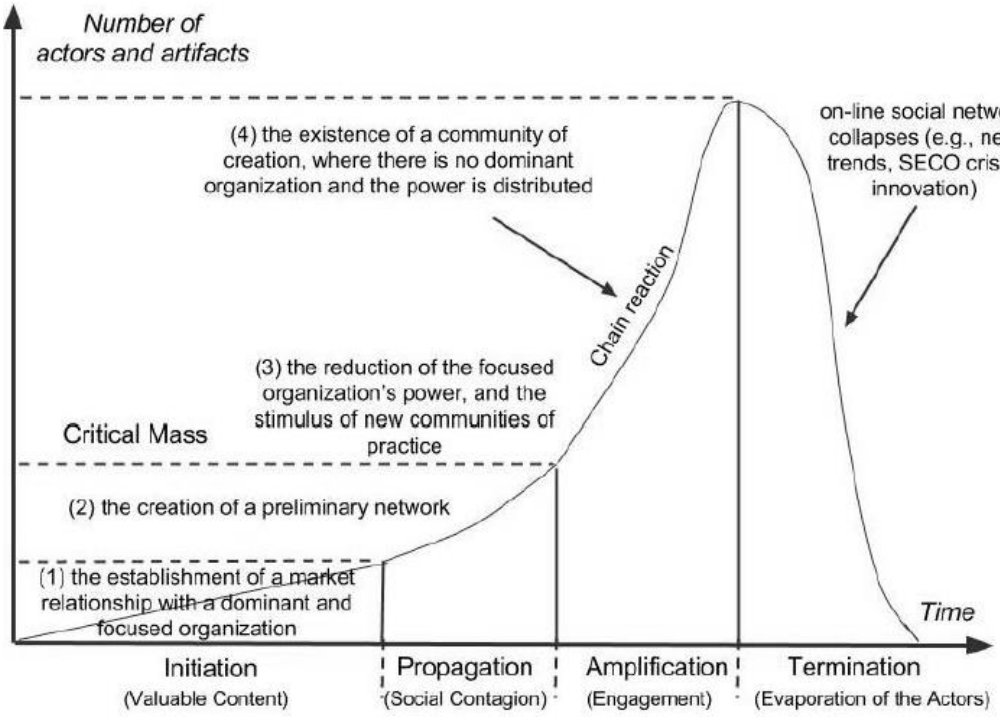

Figure 2.3. SECO Social Lifecycle. Source: (SANTOS et al., 2014)

Thus, a lifecycle model aids the understanding of how a SECO is formed and grows together with its community development. To do so, SANTOS et al. (2014) proposed a SECO lifecycle from the social network perspective based on four stages (Figure 2.3): Initiation, Propagation, Amplification, and Termination. Such lifecycle proposal covers different phases of a SECO over time according to its social network and number of actor and artifacts. Such number tends to start low (initiation) and then grow (propagation) until it reaches a maximum (end of amplification). Usually, it starts decreasing (termination) towards the ecosystem death since the community stops existing, or there is no condition to keep the ecosystem alive. It might happen because the community lacks interest due to new platforms, keystone's negligence to meet the community's demand, or strategic decision to not invest in the SECO any longer.

2.2.4. *Modeling and Analysis*

According to SEICHTER et al. (2010), communication and interaction among actors happen from the artifacts they share. Because actors have a greater turnover than artifacts in the ecosystem network, an identity is created for the artifact, transforming it into a “first-class citizen” by exploiting the network extract that holds the target information not contemplated before by ‘pure’ social networks. It is possible to map the network that represents these relationships as investigated by the sociotechnical network field (LIMA et al., 2015).

One way to map the SECO network is through the *Product Deployment Context* (PDC) model, which was created to aid an organization to obtain a view of software products and services’ architecture and dependencies (BOUCHARAS et al., 2009). PDC shows the position and relationships of SECO elements in the network. In turn, *Software Supply Network* (SSN) model comprises software, hardware, and services used to meet an organization’s demands based on PDC concepts (BOUCHARAS et al., 2009). Therefore, SSN can be used to model an organization’s SECO. Since we focus on applications, hardware representation will not be used in this work (there is no analysis that requires such SSN element). Based on SSN model, it is possible to analyze technology exchange effect by exploring mapped relationships and traded products.

PDC elements are: Product, Product of Interest, Mediator, and Hardware Product. SSN elements are (BOUCHARAS et al., 2009):

- *Company of Interest*: This actor is unique in a model representation and represents a central organization that owns the business model being investigated;
- *Supplier*: If an actor supplies at least one product or service to another actor, it is considered a Supplier;
- *Customer*: This actor uses or acquires the product or service;
- Intermediary: This actor facilitates the trade between other actors, e.g., resellers;
- *Trade Relationship*: The trade relationship is composed by at least one product or service to be traded between actors;
- *Flow of Artifacts or Services between Actors*; and

- *OR and XOR Logical Ports*: OR logical port enables one, many or all Trade Relationships. XOR logical port only lets through one Trade relationship and its flow.

Figure 2 shows an example of SECO. That representation states clearer the SECO strategy and elements, but it does not offer a structure that allows further analysis beyond a linear visual representation – it is not difficult to imagine that real cases are so complex that this representation might not be appropriated to do so. Moreover, there is no computational tool to support SSN models.

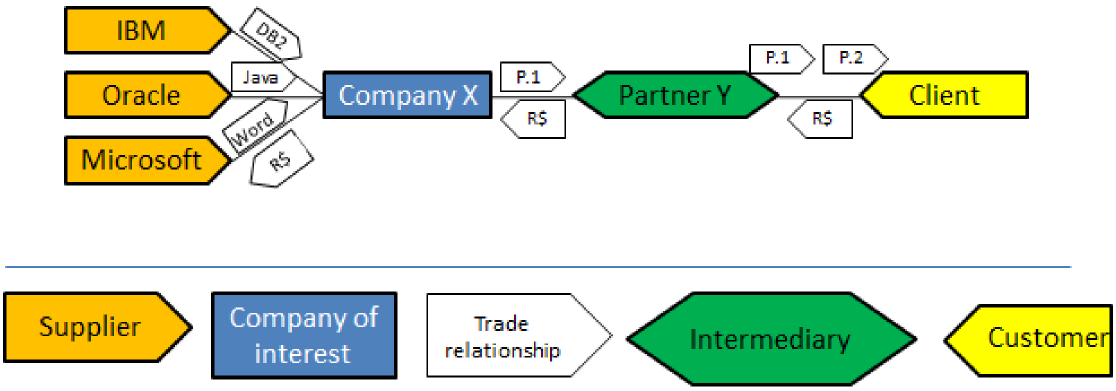

Figure 2.4. Example of a SECO modeled by SSN

Another way to represent a SECO is through Graphs Theory that is free of semantics and can be applied to several contexts where a network is indicated. There are several types of nodes, e.g., actors, companies, technologies, applications, or any existing type in the SECO context. Edges represent existing relationships in a SECO, e.g., technology buying/selling, or application download/upload. In this representation, it is possible to use concepts and algorithms from Graphs Theory to calculate size, centrality, connectivity and other attributes that can be analyzed from the network visualization. Those algorithms bring relevant meaning to health since properties such as connectivity and number of specific nodes can be calculated even if the complexity scales up.

Figure 2.5 exemplifies the same SECO modeled with SSN in Figure 2.4, but using graphs. The only information not visible is the value exchanged by the ecosystem actors. However, this information can be used as an edge's weigh, so the information is not lost and can be explored in algorithms that use the notion of weight.

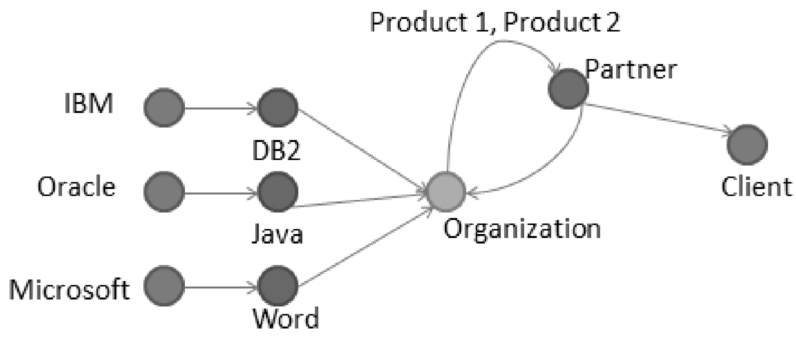

Figure 2.5. Representation of SECO as graphs

2.3 Technology Management for SECO Platforms

Technology management aims to maintain an organization's IT architecture, i.e., a set of integrated technical decisions that guides an organization to meet its business needs (WEILS & ROSS, 2004). Thus, technology management is used to standardize processes and technologies related to an organization's applications.

2.3.1. Maintaining a SECO Platform

IT architecture modifications must be performed with planning (and care) since they change organizational standards (ROSS, 2003). For example, choosing technology that fails to support a legacy system can cost a lot for the organization or even a technology that results in training costs for all teams without sufficient benefits to justify those costs. Managing technologies in a SECO can be a great challenge because of interactions and community participation.

When selecting a technology from a set of candidates, an acquirer organization is choosing to engage in the selected technology's SECO. This is a complex process and implies further decisions on future organization's projects (JANSEN, 2014), e.g., future developments may need to follow newer technology or different versions than the one defined in the IT architecture. Currently, the way one gets information is to study documentation of candidate technologies, ask other organizations and consultants, and/or assess the risk of joining a technology's SECO based on specialized consulting or market analysis (JANSEN, 2014).

Regarding the SECO architecture groups proposed by MANIKAS (2016) – Software Engineering, Business and Management, and Relationships –, platform is mainly concerned with the Software Engineering group. However, changes in the platform affect all groups according to their viewpoints.

2.3.2. The Role of Technologies in SECO

According to the SECO strategy and guidelines, it is possible to standardize processes and technologies for software application development. As such, changing technologies within the platform development must be carefully performed since such action affects the organization's standards. There are also organizational constraints that may affect technology adoption or discontinuation (SHAFIA et al., 2015):

- Organization policies and standards, e.g., encourage open source software or national suppliers, or not accept certain types of proprietary licenses;
- Legislation, e.g., especially in cases of public companies, a country's legislation may affect candidate technologies regarding taxation and economic embargoes;
- Economic issues, e.g., budget for the period and country's economic situation; and
- Problems of organizational culture, e.g., aversion to paradigm shifts, rejection of technologies that reuse external components, and rejection of certain vendors.

Modifications in IT architecture involve adoption of a new technology, removal of part of the architecture or technology replacement. Managing changes in such architecture is not a trivial task, as they affect the development or acquisition of new applications since technologies support SECO platform applications and infrastructure. In addition, it may affect organizational teams regarding new technology development, version change and license switching costs, or even applications that depend on discontinued technologies.

Evaluating a technology in relation to pre-established, manageable and well-structured data gives the process more transparency, as a list of criteria can be checked. In (FREITAS & RECH, 2003), one of the most successful actions in companies is to use well-defined procedure in IT acquisition. Part of the process definition is to define criteria for evaluating candidate technologies (DURRANI et al., 1998).

Another factor that contributes to the problem of maintaining the IT architecture is that the source of information used in assessing technologies is often informal and internal to the organization, or consulting opinions that do not consider the communities surrounding each technology (and its respective SECO). Such communities can influence aspects, such as quality, support, maintenance, and continuity of technologies.

2.4 Technology Acquisition

Maintaining a SECO platform refers to operations of including or removing technologies. When including a technology in a project, it may be possible to choose from a technology owned by the organization or to acquire one from an external partner.

2.4.1. Traditional Acquisition Processes

Several organizations do not implement a process for acquisition. It might not be necessary depending on the organization's size, or it is necessary but it is performed solely by an IT manager's tacit knowledge so that the reason for acquisition decisions becomes a tacit knowledge. Some organizations develop their own processes, others use processes well established in the software industry, e.g., MPS model (based on ISO/IEC and CMMI guides). MPS model defines a process for acquiring software and services. There are six modalities of acquisitions (SOFTEX, 2013):

- COTS (Commercial off-the-shelf): scope is defined;
- MOTS (Modifiable off-the-shelf): software artifact can be partially modified;
- FD (Full development): customized software on demand;
- Open scope development services; and
- Related services (maintenance, training, technical assistance, customization).

The process can be customized for each organization as long as they meet some basic demands about defining a formal process. The process for acquiring software and correlated services (S&SC) steps is represented in Figure 2.6 and includes four stages:

- **Acquisition preparation**: this stage is responsible for establishing acquisition requirements and objectives. If necessary, a market analysis and consulting can be performed. Once it is ready, information is communicated to possible suppliers. After executing requirements' refinement based on suppliers' feedback, the acquirer should define the expected quality, selection criteria, and acquisition strategy. This stage defines not only criteria for selecting a supplier, but also for accepting a software product or service, as well as some possible risks;
- **Supplier selection**: a supplier is evaluated before its software product or service. This evaluation comprises supplier capability, requirements specification, and proposal itself. According to those elements, a list of preferential suppliers is formed and the proposals they have sent are assessed

to choose one of them. Proposals present the technical solutions they offer as well as supplier information. The organization evaluates a proposal by examining: process, products, if they meet optional software requirements, effort to acquisition, cost to make an acquisition viable, deadlines, and prices. Once a supplier is chosen, a contract is negotiated;

- **Contract monitoring**: the organization will monitor the supplier performance according to the contract terms. If modifications are necessary, an agreement between organization and supplier should be reached. Problems, changes, performance, and communication are registered and monitored; and
- **Client acceptance**: deliverables are evaluated according to acceptance criteria defined in this stage based on tests, acquisition plan from the first stage, and contract requirements. If any conflict emerges, it should be firstly resolved with the supplier before accepting and informing the result.

Public organizations have particularities and might not be flexible in elaborating their own criteria. For example, the city hall in Rio de Janeiro follows an acquisition process similar to MPS model[2]. The city hall's IT department uses a well-defined process for software acquisition and a repository of lessons learned. The stages are:

- **Contract planning**: this stage addresses needs, requirements, acquisition strategy, and supplier selection criteria. The strategies fall into four categories: existing solution from partners, i.e., Government Off the-shelf (GOTS); software ready and defined scope (COTS); software ready but modifiable (MOTS); and develop the entire software (FD);
- **Supplier selection**: this stage aims to evaluate suppliers' capabilities, select the supplier, and negotiate and prepare a contract;
- **Contract management**: this stage aims to establish communication, revise supplier performance, arrange alterations, and monitor problems; and
- **Client acceptance**: this stage aims to prepare acceptance, evaluate the product, review the contract, and accept it.

The organization also stores, maintains, and evolves acquisition projects and artifacts whose process is influenced by legislation, regulations, and models.

[2] http://prefeitura.rio/web/aquisicaodesoftware/ (In Portuguese).

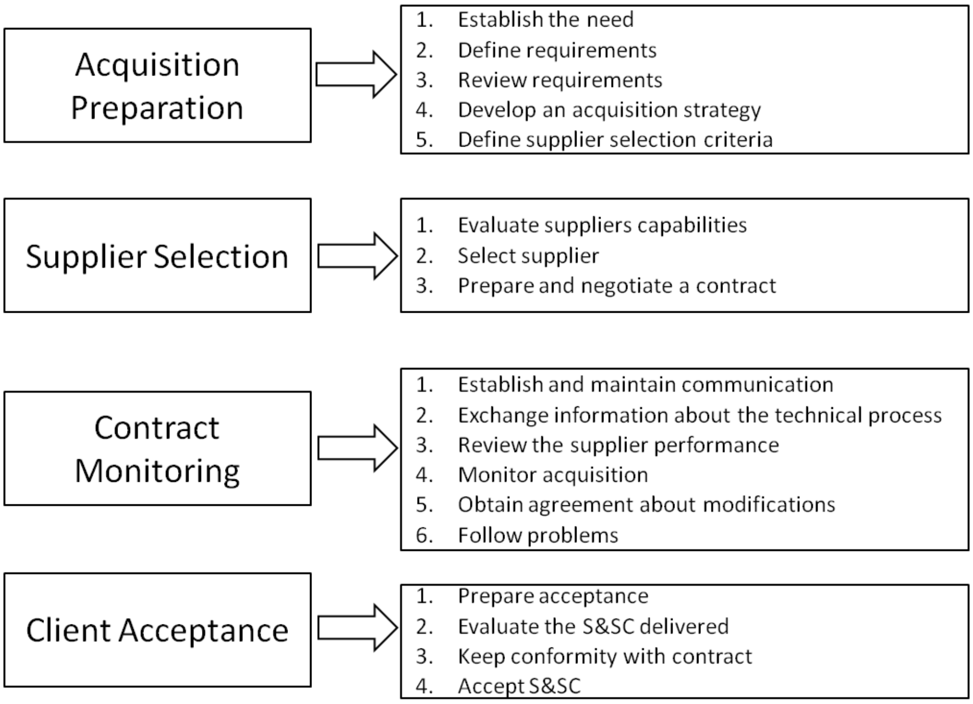

Figure 2.6. MPS acquisition process. Source: (SOFTEX, 2013)

2.4.2. Technologies Acquisition Processes

A software acquisition process can be adapted to technology acquisition. This research uses MPS acquisition process for software and services as a baseline. According to the definition of activities in each stage of such process, no activity was described particularly for software or services. Artifacts used in that process, e.g., requirements, test cases, and supplier information, are applied to technologies with little (or no) loss. There are some different concerns regarding criteria and process type. As technologies are supporting artifacts for applications, it is rare for an organization to develop or modify technology programming; therefore, the type of technology acquisition falls mostly under COTS or GOTS categories. Technologies to be inserted into IT architecture will support organizational applications and become a standard. As such, many dependencies will be created. It is necessary to be aware of compatibility with other SECO platform's applications. There might not be necessary to arrange modifications, but there may be a need for configuration and extensibility.

2.4.3. Acquisition Process in the SECO Context

Software or technology acquisition process evaluates not only a product to be acquired but also a supplier. Two SECO principles are *relationship with external players* and *supplier as a SECO actor*. MPS model applies those principles throughout the acquisition process. Some activities could focus on the SECO context so that it is more appropriate when a keystone is deciding for a technology. The acquisition preparation stage should be adapted for the SECO context. The activities are described in Table 2.3, as well as how SECO interferes with it.

Table 2.3. Considerations from the first step of MPS acquisition process (SOFTEX, 2013)

Activity	Overview	Consideration for the SECO context
Establish the need	Establishes organization's need to be met with a planned acquisition.	The need for an acquisition requires clarifying its scope and priority. The impact might fall outside the organization, since SECO has external developers that may acquire/change technologies.
Defining requirements	Defines the set of software requirements an organization is looking for, as well as other requirements from legal constrains, financial, deadlines, and other similar demands.	Because SECO has an underlying community and a platform, requirements need to encompass their demands as they are defined by an organization.
Revise requirements	Analyzes requirements and the need for acquisition in order to refine them.	This activity does not change. It just encompasses communities' demands that may not be aligned with the acquisition needs or priorities. Therefore, it is necessary to revise them too.
Develop an acquisition strategy	Chooses an acquisition method that better suites the established needs, e.g., COTS, MOTS, GOTS, or full development.	The choice for a specific SECO might differ according to its relationships with suppliers and the nature of an acquisition. For example, if a need for acquiring a database management system is established, there are several popular suppliers and it hardly will be developed from scratch, so COTS and MOTS are appropriate.
Define the supplier selection criteria	Establishes how a supplier is evaluated as well as the basis for such evaluation. From those criteria, a supplier is selected.	SECO criteria may need to consider supplier availability since it may handle the acquisition product and requires support from the supplier. These criteria may depend on the SECO platform nature, e.g., an open source SECO requires technologies that follow the same copyright protocols, and that is defined by a supplier.

2.5 Conclusion

By modifying the IT architecture, an organization also modifies its SECO based on another SECO in which the technology supplier is inserted. This is not a trivial task and requires information about candidate technologies (e.g., community, adherence, quality etc.) as well as their SECO network that affect technology selection (e.g., teams with knowledge in a candidate technology, government policies, restrictions, and standards).

In addition, the SECO perspective brings information from external relationships. This is important because supplier relationships, user community support, and other factors from outside the organization can determine the success of technology acquisition and adoption.

As presented in Section 2.2, SECO has a few different definitions but the main elements are actors, artifacts, platform, and relationships. They are all explored when an acquisition round is performed. SECO platform features bring more concerns for an acquisition round since participation of external players in SECO is highly relevant. Therefore, they have easier access to the platform and rely on it for their own projects. (BOSCH, 2009).

Hence, when performing an acquisition round, maintaining IT architecture is a relevant aspect since it changes the platform available for the organization and external developers (SANTOS, 2016). From the keywords of 90 studies extracted in a literature review on SECO (MANIKAS, 2016), *architecture* is the top keyword appearing in 49 studies, demonstrating the relevance of researching this perspective in SECO. Other concepts related to this research made the top 25 keywords list as shown in Table 2.4.

From this study on the SECO literature, next chapter presents two exploratory studies to explore SECO concepts. They reveal new resources that this research can use to better explore SECO relationships in IT architecture maintenance. In addition, they support this research by identifying information about artifacts that are not sufficient for an acquiring organization in software negotiation and purchase processes. Those studies use an infrastructure that organizes types of actors, artifacts, and SECO relationships.

Additionally, for the approach definition and studies that grounded its conception (mapping study and survey with experts), it was fundamental to understand what forms a SECO and how an organization maintains its SECO platform (another motivation for the exploratory studies). As such, the proposed approach supports IT architecture maintenance exploring SECO elements defined in this chapter.

Table 2.4. Related concepts listed in the top 25 keywords from the SECO literature for SECO architecture group

SECO Architecture Group	Rank place: Keyword (paper count)
Software Engineering	1st: Architecture (49) 10th: Platform (17) 11st: Model (17) 16th: Maintenance (13)
Business and Management	6th: Management (21) 11st: Architecture (12) 12nd: Network (10) 14th:Communities (9) 20th: Health (8)
Relationships	4th: Management (14) 6th: Network (12) 7th: Architecture (12) 9th: Social (12) 20th: Communities (8) 22nd: Platform (7)

Chapter 3 – Exploratory Studies

In this chapter, two exploratory studies are discussed with the purpose of identifying features to help us to reach the objectives proposed in Chapter 1 based on the context described in Chapter 2. Those studies were published in academic conferences and encompass observational studies to initially assess SECO concepts based on experts' opinion. Therefore, lessons learned are explored to find features that benefit this research. The sociotechnical resources used by the studies are part of the infrastructure the proposed approach develops.

3.1 Introduction

As indicated in Section 1.4, the main objective of this research is to support technology selection from a SECO platform. An acquisition process is used in most organizations to acquire software application, component, service, or technology. Negotiation with a supplier (or potential suppliers) that competes for an acquisition contract is an inherent part of any acquisition process. As such, supporting negotiation processes and learning from past negotiations can benefit an acquiring organization on few stages of the acquisition process.

Some of the fundamental SECO elements are *community* and *relationships with external players* as suppliers, market consultants, and users. When external players interact with a platform and its artifacts, they participate in a network surrounding a specific SECO. Such network is formed by social, technical, and sociotechnical interactions. Negotiation is an interaction that involves different SECO actors and technical artifacts.

A software repository supports some technical challenges since a technical network is stored and accessible to SECO actors. Resources based on social networks sites can assist the social side of a sociotechnical network. In (LIMA et al., 2016b), the main types of actors, artifacts, and resources are studied from the literature and executing a survey. However, concepts from social interaction analysis are not widely employed in SECO (SANTOS & OLIVEIRA, 2013). In this regard, SEICHTER et al. (2010) identified eight social network sites' features: Profiles, Wall, News Feed, Data

Sharing, Teaming, Searching, Suggestions, and Messaging. Those features support SECO relationships in which actors take part.

Therefore, they can help negotiation processes as well as SECO analysis and monitoring. The work described in this chapter presents how to use those features in a SECO supported by a component library that serves as more than a repository, i.e., it supports a variety of sociotechnical relationships. An exploratory study from SANTOS et al. (2017) is described in Section 3.2, and another from LIMA et al. (2016) in Section 3.3.

3.2 Supporting Negotiation with Sociotechnical Resources in the SECO Context

In a SECO supported by a component repository environment, it is common to find producers, consumers, and repository managers as actors (SANTOS & WERNER, 2010). Their interactions add high value to this type of SECO, creating useful information about a SECO and artifacts handled in a given relationship. Hence, it is important to extract and analyze sociotechnical network data as they represent those relationships (MENS & GOEMINNE, 2011).

This first exploratory study lies in the context of the Brechó Project (MARINHO et al., 2009; WERNER et al., 2009; SANTOS et al., 2010; SANTOS & WERNER, 2011) and reported in SANTOS et al. (2016). Brechó started as a web based repository for reusable components, or products. This repository evolved to support advanced mechanisms, such as purchase, negotiation, evaluation, teams and social features to support software asset management, called Brechó-EcoSys platform. As such, there is support for a sociotechnical network surrounding a common platform. Brechó-EcoSys represents a reuse-based SECO comprising an organization’s actors, artifacts, platform, and interactions.

Since SECO actors trade software assets within Brechó-EcoSys, some negotiation stages were explored (RODRIGUES et al., 2011):

- *pre-negotiation*: in this stage, the available information is gathered and alternatives are considered;
- *conduction of negotiations*: proposals are received and analyzed. There may be a need for establishing communication and counter offers; and
- *post negotiation*: a supplier is defined, both parties are committed to the negotiation object and they agree on the proposal and valuation criteria.

The negotiation process implemented in Brechó-EcoSys is shown in Figure 3.1. A consumer and a producer exchange proposals until an agreement is reached, or one gives up the negotiation. Each actor has access to product information, traders' profile page and his/her proposals' messages at Brechó-EcoSys. This information is essential to decision making as it supports proposal evaluation. A negotiation process always starts with a consumer trying to negotiate a product he/she is interested in. A producer can make his/her product negotiable, or not.

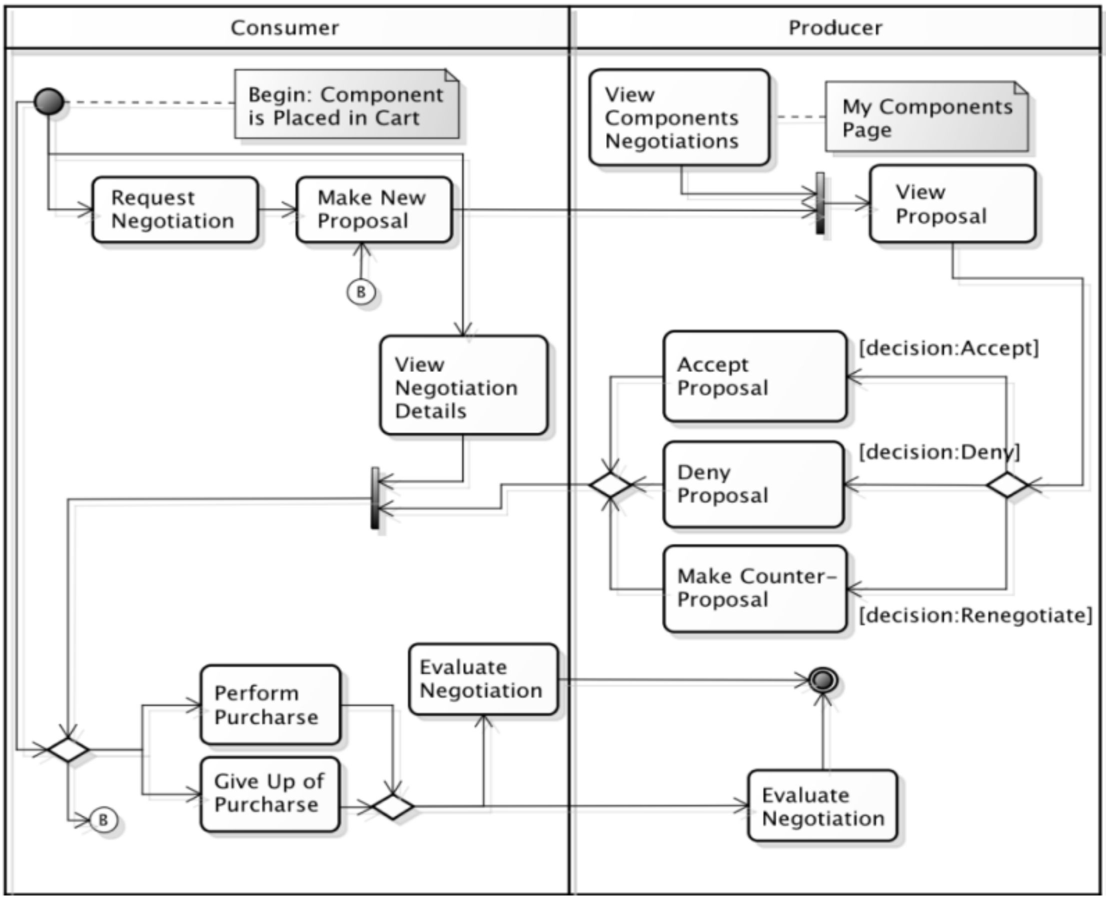

Figure 3.1. The negotiation process implemented at Brechó-EcoSys.
Source: (SANTOS et al., 2017)

Negotiation steps at Brechó-EcoSys are shown in Figure 3.2. A consumer adds a product in his/her shopping cart and then a negotiation starts if the product is negotiable. At that point, the consumer opens a negotiation proposal based on product information. Such proposal consists in a suggestion of price and a justification.

The same structure is presented to the producer for response. All proposal history is registered at Brechó-EcoSys. The consumer can check product information provided by the producer and negotiator profile containing past negotiations' statistics and evaluations so that he/she makes a decision, as illustrated in Figure 3.3.

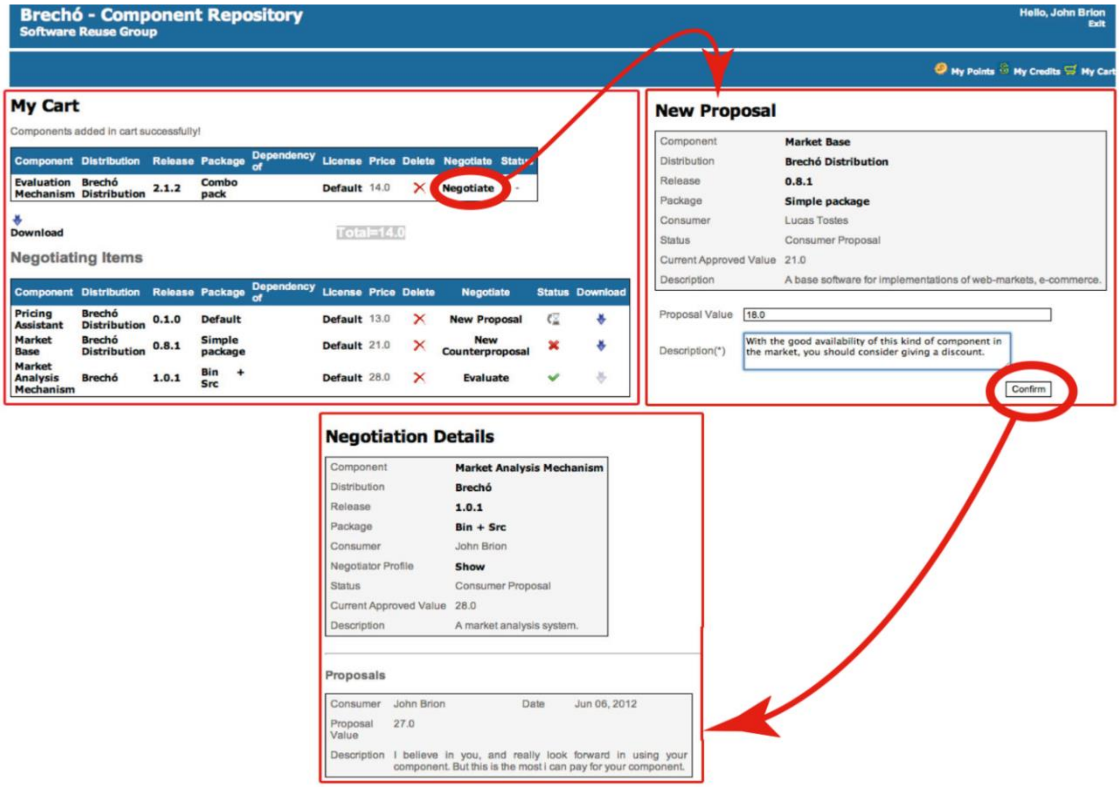

Figure 3.2. Negotiation functionalities at Brechó-EcoSys.
Source: (SANTOS et al., 2017)

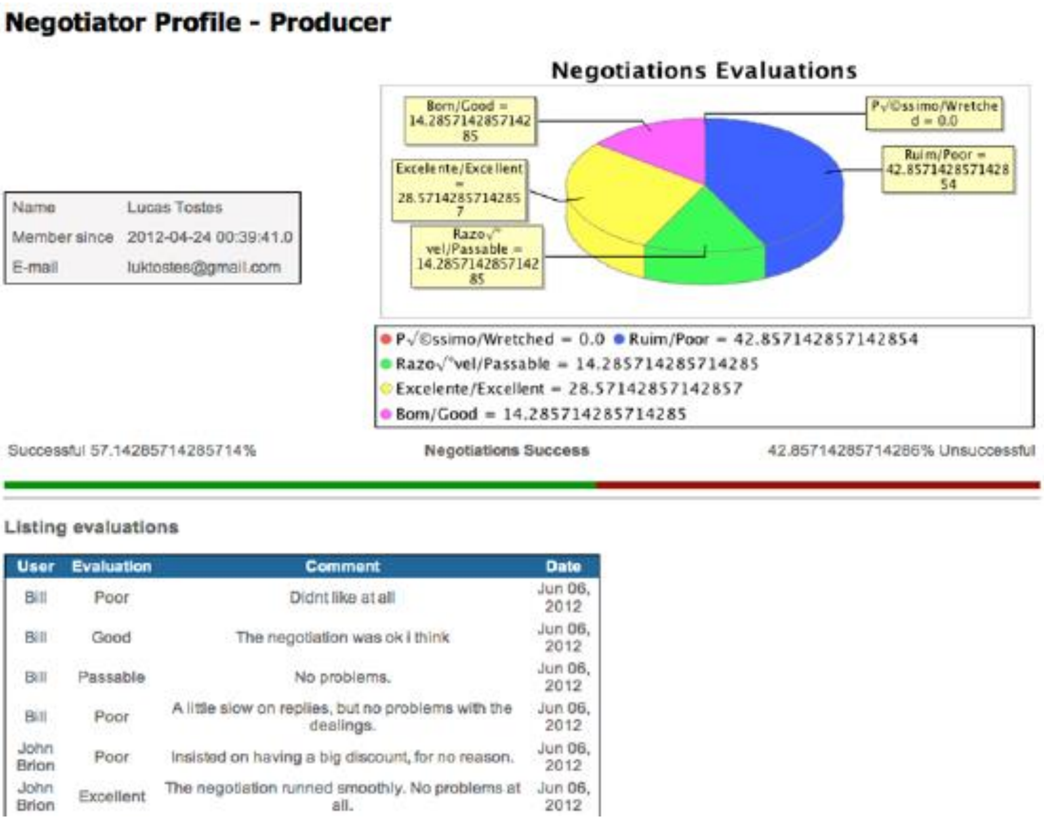

Figure 3.3. Negotiator profile at Brechó-EcoSys.
Source: (SANTOS et al., 2017)

Based on Seichter et al.'s work on social networks in SECO (SEICHTER et al., 2010), social resources were identified as features to be implemented at Brechó-EcoSys aiming to aid consumers to have access to product information besides existing data provided by producers. In addition, social resources consist in tools for organizations, developers and users communication, as well as for information and community opinions management.

Those resources are: profile, forums, requirements coordination support, evaluation system, teams, tag clouds, and news feed (LIMA et al., 2015). Such Brechó-EcoSys features can reveal SECO trends and useful discussions for negotiation processes. All sociotechnical network resources implemented at Brechó-EcoSys are available at "My Network" section, as shown in Figure 3.4. This, each actor sees a different content at such section.

Figure 3.4. My Network Panel at Brechó-EcoSys. Source: (SANTOS et al., 2017)

"My Forums" resource lists the forums an actor takes part. Forums are open for anyone's participation and refer to an artifact or an organization's team. An artifact's forum is managed by its producer, i.e., user, team or external developer.

A forum is structured in three sections: (i) *Topics*, used for general discussions, e.g., user asking for help and reporting bugs. Each message can be evaluated by a forum participant voting 'positive' or 'negative'; (ii) *Suggestions*, where participants can register any suggestion, e.g., new functionalities and new releases; and (iii) *Requirements*, where a producer registers requirements for a product (visible for the community) and external developers can provide solutions. Suggestions also can become requirements if an organization's manager (playing as a keystone) is able to discover community demands. Producers and consumers can "follow" a requirement from a product forum. They also have a panel for managing the requirements they are responsible for, as well as the ones they follow. Thus, this resource supports a strategy for requirements coordination.

Actors can create teams at Brechó-EcoSys to support development teams, organization departments, and users groups. In this context, each team has one member as a manager. Additionally, "My Profile" section informs the actor what roles he/she performed within the SECO, i.e., producer, consumer, or user.

A proportion is calculated according to the actions an actor takes at Brechó-EcoSys, e.g., publishing a product counts as producer, purchasing counts as consumer etc. "Tag Cloud" resource mines the terms frequency from forums an actor takes part as well as his/her teams' descriptions, providing relevant trends according to the actor's interests within the ecosystem. The "Suggestion" resource encompasses repository recommendations based on an actor's forums and requirements he/she follows. "News feed" resource shows SECO updates regarding information such as team actions, product status, and new releases.

With the purpose of evaluating sociotechnical resources to support product negotiation in the SECO context, a feasibility study was conducted. Participants performed tasks at Brechó-EcoSys, playing as consumers and producers in some negotiation scenarios supervised by researchers involved in this work. The hypothesis was that *introducing sociotechnical mechanisms on the negotiation process improves the negotiator capabilities (both buyer and seller) in the SECO context*. An electronic form was elaborated with four sections: (1) Informed Consent; (2) Characterization; (3) Task Execution; and (4) Evaluation. Seven participants completed the study on November 3rd and 4th, 2016. Several Brechó-EcoSys resources were used, but this study focused on tag cloud and forum support, since they provide information new to the platform linking technical aspect (software artifacts) and social aspect (user participating in the forum and their interests represented by the tag cloud).

From seven participants, four said that the use of forums helps a negotiation process, one said 'partially', and two answered 'no'. The same answers were obtained for the use of tag cloud in a negotiation process. Participants were asked to list their insights on the negotiation process based on the Brechó-EcoSys platform. Some participants left suggestions for improvements, as for example:

- Playing as a consumer:
  - *Knowing what the community thinks about a technology is a valuable information for choosing what artifacts to acquire. Resources such as forum and tag cloud helped me in this process*;
  - *If a consumer is still selecting products for acquisition, he/she should gather information on the artifact before the negotiation starts, so that the proposal value makes sense*;
  - *The process has the required activities for a negotiation, such as direct channel with producers, consumers' opinion on available products and existing producers etc.*
- Playing as a producer:
  - *The proposal acceptance should be informed to the other party and access to social information is considered important*;
  - *It is important that both consumer and producer (negotiators) knows each other in order to better arrange product prices*;
  - *It has all the necessary steps and subsidies to aid producers in finding both consumer information and past discussions*.

3.3 Supporting Socialization, Monitoring and Analysis in the SECO Context

As previously mentioned, an acquisition process is critical for an organization and requires inputs such as information about dependencies, technologies, suppliers, licensing, and support. Such data use to be stored in an organization's software asset base and support an acquiring organization to be able to select a product to be acquired (FINKELSTEIN, 2014). Many acquirers have no access to a documentation structure, being hard to evaluate demands and solutions over time. The lack of community participation and asset base management creates difficulties for SECO monitoring. An automated solution for managing and monitoring SECO is necessary (SANTOS, 2016).

In this context, Brechó-EcoSys repository presented in Section 3.2 can support interactions among actors and artifacts with those sociotechnical resources, not only for product negotiation (product acquisition time), but also for demand analysis (acquisition project time). However, to analyze and visualize such sociotechnical network, software artifacts, actors, and their relationships were stored in Brechó-EcoSys. Therefore, a second exploratory study was performed and reported in (LIMA et al., 2016a). In this context, data were exported to a network analysis and visualization tool implemented as a Gephi[3] plug-in. As such, measurements on sociotechnical networks can be calculated to aid SECO monitoring regarding demand and solution analysis. This process is shown in Figure 3.5.

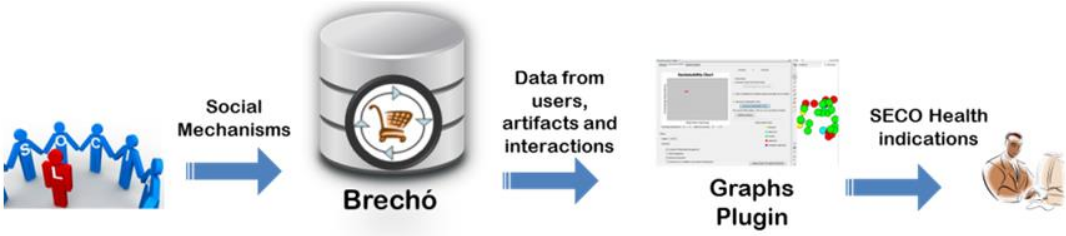

Figure 3.5. Brechó-EcoSys extension for sociotechnical network analysis and visualization. Source: (LIMA et al., 2016a)

"Forum" resource was evolved to register demands and community discussions regarding an artifact. "Tag Cloud" resource displays the most frequent terms in the SECO. In this case, it may be used to provide an overview of community discussion topics. Moreover, to support demand and solution analysis, SECO elements registered at Brechó-EcoSys are:

- *application* (APP): all applications an organization uses must be registered and are identified as APP, e.g., SAP and ERP systems;
- *technologies* (TEC): all technologies that support an organization's APP's, e.g., programming languages and database management systems;
- *demands* (DEM): a demand is a need of at least an organization's department;
- *candidate solutions* (CAN APP): all applications that are being considered to the acquisition, i.e., all candidates for a specific demand; and
- *business objectives* (OBJ): all business objectives the organization uses to reach its strategy according to its business model.

In addition, there are relationships, such as dependencies (between applications), supporting (between technologies and applications), and satisfaction (between business objectives and applications). In a given moment, a SECO comprises applications, objectives and technologies (AS-IS). In this context, a demand analysis support implemented at Gephi simulates the effect of considering a new acquisition idea that meets organizational objectives and requires evolving organizational applications

[3] The Open Graph Viz Platform. Available at https://gephi.org/

(WHAT-IF). After that, such support also simulates the effect of selecting some candidate applications (TO-BE). This process is presented in Figure 3.6.

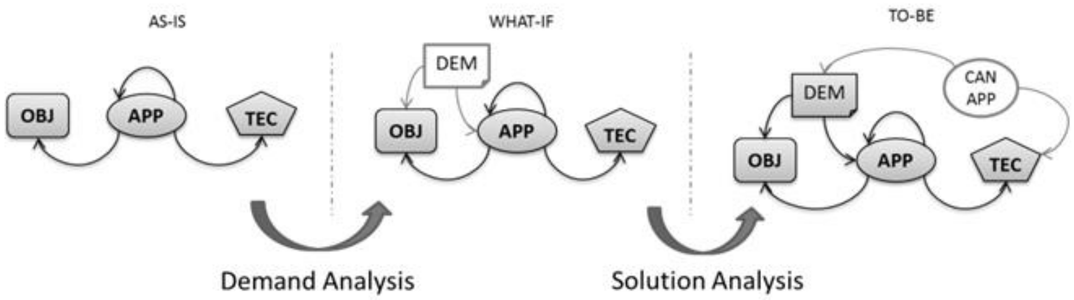

Figure 3.6. SECO elements related to demand and solution analysis.
Source: (LIMA et al., 2016a)

Sociotechnical analysis and visualization at Gephi aim to help an organization to be aware of supplier dependency and business objective synergy to maintain its SECO as sustainable as possible. The SECO sustainability can belong to one of four proposed quadrants (SANTOS, 2016): (a) *subsistence*: few technologies support many applications and few objectives are satisfied by many applications; (b) *diversity*: dependency on technologies is balanced, but most applications do not meet many objectives; (c) *fidelity*: a small set of technologies support the ecosystem, but most of the applications satisfy all the organization's objectives; and (d) *sustainability*: it is the ideal situation where an acquirer has low technology dependency and high objective synergy.

Two measurements were proposed by SANTOS (2016) to analyze SECO sustainability: (i) *objective synergy* (OBJ-SYN) monitors to which degree the business objectives are satisfied by existing applications (value between 1 and 100); and (ii) *technology dependency* (TEC-DEP) monitors to which extent the existing applications depend on the current technologies (value between 1 and 100). The pair (OBJ-SYN, TEC-DEP) created a point on the sustainability chart that indicates the SECO status. This point needs to be recalculated after new rounds of demand and solution analysis.

Gephi plug-in's panel for performing that analysis is shown in Figure 3.7. The mechanisms are organized as follows:

1. **Sustainability chart:** OBJ-SYN and TEC-DEP values for the current SECO configure a point in the chart;
2. **Filtering options:** allow a user to select registered demands to be included as a SECO need, thus updating the sociotechnical network. When performing a

solution analysis, each selected demand enables its candidate solutions and the sociotechnical network is also updated with the chosen solutions;

3. **Node colors:** explain what color represents each type of node according to the SECO elements;
4. **Instructions and actions buttons:** present steps to calculate a sustainability point (using functions from (7));
5. **Chart information:** shows information on the previous and current charts;
6. **Network visualization:** is a native Gephi's panel and shows a graph built from the sociotechnical network extracted from software asset base registered at Brechó-EcoSys. This graph is updated after demand and solution selection; and
7. **Graph algorithm:** is a native module and makes graphs algorithms available.

In order to evaluate SECO monitoring resources to support demand and solution analysis in the SECO context, a feasibility study was conducted. Participants performed tasks at Brechó-EcoSys playing as IT managers and architects in some acquisition scenarios supervised by researchers involved in this work. Some tasks were performed, simulating demand selection and then solution selection for each selected demand. After that, participants filled a feedback questionnaire. The study's main question was: *Are participants able to realize the impact of SECO monitoring in the software acquirer's IT management activities for demand and solution analysis, regarding effectiveness and efficiency?*. Five practitioners participated in this study in June, 2016.

Participants' feedback was analyzed and the following findings were summarized from this study:

- "What were the biggest difficulties in performing the proposed tasks?": *difficulties in performing steps involved in Part 4 of the plug-in's panel*; *difficulty in visualizing some data since points were too close in Part 1 of the plug-in's panel*; and *difficulties to find the list of team's members*;
- "If you are missing resources, please write here": *storing SECO network graphs' historical series in order to allow us to evaluate different combinations*; and *automatic comparison of different SECO configurations (scenarios)*;
- "In your opinion, what are the most useful resources?": *sustainability chart visualization and simulations of selection's combinations*; *forum's structure*

(by specific themes and by discussions/suggestions); and *trend topics mechanisms (tag cloud)*; and

- "Do you have any suggestion?": *improve Gephi' plug-in usability with richer graphical resources*; and *graphical resources to support the forums*.

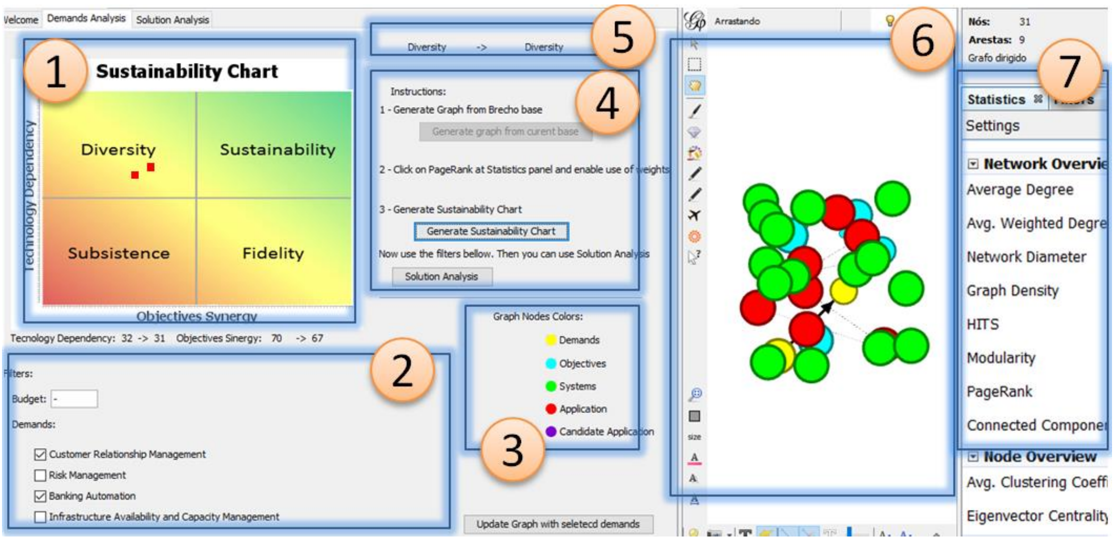

Figure 3.7. Brechó-EcoSys extension as a Gephi's plugi-in

Participants realized how the proposed infrastructure can benefit IT management and monitoring activities in the SECO context. Overall, they considered mechanisms provided by Brechó-EcoSys useful. The most popular suggestions were: (i) improve steps to generate the sustainability chart; and (ii) show simulation history to compare and select different acquisition options. This study allowed us to collect suggestions for improvement and corrections, e.g., visualize historic data of simulations, and enable options for resetting the network to its original structure.

3.4 Conclusion

As discussed in Chapter 2, negotiation is an important activity for acquisition processes. Regarding supplier selection, suppliers' proposals are received by an acquiring organization, and then negotiations rounds are played to select a supplier. After that, a contract can be defined on the final terms agreed after the negotiation process.

In this context, a SECO platform was developed, called Brechó-EcoSys. From the first exploratory study (Section 3.2), negotiation was evaluated from the perspective of sociotechnical resource support. Information on products (provided by producers) and actors (negotiator profiles) were explored at Brechó-EcoSys. In the SECO context, it is important to hear the community's opinion so that the ecosystem can be alive. In turn, from the second exploratory study (Section 3.3), ecosystem monitoring was evaluated with sociotechnical network analysis and visualization. In the SECO context, different demand and solution selections can affect the acquisition process.

Both exploratory studies reinforce benefits of sociotechnical network analysis to make decisions in the SECO context. From the studies described in this chapter, the following considerations were summarized to this research:

- Acquisition encompasses negotiation and can be benefited from the use of forums, requirement information, communities suggestions and discussions, tag clouds, and negotiator profiles;
- Information on the SECO community, negotiators, and SECO trends are useful in negotiation activities (social perspective). In turn, different relationships among SECO elements are considered in monitoring activities (business perspective), including demands and business objectives. However, we observed a lack of architecture criteria to compare candidate solutions for acquisition (technical perspective). Those criteria and a sustainability chart can be used as acceptance criteria defined in the acquisition processes;
- Sociotechnical network can represent a SECO and its elements can be used to support demands and solutions analysis (and then acquisition);
- Data visualization was a concern in both studies. It helps an acquiring organization to be aware of what is going on in negotiations, and shows tendencies calculated from a SECO monitoring support. Important network properties, such as hubs, density, and connectivity, were not available to acquirers in the existing SECO tool support;
- As a negotiation process ends with no (or one) chosen supplier, SECO monitoring can be performed over time to narrow down suppliers and candidate solutions (before negotiation rounds). Hence, a negotiation can start with the best potential suppliers. They may not be the best suppliers, but they are the most appropriated for the SECO particularities since they are mapped in the network; and
- An acquisition process starts with requirements definition and refinement. This is supported by suggestions and requirements in existing forums.

Suggestions can modify/change to requirements based on community needs; so far, it was centralized in an acquiring organization (SECO keystone).

The infrastructure offered by Brechó-EcoSys is used in this research since it provides sociotechnical resources and SECO monitoring that benefit acquisition processes. Additionally, SECO is structured at Brechó-EcoSys to support different types of actors and relationships involved in an acquisition. In order to identify criteria used for acquisition in the SECO context, a mapping study was conducted to find quality attributes related to SECO platform and architecture as described in the next chapter.

Chapter 4 – Mapping Study

As concluded in Chapter 3, it is necessary to establish baseline criteria for selecting technologies to maintain a SECO platform. As such, the mapping study presented in this chapter extracted a list of potential criteria from the SECO literature. After that, such criteria were classified into critical factors and attributes so that IT management teams can use (a subset of) them to evaluate candidate technologies.

4.1 Introduction

In the SECO context, knowing what information is relevant to the platform's architecture becomes difficult, since SECO includes external actors and their interactions with the platform. This problem already exists outside the SECO context, and becomes even more critical due to the speed of technological evolution, i.e., when a platform and its software applications need to be evolved due to technology obsolescence. In SECO, the relations tend to be symbiotic (MANIKAS & HANSEN, 2013).

Therefore, the impact of including/removing a technology is substantial since it is manipulated by actors and support SECO's systems. Hence, it is necessary to define evaluation criteria to compare and select technologies to be adopted, discontinued or replaced in a SECO (DURRANI et al., 1998). Such criteria can emerge from attributes related to architecture within the ecosystem that encompass a platform and its technologies. In this research, architecture attributes are considered quality attributes comprising different architectural facets that can be found in SECO, e.g., platform architecture, SECO architecture, or software architecture.

In this context, this chapter investigates a set of architecture-related quality attributes to aid IT managers and architects to understand how technology selection can affect the SECO platform, as well as how to take actions to mitigate the negative effect. Architecture attributes were extracted from the SECO literature and focus on information related to technology acquisition criteria regarding addition, discontinuation or replacement in a SECO platform. To do so, we analyzed a set of papers selected in a previous systematic mapping study on SECO architecture (FRANÇA, 2017) to collect those attributes. As a result, we analyzed 44 papers and 64 quality attributes were identified and classified into 11 critical factors. In this case, critical factors are macro attributes that encompass other specific attributes.

This work serves as an initial basis to aid IT managers and architects to understand how their choices regarding technology acquisition can affect a SECO platform, as well as the actions to diminish harmful effects. Moreover, with the intention of comparing this research to a well-accepted related work, ISO/IEC 25000 (2014) characteristics were analyzed against the critical factors, looking for similarities and non-explored attributes that can reveal a new context to be considered.

Section 4.2 describes how the mapping study was planned. Section 4.3 presents the execution and initial data obtained, the complete data resulting from the study's execution is presented at Section 4.4. A better discussion of the results, and what they mean to the research, is explained at Section 4.4. Section 4.5 concludes the chapter with the final considerations.

4.1.1. The Previous Mapping Study

The researcher responsible for this Master thesis participated in a previous mapping study conducted by four researchers from the Systems Engineering and Computer Science Program at COPPE/UFRJ (FRANÇA, 2017): a Master student and a PhD student; both supervised by the same two PhD researchers. This mapping study primarily investigated how scientific literature studies software architecture in the SECO context, e.g., key characteristics, research needs, and reference architectures. The search string covers title, abstract and keyword with the terms “software ecosystem” and “software architecture” (and their plural variations). The search string was:

(“software architecture” OR “software architectures”) AND
(“software ecosystem” OR “software ecosystems”)

For each search engine, the search string was adapted according to the machine syntax rules, but maintaining the terms and logical operators. For the automatic execution, a search string was run on the Scopus, Springer, IEEE, ACM, and Science Direct search engines in February 2016 without executing snowballing.

This first mapping study grounded the study presented in this chapter. In addition, accepted papers and search strings were reused as starting point for the mapping studied to serve as a corpus for the extraction of architecture-related quality attributes for technology selection in SECO.

4.2 Planning

The goal of the mapping study is to investigate architecture-related quality attributes for technology selection in SECO. The main motivation is to aid IT managers and architects to understand how to compare and evaluate technologies that sustain a SECO platform. Critical factors are macro attributes that encompass other attributes that affect a SECO platform and its technologies. The following research questions (RQ) help addressing this study's goals:

RQ1. What are the architecture-related quality attributes that describe or qualify software ecosystems and their platform regarding the architecture perspective?

RQ2. How do the architecture-related quality attributes relate to each other?

The activities planned for this study are illustrated in Figure 4.1. The set of studies was obtained after executing the mapping study (Step 1). Then, the full reading allowed us to extract the attributes and also track the source papers (Step 2), as well as identify relations among attributes described in the selected papers and other possible associations (Step 3). From such relations, it was possible to group the attributes based on similarities, level of abstraction, or interactions reported at the papers (Step 4). Finally, we analyzed the possible effects those attributes could have on a SECO platform (Step 5).

This mapping study followed the same procedure of the previous study described in Section 4.1.1. Thus, the search string was the same and it was run again at the same search engines, but it considered the publishing year of 2016 since the previous study only partially covered this year.

The study was conducted by a Master student and supervised by two PhD students. There was not a specific term to be searched for, i.e., studies were scavenged for any term that characterized a SECO as well as its architecture or platform, considering that all the included studies have discussed SECO/architecture.

As inclusion criteria, the studies must meet the following requirements:

- The studies must present a discussion about SECO, its elements and architecture, regardless of which element of the SECO they focused on;
- The studies must not be a result of the previous mapping on Section 4.1.1 in order to avoid duplicated;
- The studies must be written in English or Portuguese; and
- The studies must be available online.

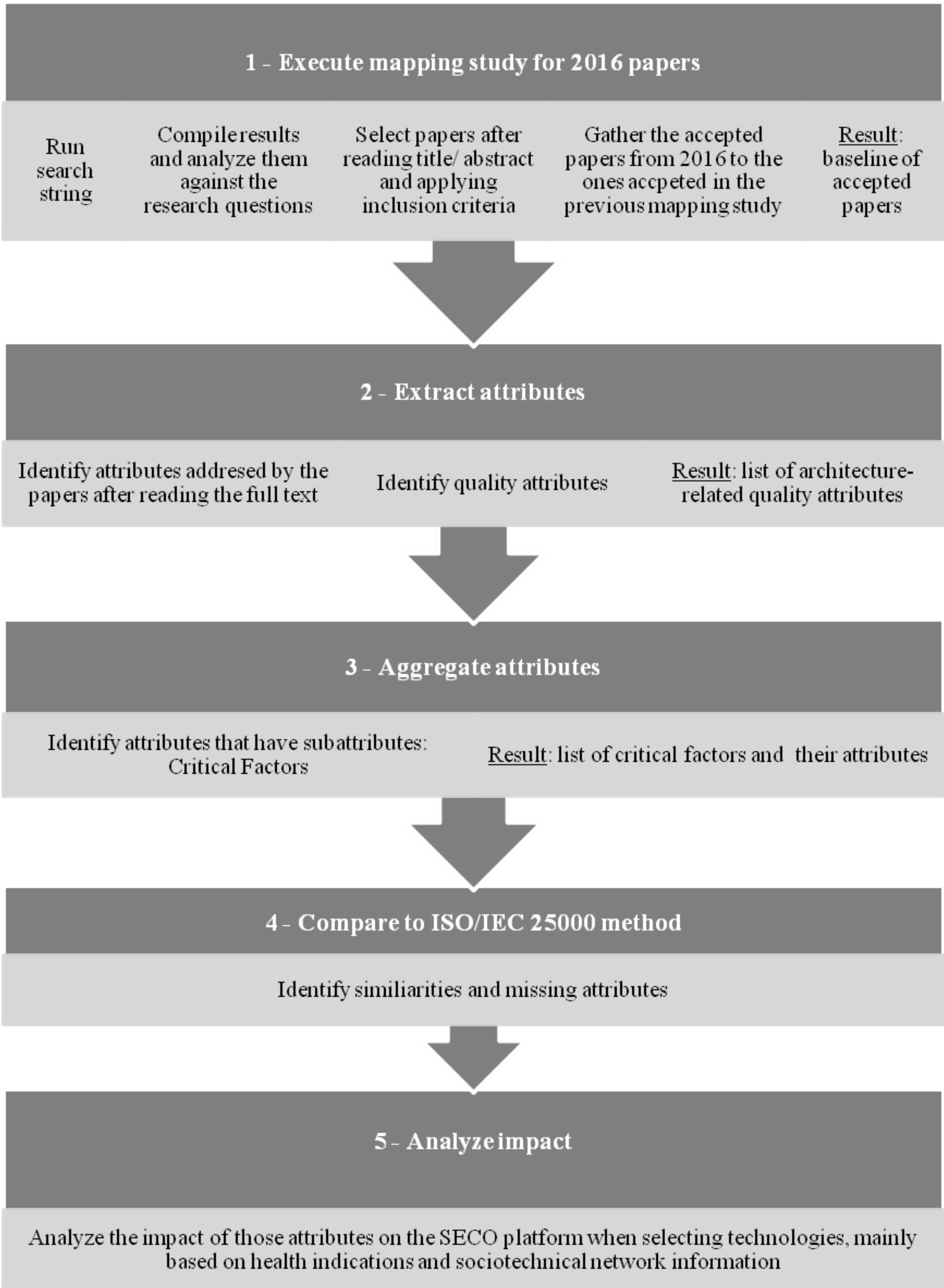

Figure 4.1. Mapping study methodology

4.3 Execution

The execution was performed in January 2017, so that we reached as many studies published in 2016 as possible along with those studies brought from the previous mapping study (Section 4.1.1). In MANIKAS (2016), a systematic literature study captured the main keywords related to ‘software ecosystem’. Aside from “ecosystem”(s) and “software” keyword, the third popular term was “architecture”(s)/”architectural” and they were accompanied in the papers keyword fields by “open”, “parallel”, “service oriented”, and “software”. Since there was no keywords for “technology architecture” or “IT architecture”, the search string was generalized for the expression “software architecture” since it had criteria that might fit technologies (technologies are a software product nonetheless) and it represented a very common expression for SECO context according to MANIKAS (2016).

Table 4.1 lists the search engines, how many studies resulted from the search step (before applying inclusion), how many studies were found after running the search string (out of the previous set); and the number of accepted studies from 2016 to be included. At Scopus, some studies were rejected because they already appeared at other search engines. Accepted studies from the previous mapping (34, see the first column of Table 4.1) were also accepted in our mapping. Additionally, 10 new studies were included from the execution regarding the year of 2016 (third column of Table 4.1).

Table 4.1. Studies resulted from the mapping study extraction

Search Engine	Previous Mapping Hits	New studies (year 2016)	Accepted studies (year 2016)
ACM	48	9	5
IEEE	27	8	3
ScienceDirect	43	0	0
Springer	83	8	2
Scopus	68	2	0

4.4 Results

The final literature base is composed by papers published from 2009 to 2016. After reading the title, abstract and keywords, few papers were excluded because they fell out of the scope/context of this work. Some papers were not reachable (i.e., full text was not available online, although we requested some of them to the authors) and thus removed from the literature base.

From the 44 accepted studies, 16 (36.36%) did not present architecture-related quality attributes related to SECO or to its architecture or platform (paper IDs 04, 08, 16, 17, 25, 27, 30, 31, 34, 36, 39, 40, 41, 42, 43, and 44). Many papers mention the same attribute, e.g., 11 papers cite “integration”, even appearing in different SECO contexts. Quality attributes were mentioned as attributes, for example, “openness”.

The complete list of attributes and their sources (paper ID) are shown in Table 4.2 (the list of papers is presented in Appendix I). Attributes seen as technology evaluation criteria were explicitly mentioned in the papers as SECO quality attributes, or key factors, properties or challenges. In addition, some papers report SECO requirements regarding the platform architecture. Other attributes are nouns and adjectives used to describe a specific SECO; in this case, studies or more generic models in the context of architecture or platform.

Some attributes had very similar meanings, so they were aggregated into only one, e.g., "extension" and "extensibility". Some attributes were explicitly mentioned while others were described as challenges or key factors. An example of extraction of a most implicit form is "This is because the platform architecture should enable the integration of third-party applications" [paper ID 12]. In this case, there is no explicit mention to a quality attribute or even a technical attribute, but integration would be an essential requirement for a SECO platform architecture.

To integrate third-party applications to the platform, such platform must be extensible, thus extensibility is also considered a relevant attribute. An example of attributes that form a critical factor is: "Flexibility mechanisms for anticipated change can be based on the openness mechanisms that might already be present in the system" [paper ID 24]. Therefore, "flexibility" is considered as an attribute of "openness".

Figure 4.2 shows the distribution of attributes and respective number of papers that identify them. Only 6.2% (4 attributes) has more than five citations. Perhaps the great number of attributes with only one citation (42.2%) is due to the fact that specific SECO contexts are explored in the studies. Although the set is general, it also reaches many different contexts.

Table 4.3 shows the classification of attributes according to the papers indications and how some attributes can comprise others as critical factors, e.g., "licensing", "buildability" and "openness" can represent "cost". The last three critical factors are health measures according to JANSEN (2014). Since the candidate technologies should be compared from assessing critical factors, such subset of attributes can be useful to make an initial evaluation of the technology acquisition effect on SECO heath, depending on the selected technology. Robustness measures how the ecosystem recovers from disturbances in its structure or network of actors, e.g., ability to keep developers active after a supplier's collapse. Productivity indicates the level of SECO activity, e.g., application development rate. Niche creation refers to opportunities for building new groups of members within a SECO, e.g., incorporate mobile or cloud plug-ins for development.

Table 4.2. Architecture-related quality attributes and the studies that mentioned them

ID	Technical attribute/Paper ID	ID	Technical attribute/Paper
1	Accessibility [01][22]	33	Modularization [12][13][19][37]
2	Availability [21] [24][26]	34	Niche creation [13]
3	Backwards compatibility [22]	35	Offline capability [20]
4	Buildability [07]	36	Open interfaces (for components) [32]
5	Commonality [06][19]	37	Openness [01][02][21][22][24] 32][37]
6	Component dependency [05][22]	38	Parallel development [35]
7	Composability [14][15][19][29][32]	39	Performance [11][21][24]
8	Configurability [02][14][15][32]	40	Portability [22][37]
9	Consistent user interface [14][15]	41	Productivity [13]
10	Complexity [11]	42	Quality [14][18][38]
11	Cost [18]	43	Quality of extensions [29]
12	Components decoupling [05][32]	44	Rate of change [22][37]
13	Extensions' delivery [22]	45	Reliability [03][33][24][26]
14	Dependability [14][15]	46	Resiliency [37]
15	Deployability [14][15][35]	47	Reuse [07][37]
16	Extensions' deployment [22]	48	Robustness [13]
17	Documentation [05][22]	49	Safety [29][24]
18	Efficient use of system resources [18]	50	Scalability [09][10][11]
19	Evolution/Evolvability [03][29][32][37]	51	Security [03][21][24][26] [33][37]
20	Extensibility [01][09][10][12][23][24] [29][35]	52	Shared information [38]
21	Extension [13][21][23]	53	Simplicity [37]
22	Flexibility [09][10][18][24][37]	54	Stability [14][37]
23	Framework stability [22]	55	Standardization across the platform [22]
24	Hard real time requirements [18]	56	Support (fast and with quality) [22]
25	Innovation [18]	57	Synchronization [20][21]
26	Integration [01][03][05][07][12][13][18] [19][21][29][37]	58	Testability [35]
27	Interface stability [03][13][18][33] [38]	59	Transparency [13]
28	Interoperability [24][28]	60	User experience [21][24]
29	Licensing [01][32]	61	Understandability [35]
30	Learnability [22][24]	62	Variability [06][11][18][19][26]
31	Maintainability [15][35][37]	63	Version compatibility [37]
32	Modifiability [01][07][13][26]	64	Working facilities [38]

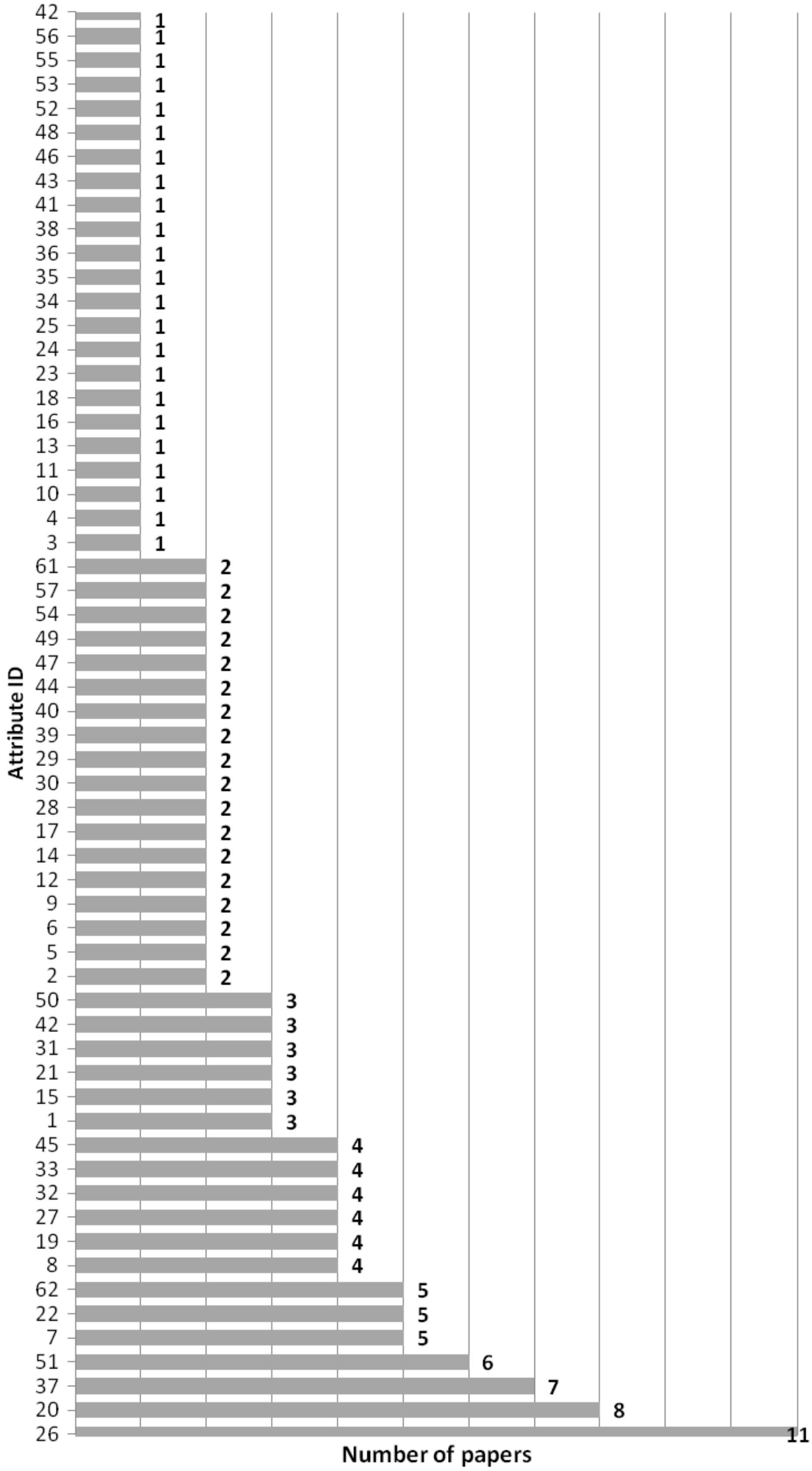

Figure 4.2. Number of citations for each attribute

Table 4.3. Mapping study results organized as critical factors and attributes

Critical Factor	Attributes
CF1 - Configurability	Commonality, Variability
CF2 - Cost	Buildability, Licensing, Openness
CF3 - Extension	Buildability, Extensions' delivery, Extensibility, Extensions' deployment, Modifiability, Standardization across the platform
CF4 - Openness	Accessibility, Availability, Flexibility, Licensing, Performance, Reliability, Safety, Security, Synchronization, User experience
CF5 - Quality	Certification, Efficient use of resources, Hard real time requirements, Quality of extensions, Testability
CF6 - Reuse	Composability, Components decoupling, Cost, Dependability, Extensibility, Integration, Modularization, Open interface (for components), Transparency, Understandability
CF7 - Scalability	Complexity, Extensibility, Interoperability, Performance
CF8 - Stability	Framework stability, Interface stability, Rate of change, Parallel development
CF9 - Support	Documentation, Shared information
CF10 - User experience	Accessibility, Consistent user interface, Documentation, Simplicity
CF11 - Version compatibility	Backwards compatibility, Maintainability, Portability
CF12 - Niche creation	Innovation, Work facilities
CF13 - Robustness	Availability, Offline capability, Resilience, Stability
CF14 - Productivity	Extensions' delivery, Deployability, Learnability

4.5 Analysis

The extraction resulted in 64 architecture-related quality attributes. After analyzing the attributes' association, we observed that "quality" is connected to "certification". Thus, certification was considered as an attribute, too. Some results easily derive metrics, e.g., "dependability": possible metrics are number of function parameters, and number of external APIs necessary for building an application. Other attributes are more subjective and require a deeper analysis where different levels can be recognized, e.g., "rate of change": what is a high, low or steady rate of change? What is the baseline?

The more generic attributes (bold font in the row above quality attributes in Table 4.3) are critical factors. They help technology assessment as they represent categories of criteria for comparing candidate technologies. Attributes associated with critical factors (subsequent rows in Table 4.3) can be perceived as different perspectives to assess a factor.

Some associations can repeat for different factors, e.g., "availability" is associated to "openness", since an open source application architecture might be more available than a proprietary one with restricted licenses; at the same time, it is associated to how robust a SECO can be. Those associations were directly extracted from the papers, or assigned by the researcher according to critical factors and attributes' definition in the papers. An association happens in cases when an attribute definition includes another one, then the attribute becomes a critical factor related to the attribute contained in the definition, even if both are not explicitly linked as key factors, challenges, or another similar relationship.

It might not be necessary to use the whole list of attributes, since a specific organizational context might differ from others', i.e., one may require only a subset of attributes that applies to the SECO platform technologies. In that case, it is useful to create scenarios that determine a minimum subset of attributes. Organizational context requires different assessments, e.g., a government department must assess "cost" and "quality" rather than platform "openness"; on the other hand, a multinational company might need "scalability" rather than "version compatibility".

For step 5 of the methodology presented in Figure 4.1, it is important to evaluate the technology effect on attributes related to SECO health. As such, health is a property that reflects how well a SECO is (MANIKAS, 2016). Maintaining the SECO platform affects software use and development. Health measurements may offer an indication of the ecosystem status and allow ecosystem comparison (MANIKAS, 2016). In addition, health can support decisions related to making corrections and improvements over the platform architecture (MANIKAS & HANSEN, 2013).

Health measures for SECO are shown in Table 4.4. JANSEN (2014) defines indications for the health measures in Open Source Ecosystem (OSE) and they overlap attributes' associations, bringing some new possible metrics. Three levels are described: theory, network, and project. For evaluating a SECO technology, network level becomes more appropriate because it considers organization, interactions and projects.

Table 4.4 lists network level metrics with possible association with critical factors in the third column. Many ecosystems reveal statistics and information on their projects usage/downloads and documentation. Therefore, the metrics may be applicable for proprietary and closed platforms too. The impact of a technology entering or leaving a SECO can be assessed by comparing health indications before and after technology selection. Furthermore, network metrics that affect some critical factors may be a comparison element, e.g., the speed of a SECO network topology change may indicate lack of "stability"; network connectivity around a new technology may refer to "niche creation".

Table 4.4. Critical factors versus SECO health indications

Health Indicator	**Metrics from (JANSEN, 2014)**	**Related Attribute**
Productivity	(1) New related projects (2) Downloads (new projects) (3) New knowledge about ecosystem (4) Events	- - (3) Support (4) User experience
Robustness	(5) Number of active projects (6) Project connectedness/Cohesion (7) Core network consistency (8) Outbound links to other SECO (9) Switching costs to other ecosystem	- - (7) Stability - (9) Cost
Niche creation	(10) Variety in projects	-

With the set of critical factors and attributes, it is possible to compare technologies based on properties studied in the SECO literature. Depending on the SECO context or type, the whole set of criteria might not be necessary. Therefore, an acquiring organization can decide what information is available or relevant. Critical factors consist of an aggregation based on relationships indicated in the selected papers. Attributes only cited once might be too specific, new or less relevant. Since it is a long list, practitioners may want to start assessing technologies after using a subset of attributes, e.g., the most popular ones.

The study results represent a first step towards technology comparison process in the SECO context. SECO health can be used for technology comparison: an acquiring organization may want to know what will happen to its SECO health if a candidate technology is chosen as well as to analyze other candidates according to the attribute list. Moreover, an organization can compare all candidate technologies from the same architectural category, such as operating system or database.

It can minimize decision bias (commonly based only on manager experience) and better justify technology selection rather than being an *ad hoc* process. For each attribute, an interpretative scale might be associated, e.g., for cost: range from feasible to not feasible. IT management team then should choose a value within the range and at the end its members will have a comprehensive comparison of technology candidates.

4.5.1. ISO/IEC 25000 Comparison

When looking at the literature on software product evaluation based on quality attributes, there are many proposed quality models (MIGUEL et al., 2014). Assessing quality from standards that compose the ISO/IEC 25000 series, also known as SQuaRE (System and Software Quality Requirements and Evaluation), can help IT management teams in acquisition rounds (ISO/IEC 25000, 2014).

However, those guidelines reflect traditional paradigms that leave SECO out of scope. ISO/IEC 25000 defines eight characteristics and 31 sub-characteristics to assess product quality, presented in Figure 4.3 and Figure 4.4. They use a similar structure to the one presented in this research, i.e., critical factors and quality attributes would correspond to characteristics and sub-characteristics from ISO/IEC 25000 SQuaRE.

Characteristics listed in ISO/IEC 25000 consider software product and systems quality while critical factors have been extracted to aid IT architecture maintenance, i.e., managing an organization's standard technologies. Nevertheless, there is a high resemblance in their use and definition.

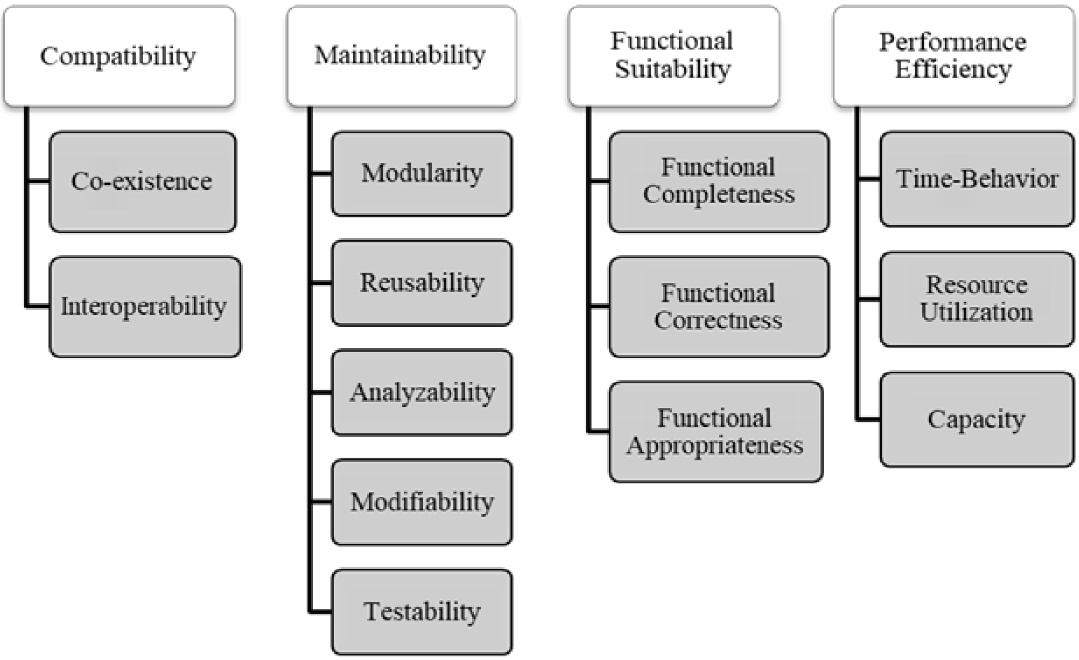

Figure 4.3. ISO/IEC 25000 SQuaRE characteristics and sub-characteristics (part 1)

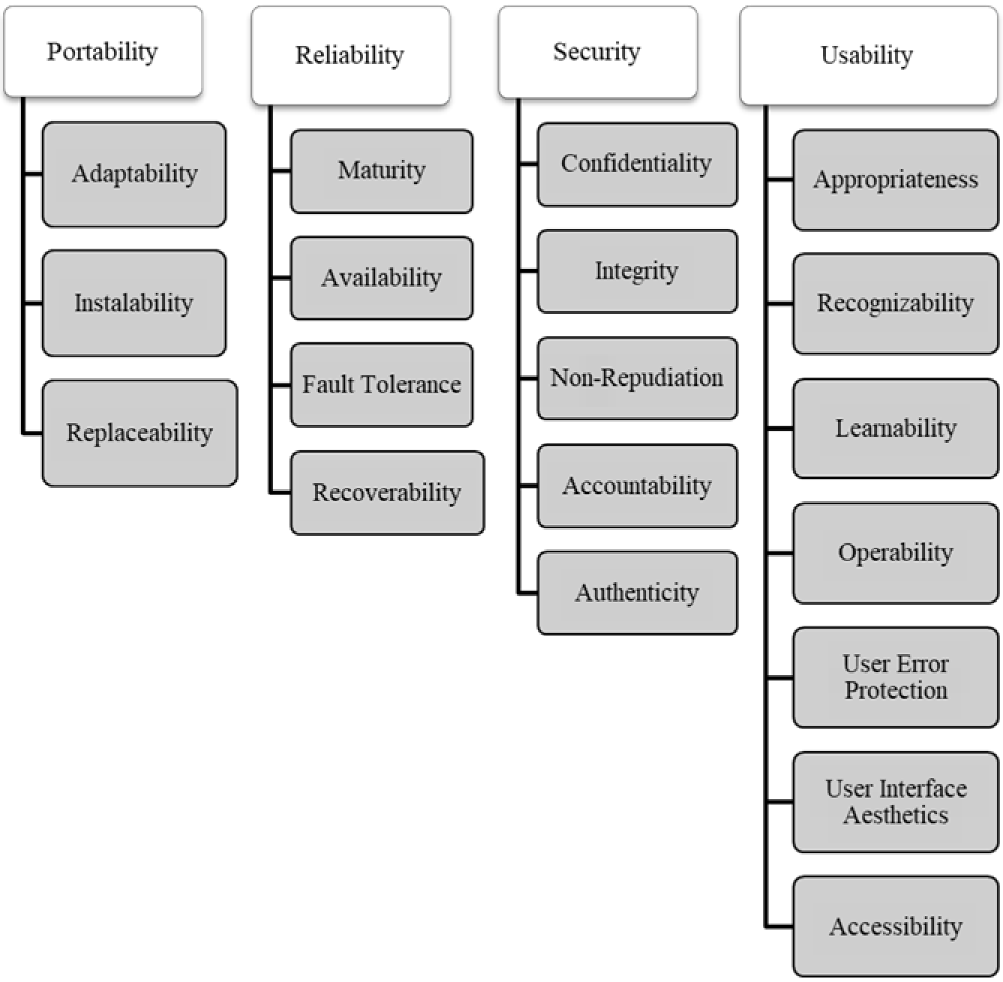

Figure 4.4. ISO/IEC 25000 SQuaRE characteristics and sub-characteristics (continuation)

Critical factors and ISO/IEC 25000's characteristics present many similarities, as shown in Table 4.5. Columns represent ISO/IEC 25000's characteristics and rows represent SECO's critical factors. If applicable, each cell contains a critical factor or attribute that is related to an ISO/IEC 25000's characteristic, also considering its sub-characteristics. For example, the critical factor "extension" (third row) has an attribute "modifiability" that is similar to "portability" ("adaptability" sub-characteristic).

Table 4.5. SECO's critical factors versus ISO/IEC 25000's characteristics and sub-characteristics

Critical Factor	**ISO/IEC 25000 Characteristics**							
	Compatibility	**Maintainability**	**Functional Suitability**	**Performance Efficiency**	**Portability**	**Reliability**	**Security**	**Usability**
Configurability	-	Variability	-	-	Variability	-	-	-
Cost	-	-	-	-	Licensing	-	-	-
Extension	-	-	-	-	Modifiability	-	-	-
Openness	-	-	-	Performance	-	Availability Reliability	Security	Accessibility
Quality	Efficient use of system resources	Testability		Efficient use of system resources	-	-	-	-
Reuse	-	Composability Modularization Components decoupling	-	-	-	-	-	-
Scalability	Interoperability			Performance	-	-	-	-
Stability	-	-	-	-	-	-	-	-
Support	Shared Information	Documentation	Documentation	-	-	-	-	-
User experience	-	-	-	-	-	-	-	Consistent user interface
Version Compatibility		Maintainability			Portability	-	-	-
Niche creation	-	-	-	-	-	-	-	-
Robustness	-	-	-	-	-	Availability Resilience	-	-
Productivity	-	-	-	-	-	-	-	Learnability

Some critical factors and attributes are not similar to the ISO/IEC 25000's definitions but might be related to. For example, "maintainability" (ISO/IEC 25000, 2014) might be affected by "scalability" (critical factor) and "stability" (critical factor) might affect "reliability" (ISO/IEC 25000, 2014).

Since quality attributes are related to SECO platform and architecture, "security" (characteristic) is just one attribute of "openness" (critical factor). "Openness" degree is a very important concern for the SECO platform and "security" is relevant in this regards. In ISO/IEC 25000, "security" relates to software use as its sub-characteristics reflect user data manipulation, e.g., "confidentiality" and "authenticity".

ISO/IEC 25000 models lack characteristics to address SECO concerns related to the external player activities (development of extensions or applications). Those matters are illustrated by quality attributes that had no correspondence, e.g., "extensions' deliver", "extensibility" and "quality of extensions". All ISO/IEC 25000's characteristics are considered by at least one critical factor. On the other hand, "stability" and "niche creation" (SECO's critical factors) are not similar to any ISO/IEC 25000's characteristic (according to the sub-characteristics' definition). "Stability" encompasses "framework stability", "interface stability", "rate of change", and "parallel development".

It may be due to different scopes considered by ISO/IEC 25000 (software product or system quality) and SECO (organization's internal and external relationships). "Niche creation" is inherent to SECO and then creation of opportunities consequently generating niches inside the SECO. "Niche creation" involves an artifact as means for new opportunities, a community as a recipient of opportunities, and an acquiring organization (SECO keystone) as a beneficiary and manager.

4.6 Threats to Validity

We can point out some threats to validity as follows: the literature base of the mapping study could overlook some studies with architecture-related quality attributes; attributes might be incorrectly identified; and attributes might not be identified from the accepted studies; and the attributes extraction did not follow a formal method. A global survey with experts on related areas was executed to evaluate the mapping study results and get new suggestions (Chapter 5). The main objective was to ask experts (practitioners and researchers) whether the identified attributes are relevant for the

SECO context and to which extent they are appropriate to aid IT managers and architects to compare technologies. Consequently, the list was updated with evaluated attributes as well as experts' suggestions based on their experience. The attributes' extraction does not consider differences among SECO contexts, e.g., mobile sector, health sector or agriculture section. Therefore, this set of attributes is an initial list and must be broken into subsets according to the suitability for each SECO platform (IT management team's members should select a subset of attributes to work with).

4.7 Conclusion

A SECO platform broadly supports software artifact use and development. In this context, technologies that support a SECO platform affect who enters or keeps playing within a SECO. Such technologies are usually referred as standards as they are used by both acquiring organization and external actors.

Candidate technologies to be adopted/changed/discontinued need to be carefully compared to keep or improve how well a SECO platform works. Hence a baseline of attributes is necessary for comparing technologies in the context of SECO platforms. Managing platform technologies brings many benefits to an acquiring organization, e.g., technology standardization, money savings, unnecessary acquisitions avoidance, and controlled number of technologies. Fast market changes, deployment of new versions or support discontinuation require frequent modification and assessment of a SECO platform's reference technologies.

In addition, there are impacts on finances, users, politics, training, and other perspectives that need to be considered when an organization is changing platform technologies. It is necessary to compare several candidate technologies – what is a few different in the SECO context as discussed in this chapter. Information used to compare technologies should cover not only technical properties but also sociotechnical elements, i.e., communities (users, developers and organization), feasibility, quality, cost, and support. This is due to the fact that the SECO perspective brings to the stage external information regarding organization/platform and relationships. A comparison with ISO/IEC 25000's characteristics suggests that SECO's critical factors have a good coverage of software quality attributes while considering specificities of the SECO context, its technologies and platform concerns.

As a result, this chapter identified a set of architecture-related quality attributes that may aid IT managers and architects maintaining their SECO platform and technologies. That information was extracted from the literature based on a mapping study. We analyzed 44 studies and 64 attributes were identified and grouped by 11 critical factors, i.e., macro attributes that encompass other specific attributes (all attributes are described at Appendix II). The main contribution of this chapter is the identification and summary of architecture attributes (as well as their associations) that affect a SECO platform and its technologies. This set was investigated in Chapter 5 for assessing the relevance in supporting IT managers and architects to compare candidate technologies for acquisition and then to maintain an acquiring organization's IT architecture in the opinion of researchers who are experts on SECO, software architecture and correlated related areas.

Chapter 5 – Survey

Chapter 4 presented a mapping study that resulted on a set of critical factors and their attributes that can be used as technology assessment criteria in SECO platform. Those attributes only appear scattered in the scientific literature (and evaluated by their corresponding authors). In this chapter, experts on related topics were asked to assess the relevance and appropriateness of each attribute to evaluate and update the list according to participant's suggestions.

5.1 Introduction

Once a list of critical factors and attributes for supporting technology selection in a SECO platform was built from the mapping study presented in Chapter 4, it is important to verify how appropriate and useful they are in the real world. To do so, a survey with experts on SECO, technology selection and IT management/architecture was conducted.

The participants were selected from taking part as referees or organizers in international conferences regarding SECO research. From their assessment, the set of attributes were evaluated, updated and then used to develop a solution in this research. We asked how relevant each critical factor is for technology selection in an organization. For each critical factor, we asked to which extent each attribute is relevant for the critical factor they belong. The goal was to capture suggestions on attributes (addition to, removal from or change critical factors).

This study is important to evaluate the results captured from the literature in the opinion of experts on SECO, software architecture and correlated related areas. SECO-AM approach (presented in the next chapter) uses those critical factors so that IT managers and architects can choose criteria for technology analysis from an evaluated, refined set. The use of a set of criteria makes easier the comparison among technologies as IT managers and architects can report and discuss each candidate technology in the same criteria.

Section 5.2 presents the planned steps and instruments for the survey. Section 5.3 describes how the execution was performed based in the plan from Section 5.2. Section 5.4 presents the results captured from the survey questionnaires and Section 5.5 discusses the results aiming to find a final set of criteria. Section 5.6 lists some threats to the study's validity that need to be considered when analyzing the results. Section 5.7 concludes the chapter with the main results from the survey.

5.2 Planning

The survey consists of an electronic questionnaire written in English to be filled in 20-30 minutes. It was sent to the invitees' e-mails; in this case, experts in SECO, technology selection and IT management/architecture. The complete questionnaire is presented in Appendix III, and it is divided as:

1. Research Summary;
2. Term of Consent;
3. Characterization Form;
4. Critical Factors' Relevance; and
5. Critical Factors' Attributes Relevance.

Considering the objective of capturing participants' experience, it was used a five-point scale similar to previous surveys executed by SECO researchers (ALBERT, 2014; LIMA, 2015, SANTOS, 2016):

- Don't Know it;
- Don't Know, but I've heard of it;
- I know;
- I know it and have some experience; and
- I have much experience with it.

5.2.1. Objective

This survey objective was to investigate if the critical factors presented in Chapter 4 are relevant for technologies selection in a SECO platform. As a result, experts' opinions on the critical factors and their attributes were collected. The following questions guided the survey participants:

- How relevant are the critical factors?
- How relevant are the set of attributes assigned to each critical factor?
- Is there any misplaced, missing, or inappropriate attribute or critical factor?

From the experts' opinions, critical factors and their attributes were evaluated. In addition, this survey studied if the attributes represent relevant perspectives on the related critical factors. In Table 5.1, the goal of this survey is described following the GQM model (BASILI et al., 1994).

Table 5.1. GQM for the survey goals

Analyze	*List of critical factors and their attributes*
With the purpose of	*Characterize*
With respect to	*Relevance*
The point of view of	*Experts who are researchers on SECO, software architecture and correlated research areas*
In the context of	*IT management activities working with the decision making*

5.2.2. Participants

The survey used an electronic questionnaire for collecting information from invited experts. 144 participants were invited from 22 countries. Invitations were sent by e-mail and participants were chosen from websites of events related to this Master thesis' research topics, including:

- ICSOB[4]: 2015, 2016 and 2017;
- WDES[5]: 2015, 2016, and 2017;
- IWSECO[6]: 2014, 2015, and 2016; and
- WEA[7]: 2014, 2015, and 2016.

5.3 Execution

E-mails inviting the selected experts were sent on June 26th, 2017. Answers were collected between June 28th, 2017 and August 21th, 2017. From those 144 researchers invited to participate in this survey, 28 invitees responded the questionnaire (19.4%). A rate of response of 20% is adequate when the sample size exceed 100 (NULTY, 2008), thus this survey response rate is acceptable considering the samples size of 144. It was mandatory to fill the questionnaire' parts: (1) Research summary, (2) Term of Consent, and (3) Characterization Form. Participants had no obligation to answer all the relevance questions from parts (4) Critical Factors' Relevance and (5) Critical Factors' Attributes Relevance, in case they thought some assessments did not apply.

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[4] ICSOB – International Conference on Software Business. Available at: https://icsob2017.wordpress.com/
[5] WDES – Workshop on Distributed Software Development, Software Ecosystems and Systems-of-Systems. Available at: http://sesos-wdes-2017.icmc.usp.br/
[6] IWSECO – International Workshop on Software Ecosystems. Available at: https://iwseco.org/
[7] WEA – Workshop on Software Ecosystem Architectures. Available at: http://wea.github.io/

5.4 Results

Next subsections present the results obtained from the questionnaire according to the survey's sections. Participants' considerations and suggestions are also discussed.

5.4.1. Characterization

Participant's experience on the related topics was relatively high, as presented in Figure 5.1. Characterization information shows that the participants are composed of 86% of Postdoctoral/Ph.D. (Figure 5.2). This index demonstrates their experience as researchers on the related topics and likely strengthens their contribution to this survey. Besides, participants can be considered experts in the related topics with experience on research and industry according to the characterization information from Figure 5.1 and Figure 5.2 .

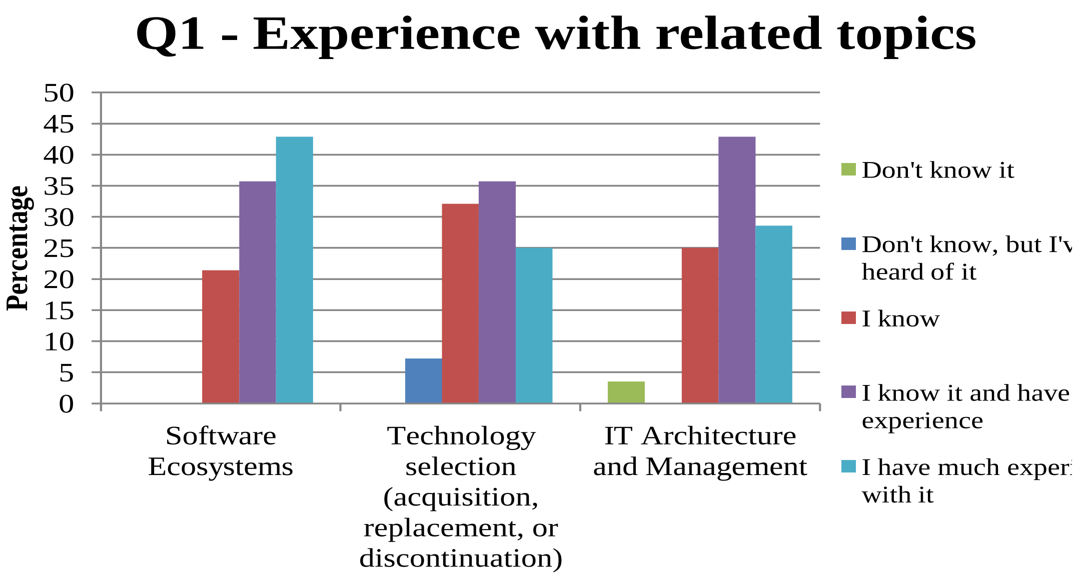


Figure 5.1. Participant's responses regarding experience with related topics

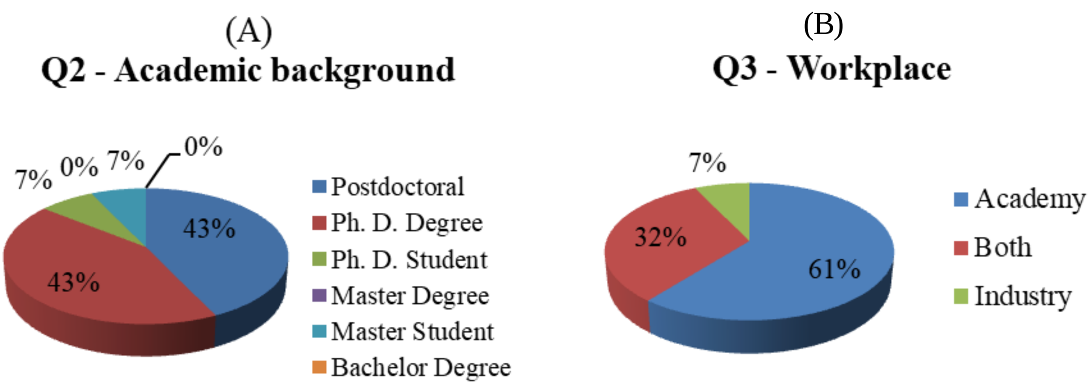


Figure 5.2. (A) Q2 - Participants' academic background, and (B) Q3 - Participants' workplace

5.4.2. *Critical Factors*

All critical factors were assessed as ‘Some relevance’ and ‘Highly relevant’. As shown in Figure 5.3, ‘No Relevance’, ‘Little Relevance’ and ‘Limited Relevance’ answers all together did not reach 50%. It means that experts find those critical factors relevant and therefore applicable for technology selection in a SECO platform. Few features were suggested, some of them already presented as attributes of critical factors. Participants had not seen the attribute list before the question regarding suggestions of critical factors, so it is positive that they might recommend some features that are attributes already proposed by this research.

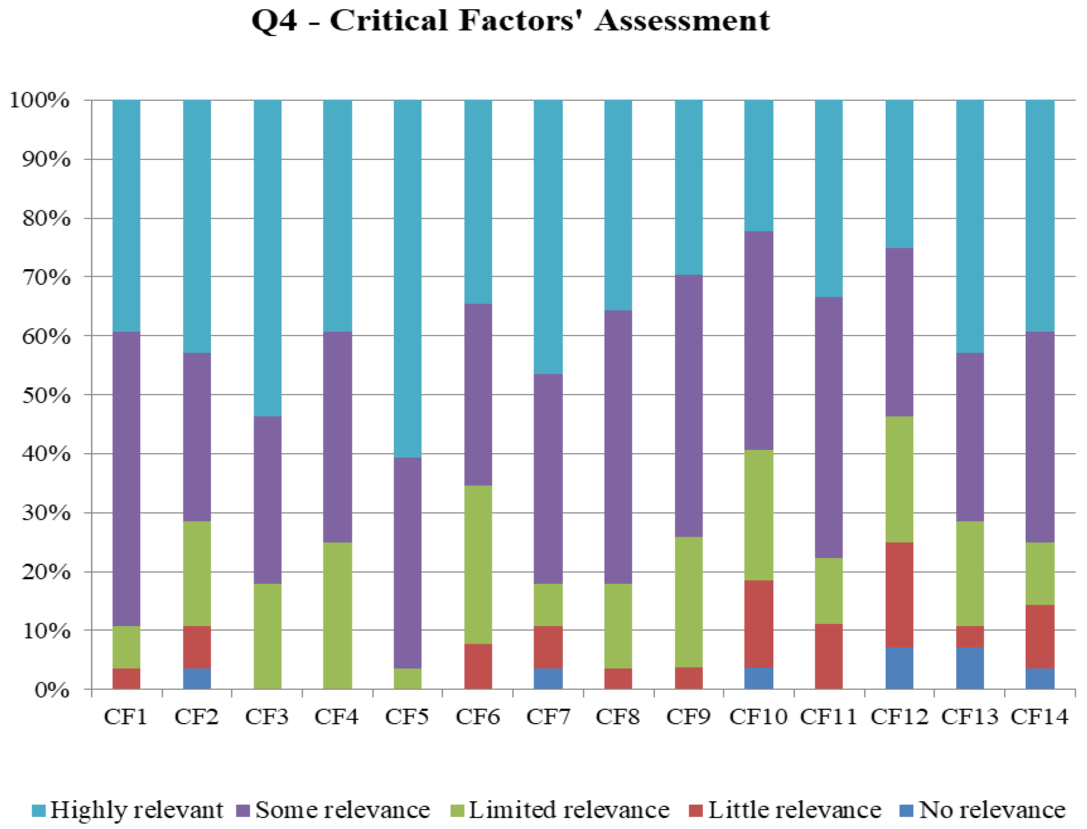


Figure 5.3. Critical factors relevance assessment

The critical factors from Figure 5.3 are:

- CF1. Configurability;
- CF2. Cost;
- CF3. Extension;
- CF4. Openness;
- CF5. Quality;
- CF6. Reuse;

CF7. Scalability;

CF8. Stability;

CF9. Support;

CF10. User experience;

CF11. Version compatibility;

CF12. Niche creation;

CF13. Robustness; and

CF14. Productivity.

Some participants identified critical factors that might be interrelated, although this study did not consider such relationships. From the 28 participants, 15 left general comments about the critical factors. Those comments are reproduced in Table 5.2 and Table 5.3, where each cell represents a participant that made a comment along with the researcher's considerations.

Table 5.2. Comments about the SECO's critical factors (Part 1)

Q6 - General comments about the critical factors and researcher consideration
*Despite the fact you considered an important number of factors, you probably should specify for *which* aspect(s) of technology selection each of the factors is relevant (or not).* **Researcher consideration:** There is an initial mapping regarding our literature study.
Very generic. **Researcher consideration:** A glossary of terms was summarized from the definitions according to our literature study in order to improve the list (Appendix II).
Not each of the factors is similarly important for a particular software ecosystem. Factors may be interpreted differently - judging the relevance would be easier if a definition was provided. **Researcher consideration:** Each IT manager can select the most relevant subset for his/her SECO platform. A glossary of terms was summarized from the definitions according to our literature study to improve the list.
Distinction between Stability and Robustness is unclear. Quality is too broad and vague. **Researcher consideration:** A glossary of terms was summarized from the definitions according to our literature study to improve the list (Appendix II). In addition, there are attributes assigned to each critical factor that can better describe the critical factor's perspectives.
I would argue that different ecosystems have different needs, so it is not very clear what kind of information do you plan to elicit in Q4. **Researcher consideration:** Each IT manager can select the most relevant subset for his/her SECO platform.
Some of the critical factors are directly related, for example, openness and trustworthiness. **Researcher consideration:** As the critical factors may be chosen (or not), IT manager can judge if those critical factors are related and can choose both.

Table 5.3. Comments about the critical factors (continuation)

Q6 - General comments about the critical factors and researcher consideration
I think they satisfy the purpose when it is necessary to select technologies for an ecosystem. **Researcher consideration:** None**.**
A good set of critical factors. Researcher consideration: None.
As most of the positive attributes of a software system are relevant in most application areas, most of my ratings are not specific to software ecosystems. **Researcher consideration:** None**.**
The relevance of each factor depends on the context and domain of the software ecosystem. Therefore, the above ranking may be somehow biased. For example, in a particular context the scalability of a component may be the most critical factor. While in other situations user experience is the most important. I believe the context of the technology selection must be taken into account for a correct ranking of factors. **Researcher consideration:** Each IT manager/architect can select the most relevant subset for his/her SECO platform. A glossary of terms was summarized from the definitions according to our literature study to improve the list (Appendix II).
I am not sure about CF-6. **Researcher Consideration:** CF6 is reuse. The participant did not explain the issue.

5.4.3. *Critical Factors' Attributes Assessment*

For each critical factor, participants were asked for assessing how relevant its attributes are, based on a five-point scale, as shown in Figures 5.4 to 5.17. For CF1, the majority of participants found both attributes to be 'highly relevant' or with 'some relevance'. *Variability*'s relevance was very expressive in comparison with the *commonality*, 82.1% voted 'highly relevant' or 'some relevance', perhaps *variability* is a most popular term. In addition, two papers indicated *commonality* and five cited *variability*.

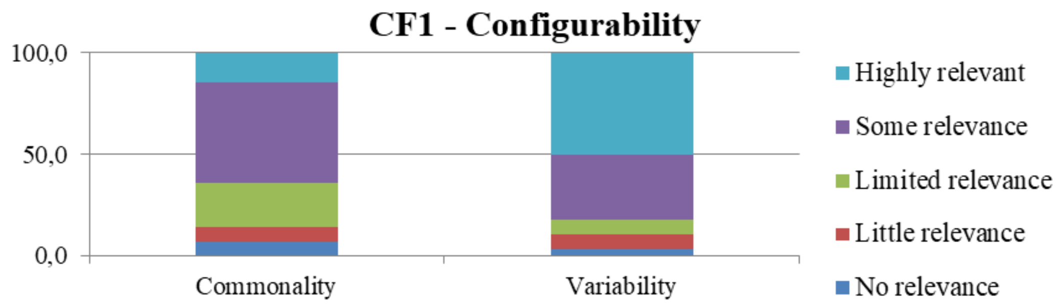


Figure 5.4. Attributes' assessment for CF1

CF2 attributes are balanced when comparing the sum of 'highly relevant' and some relevance. Those terms are not strange to researchers and are related. For example, a close platform (low *openness*) might be private software and its *licensing* may have some *cost*.

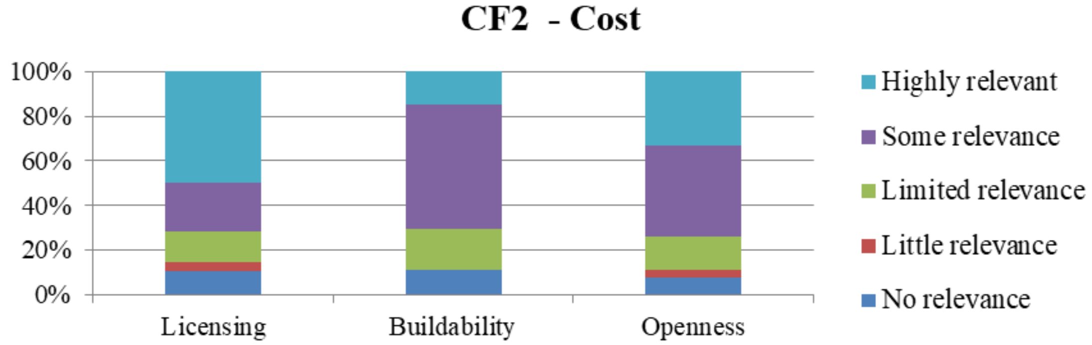


Figure 5.5. Attributes' assessment for CF2

CF3 has only one of its six attributes that has been voted as 'no relevance', if fact 'little relevance' is 3.7% in average among its attributes. Those are low rates in comparison with other critical factors reaching over 60% of the top level of relevance in the scale. *Extensibility* and *modifiability* are the two top attributes for this critical factor. In fact, it is necessary to study if (and to what extend) its *extensibility* goes and what can be modified when extending a technological platform. Other attributes such as *standardization* and *buildability* can make it easier or not to extend the platform (but are not essential).

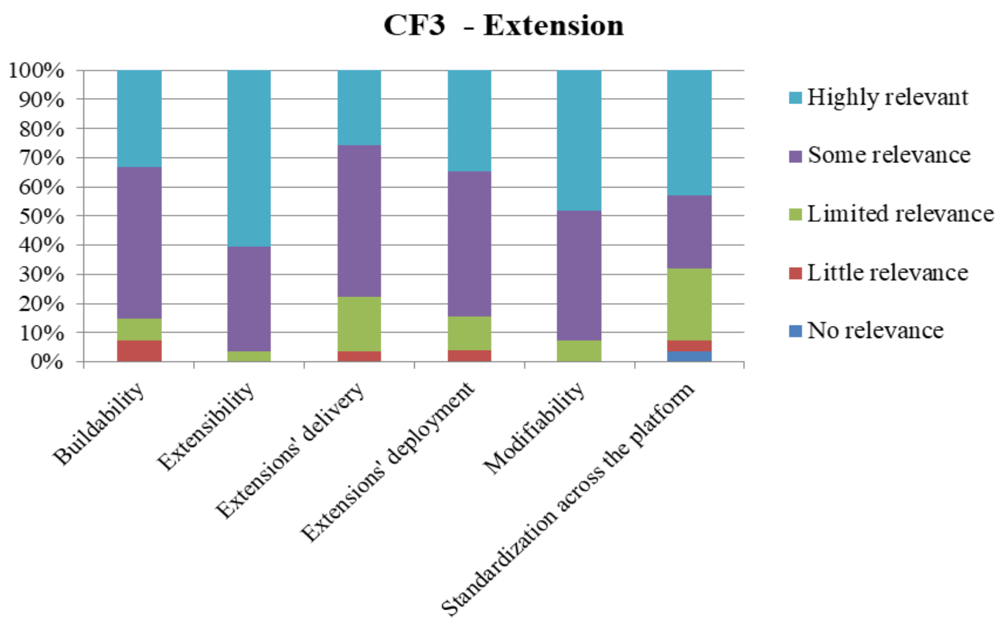


Figure 5.6. Attributes' assessment for CF3

CF4 refers to *openness* and was the third most cited quality attribute in the mapping study presented in Chapter 4. The best-evaluated attributes are *flexibility* and *security*, but *availability* is the only one that had no vote for 'no relevance'. The more a platform is open, the more susceptible to attacks it might be, since more people have access to it. That might be the reason why *security* is so relevant.

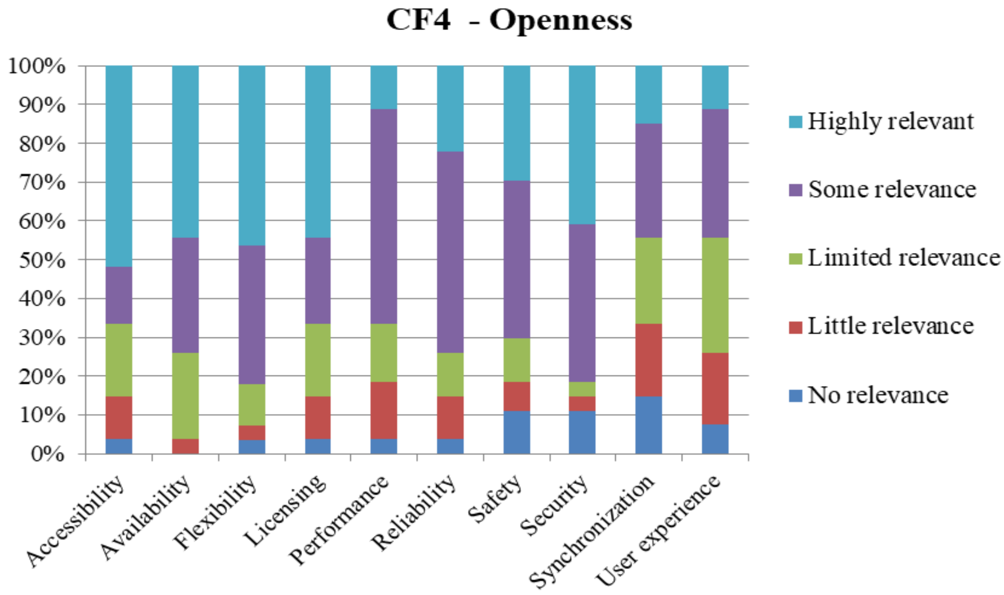


Figure 5.7. Attributes' assessment for CF4

CF5 was the top relevant critical factor with 60.7% of 'highly relevant' votes. *Testability* had no vote for the lower two levels of relevance and it was the attribute with more 'highly relevant' attributes. On the other hand, *certification* was not as well evaluated. *Testability* refers to the capability to be tested by anyone and *certification* implies a third party attesting for the quality. Perhaps, researchers involved in a development project prefer being able to test rather than trusting some institutions' opinions. In addition, the level of *quality* required varies with the type of software, being able to test it may allow them to generate clear and personalized information.

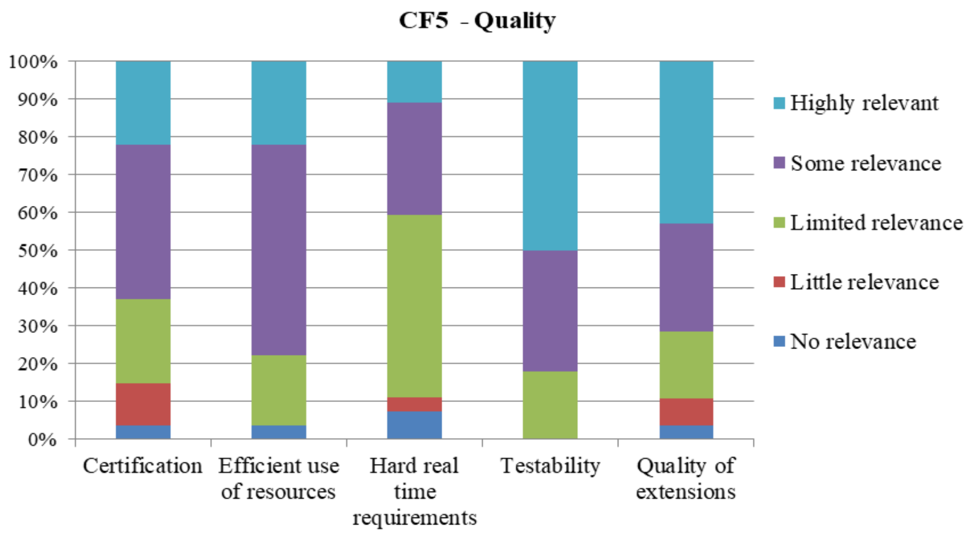


Figure 5.8. Attributes' assessment for CF5

Reuse (CF6) is a critical factor that is hard to find properly in several organizations. The most highly relevant attributes are *extensibility*, *integration*, and *modularization*. Those are some of the most technical attributes. Attributes such as *transparency*, *understandability*, and *cost* are usual complaints among practitioners, but they were not assessed by the experts with upper level of relevance.

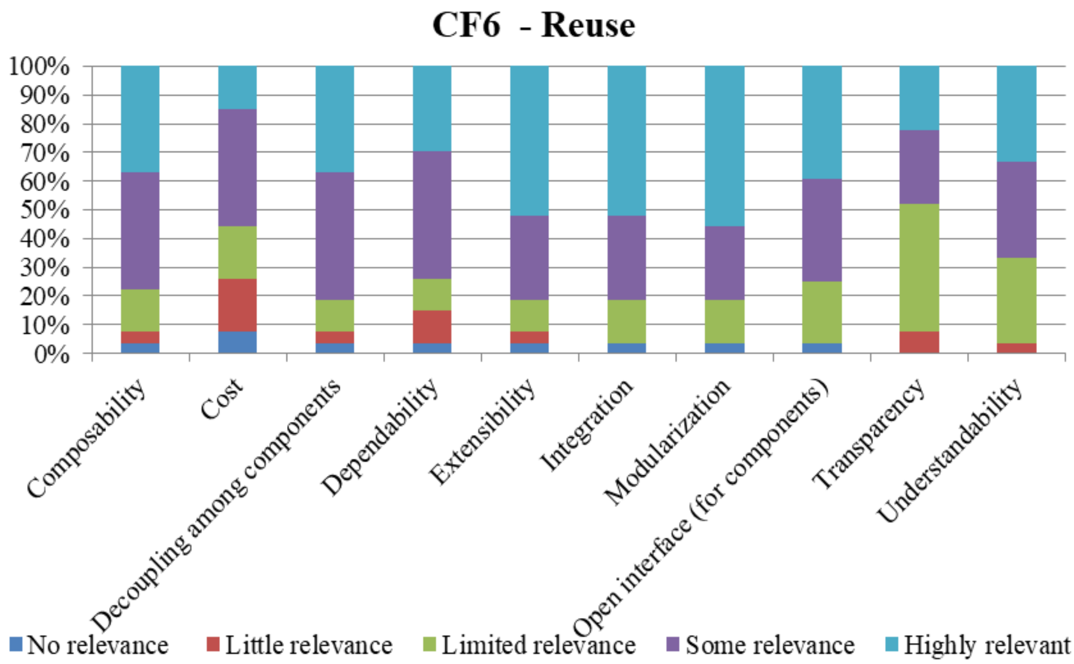


Figure 5.9. Attributes' assessment for CF6

A usual concern when scaling up a platform is that its *performance* would not keep up with more users or greater data flow. In CF7, *performance* was not considered the most 'highly relevant'. A platform that is augmented in scale may also be harder to keep good maintenance level and *cost*. Participants said they did not miss any attribute, not even for *cost*, since it was listed in this research.

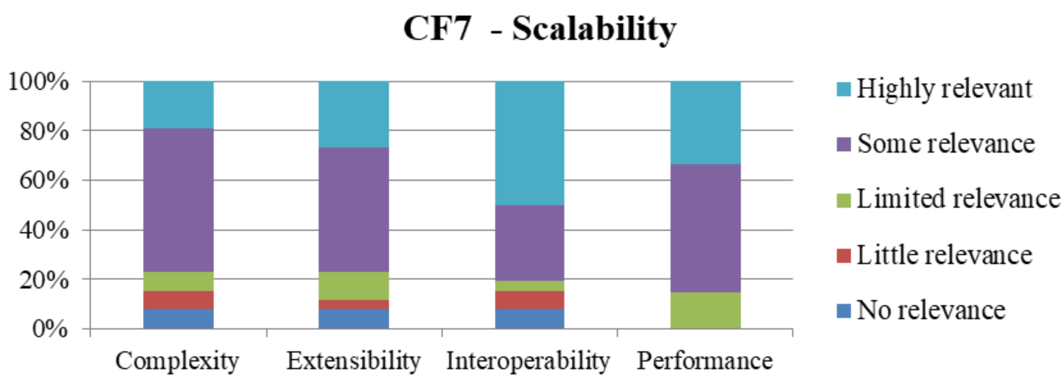


Figure 5.10. Attributes' assessment for CF7

CF8's most relevant attributes refer to the *stability* of the platform components (frameworks and interface). *Parallel development* may interfere with matters of time, but it was not considered very relevant since it is not a dominant practice in organizations. *Rate of change* might depend on the *framework and interface stability*, since their rate of change can influence the platform's demands for changes.

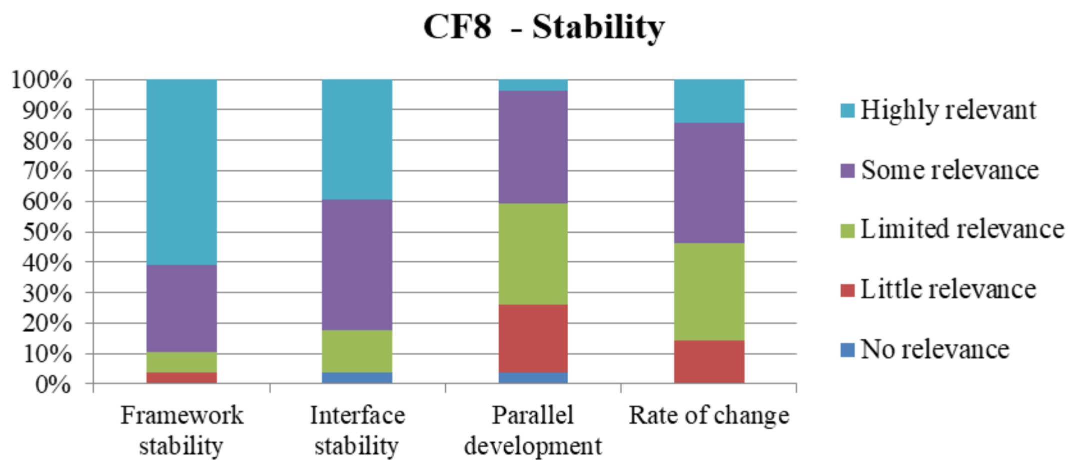


Figure 5.11. Attributes' assessment for CF8

CF9's attributes' assessment are very similar. *Documentation* is essential for supporting developers in understanding the functionalities and differences between releases. The *shared information* is not necessary from external parties, e.g., forums and FAQs, but also among the developers and architects working in the platform that also refer to non-technical problems, such as lack of communication.

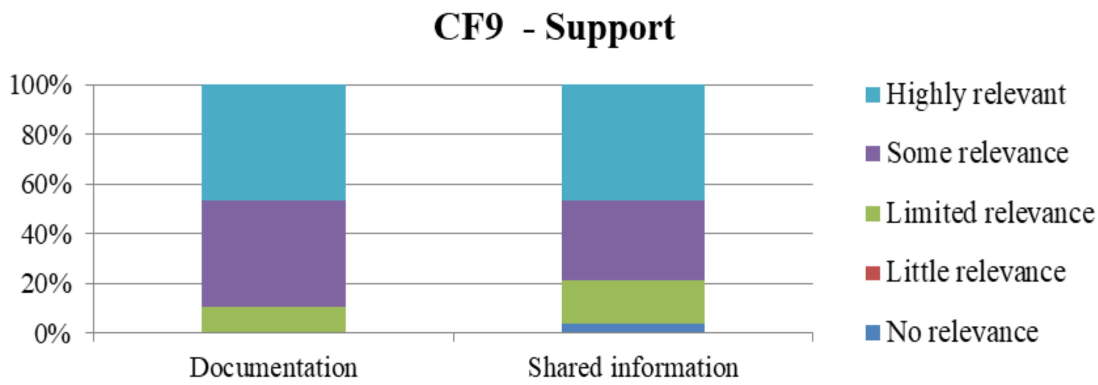


Figure 5.12. Attributes' assessment for CF9

User experience (CF10) is essential for a SECO that deals with end users, as they can stop using the platform if user experience fails. User experience is not restricted to the interface they interact with, but also to how easy and simple it is to find and use the platform's information and functionalities. For example, a developer that easily finds downloads and forums in a simple SECO portal has a better experience than using a repository full of information and permission requirements to simply access a forum.

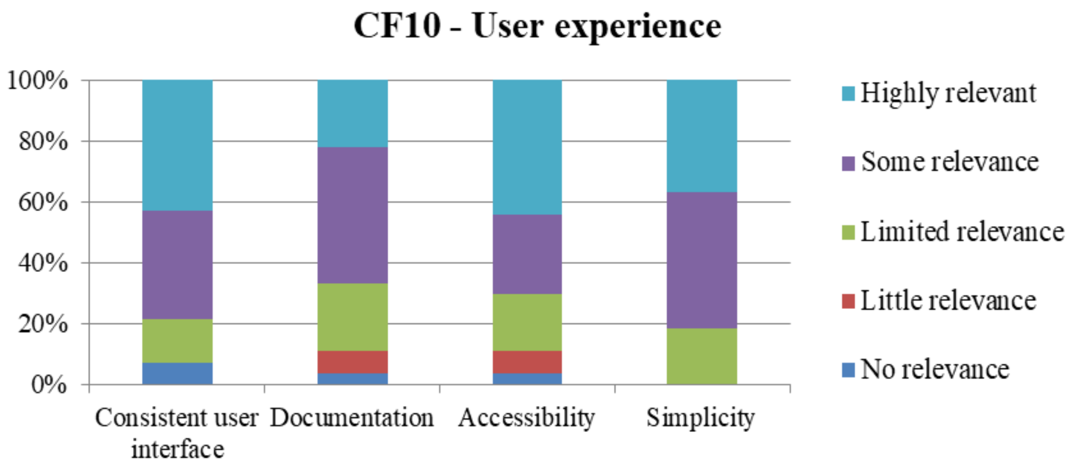


Figure 5.13. Attributes' assessment for CF10

Version compatibility (CF11) considers the compatibility of functionalities among the platform versions. In the viewpoint of developers using the platform for their own development project independently from an organization (very common in SECO), it is very harmful to keep changing the stable platform version based on all releases. All attributes are equally 'highly relevant'. *Backwards compatibility* and *maintainability* influence the problem a developer has to face during the development process. In a bigger change (e.g., replacing the platform), the project might suffer with specific native functionalities and it should be necessary two separate projects, e.g., developing for different app's versions (one for Android and another for iOS).

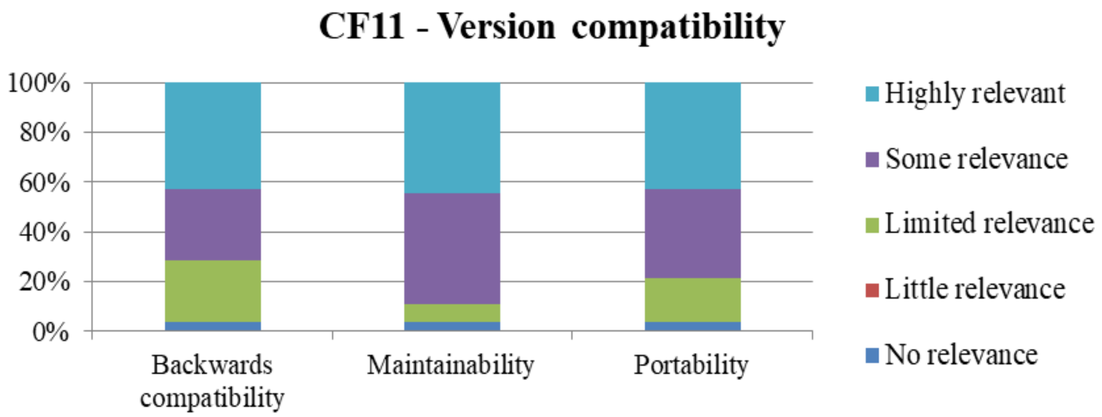


Figure 5.14. Attributes' assessment for CF11

Niche creation (CF12) is a health indicator for SECO. The more and diverse opportunities the SECO provides, the better its niche creation is. *Innovation* is the most relevant attribute and directly relates to niche creation. When a SECO produces and promotes innovation, new opportunities and niches are created. Such scenario can keep users close to the platform and bring new ones as well, since they find innovative features that might be unique and only found in a given SECO.

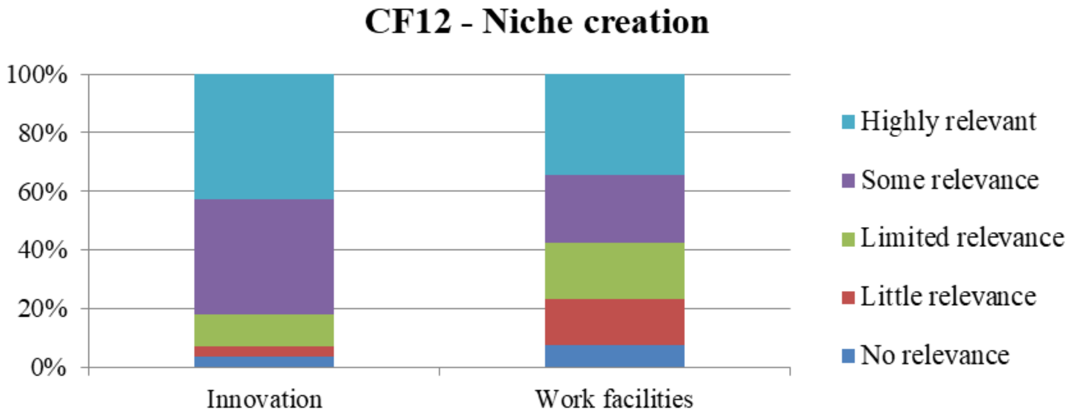


Figure 5.15. Attributes' assessment for CF12

Robustness (CF13) is defined as the capability of a SECO to resist disturbances. *Availability* is assessed as the most 'highly relevant' attribute. It makes sense since comparing SECO *availability* before and after a disturbance may be an indication of how much a SECO is robust. For that, other attributes influence a SECO regarding the platform and technologies, e.g., how resilient and stable are the technologies that support the platform. The *offline capability* was not considered very relevant, perhaps because it is a very particular requirement (not all platforms concerns with offline capability).

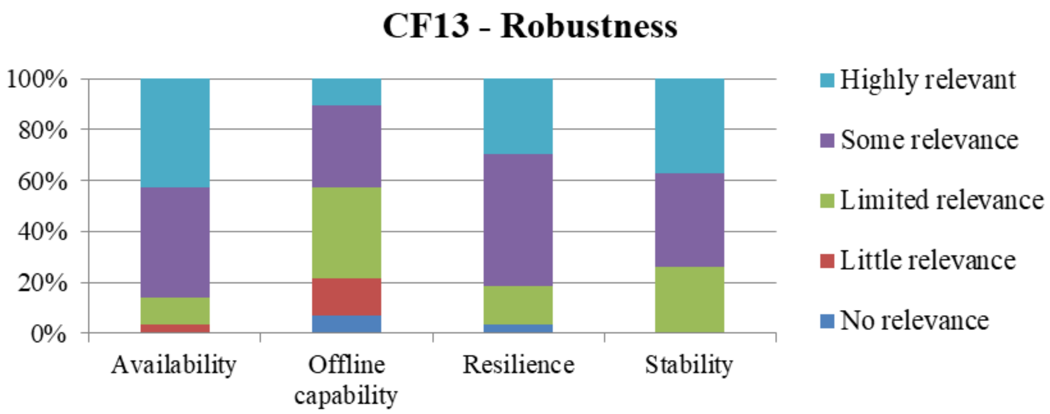


Figure 5.16. Attributes' assessment for CF13

Productivity (CF14) reflects how many projects the SECO produces. The relevance of each attribute does not differ much. All attributes refer to the existence of external parties developing on that platform. *Deployability* affects how fast a developer is able to deploy and then publish his/her projects, affecting the individual productivity that composes the overall productivity. *Extension's delivery* may stop the projects' developments if the platform extension is not updated (or a new one is not delivered). *Learnability* can prevent new projects to begin. If understanding is too difficult, the rate of developers giving up their projects may increase; thus, the overall productivity falls.

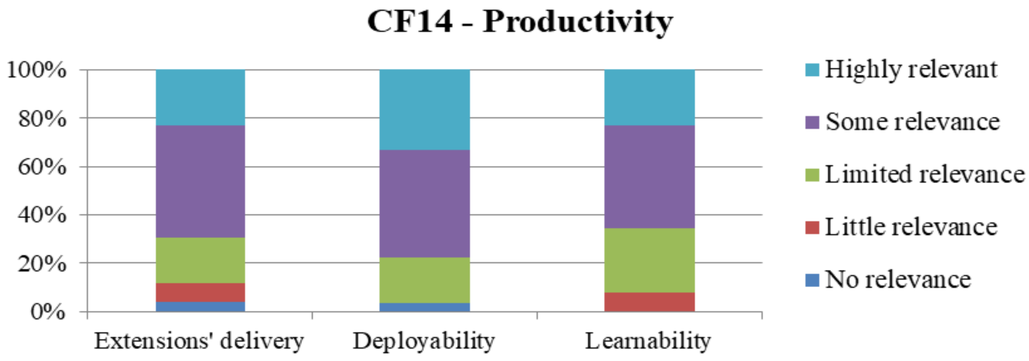


Figure 5.17. Attributes' assessment for CF14

The majority of participants voted for at least 'some relevance' for all attributes, then no attribute was removed at first. Collected suggestions were confronted to the assessments to decide whether or not they should be adopted. Putting together votes for the two highest relevance points in the scale ('some relevance' and 'highly relevant'), attributes that did not have at least 50% of votes are:

- Synchronization and User experience for CF4 - Openness;
- Transparency for CF6 - Reuse;
- Parallel development for CF8 - Stability; and
- Offline capability for CF13 - Robustness.

Regarding "Q8a. If you answered 'Yes' for Q8, please include your suggestions bellow", suggestions for critical factors and their attributes were:

- *Stability is not a criterion and an attribute to Robustness. That's either misleading or wrong*;
- *Why does Reuse have the sub-perspective Cost, while Cost is also a Critical Factor by itself?*;
- *Many precise definitions are needed*;
- *Considering that some critical factors are related in some degree, attributes that characterize them need to be in the associated set. For example, (i) interoperability could be copied to the reuse, (ii) decoupling among components and composability could be copied to extension*;
- *Consistent user interface and documentation: I have doubts if these attributes really are necessary for CF10 [User experience*];

- *I suggest a survey on the literature related to software quality attributes or nonfunctional requirements. I had difficulties in some correlations among critical factors and quality attributes*;
- *"Consistent user interface" could be copied to "CF5 - Quality*";
- *In my opinion, it is hard to rank the relevance of the attributes above without a clear definition of what they mean. I was in doubt regarding the meaning of several, such as: Offline capability, Work facilities, Parallel development, Hard real time requirements etc. A glossary and more information would be beneficial to ensure the reliability of the answers*; and
- *Maybe parallel development moves to Productivity*.

In Table 5.4, we listed some suggestions of critical factors/attributes and their respective relevance. Additionally, participants could comment freely about the attributes associated to critical factors, as shown in Table 5.5.

Table 5.4. Responses for Q9 – Missing attributes for the critical factors

Q9 – In your opinion, is there any other attribute not included in the list regarding any critical factor? If so, please include your suggestions and their respective relevance level according to the same scale as Q8. Do not forget to mention the associated critical factor.
Extension (interoperability) - 'highly relevant'; *Extension (decoupling among components) - 'highly relevant';* *Reuse (interoperability) - 'highly relevant';* *Openness (interoperability, decoupling among components, extensibility) - 'highly relevant'.*

Table 5.5. General comments about the attributes associated to the critical factors

General comments about the attributes associated to the critical factors
Not well defined: for example what is "work facilities" in Niche creation?
I am somewhat in doubt what can be learned from rating so many abstract terms. As said before, there is a risk that not all respondents understand the same thing under each term. The terms are abstract and lack a definition, and also, the respondents shall judge the factors/perspectives for SECO in general, not for a single "specific" SECO. Given that, the scores given by the respondents must be taken with a big grain of salt. Maybe, at least the list of critical factors and perspectives can be made more comprehensive, or few elements may be filtered out by performing this study.
As above, trying to find the common denominator to very different ecosystems might be too ambitious.
When I put score 0, I think the factor should not be there, is misplaced.

Only four participants left comments; they mainly expressed concerns about lack of definitions and variations on relevance according to different SECO contexts. Those are considered threats to validity and discussed in Section 5.6.

5.5 Analysis

The survey shows positive relevance on the use of SECO's critical factors and attributes. Table 5.6 presents the percentages of the two highest grades in the response scale ('some relevance' and 'highly relevant') for each critical factor. No critical factor was dismissed since no participant asked for removal of any in the questionnaire. Consequently, no critical factor was excluded from the list.

Table 5.6. Critical Factors' evaluations in percentage related to the total number of respondents for each questions. SR = Some Relevance; HR = Highly Relevant

	CF1	**CF2**	**CF3**	**CF4**	**CF5**	**CF6**	**CF7**	**CF8**	**CF9**	**CF10**	**CF11**	**CF12**	**CF13**	**CF14**
SR	50.0	28.6	28.6	35.7	35.7	30.8	35.7	46.4	44.4	37.0	44.4	28.6	28.6	35.7
HR	39.3	42.9	53.6	39.3	60.7	34.6	46.4	35.7	29.6	22.2	33.3	25.0	42.9	39.3

Regarding "Q5 – In your opinion, did you miss any critical factor not included in the list?": 57% of the participants said they did not miss any critical factor. On the next question "Q5a – If you answered 'Yes' for Q5, please include critical factors (or edit existing ones)", some participants suggested few properties as critical factors, as summarized below with the researchers' considerations:

- Institutional policies;
- Vendor trustworthiness;
- Continuity;
- Market speed;
- Flexibility, portability, trustworthiness, sustainability, interoperability;
- Security, integrity, portability;
- Innovation;
- Flexibility and communication;
- Buildability and learning curve (i.e., how easy it is to learn it);
- Architecture;
- Usability; and
- Supplier reputation.

As part of the IT management constraints for SECO platforms in Section 2.3, several types of *institutional policies* were considered as nontechnical issues. Consequently, they were not considered as criteria for selecting technologies at this point. Therefore, we argue that institutional policies should be considered but as a previous step.

The set of criteria used in this research (list of critical factors) relate to SECO platform as well as to its architecture and technologies. Thus, properties such as *vendor trustworthiness*, *continuity*, *market speed*, *sustainability*, *communication*, and *supplier reputation* were not considered as critical factors. They are relevant for technologies' assessment in other dimensions, e.g., transactional. Moreover, they should not be dismissed but rather evaluated at a previous step.

Flexibility, *portability*, *interoperability*, *flexibility*, *buildability*, and *learning curve* are already addressed by the following attributes: "flexibility" (CF4 - Openness), "portability" (CF11 - Version compatibility), "interoperability" (CF7 - Scalability), "buildability" (CF2 - Cost, and CF3 - Extension), and "learnability" (CF14 - Productivity). It is a positive outcome since it shows that experts in the related topics anticipated some attributes because they had only seen the critical factors before the referring question.

From all 64 attributes (some of them are repeated from different critical factors), only five had less than 50% when putting together 'some relevance' and 'highly relevant'. In order to decide if they should be removed, we looked into participants' suggestions and comments to find out if anyone expressed an intention of dropping these attributes out of the list.

Table 5.7. Lowest evaluated attributes. HR = Highly Relevant

Critical Factor	**Attribute (NR)**	**Suggestions**
CF4 - Openness	Synchronization – 14.8% User experience – 14.8%	Eliminate -
CF5 - Quality	Hard real time requirements – 7.4%	-
CF6 - Reuse	Transparency – 22.2%	-
CF8 - Stability	Parallel development – 3.7%	Move to CF14 - Productivity
CF13 - Robustness	Offline capability – 10.7%	-

Hence, comments were searched for explicit suggestions of removing those attributes (if pointed by at least one participant). In addition, there was suggestion for both attributes. As a result, “synchronization” was eliminated from CF4 - Openness and “parallel development” was moved to CF14 - Productivity. The suggestions for lowest evaluated attributes are listed in Table 5.7.

From Q8 (“In your opinion, is there any misplaced attribute, i.e., any attribute should be moved or copied to another critical factor?”), 68% of participants said they did not think any attribute was misplaced. Suggestions from the ones who expressed their opinions about Q8, Q9 and Comments, as well as our considerations, are discussed below:

- **Eliminate stability from robustness**: As stability is a critical factor, we have decided to remove the “stability” attribute;
- **Interoperability could be copied to reuse**: As more than one participant made that suggestion and assigned it as ‘highly relevant’, the suggestion was accepted;
- **Decoupling among components (‘Highly relevant’), interoperability (‘Highly relevant’) and composability could be copied to extension**: As more than one participant made that suggestion and assigned it as ‘Highly relevant’, the suggestion was accepted;
- **Consistent user interface and documentation: I have doubts if these attributes really are necessary for CF10 - User experience**: ‘some relevance’ and ‘highly relevant’ answers (percentage) were checked to decide if those attributes should be removed. “Consistent user interface” and “documentation” have 78.6% and 66.7%, respectively. As the majority of participants think those attributes are much relevant to CF10 - User experience, they will remain part of this critical factor;
- **Consistent user interface moves to CF5 - Quality**: The suggestion was accepted as it is; the attribute was copied to CF5;
- **Parallel development moves to productivity**: “Parallel development” was rated 40.7% when ‘some relevance’ and ‘highly relevant’ were put together. As such, it might not be at the right place. Therefore, the suggestion to move it to “productivity” was adopted;

- **Interoperability, decoupling among components, and extensibility as part of openness assessed as 'highly relevant'**: Suggestions were accepted; and
- **Some attributes are misplaces: in CF4 - Openness: synchronization, security, safety, and flexibility; In CF3 - Extension: standardization across the platform; and In CF2 - Cost: openness, licensing, and buildability**: Critical factors as attributes were removed ("openness" in CF2). A participant said that other attributes are misplaced, but did not say where they should go. Thus, unless other participants had discussed them, those attributes were not moved.

5.6 Threats to Validity

Some threats to validity for this survey are related to instruments, methods, researchers, and participants are:

- A glossary with critical factors' and their attributes' definitions captured by the mapping study was not available at the time of execution (available at Appendix II). Although most of the terms are common at the literature and participants are experts in the related topics as their characterization profile, some participants might have slightly different conceptions of the same term used for critical factors and attributes;
- Participants were free to not assess critical factors and attributes, as some questions missed zero, one or two answers. All participants had the same choice of not answering some questions. Thus, the percentage used in the results is relative to the ones who answered, since some people did not answer a few questions. The question with the most absent values had two missing answers compared with the total of 28 participants, then they are not threatening to the study significance;
- The survey was executed as an electronic questionnaire to reach the international community. Interviews might help to collect more data outside the questionnaire (informal), although the survey had questions for comments;
- It was not executed a pilot before the main study. The questionnaire could have been improved before the main execution;

- It could not be assured that the sample size was optimal and that they had a high representativeness of the population; and
- The scale used to assess relevance (Likert) cannot assure that participants are using the same criteria for each relevance level.

5.7 Conclusion

After analyzing participants' suggestions as well as consulting their respective proposed relevance levels, the set of critical factors and their attributes was updated after removing, including, copying or moving some attributes, as explained in this chapter. In addition, some critical factors that appeared as attributes were removed. The final list is presented in Table 5.8.

The majority of participants did not think that any attribute or critical factor has 'some relevance'. The list is very generic since critical factors and attributes encompass different SECO contexts according to some participants. However, the idea is that an IT manager/architect chooses a subset to apply in technology selection rounds, i.e., the list is flexible enough to have a subset that is suitable for an acquiring organization regarding its particularities and its SECO context.

At the end, the produced list is an instrument that helped us to develop a solution approach to support IT management activities, such as IT architecture maintenance based on technology selection in the SECO platform. That is, technology acquisition in this study is based on explicit criteria (not only on tacit knowledge).

Therefore, such process might be easier to justify, verify, and replicate in different technology categories and organizational projects. Those indications are valid and relevant for the set of participants characterized mostly as expert researchers, and therefore they are used in the approach, still pending verification with practitioners. Many participants raised concerns about a critical factor being an attribute of another's. To avoid any confusion and keep clear levels (critical factor and attributes), critical factors that appeared as attributes were eliminated as attributes.

Table 5.8. Final set of critical factor and attributes

Critical Factor	Attributes
CF1 – Configurability	Commonality; Variability
CF2 - Cost	Buildability; Licensing
CF3 - Extension	Buildability; Extensions’ delivery; Components decoupling; Composability; Extensibility; Extensions’ deployment; Interoperability; Modifiability; Standardization across the platform
CF4 - Openness	Accessibility; Availability; Components decoupling; Extensibility; Flexibility; Licensing; Interoperability; Performance; Reliability; Safety; Security
CF5 - Quality	Certification; Efficient use of system resources; Consistent user interface; Hard real time requirements; Quality of extensions; Testability
CF6 - Reuse	Composability; Components decoupling; Dependability; Extensibility; Integration; Modularization; Open interface (for components); Transparency; Understandability; Interoperability
CF7 - Scalability	Complexity; Extensibility; Interoperability; Performance
CF8 - Stability	Framework stability; Interface stability; Rate of change
CF9 - Support	Documentation; Shared information
CF10 - User experience	Accessibility; Consistent user interface; Documentation; Simplicity
CF11 - Version compatibility	Backwards compatibility; Maintainability; Portability
CF12 - Niche creation	Innovation; Work facilities
CF13 - Robustness	Availability; Offline capability; Resilience
CF14 - Productivity	Extensions' delivery; Deployability; Learnability; Parallel development

Chapter 6 – SECO-AM Approach

The background presented in Chapter 2 and studies described in Chapters 3, 4 and 5 based the definition of an approach for supporting IT architecture maintenance and analysis of an organization's ecosystem, named SECO-AM. This chapter describes SECO-AM and a tool support used for assessing the feasibility of applying the approach in an industrial scenario (Chapter 7).

6.1 Introduction

Analyzing a SECO network is not trivial, as its relationships are complex and need balance similarly to natural ecosystems. In addition, it does not have enough support according to the initial ad hoc literature review (Chapter 2). The information available to IT managers and architects for making decisions is often tacit knowledge or data spread through several outdated documents.

Thus, organizing information in a structured base can simplify part of the technology selection process. It is valuable for IT managers and architects to be able to understand how their SECO is formed and the relationships among its elements. In other words, they require information and a visualization model that helps them to identify connections that they missed in their analysis, e.g., system's and technology's dependencies.

Once IT managers and architects comprehend how their decisions disturb the ecosystem, they learn lessons to be considered for future decisions. The process of making the decisions involved in the maintenance of an organization's IT architecture can be repeated for other candidates or even other categories, but the process can be used in other situations as well as the selected criteria. This process of maintaining IT architecture corresponds to acquire/discontinue/replace a technology. As such, related data serve for future references, explanations, auditing, and reuse of criteria.

In this context, we developed a solution approach based on the principle that the selection process data, e.g., users, technologies, categories, and analysis, is already registered at Brechó-EcoSys platform, including technologies and systems. As explained in Chapter 3, Brechó-EcoSys platform stores software components and services, offering features of market platform, e.g., purchase and user profile.

Then, the platform was updated with sociotechnical resources, named Brechó-EcoSys. Those resources provide information about software, communities, and negotiation rounds. Therefore, the proposed approach is richer when used Brechó-EcoSys' resources. Hence, Brechó-EcoSys stores the organization's information and technical artifacts from the portfolio; manages SECO's analysis reports; and explores information for each technology candidate to be discontinued or acquired.

This approach is a 'second step', i.e., it applies to IT architecture management when the candidate technologies are known. Such candidates are compared based on an analysis performed through Brechó-EcoSys resources and then the SECO is understandable from exploring a visual support and ecosystem network measures.

This chapter is organized as follows: Section 6.2 describes the research questions and SECO-AM requirements; Section 6.3 defines the SECO-AM approach and its elements; Section 6.4 presents a tool support for the main features of SECO-AM; Section 6.5 discusses the related work and compares them to the requirements defined at Section 6.2; and Section 6.6 concludes the chapter presenting the main results from the approach and tool support.

6.2 Research Questions and Requirements

The main goal of this research is to develop a proposal to support an IT management team in maintaining a SECO platform based on technology selection decisions and analysis of impacts they have on the organization's structure and strategy from the SECO perspective. The following research questions were defined focusing on that goal and derived from challenges and gaps found in the literature about SECO:

- RQ1: How to support IT managers and architects in selecting technologies for maintaining IT architecture in the SECO context?
- RQ2: Can a visual support for analyzing a SECO network help IT managers and architects to understand what is happening in an ecosystem?

Chapter 3 summarized the main observations from our exploratory studies. Considering those points, it was possible to extract features that are requirements for our solution approach.

- Information on technology communities' activities can help IT managers and architects to make decisions based on how much they would rely on the community, e.g., if an open-source technology is a candidate for acquisition and IT managers and architects prefers to rely on the community support rather than buy a support plan, they can choose such technology based on community activity level.

Requirement #1: (R1) The approach must inform IT managers and architects about the community activity level, if available;

- We observed from the mapping study's and survey's results that there is a lack of architecture criteria to compare candidate solutions for acquisition (technical perspective). Technical criteria might not be a mandatory condition since organizations have other concerns, e.g., financial, politics, and bureaucratic processes. Regardless of any factor, technical criteria are highly relevant for selecting technologies, since they affect the systems they support.

  Requirement #2: (R2) The approach must offer technical criteria regarding software architecture perspective;

- A sociotechnical network can represent a SECO. Its elements can be used to support demands and solutions analysis (and then technology acquisition). However, most organizations are not aware of how their decisions affect the ecosystems they participate.

  Requirement #3: (R3) The approach must provide different visualization perspectives of the ecosystem in which an organization is a keystone, monitoring its elements, e.g., technologies, systems, analysis; and

- Data visualization was a concern in both exploratory studies: it helps an acquiring organization to be aware of what is going on in negotiations, and shows trends from a SECO monitoring support. Important network properties such as hubs, density and connectivity are not available to an organization in the existing SECO tool support.

  Requirement #4: (R4) The approach must support technology centrality calculation to identify hubs in a SECO as well as provide clustering measures to have a sense of technology connectivity and ecosystem niches.

The mapping study (Chapter 4) and the survey (Chapter 5) previously described allowed us to come up with the following requirements:

- **Requirement #5**: (R5) The technology assessment criteria must be assessed in the perception of IT managers and architects since it is not possible to always have the criteria quantitative metrics;

- **Requirement #6: (R6) The approach must offer general technology assessment** criteria to be applied in different contexts; and
- **Requirement #7**: (R7) The approach must allow IT managers and architects to choose the most appropriate technology assessment criteria for their specific SECO.

6.3 Approach Definition

SECO-AM (**S**oftware **E**cosystems - **A**rchitecture **M**anagement) approach has four main modules for achieving the research goal, as illustrated by Figure 6.1. **SECO Monitoring** module is mainly used by IT managers and architects, since they make decisions using the process modeled in this chapter. However, depending on the organization IT department structure, one IT manager may use such module and then the whole team can discuss the results at a meeting (or this task may be delegated to a trusted IT architecture).

Monitoring consists of keeping analyzing what might affect the SECO status. Such analysis may be external to the organization, i.e., hired consultants, external partners or research, and advisory firms that report on IT market (consulting companies). This type of analysis is covered by SECOGov approach (ALBERT, 2014). SECOGov aims to support the software asset governance in ecosystems and brought to Brechó-EcoSys the initial concept of 'SECO analysis'.

SECO-DSA (SANTOS, 2016) allows visualization of the network before and after the selection of solutions for the chosen demands. In SECO-AM, we refined this mechanism by including technology comparison support and registration attached to a given SECO analysis. The second part is to perform an internal analysis of candidates for acquisition/ discontinuation, according to IT managers and architects' interpretation and perception included as SECO-AM approach feedback.

The specific task of preparing technology assessment criteria and applying them in some candidates is performed by IT architects. As such, they use **Technology Assessment** module to choose a subset of criteria, i.e., critical factors and attributes to be used in a specific analysis. In other words, IT architects may choose the critical factors to be considered and then the respective attributes and their weights. As a result, each technology candidate is assessed regarding the same set of attributes so that IT architects must insert their perceptions for the set of selected attributes.

The IT architect's perception is weighted by the attribute's value previously defined. Hence, technologies are assessed based on the same criteria, but each assessment is performed by an IT manager using the set of criteria that fits his/her organization, as he/she judge the criteria according to his/her personal experience and knowledge.

An analysis is then created for a particular category of technology defined at Brechó-EcoSys. Consequently, the technologies available for an analysis are the ones registered in the same technology category. This module supports IT architect reasoning on providing a well-defined, explicit criteria list, since the way organizations perform analyses are based on tacit knowledge and analysts' experience (in this case, IT architects responsible for the analysis).

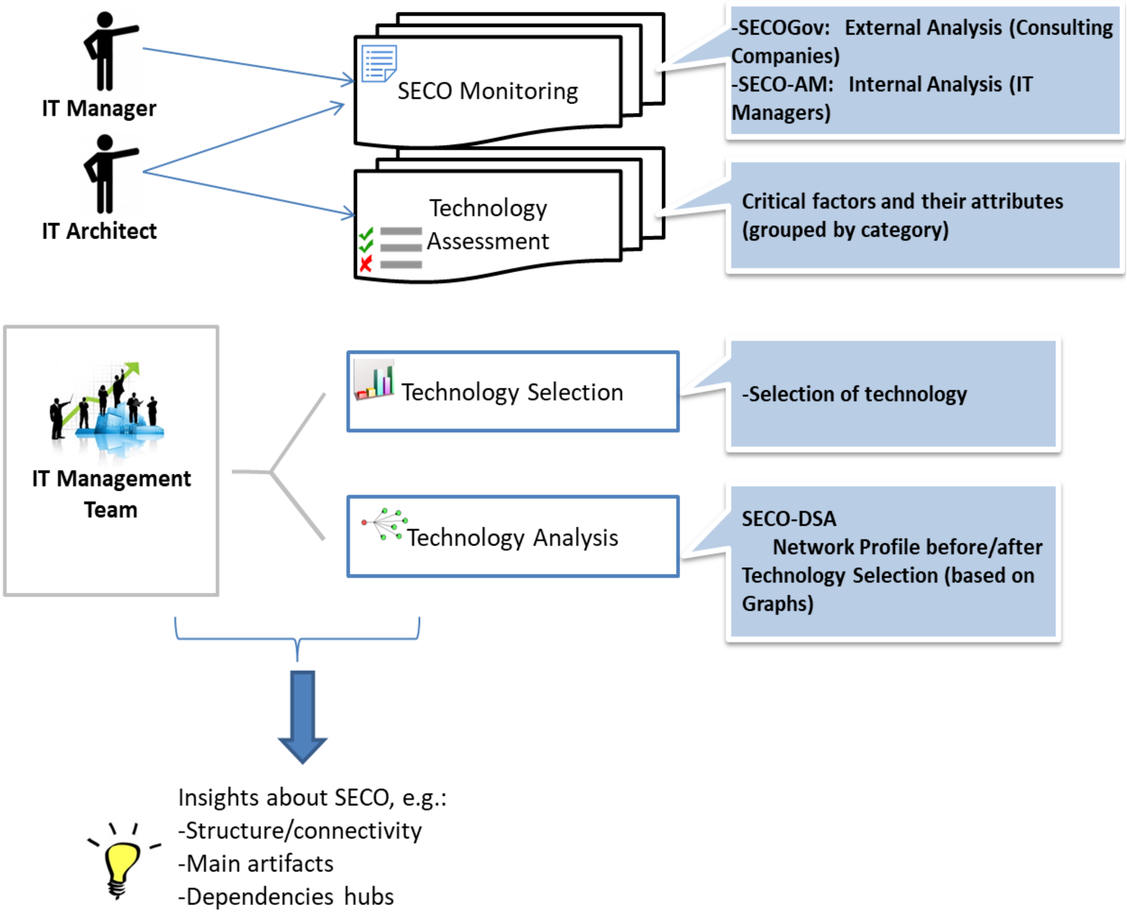


Figure 6.1. Initial SECO-AM design

Performing the analysis by category is important but it needs to be based on explicit criteria to guide discussion among IT architects, justification for IT managers and architects , and line of reasoning. IT architects might perform the tasks separately and compare results grounding reports before meeting for a more concise discussion. IT architects should be registered at Brechó-EcoSys; thus, IT managers and architects can assign them to specific analyses.

Select Technology module aims to support technology comparison from criteria assessment. IT architects and managers compose the IT management team and they need visual aid to compare technologies side by side, according to the perception of each analyst assigned to an specific analysis. Hence, an analysis is performed at a time. The perceptions are weighted and added for each attribute; as a result, each technology gets a score.

SECO Analysis module is defined for supporting the visualization of different perspectives of the organization's SECO represented by specific networks. In addition, this module provide information the IT management team does not consolidate in a unique view (or they do not exist), since SECO concepts are not known, newly discovered or not widespread within the organization.

There are several networks formed by the elements and connections from a SECO. SECO-AM intends to use the networks described in Table 6.1 that derive from available information at Brechó-EcoSys. Those networks are built using Graphs Theory and connect nodes with edges based on the meaning of the types of nodes and connections. For each network in Table 6.1 (represented by a row), the second column indicates what types of nodes the network will have. Third column describes the relationship connecting the nodes.

In Figure 6.2, we explained the benefits the network visualization offers to IT managers and architects and the measures provided to them. Those measures are calculated for specific networks using well-established graphs algorithms (e.g., clustering), or the network structure (e.g., number of connections).

Additionally, it is possible to provide information that would be obscured if there were a large number of systems and technology, e.g., technologies registered but not used or marked as discontinued, number of technologies, systems in development etc. In order to help IT managers and architects to analyze a SECO, each type of node has a different color, the tool's screens have guidelines, and analyses based on the assigned criteria are available for consulting or reassessment. Each technology's scores may be used as weight in the graphs algorithms.

Table 6.1. Networks considered by the SECO-AM

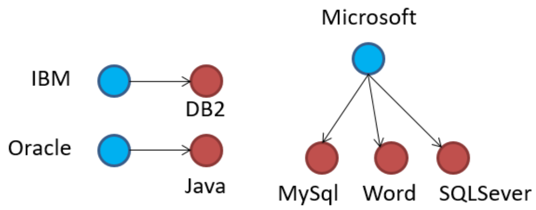
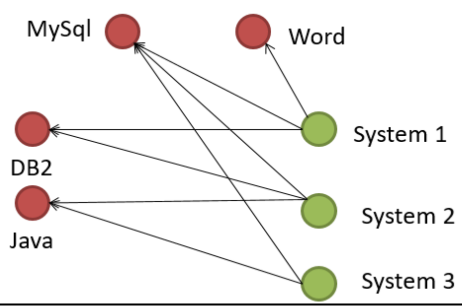
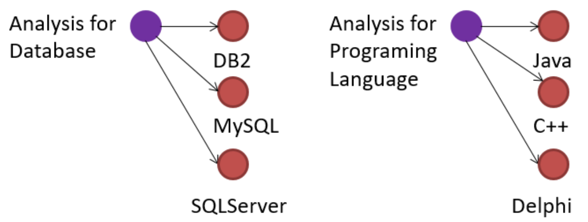
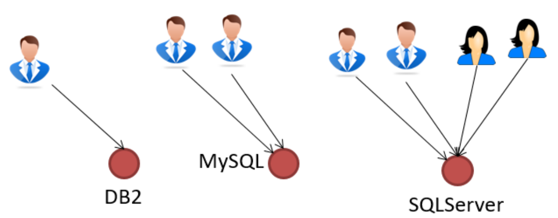
Name	Elements	Relationship
Supplier Dependency	Organization and Technology	*Supply*: In Brechó-EcoSys, this is captured from producers of IT components (marked as 'technologies'). Example: 
Technology Dependency	System and Technology	*Dependency*: Systems depend on the support provided by a set of technologies. In Brechó-EcoSys, this is captured from a dependency between components marked as 'technologies' and as 'systems'. Example: 
Potential Candidates' Analysis	Analysis and Technology	*Candidate*: Each analysis has a set of potential candidate technologies. In Brechó-EcoSys, this is captured from analysis and components (marked as 'technologies'), if both are assigned to the same technology category. Example: 
Technology Community	Technology and Team	*Community*. In Brechó-EcoSys, this is captured from a component marked as 'technology' and users participating in their related forums. Example: 

Table 6.2. Benefits and metrics

Name	Benefits	Measures
Supplier Dependency	The visualization of this network offers the capacity to find suppliers that concentrate most technologies adopted in the organization's SECO. Therefore, it is possible to identify if the organization is captive of a supplier, or even a supplier that controls a technology considered as vital to the ecosystem.	*Weighted number of connections*: Instead of having the sum of connections with each technology, it can be done by the number of systems they support. Example: in an organization's SECO, Microsoft controls 3 technologies and Oracle 1, but the 3 Microsoft technologies support 8 systems and Oracle's supports 10; thus, we can see such SECO more dependent on Oracle technology.
Technology Dependency	This network shows how dependent on a technology an organization is according to the systems it supports. When analyzing the chance of discontinuing a technology, the impact on the ecosystem becomes clear. We can look at how many (and which) systems will no longer have support. It also benefits the ecosystem when looking at replacing technologies. IT managers and architects can identify if they can discontinue 2 technologies and replace them by one that maintains the systems previously supported by the 2 old technologies (cost save).	*Technology centrality*: the HITS algorithm calculates how central/important a node is depending on its connections. *Clustering*: The clustering algorithm finds groups in the network. In a network that connects systems/technologies, the more groups it has, the more a dependency is spread through the technologies. If many groups exist, technology discontinuation may affect the groups it is part of (and not hinder others). A group means that it elements have similarities, similar to the niche creation concept. The more groups a SECO has, the more niches it has and then the more opportunities it offers.
Potential Candidates' Analysis	This network makes clear the options IT managers and architects have in an analysis. They may discover if there is a technology equivalent to a candidate, so there is no need for acquisition. There is not explicit knowledge about that before.	-
Technology Community	This network represents the community around the technology with respect to external users and internal teams. External users can be registered in Brechó-EcoSys to represent users, clients, and teams characterizing the organization departments using (or interested in) a technology.	*Community*: Number of connections to a technology. This may indicate the community size around the node. *Community activity*: Number of posts at a Brechó-EcoSys's forum for a technology.

The activities to select candidate technologies are presented in Figure 6.2. The process starts in Brechó-EcoSys as the user creates an analysis for a category. To start the process, it is assumed that Brechó-EcoSys is already configured for an organization's SECO, i.e., categories, suppliers, technologies, systems, and dependencies are already registered at the platform. If an analysis is already registered, a user can start from the 'Get information on the candidates in Brechó-EcoSys' task.

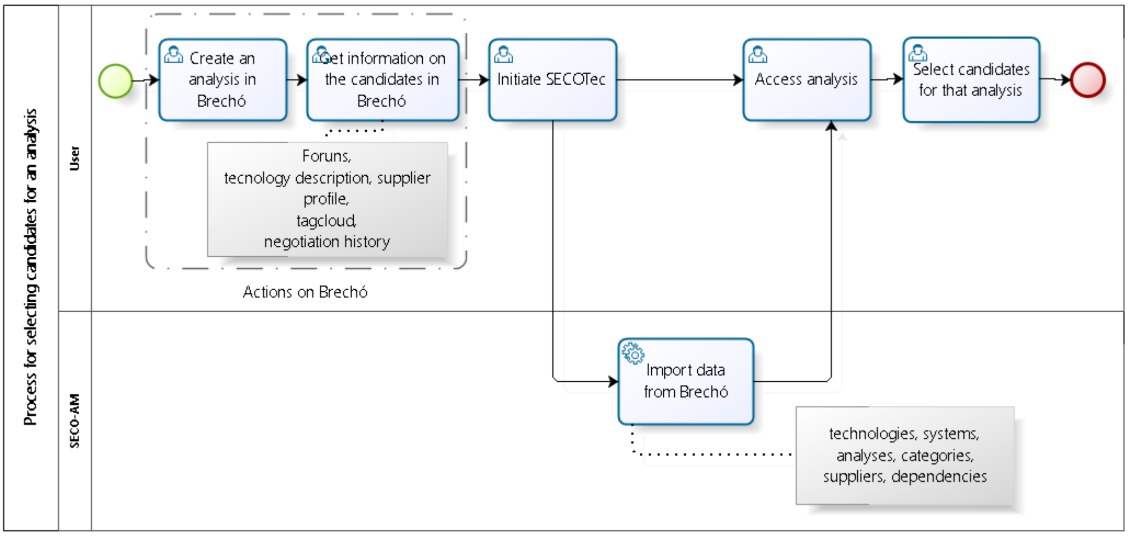


Figure 6.2. Selecting candidate technologies for an analysis

The technology assessment follows the process in Figure 6.3. The user can select one or many critical factors and it is possible to select one or many attributes from each critic factor so that the criteria is better suited to the organization's context.

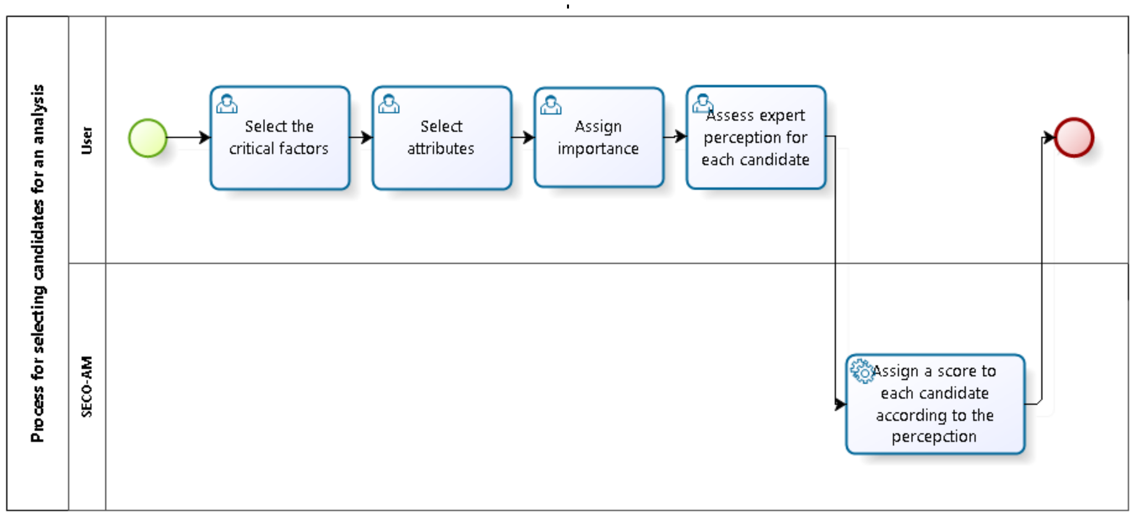


Figure 6.3. Assessing candidate technologies

Figure 6.4 shows the visualizing and monitoring process. The processes indicates a 'User' generically because, depending on the organization and the task, it can be used by IT architectures or managers.

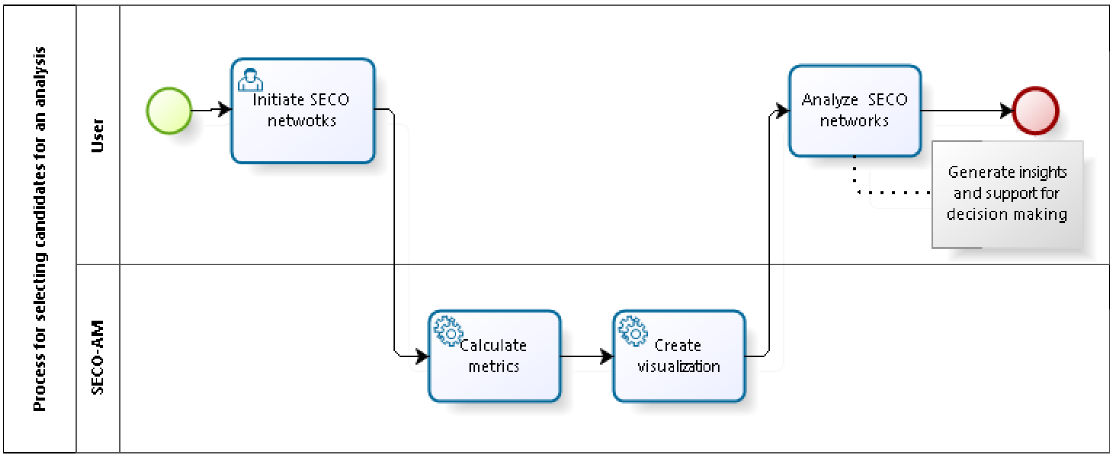


Figure 6.4. Analyzing an organization's SECO

6.4 Tool support

In order to support the SECO-AM approach, a tool support was developed. This tool imports data from Brechó-EcoSys platform and extract information to help IT managers and architects in technology assessment in the SECO perspective. The tool was implemented in Java, MySQL, Tomcat, Apache, using NetBeans 7.3.1, JPA, and JUNG graphs API for graph manipulation and visualization. The prototype has 2,017 lines of code (LOC), aside from the files creates by JPA and graphic interface. Many database tables used were captured from Brechó-EcoSys sql script file. In addition, two new tables and twelve Java classes were created.

6.4.1. Tool's Motivation

SECO-AM describes the support for IT managers and architects to maintain IT architecture using information about technologies, assessment criteria, visualization and data they might not have before considering the SECO perspective. To verify how feasible SECO-AM is for IT managers and architects, a prototype that implements the main features described in Section 6.3 was developed.

6.4.2. Tool's Requirements

As the tool support is a prototype, it does not implement all SECO-AM requirements. The tool implements the following requirements considered as essential:

- (TR1) The tool shall provide a user with analyses previously registered;
- (TR2) The tool shall allow a user to select technology candidates to be assessed according to the analysis category;
- (TR3) The tool shall allow a user to choose critical factors for an analysis;
- (TR4) The tool shall allow a user to choose attributes for each critical factor selected for an analysis;
- (TR5) The tool shall allow a user to add his/her perception for selected attributes for each technology candidate and display the final score;
- (TR6) The tool shall implement the following SECO networks: Supplier Dependency, Technology Dependency, and Potential Candidates' Analysis; and
- (TR7) The tool shall indicate number of technologies, discontinued technologies, centrality, and clustering measures for Technology Dependency.

6.4.3. Tool's Architecture

The tool's architecture is presented in Figure 6.5. The tool imports data from Brechó-EcoSys database to perform the main modules implementing the tool's requirements.

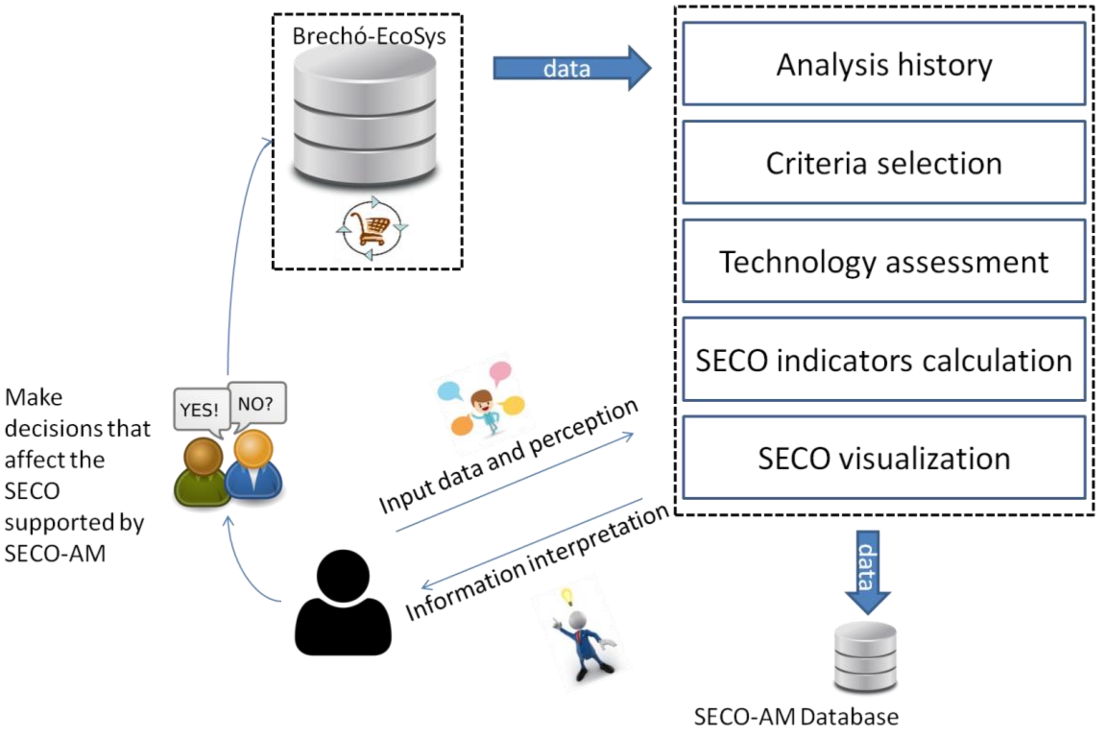


Figure 6.5. Tool's overview

The data generated is stored in a local database originated by the user's inputs and tool's calculations. Information provided to IT managers and architects will be interpreted to generate insights since the goal is to support decisions (and not to make it). Once the IT management team makes a decision, Brechó-EcoSys is updated since a selected technology is not a candidate anymore and then affects other SECO elements registered at Brechó-EcoSys. Next time the tool is used, the data is updated.

It was necessary to extent Brechó-EcoSys model as presented in Figure 6.6.

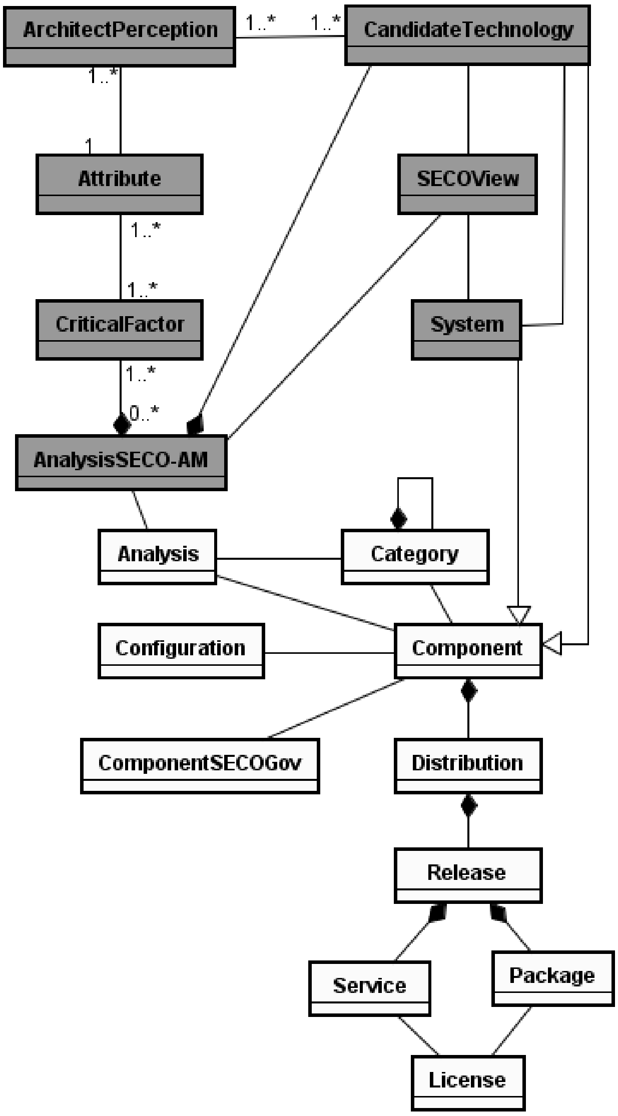


Figure 6.6. Brechó-EcoSys extension

The model is based in storing and handling components that are categorized by the user. The components are composed of at least one distribution, each distribution is composed by releases. The release may have a package with artifacts (e.g., source code and manuals) or service parameters. Each release is assigned to license.

The configuration was created to make easier for new people in the organization to understand what tool they would need according to his/her profile. Therefore, it is a grouping of components. Each component can also be part of one or many analyses according to its category. This analysis allows users to report information about maturity, suppliers, benefits, time do adoption, etc. Dark entities are the ones used in this approach and the lighter ones already existed in Brechó-EcoSys. The entities are stored in the prototype database and can update Brechó-EcoSys' database as future improvements, except 'SECOView'.

Brechó-EcoSys' original analysis module already has a field for uploading a file containing a report of the candidates' comparison. On the other hand, SECO-AM performs an analysis on top of the information of the original analysis module as well as criteria and candidates. 'Technology' and 'System' are types of 'Components' and inherit their 'Category' and 'Dependencies'.

6.4.4. Prototype

The prototype offers the option to visualize the organization's SECO or to start from consulting the analysis and end in the visualization. Figure 6.7 shows the prototype's main screen. An analysis registered in Brechó-EcoSys is listed and its main data are displayed as presented in Figure 6.8. Each analysis can be detailed as shown in Figure 6.9. The data displayed in this screen are brought from Brechó-EcoSys. The user can choose a candidate to be investigated in an analysis, selecting at least one from the available list and confirming it.

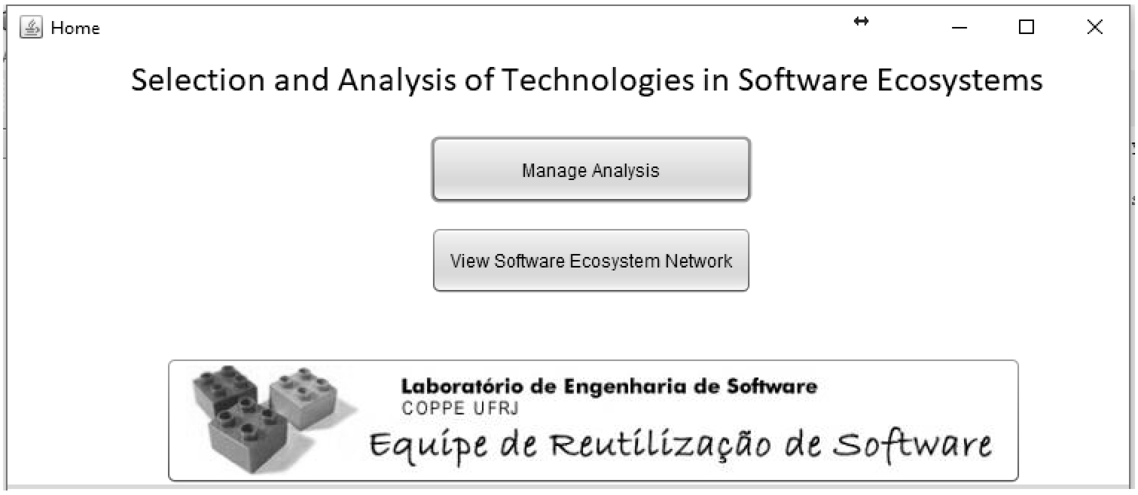


Figure 6.7. SECO-AM's main screen

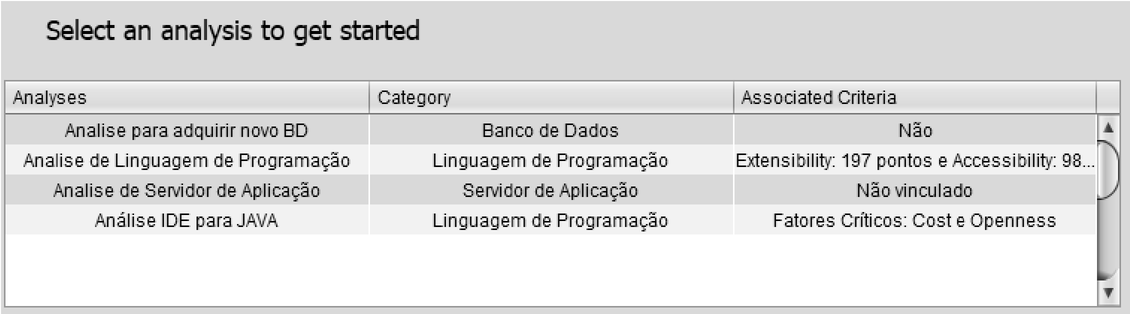


Figure 6.8. Registered analyses

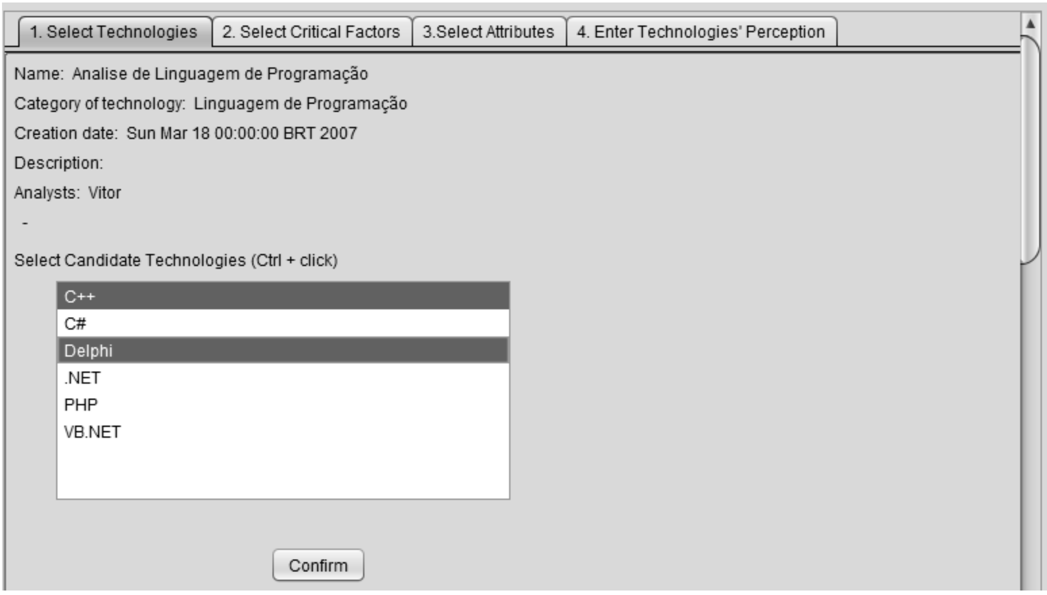


Figure 6.9. Analysis details

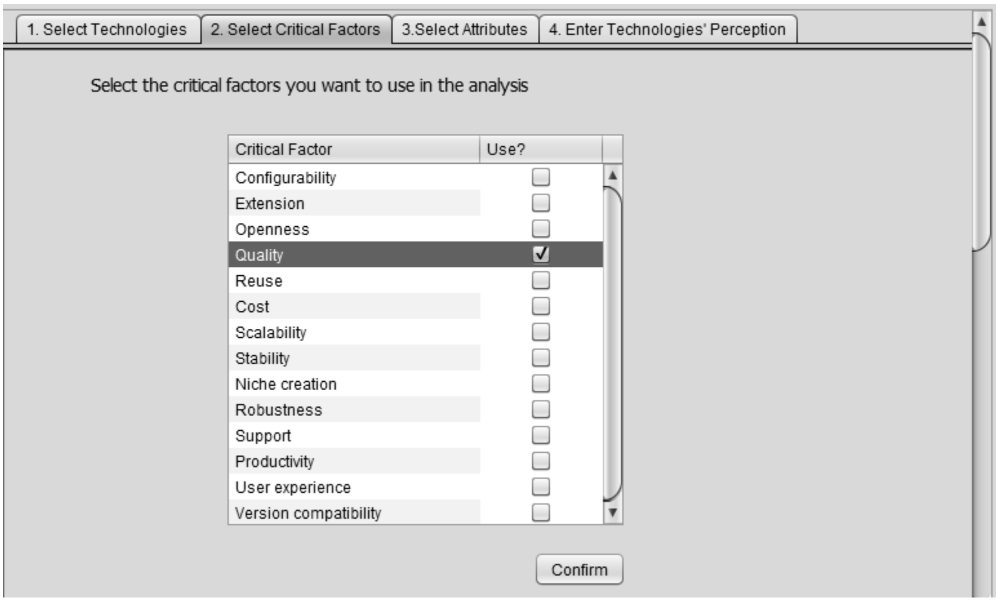


Figure 6.10. Selecting critical factors

As shown in Figure 6.10, the complete list of critical factors resulting from Chapter 5 is available so that a user can select which ones to use in an analysis. For each selected critical factor in Figure 6.10, a list of its attributes according to Chapter 5 is available (Figure 6.11).

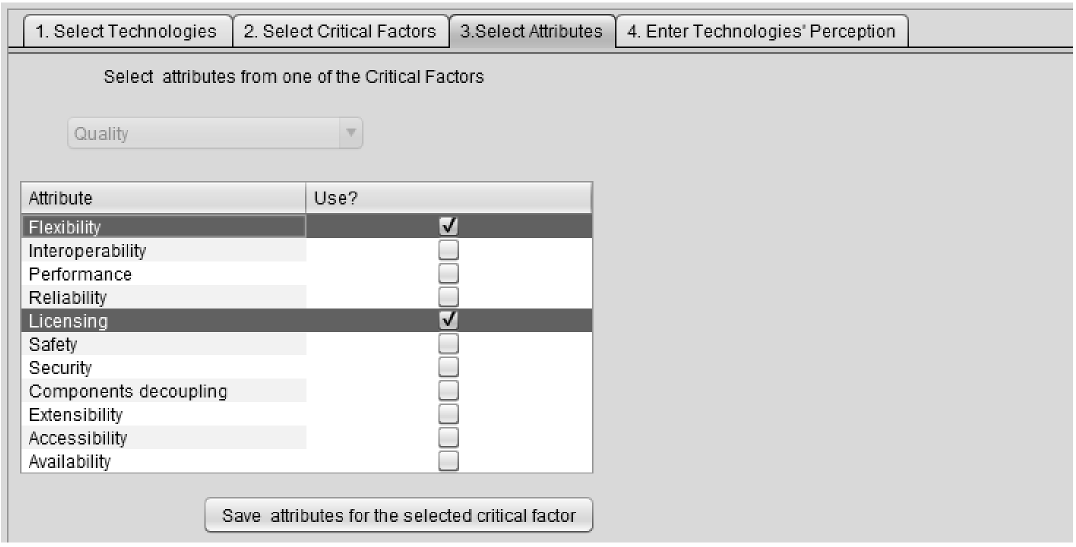


Figure 6.11. Selecting attributes

After choosing the attributes to be used in an analysis, all selected candidate technologies are displayed (side by side). For each attribute, there is a scale of perception, as shown in Figure 6.12. This perception is captured according to VAS (Visual Analog Scale) (KNOP et al., 2001). VAS is used in Medicine contexts to measure pain. It is a scale with no defined intervals to display so that users can choose a point according to their perceptions in a continuous interval translated from 0 to 100.

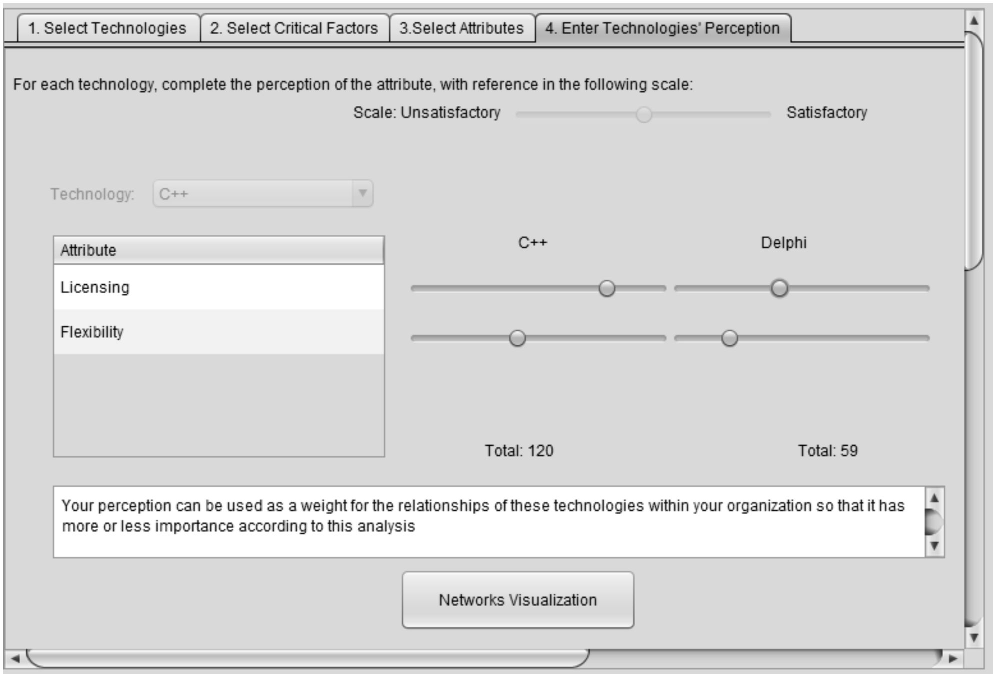


Figure 6.12. Assessing candidates

SECO-AM's prototype uses this scale to capture how satisfactory a candidate technology is considering each attribute. The technology perception scale goes from 0 (unsatisfactory) to 100 (satisfactory). Each perception adds a value to the final score for each candidate technology. As such, IT managers and architects can easily compare technologies and then ground their discussion so that a consensus can be reached based on technical analysis. The next step is to visualize the organization's SECO including the relationships the candidate technologies would have to complement the comparison, not only comparing them with each other, but also observing their interaction with the organization's systems.

There is a tool's screen for each network and a side panel to display a brief textual help. This panel (Figure 6.13) explains what each network means and how it was built. Some information is indicated since it could be lost in the network: number of technologies, systems in development, and discontinued technologies, as they may be analyzed differently. The centrality measure is relative to the Technology Dependency network (it denotes how important a technology is). The selected graphs algorithm was HITS[8] because it assigns hub's and authority's scores for each node and the results are influenced by the network topology.

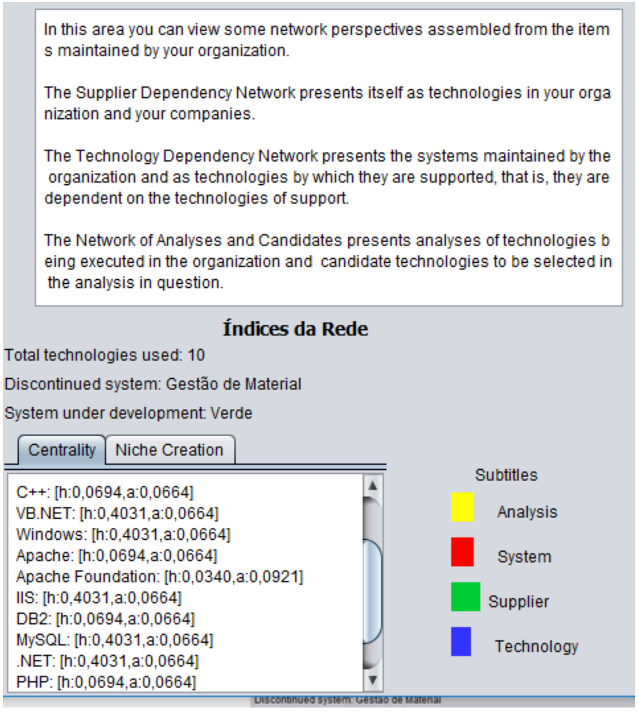


Figure 6.13. Side panel for SECO indicatons

[8] HITS algorithm description. Available at: http://jung.sourceforge.net/doc/api/edu/uci/ics/jung/algorithms/scoring/HITS.html

The calculation results in two measures; we use 'h' metric provided by the graphs API as a metric of how central is a node compared to the others in the same network. This metric is normalized by the maximum hub value (maximum h) found among the nodes results, so it means how central a technology is relatively to others in the network. The more connections it has, the more central (hub) it is. The niche creation tab calculates the number of clusters in the Technology dependency network and the number of clusters if a specific candidate is removed from the SECO. That helps an analysis for discontinuation, since the manager knows how the SECO topology/niches may change if a candidate is removed.

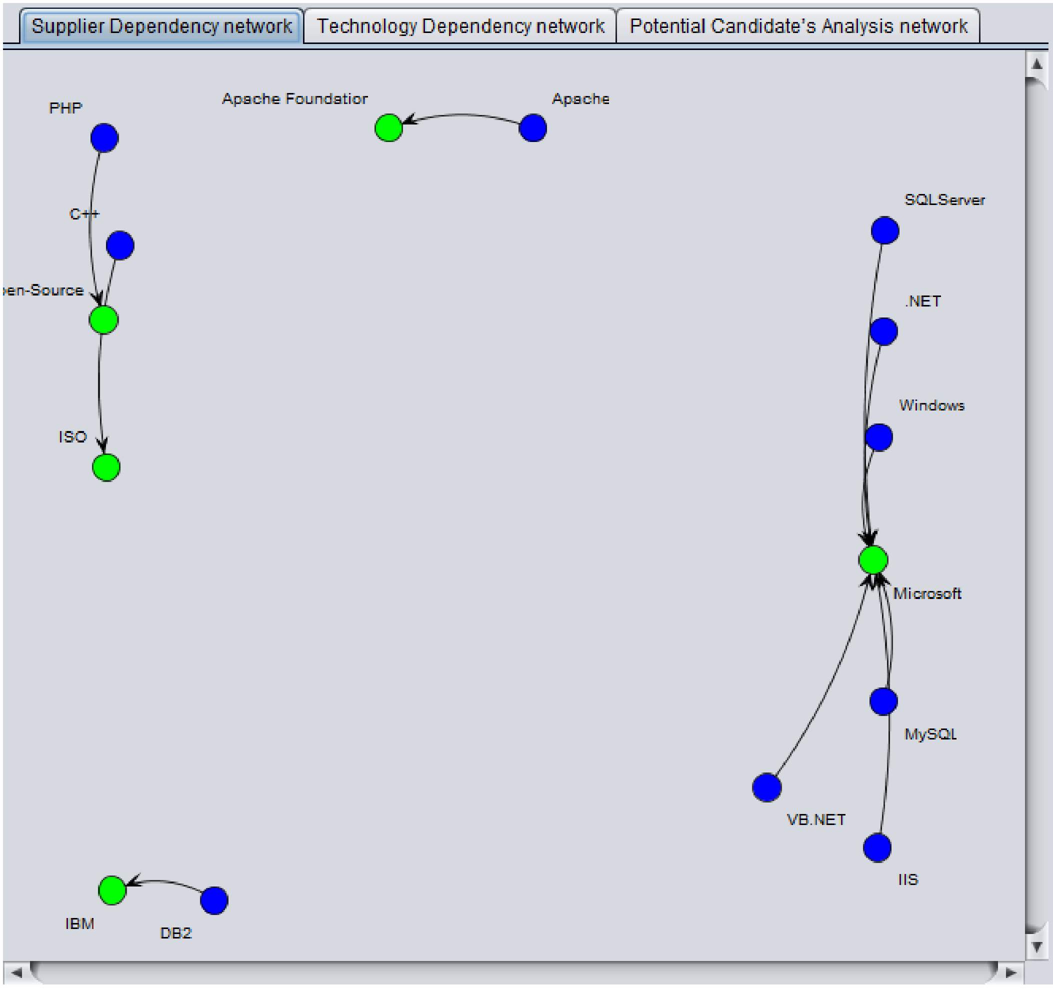


Figure 6.14. Supplier Dependency network

The three networks SECO-AM's prototype implements are illustrated in Figure 6.14 (Supplier Dependency), Figure 6.15 (Technology Dependency), and Figure 6.16 (Potential Candidates' Analysis). The side panel is always shown to users and also displays used colors (and what they represent).

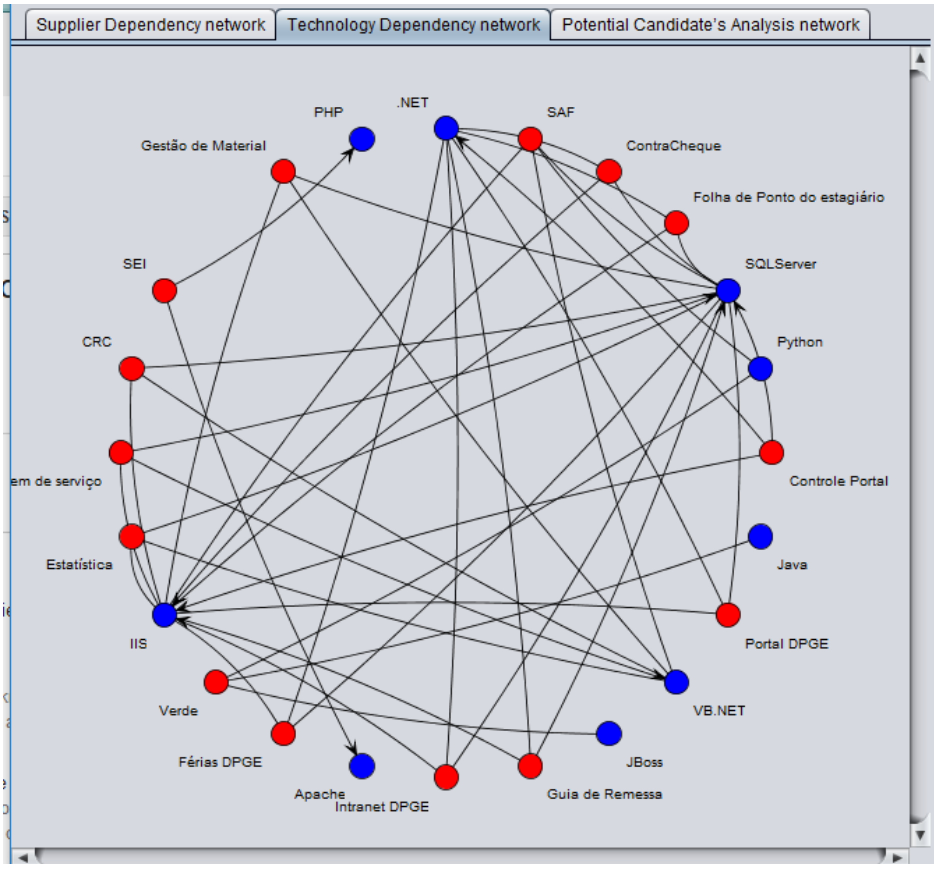


Figure 6.15. Technology Dependency network

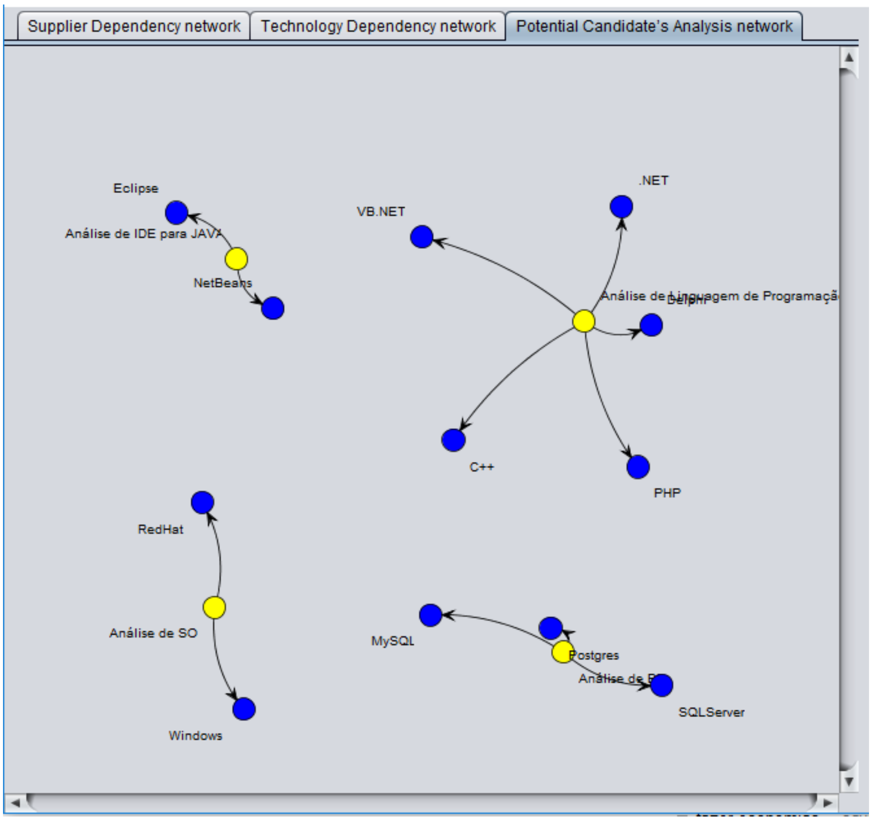


Figure 6.16. Potential Candidate's Analysis network

6.4.5. *Discussion*

During the prototype development, some improvements were uncovered and planned for a next release, e.g., visually differentiate edges thickness according to the type of technology (if it is candidate or not), and display more information about the node when clicking on it.

Although we did not implement 'Community' network in this prototype, other networks show potentials for making visible the overall SECO elements and its connections. Those connections were registered at Brechó-EcoSys; however, they were not easily analyzed in the previous version of the platform. Positive and negative points are indicated in Figure 6.17, as well as opportunities for improvement, based on SWOT matrix (Hill & Westbrook, 1997).

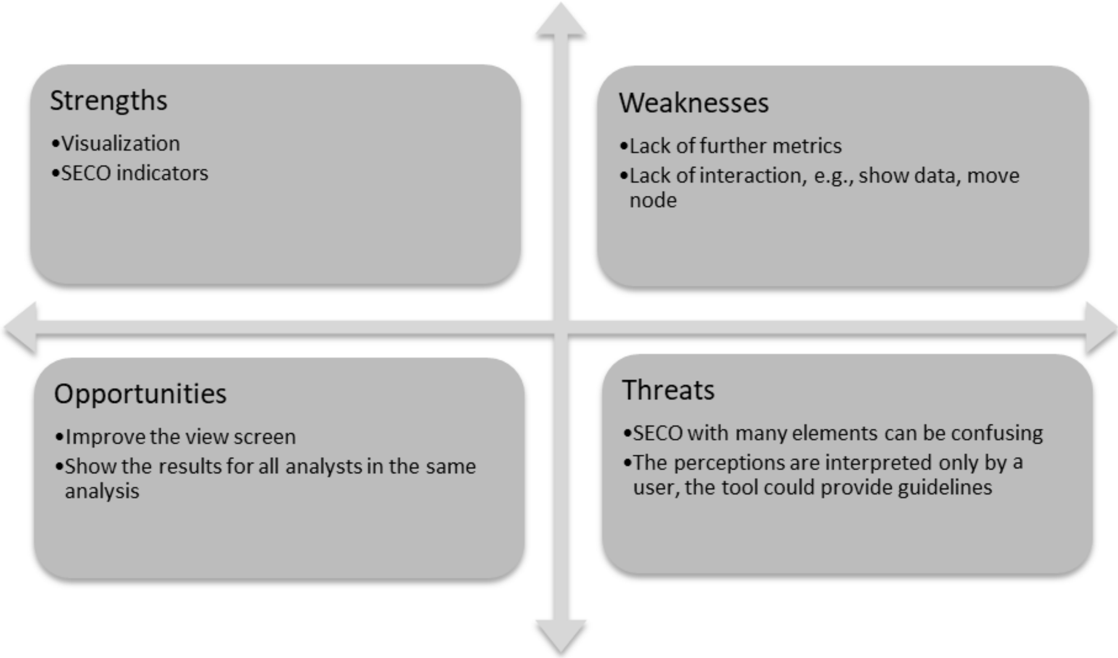


Figure 6.17. SWOT matrix

6.5 Related Work

As a result of the initial literature review and the studies performed in the previous chapters, some related work could be mentioned aiming to compare the SECO-AM with the existing work found in the SECO literature. Each work is described and then compared regarding the existence of features SECO-AM offers and those ones the related work provides, indicating Y=Yes, N=No, P=Partially.

BOUCHARAS et al. (2009) aimed at modeling software products and SECO elements formally using UML metamodeling (Software Ecosystems Modeling – SEM).

There is no tool support for SECO modeling and the suggested model identifies network's interaction on a technical perspective. BERK et al. (2010) focus on the main characteristics a SECO has and try to describe its business model to evaluate its characteristics. This work, named SECO Strategy Assessment Model (SECO-SAM), also focuses on the Independent Software Vendor (ISV) level. YU & DENG (2011) focus on the relationships with external players, e.g., dependencies among organizations and end-users. They also model a few SECO elements, a weakness of this work is the fact that they did not use a storage system or tool support, making it difficult the approach adoption.

In (VAN LINGEN et al., 2013), some open source SECO health factors are identified and used in real cases to compare Drupal SECO, WordPress SECO, and Joomla SECO. Several factors reflect the profile of a specific technology and its community, but it is not discussed how to use this information for maintaining the IT architecture of an acquiring organization.

In (JANSEN, 2014), productivity, robustness and niche creation health measures are detailed in more specific metrics at project and network level from the theory found in several other works. For example, at project level: new downloads, organizational maturity and multiple markets; and at network level: events, number of active projects and variety in projects. The author does not focus on IT architecture issues, but rather on the choice of SECO based on health issues.

The work presented in (PEREIRA & ALMEIDA, 2014) discusses IT architecture and what is considered by existing frameworks to support IT architecture modeling and instantiation: organizational structure, organizational activity, electronic services and support information systems, conceptual information models and what can supporting an infrastructure. These are internal organizational data important for defining the IT architecture. However, the work does not consider what happens in an exchange of technology, or even use data from the community.

AXELSSON et al. (2017) defines a software ecosystem architecture to help various types of stakeholders in selecting system components. They define stakeholders concerns related to architecture perspective and SECO characteristics to base the framework COACH (Component Options Analysis in Cooperation with Humans) . Ontologies are used in the process of decision-making supported by the framework and a prototype was developed. The socio-technical networks are not explored as well as the definition of clear criteria.

Thus, there are several challenges in relation to unexplored IT architecture modifications, especially the SECO perspective on relationships and socio-technical networks. In addition, SECO modeling is studied but there is no consensus for notation. Model visualization is not always a concern neither implemented in a tool support. SECO-AM provides key features that support IT managers and architects' activities, differently from related work visual aid: new information as graphs measures, evaluated criteria, and flexibility to several contexts during the technology assessment. Table 6.3 indicated the comparison among related work according to if they attend to SECO-AM requirements (N=No; Y=Yes; P=Partially).

Table 6.3. Related work comparison (Y = Yes, P = Partly, N = No)

Approach requirements	**(BOUCHARAS et al., 2010)**	**(BERK et al., 2010)**	**(YU & DENG, 2011)**	**(VAN LINGEN et al., 2013)**	**(JANSEN, 2014)**	**(PEREIRA & ALMEIDA, 2014)**	**(AXELSSON et al., 2017)**
(**R1**) The approach must inform IT managers and architects about the community activity level, if available.	**N**	**N**	**N**	**Y**	**N**	**N**	**N**
(**R2**) The approach must offer technical criteria regarding software architecture perspective.	**N**	**N**	**P**	**N**	**Y**	**N**	**P**
(**R3**) The approach must provide different visualization perspectives of the ecosystem in which an organization is a keystone, monitoring its elements, e.g., technologies, systems, analysis.	**Y**	**P**	**P**	**N**	**N**	**P**	**P**
(**R4**) The approach must support technology centrality calculation in order to identify hubs in a SECO as well as provide clustering measures to have a sense of technology connectivity and ecosystem niches.	**P**	**P**	**N**	**P**	**Y**	**N**	**N**
(**R5**) The technology assessment criteria must be assessed in the perception of IT managers and architects since it is not possible to always have the criteria quantitative metrics.	**N**	**N**	**N**	**N**	**N**	**N**	**P**
(**R6**) The approach must offer general technology assessment criteria to be applied in different contexts.	**N**	**N**	**N**	**N**	**Y**	**N**	**P**
(**R7**) The approach must allow IT managers and architects to choose the most appropriate technology assessment criteria for their specific SECO.	**N**	**N**	**N**	**N**	**P**	**N**	**N**

6.6 Conclusion

In this chapter, SECO-AM approach was presented. It aims to support IT managers and architects on maintaining IT architecture, considering the affect the decision making has over the organization's SECO. Chapter 3 resulted in some features that are not deeply explored in the literature but has potential to aid decision making, e.g., visualization of SECO elements and connections, sociotechnical networks measures, and defined assessment criteria. The approach described in this chapter contemplates some of those features and uses the assessment criteria from Chapter 5 as starting point, so that IT managers and architects can select the most appropriate ones according to their organization's context and needs.

SECO-AM defines some networks involving technical elements (technology, analysis, and systems) and social (suppliers, users, and teams). Moreover, some measures can be calculated using Graphs Theory so that new information on the SECO can be uncovered. The main features were implemented in a SECO-AM's prototype as a proof of concept. The prototype implements the analysis process, visualization of three types of SECO networks, and some measure support. Although it is a first version, the prototype has potential to support the approach features as discussed in Chapter 7.

In order to evaluate SECO-AM feasibility, the prototype was used in a real case scenario to collect practitioners' opinions. The data of an organization's IT architecture portfolio were registered and technology assessment and SECO analysis processes were studied through the execution of tasks with and without the tool support. Such study has the intention to capture indications if the tasks are better performed with the tool support.

Chapter 7 – Evaluation

Chapter 6 defined the approach for aiding IT managers and architects to maintain IT architecture based on the SECO perspective and described a prototype that implements the main features identified in our studies. In order to assess the approach's main features, a feasibility study was conducted using the prototype in a concrete industry scenario. This chapter describes its planning, execution, and results.

7.1 Introduction

The purpose of this study is to assess the feasibility of SECO-AM approach in the opinion of industry experts (practitioners as IT managers and architects, or even other stakeholders) who are responsible for maintaining IT architecture in the organization's SECO. The type of company on which this approach focuses is a software acquiring organization. To support their main objectives/processes, such organizations rely on technologies to support the systems on which they are based on, even if the organization's business is not software, e.g., an organization whose main goal is to sell books through an online website also acquires technologies to support its systems.

For evaluation, we used an organization's database in which the application portfolio is registered, as well as management of its technologies. Section 7.2 describes the feasibility study steps and instruments. In Section 7.3, it is presented a pilot execution to capture adjustments from a user outside the research context, simulating the invited participants. The execution with eight participants is described in Section 7.4. Analysis of the participants' information is discussed in Section 7.5. Results of all questions and comments are listed in Section 7.6. Section 7.7 identifies some threats to validity. Section 7.8 gathers the main results and contributions.

7.2 Feasibility Study

7.2.1. Planning

This section describes how the evaluation was planned based on a previous feasibility study (SANTOS, 2016). This study is an initial evaluation of SECO-AM in the perspectives of its utility and ease of use based on TAM Model. TAM Model

(Technology Acceptance Model) fundaments in two perceptions (DAVIS, 1993): (i) perceived utility; and (ii) perceived ease-of-use. This model gives an idea on how users will accept a new tool as well as perceptions of use. Therefore, using the prototype in a real scenario gave the approach an indication of how it would be its acceptance.

7.2.1.1. Specific Goals

This study's specific goals are identified as G1, G2, and G3.

G1. Characterize the benefits and deficiencies of supporting IT manager and architects to maintain IT architecture based on the technology assessment and SECO analysis using SECO-AM approach;
G2. Characterize ease of use; and
G3. Characterize utility.

The study's goals are described using GQM (Goal-Question-Metric) (BASILI et al., 1994) in Table 7.1 for G1, Table 7.2 for G2, and Table 7.3 for G3.

Table 7.1. G1 (feasibility)

Analyze	*SECO-AM tool*
With the purpose of	*characterize*
With respect to	*technology assessment and SECO analysis*
The point of view of	*IT managers and architects*
In the context of	*IT maintenance activities in an acquiring organization*

Table 7.2. G2 (ease of use)

Analyze	*SECO-AM tool*
With the purpose of	*characterize*
With respect to	*ease of use*
The point of view of	*IT managers and architects*
In the context of	*IT management activities to maintain IT architecture*

Table 7.3. G3 (utility)

Analyze	*SECO-AM tool*
With the purpose of	*characterize*
With respect to	*utility*
The point of view from	*IT managers and architects*
In the context of	*IT management activities to maintain IT architecture*

7.2.1.2. Questions and metrics

The main research question for this study is defined in **Q1** and represents whether participants are able to perceive the impact of technologies assessment and SECO analysis in IT architecture in a SECO perspective.

Q1: Are participants able to realize the impact of technology assessment and SECO analysis in an acquiring organization during IT management activities for IT architecture maintenance?

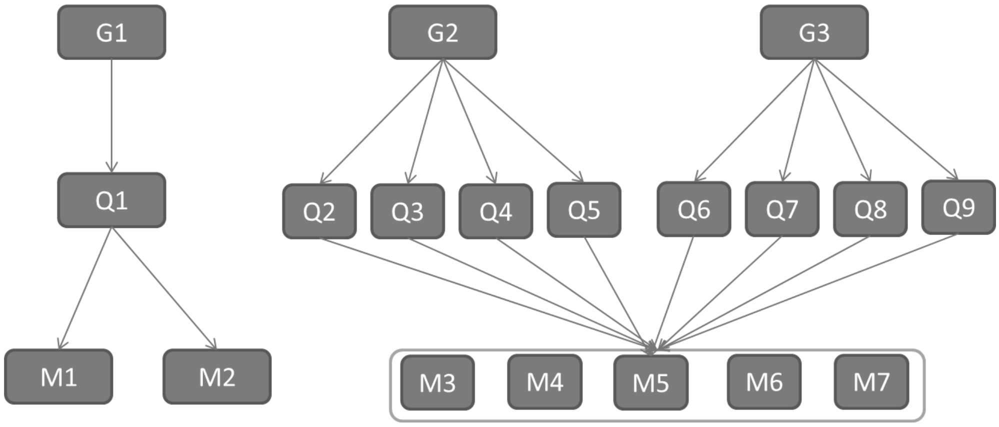


Figure 7.1. GQM model for evaluation

This perception will be measured through the responses given by the participants to the study's tasks. Therefore, the following metrics were defined:

M1: Effectiveness

Effectiveness measures the relationship between results (questions correctly answered) and objectives (number of questions). The calculation uses the following formula:

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

M2: Efficiency

The efficiency measures the relationship between results (questions correctly answered) and resources (time spent). The calculation uses the following formula:

$$Efficiency = \frac{number\ of\ correct\ answers}{time\ slot}$$

As shown in Figure 7.1, there are other eight questions (Q2 to Q9) associated to G2 and G3. These questions aim to capture the perceptions of ease of use and usefulness (or utility) according to the TAM model related to SECO-AM's tool as described in Table 7.4. For each question Q2-Q10, participants had the options: *Totally Agree*, *Agree*, *Neither Agree Nor Disagree*, *Disagree*, *Strongly Disagree*. Metrics M3-M7 from Figure 7.1 are described as follows:

- 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"; and
- M7: Number of participants who choose "Strongly Disagree".

Table 7.4. TAM Model's questions for evaluating SECO-AM's tool (also shortly called 'SECO-AM')

Question	Description	Aspect
Q2	I easily learned how to use SECO-AM	Ease of use
Q3	I used SECO-AM the way I wanted to	
Q4	I understood what was happening in my interaction with SECO-AM	
Q5	I easily performed the tasks using SECO-AM	
Q6	I considered SECO-AM useful for technology assessment and SECO analysis	Utility
Q7	SECO-AM allowed me to understand how applications and technologies of the acquiring organization relate to elements of a SECO (e.g., suppliers, customers, users)	
Q8	SECO-AM improved my performance while performing the proposed tasks compared to current procedures adopted in my organization	
Q9	SECO-AM supported IT management activities to maintain IT architecture	

7.2.1.3. Definition of Hypotheses

In this study, the following hypotheses were defined:

● **Null Hypothesis (H01)**: There is no difference between **efficiency** of IT management activities for maintaining IT architecture based on technology assessment and SECO analysis with or without the SECO-AM tool.

H01: $Efficiency_0 = Efficiency_1$, where:

$Efficiency_0$ = *Efficiency without SECO-AM tool*

$Efficiency_1$ = *Efficiency with SECO-AM tool*

Alternative Hypothesis (HA1): The efficiency with the use of SECO-AM tool for performing IT management activities in IT architecture maintenance based on technology assessment and SECO analysis is greater than the efficiency of performing activities without SECO-AM tool.

HA1: $Efficiency_1 > Efficiency_0$

● **Hypothesis Null (H02):** There is no difference between **effectiveness** of IT management activities for maintaining IT architecture based on technology assessment and SECO analysis with or without the SECO-AM tool.

H02: $Effectiveness_0 = Effectiveness_1$, where:

$Effectiveness_0$ = Effectiveness without SECO-AM tool

$Effectiveness_1$ = Effectiveness with SECO-AM tool

Alternative Hypothesis (HA2): The effectiveness with the use of SECO-AM tool for performing IT management activities in IT architecture maintenance based on technology assessment and SECO analysis is greater than the effectiveness of performing activities without SECO-AM tool.

HA2: $Effectiveness_1 > Effectiveness_0$

7.2.1.4. Participants

Participants were selected by convenience, respecting experience on activities related to IT management. Participants are part of a Brazilian large juridical organization along with a research institution participating together in a software development project. The organization's domain is different from IT, but it has an IT department with over 50 practitioners spread through the State of Rio de Janeiro, Brazil. They are responsible for acquiring software and some system development projects.

7.2.1.5. Tasks

In this study, tasks were defined to guide participants in the use of tool's features. In addition, a feedback questionnaire captures the perception on IT architecture maintenance activities in an acquiring organization in the SECO perspective. These tasks were performed during IT management activities related to select candidate technologies based on technology assessment and SECO analysis. From the work of (SANTOS, 2016), three types of tasks were used, as specified below:

- **Filtering Tasks (FT):** This set consists of asking participants to identify available information. If a participant cannot perform these tasks, he/she should be removed from the analysis. This situation may indicate problems in understanding the tool or the tasks. Examples of these tasks are:
  - What is the name of the analysis related to the category 'Database' registered by the organization?
  - How many technologies compose the organization's SECO?
  - What critical factors are considered for the IDE Analysis regarding JAVA?

- **Basic Tasks (BT):** These tasks require the participant to capture information and interpret the results in the tool. These tasks are not direct as FTs and require participants to interpret data and available graphics. Examples of these tasks are:
    - What is the main criterion involved in analysis of Operating Systems?
    - With which technology do the organization's applications have more dependencies?
    - Which systems are discontinued and remain registered in the organization? (List at least one system)
- **Assimilation Tasks (AT):** These tasks are the most complex, depend on the participant's knowledge, require some reasoning for information interpretation and involve typical tasks for IT management. Examples of these tasks are:
    - Which programming language technology should not be selected for discontinuation if you choose not to interfere in applications under development?
    - Which database technology should be selected for acquisition to increase the niche creation of applications in production?
    - If .NET programming language is replaced by Python, what impact does it have on the state of the organization's SECO? That is, does the organization improve its indicators, i.e., niche creation, community activity, dependencies etc.?
    - Which technology provider is central (HUB) in the organization?

Participants performed tasks without division or typing. From the data prepared for the study (based on the organization's portfolio), the correct answers were identified according to the portfolio and with previous semi-structured interviews with two IT managers from the organization. Thus, both groups performed the same tasks.

7.2.1.6. Data

The study uses real data from systems and their supporting technologies, users, and technology vendors according to the organization's portfolio. Candidate technologies are alternatives in the market, but outside the portfolio. Dependency and production relationships were extracted from the portfolio. From the organization portfolio, we extracted the following data for the study (type and quantity):

- Systems: 14;
- Technologies: 10;
- Analysis: 4; and
- Suppliers: 5.

7.2.1.7. Groups

With the intention of better understanding the influence of SECO-AM in IT management activities, two groups were used to compare results. First group responded to the tasks performing the activities as they carry out in their organization, and second group using the tool support that implements SECO-AM. Participants answered a characterization form and were ranked according to the sum of their IT management experience and academic background score. As such, two groups with similar profiles were created to minimize the influence of a participant's profile in a group. Participants ordered as even numbers were Group 1 (without tool) and the odd ones formed Group 2 (with tool).

Participants informed their experience in IT management activities in number of years and months. Academic background could be selected from the following options, with the corresponding scores:

- 8: Post-Doctorate;
- 7: PhD completed;
- 6: PhD in progress;
- 5: Master degree completed;
- 4: Master in progress;
- 3: Specialization completed;
- 2: Specialization in progress;
- 1: Bachelor completed; and
- 0: Bachelor in progress.

Each group had four participants and performed the same set of tasks with the differentiation of the use of the tool by one group. The group that did not use the tool performed the tasks as they use to do and with sources of information that participants already had, mainly the organization's portfolio. They should also describe how they would obtain the information and the correct answer for each task.

7.2.1.8. Variables

In the study, there are independent and dependent variables. Independent variables indicate study points that may influence the results; presenting the cause of the interference (they may obscure causes of observed effects). Dependent variables represent the result of the experimentation process (TRAVASSOS et al., 2002). These variables are relative to the study's objectives and observations.

The *independent variables* in the study are:

- The tool used to support IT management activities in IT architecture maintenance based on technology assessment and SECO analysis. This variable can represent two treatments: (i) the use of SECO-AM tool; (ii) the use of typical IT management tools.

The *dependent variables* are:

- Number of correct answers for each participant; and
- Time spent to perform the proposed tasks.

7.2.1.9. Instruments and Preparation

This section defines which resources were used during the evaluation and how the evaluation was prepared. For this study, six main instruments have been designed and can be fully verified in the Appendices (in Portuguese):

- Informed consent form (see Appendix IV);
- Participant characterization form (see Appendix V);
- Theoretical background on SECO (see Appendix VI);
- Instructions for use of SECO-AM tool (see Appendix VII);
- Form for conducting the study (tasks) (see Appendix VIII); and
- Study evaluation questionnaire (feedback) (see Appendix IX).

The first instrument ensures the consent of a participant to use the collected data anonymously and confidentially. Previously to the study execution, a participant responded to the characterization form used to compose the groups. SECO concepts were briefly introduced for each participant (both groups). For Group 2, it was presented how SECO-AM tool works; a guide for the necessary steps was available at any time during the study.

The form containing the set of tasks and spaces for answers to collect the results was another document. Both the researcher and the participant captured the period from the first question in this form until the end of the last question. After completing all the tasks, each participant responded to the study evaluation questionnaire to obtain impressions, suggestions and other information from the participant's perception.

7.3 Pilot

A postdoc researcher on Software Engineering at Reuse Software Lab (COPPE/UFRJ, Brazil) conducted a trial as pilot in January 2018. This pilot aimed to identify flaws at the questionnaires and tool's interface. This execution followed the planning for the group using the tool and all corresponding forms were analyzed so that the tasks and explanations could be calibrated.

The pilot used the tool with a subset of the final data from the real scenario. Since the participant is not part of a software organization, it was not asked to perform the tasks as the group without the tool would. In the characterization form, the participant informed to have 25 years of experience on IT and architecture activities. The participant received a verbal explanation about SECO, the research goals and the tool tutorial. In total, 10 minutes were spent for this phase. Then, the participant performed the tasks in 22 minutes and scoring 8 out of 10 points.

The participant informed in the feedback questionnaire that he/she was able to perform all tasks and was satisfied with the results. The biggest difficulties informed was the understanding of new concepts coming from SECO field and SECO-AM tool, and not being able to explore the tool for a longer period. The visualization of dependencies was the strongest point.

There are suggestions referred to better explain SECO-AM concepts and goals; and inform (in the tool's screens) what is happening and the connection between the analysis' feature and SECO visualization. Those suggestions were added in the tool by showing explanations for each SECO visualization and giving examples of the new concepts.

7.4 Execution

Some adjustments were made according to the observations from the experience with the pilot and received feedback. The main execution happened between January 29th, 2018 and February 1st, 2018. The execution was individual. Each group had four participants, half of them were from the acquiring organization, and half from the institution that works in a software development project for that same organization. A few days before the study, as the invitees accepted to participate, they were asked to answer the characterization form (online questionnaire), so that they could be separated in two groups as balanced as possible considering experience/academic background.

Both groups were asked to sign a term of consent and received training on SECO for an average of 7 minutes with the support of a presentation document. The training duration varied according to the participant's questions to the researcher, since they did not know SECO concepts and the fact that their organization was part of a SECO. G1 (without the tool) proceeded to the tasks and G2 (with the tool) received a tutorial (see Appendix VII) spending about 8 minutes before starting the tasks.

For G1, it was provided the organization's portfolio to make sure that they were looking at the same version made available to the study. They were at their stations at the organization and had access to any other document they could, but they did not look for any extra document but the given portfolio. They said that they did not have many records on IT management activities related to adopted technologies or IT architecture.

7.5 Analysis

This section summarizes the collected data and analyzes them considering the participant's profile and their answers to the questionnaire.

7.5.1. Participant's Profile

Each participant was asked about his/her academic background and time of experience on IT management activities. Participants are diverse in their background: G1 had two specializations completed, one master degree completed and one PhD in progress; and G2 has one master in progress, one bachelor in progress, one specialization completed, and one specialization in progress. The differences between the groups were balanced by the experience (time).

Each group had two participants with at least ten years of experience in IT management activities. The sum of points from academic background and experience time allowed us to rank them. Participants were labeled and separated in two groups. The data are illustrated in Table 7.5, the average experience time in G1 was 7.6 years and in G2 was 7.7 years.

This indicates that they are experienced on IT management activities. Several participants reported experience in other IT activities, e.g., programming, public companies administration, systems architecture, systems project management, testing, and database integration.

Table 7.5. Participants' group formation

ID	Points for academic degree	Experience time (years)	Sum	Ranking	Group
P1	5	14	19	1	G1
P2	3	11	14	2	G2
P3	3	10	13	3	G1
P4	2	10	12	4	G2
P5	6	5	11	5	G1
P6	4	7	11	6	G2
P7	3	1.5	4.5	7	G1
P8	1	3	4	8	G2

7.6 Results

Results were analyzed regarding efficiency and effectiveness of performing the tasks, therefore considering time and number of correct answers (as described in Section 7.2) and the feedback from the evaluation questionnaire. To compare the groups, a measurement of average is considered, since the sample is too small for more robust statistical analysis. As presented in Table 7.6, the average time between the groups was not so different. Time using the tool could be lower if the participants had used its interface before. The other group used a document they should be familiar with (the organization's portfolio).

The number of correct answers was very low for G1 (without tool): the answer they gave was that they did not know the information and that they did not have records of such decisions/analysis. Therefore, they did not have documentation of past decisions on technologies they had on their portfolio: many participants reported the decision was made during team meetings or came from high businessmen (administrative hierarchy).

The higher number of points for G2 indicates the information was displayed in a clearer way and easier to find. It was possible to visualize the ecosystem in which the organization is centered. Thus, it becomes easier to look for useful information.

Table 7.6. Data from the tasks for each group performance

Variable	Group	AVG	MIN	MAX
Time (min)	G1	24.75	15	34
	G2	24	12	37
Number of correct answers	G1	5.5	5	6
	G2	8.25	7	10

In Table 7.7, the variables from TAM model (efficiency and effectiveness) is shown. G1 (without tool) had significant lower effectiveness and efficiency if compared with G2 (with tool). This result indicates that the use of the tool helped participants to answer the tasks more correctly and in less time, even though the total time spent in the tasks were similar: G1's participants scores spending the same amount of time are lower compared to G2's. There was no participant from G1 answering more questions correctly than G2, but one was more efficient since he/she performed the tasks faster. There was no participant from G1 more effective than G2.

Table 7.7. Efficiency and effectiveness for each group

Variable	Group	AVG	MEDIAN	MIN	MAX
Efficiency	G1	0.248	0.222	0.147	0.400
	G2	0.390	0.367	0.247	0.583
Effectiveness	G1	0.550	0.550	0.500	0.600
	G2	0.825	0.800	0.700	1.000

Regarding the hypotheses defined in Section 7.2.1.3, considering the sample size and variables, it was applied a non-parametric test (Mann-Whitney) to help the analysis and have more indications on the hypothesis acceptance. In addition, we analyzed a boxplot representing the data points for each variable: *efficiency* (Figure 7.2) and *effectiveness* (Figure 7.3).

Table 7.8 describes the execution values for the Mann-Whitney test configured for 90% confidence on the efficiency variable. Since p-value (0.097) is less than 0.10, the null hypothesis H01 is refused and the alternative HA1 is accepted (efficiency with tool is better than without) as the mean and median with tool are greater than without it, as show in Figure 7.2. The fact that efficiency distribution ranges are partially overlapping might cause a disturbance in the test causing a p-value very close to the threshold.

The insertion of a technology that is unknown to the participants might be a confusion factor. Nevertheless, the distribution behaves in conformity for both values, raising the averages for both variables.

Table 7.8. Hypothesis test for efficiency

η_1: median of Efficiency_No_Tool
η_2: median of Efficiency_Tool
Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
Efficien-cy_No_Tool	4	0.222496
Efficiency_Tool	4	0.366858

Estimation for Difference

Difference	Upper Bound for Difference	Achieved Confidence
-0.144362	-0.0051480	90.30%

Test

Null hypothesis	$H_0: \eta_1 - \eta_2 = 0$
Alternative hypothesis	$H_1: \eta_1 - \eta_2 < 0$

W-Value	P-Value
13.00	0.097

Figure 7.2. Efficiency data for G1 (no tool) and G2 (with tool)

Table 7.9 describes the execution values for the Mann-Whitney test configured for 95% confidence on the effectiveness variable. Since p-value (0.015) is less than

0.05, the null hypothesis H02 is refused and the alternative is accepted (effectiveness with tool is better than without) as the mean and median with tool are greater than without it, as show in Figure 7.3. The tests are not extremely strong because the sample size is small, but they serve as indicators when combined with the boxplot graphics and values from tests' results and that the insertion of the tool benefits both effectiveness and efficiency.

Table 7.9. Hypothesis test for effectiveness

η_1: median of Effectiveness_No_tool

η_2: median of Effectiveness_Tool

Difference: $\eta_1 - \eta_2$

Descriptive Statistics

Sample	N	Median
Effectiveness_No_tool	4	0.55
Effectiveness_Tool	4	0.80

Estimation for Difference

Difference	Upper Bound For Difference	Achieved Confi-dence
-0.25	-0.100000	96.97%

Test

Null hypothesis	H_0: $\eta_1 - \eta_2 = 0$
Alternative hypothesis	H_1: $\eta_1 - \eta_2 < 0$

Method	W-Value	P-Value
Not adjusted for ties	10.00	0.015
Adjusted for ties	10.00	0.014

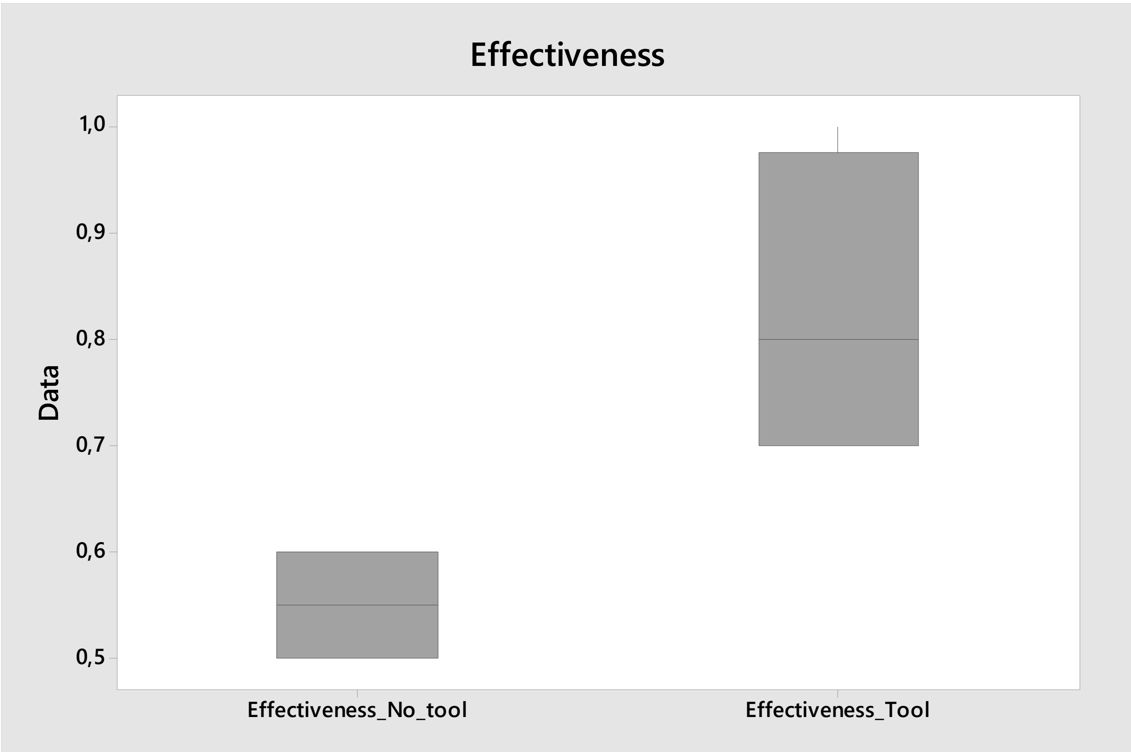


Figure 7.3. Effectiveness data for G1 (no tool) and G2 (with tool)

As a result, there is difference between the efficiency of IT management activities for maintaining IT architecture based on technology assessment and SECO analysis in favor of using the tool support. The same result is observed for H02 referring to effectiveness: this indicates that the use of the tool makes the effectiveness greater and takes to the acceptance of HA2.

All participants answered feedback questionnaires on the tasks they were asked to perform, and G2's participants answered feedback questions about the tool support. The questions about the execution of the tasks are presented in Table 7.10. All G2's participants said that they performed all tasks, while one G1's participant said 'No'. Half of participants from G1 were satisfied with the results, one was partially, and one was not satisfied.

From G2, nobody was unsatisfied with the result: one partially and 3 out of 4 were satisfied. From both groups, all participants saw the value on the approach for exploring the SECO perspective to benefit IT management activities. From G1, three participants found it easy to perform the tasks and one found it difficult. All G2's participants assessed the approach as easy to use.

Table 7.10. SECO-AM evaluation

ANSWER	GROUP	Q1 - I performed the whole set of proposed tasks	Q2 - I was satisfied with the final results	Q3 - The SECO perspective can benefit or support IT management activities, more specifically IT architecture maintenance, as well as improve the perception of its impact on the organization?
YES	G1	3	2	4
	G2	4	3	4
PARTIALLY	G1	0	1	0
	G2	0	1	0
NO	G1	1	1	0
	G2	0	0	0

G1's participants commented on Q3 (feedback from) that the SECO perspective is not a common theme in their institution and the brief, structured visualization of the systems' network helps a greater assertiveness of decision-making (P3). The SECO perspective also helps to make decisions from explicit knowledge, and not just from tacit knowledge (P5).

Moreover, if the company had done a study (or had a tool) that would help, they would certainly be better prepared for the technology changes in the market, for suppliers of these technologies, and for systems' migrations. Finally, the SECO perspective allows an appropriate evaluation of the company's decision making. Regarding the ones that used the approach (G2), they did not leave commentaries.

Q4 (feedback form) asked about the biggest difficulties on performing the tasks. A G1's participant answered that it was difficult to understand the SECO terms (P1). Time available to give full attention to the interviewer and familiarity with the subject to be able to be assertive with the answers was a challenge (P3 and P5). In addition, the lack of records on the history of changes in the organization's IT sector is a problem, according with P7.

For G2, analyzing the selection of architecture with the vision of expanding the number of niches was difficult (P2). According to P4, "*it was difficult to understand terms and codes, they could be better explained as an aid by hovering the mouse over, for example*" (P4). "*I wish I could confirm the nomenclature used to be sure of the aspects to be taken into account*" (P6). Finally, "*there are data that need to be interpreted with care, so the information is interpreted in the right way*" (P8). From those comments, we can extract suggestions for the tool to make it clearer what SECO terms mean to the organization and to IT managers and architects.

P3 (G1) also commented that "*the study of acquisition and disposal of IT tools and technologies has always been superficial, something that is learned in the worst possible way in organizations. Any tool that can aid decision making should be used by the public manager to increase the efficiency of the organization, to avoid unnecessary risks*". In turn, P1 (G1) commented that examples could help to answer some questions. P3 and P1 are in top three most experienced IT managers among the participants from both groups.

Regarding Q2-Q9 from GQM (Section 7.2.1.2), the metrics results are presented in Figure 7.4, where M3: Totally Agree; M4: Agree; M5: Neither Agree Nor Disagree; M6: Disagree; and M7: Totally Disagree. The overall result is positive: there was no disagreement on the support provided by the tool. The most helpful features were: visualization of the organization's SECO in general and dependency network.

Some participants left other explicit suggestions, mainly for inserting filters, ordering options, different views and networks. The final consideration of G2's participants made clear that the use of perceptions to assess candidate technologies create a personalized analysis, adapting the selection process to an IT manager, and made it easier to decide.

Figure 7.4. Tool support evaluation on helping to perform the tasks

The tool's most positive aspects are summarized below:

- Direct visualization of the network of dependence on technologies and suppliers;
- Visualization of existing technologies in the participants' environment;
- Easiness of visualizing technologies' centrality;
- Easy learning and perceiving how technology dependencies can affect the organization;
- Ease of use, simplicity of information interpretation, overview of company technologies; and
- Ease of use, mix of high level information and technical level (centrality).

The tool's negative aspects are described below:

- The results of the technology selection calculation was not clear;
- Lack help (tool support) and ordering options for technologies according to the selected criteria; and
- It still has no filters for views by categories, types or suppliers, for example.

Regarding the SECO analysis and visualization, participants pointed out that SECO-AM support strategic decision involving how cutting costs and investments can affect the organization. In addition, they explicitly commented that SECO-AM makes the work of IT managers and architects easier and adds value to the decisions: they had a notion of technology dependency, but the visualization makes those relationships clearer. It was pointed out that SECO-AM could be used in the process of selecting technologies using a subset of attributes, reinforcing the research findings. This research refers to the initial search for candidates that the market offers, and many perspectives are considered.

7.7 Threats to validity

Typically, study's features may influence the validity of results, termed threats to validity. There are four types of study's validity: internal, external, construct and conclusion (WOHLIN et al., 1999, TRAVASSOS et al., 2002). For this study, the following validity threats were identified:

Internal validity

- The selection of study participants and division into groups may have influenced the results, mainly because the groups had different treatments. The use of the characterization form helped to balance the groups to have similar profiles for each group;
- The exchange of information among participants who had already completed the study and those who had not already done could influence the results. This can be more serious especially with the participants who used the tool, because everyone already knows the routines of the organization. To avoid this problem, it was explicitly requested that participants did not exchange information about the study;
- The support tool itself could influence the results if the participants faced unforeseen difficulties in carrying out the study (slowness, server errors etc.);

- Participants received a brief training on the use of the tool, which consisted of reading basic information and navigability;
- Participants' understanding of the issues related to the forms was directly influenced by the way the questions were developed; if the question were poorly formulated, the study would be adversely affected (WOHLIN et al., 1999); and
- For the analysis of the data, the characterization information provided by the participants themselves was used without any certification that they were correct.

External validity

- A threat to external validity is the cutting down of a small sample of the organization's portfolio, as well as not ensuring that other relevant information is not available to participants;
- It was not possible to represent all the possible situations of a SECO. The execution scenario of the study tasks was based on the portfolio and other information provided by the organization's SECO;

Validity of construct

- The measures selected to capture the results may not had been the most appropriate to assess the validity of the approach. To minimize this risk, measures were selected to capture the information needed to answer the study questions;
- Participants were selected by convenience, considering the organization availability and suitability to the desired profile (IT management activities experts). This is a threat to validity as their behavior can be altered to influence the outcome. A random selection of participants was not possible, since participants with an IT manager or architect profile and experience in the industry were required and there were not many possible candidates.

Conclusion validity

- Sample size was small due to the desired profile, then a small number of participants may limit the validity of the study. Moreover, the study presents limitations on more robust analyzes of the results. Hence, the interpretation of the results is considered only as indications.

7.8 Conclusion

This chapter described a feasibility study executed to understand if SECO-AM was feasible as well as to capture impressions from an industrial scenario through the execution of tasks in an acquiring organization with a group of experienced practitioners. This chapter described the planning, pilot, execution, and results. The efficiency and effectiveness metrics were analyzed comparing a group that used the tool support and another that performed the tasks as they usually work in their organization/institution. Both efficiency and effectiveness were improved by using the tool support and the perceived utility and ease of use had positive results.

Suggestions and observations captured from the feedback questionnaire revealed several opportunities to improve the tool, mainly making the information clearer and easier to interpret. Participants had experience in IT management activities. They noticed that SECO is not a common perspective in their organization, but they realized the benefits of this perspective since they understood they are in a SECO and see the influence their decisions have in the network of dependencies, mainly reported as most useful. Overall, the indications extracted from this study are that the use of SECO-AM can be helpful and that they do not have a tool support currently in their organization to aid IT architecture maintenance based on technology assessment and SECO analysis.

Chapter 8 – Conclusion

This chapter describes the final considerations of this Master dissertation as well as the contributions of this research. Some limitations of this work need to be observed while discussing the results. Some gaps and suggestions identified in the studies described in Chapters 5 and 7 remain as future investigations and improvement points.

8.1 Contributions

A SECO platform broadly supports the use and development of software artifacts. In this context, the adopted technologies that support a SECO platform affect how actors enter and keep playing within a SECO. Those technologies are usually references used by an organization and external actors. Therefore, any candidate technology to be adopted, replaced or discontinued needs to be carefully compared to keep or improve how well the SECO works. Hence, there is a need for a baseline of architecture attributes for comparing technologies in the context of SECO platforms. Managing platform's technologies has many benefits to an organization, e.g., technology standardization, saving money, avoiding unnecessary acquisitions, and supporting a controlled number of technologies. Fast technology changes, deployment of new versions or discontinuation of technology support require frequent modification and assessment of the SECO platform's reference technologies.

In addition, there are repercussions for finances, users, politics, training, and other perspectives that need to be considered when an organization is changing the platform's technologies. Therefore, a set of architecture attributes can aid IT managers and architects to understand how those choices affect a SECO platform and its technologies to take actions to mitigate the negative effect. That information was extracted from the literature based on a systematic mapping study. As explained in Chapter 4, 44 papers were analyzed, and 64 attributes were identified and grouped by 11 critical factors, i.e., macro attributes that encompass other specific attributes.

As considered in Chapters 1 and 2, the problem of maintaining IT architecture in the SECO perspective is a gap found in the literature, since it is not explored much further. Organizations that need to acquire or discontinue a technology should consider some criteria to make their decisions. Frequently, the criteria is whatever the IT management team uses according to experience and tacit knowledge. This may cause some problems for the organization:

- the decision is often not registered appropriately (or not at all);
- criteria changes for each project and each IT manager/architect;
- those changes are not reported and the decision criteria/process is not easily auditable;
- technical criteria are not explicit or planned in advance; and
- SECO monitoring is very hard as there is no support for an overview of the organization technical assets (software products and services).

The main contribution of this work is to support the modification of IT architecture based on critical factors that take into account the SECO network. This support is useful for an IT management team (stakeholders who have authority to manipulate the organization's IT architecture). The following secondary contributions may be highlighted:

- **Exploratory studies:** In order to understand what resources could be applied in the research conception, two exploratory studies were described and some sociotechnical features were identified and studied (Chapter 3).
- **Mapping study:** It was executed a mapping study and results represent a contributions to the SECO literature, mainly the list of critical factors and attributes as well as the study protocol itself (Chapter 4);
- **Survey:** The experts' opinions are very important since they evaluate information on data collected from the mapping study. The opinions, final list of critical factors and attributes, and the study protocol are the main contributions (Chapter 5);
- **SECO-AM approach:** This is a contribution aiming at the support of IT maintenance activities. SECO visualization and analysis mechanisms help to identify and centralize information needed by the organization (Chapter 6);
- **Prototype tool support:** The main SECO-AM's features were implemented in a prototype that offers a tool support for organizations (Chapter 6); and
- **Feasibility study:** The feasibility study results and protocol are important outcomes of this research, since the study assesses the relevance and feasibility of applying SECO-AM's tool in a real organization and colleting the experience of practitioners (Chapter 7).

8.2 Limitations

Some limitations were identified considering the execution of the studies of conception (exploratory, mapping study, and survey) and assessment (feasibility), as well as the prototype developed. The main limitations are described as follows:

- The research considered technical criteria for the approach definition and prototype development. In SECO-AM approach, we argued that technical criteria should be considered by an organization. Other criteria need to be accounted for, e.g., institutional policies, financial regulations, market prospections. However, they are not sustained by the approach/tool support;
- The survey did not involve a number of participants for robust analysis with statistical tools;
- The tool support does not encompass all SECO-AM's features. Some graphs metrics and usability features are not fully developed;
- The feasibility study was not repeated in other organizations (small sample). Thus, the results are indications and cannot be generalized since it may vary according to different organizational contexts; and
- The list of critical factors and attributes could be better used if specific scenarios were defined and a set of critical factor could be assigned to each scenario, since some critical factors and attributes are more relevant than others according to the organization context.

8.3 Future Work

In order to enrich this approach, some suggestions identified in the survey and the feasibility study could be seen as future steps, such as:

- The research of specific SECO contexts as well as construction of scenarios that reflects a SECO type can help to make an analysis more adherent to the organizational context;
- The implementation of features suggested by the feasibility study's participants, e.g., making available a history of execution and modifications within an analysis, filters and rankings for a user; and less technical terms in favor of the organization equivalency so that IT managers and architects can better understand what is changing in their SECO;

- The snowballing analysis on the mapping studies literature base of accepted papers can be performed; and
- The execution of the feasibility study with the complete approach (and tool) with specific scenarios that would ease criteria selection.

SECO is a new perspective when compared to others in Software Engineering. As such, several problems are still to be discovered and researched. This work investigated one of those problems. Moreover, it is a concrete problem since observations from the feasibility study with experienced IT managers and architects reported that they do not have any approach or tool support for the tasks they performed. This approach has focused on the fact that SECO and sociotechnical networks can aid IT management teams in their activities. Organizations are rarely acquainted with the SECO concept (and what it can represent in their workplace). This is another issue perhaps due to the novelty of this research and practice topic.

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Appendix I - Selected Papers from the Mapping Study

ID	Paper reference
01	Mohsen A., Slinger, J.: Evaluating architectural openness in mobile software platforms. In: 4th European Conference on Software Architecture: Companion Volume, pp. 85-92. ACM, New York (2010)
02	Jakob A., Efi P., Jesper A.,: Characteristics of software ecosystems for Federated Embedded Systems: A case study. Information and Software Technology. 56(11), pp. 1457-1475 (2014)
03	Bosch, J.: Architecture challenges for software ecosystems. In: 4th European Conference on Software Architecture: Companion Volume, pp. 93-95. ACM, New York (2010)
04	Bosch, J., Bosch-Sijtsema, P.: ESAO: A holistic ecosystem-driven analysis model. In: International Conference of Software Business. pp. 179-193. Springer International Publishing, New York (2014)
05	Bosch, J., Bosch-Sijtsema, P.: From integration to composition: On the impact of software product lines, global development and ecosystems. Journal of Systems and Software, 83(1), pp. 67-76 (2010)
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Appendix II – Glossary

The terms results from the mapping study (Chapter 4) are described below. If a source paper only cites a term and not discuss it, an external source of definition is used.

1. **Accessibility** [01] [22]: "Platform accessibility means the methods and points that developers can use to extend or modify the platform" [01].

2. **Availability** [21] [24] [26]: "The degree to which a software component is operational and available when required for use" (MIGUEL et al., 2014).

3. **Backwards compatibility** [22]: "A platform is backwards compatible if it continues to support functionalities of previous versions of itself."

4. **Buildability** [07]: "Buildability refers to how easy it is to construct a desired system. It allows being open to changes during development requiring attention when diving in modules and it is usually measured in cost and time. [07]"

5. **Commonality** [06][19]: "commonality management deals with the way features and characteristic that are common across the products belong to a SECO whereas variability management is other way round" [06].

6. **Component dependency** [05][22]: "One of the key features of a software platform are the dependency and reuse mechanisms and the openness within those mechanisms. Apple, for instance, does not allow linking of third-party libraries with iPhone Apps, whereas Ruby on Rails does. For RoR a complete dependency management system maintains dependencies, which enables platform extenders to cooperatively develop shared libraries, next to regular platform extensions. Apple's iPhone, however, does not currently implement such a dependency management system, reducing reusability of other applications by platform extenders (and power of extending parties, for that matter)."

7. **Composability** [14][15][19][29][32]: "The software platform necessary to support the ecosystem must fulfill a set of properties to allow the decoupling of applications and eliminate the need for development synchronization. The architecture should allow development, integration, and validation of applications independent of

other applications. Non-technical users cannot do this themselves, it must be provided for by application and/or platform developers" [14].

8. **Configurability** [02][14][15][32]: "Configuration is concerned with product instantiation and configuration that involves multiple stakeholders" [02]. "The platform must support variability in the hardware configuration of sensors and actuators since individual products can vary within the product family" [14].

9. **Consistent user interface** [14][15]: "This is often considered important by manufacturers of embedded consumer products since much of brand recognition and willingness to stay with the product brand lies here. The other major aspect for brand distinction is the qualities provided by the hardware (precision, reliability, etc.)" [14][15].

10. **Complexity** [11]: "An increase in the number of organizations in the ecosystem will lead to an increase in the size of the platform code base as the new organizations contribute new features and variants of existing features to support the extension products they aspire to create" [11].

11. **Cost** [18]: "The larger the scope of the platform, the more development and maintenance effort is required by the platform owner. When multiple parties are involved these costs can be shared between the participants" (VAN GENUCHTEN, 2007). "Because hardware and software development is costly, this is the main reason why ecosystems became widely adopted. Firms that aim for low costs specialize on a few products so that tasks become routine" (BOLWIJN et al., 1990). "Consequently products that are developed in consort by specialized firms, especially when interfaces are pre-defined, can be made at lower costs" [18].

12. **Components decoupling** [05][32]: "The decoupling allows the release groupings to be composed, with relatively few issues. This is often achieved by more upfront work to design and publish the interface of each release group before the start of the development cycle" [05].

13. **Extensions' Delivery** [22]: Delivery of extension is mentioned as a step further from reuse, openness, and dependency mechanisms. A pattern can be applied, e.g., App store, centralizing the control over the delivery channel and development of extensions.

14. **Dependability** [14][15]: "Many embedded domains have stringent dependability requirements. These domains are probably not the first adopters of an ecosystem-based approach to software development. However, if that was the case the embedded platform would satisfy; real-time requirements for the execution of individual applications, integrity requirements, high availability, and mechanisms to eliminate undesired feature interaction if several applications interact with the same actuators" [14].

15. **Deployability** [14][15][35]: "On the business side, a SECO architecture should allow for fast and seamless deployment of different versions of the product in different usage contexts. Easier deployment means faster time to market, which is a critical business factor for ecosystem industrial actors" [35].

16. **Extensions' deployment** [22]: Deployment of extension is mentioned as a step further from reuse, openness, and dependency mechanisms. A pattern can be applied, e.g., App store, so the deployment of extensions follows their procedure and devices, contrary to other open SECO in which the deployment, i.e., making the extension available for use, can be done by a community or without certification from the organization that controls the SECO.

17. **Documentation** [05][22]: "Developers complain frequently about intransparency, poor documentation, or even missing documentation in rapidly developing platform APIs. On the other hand, the platform extenders are positive about platforms for which sufficient documentation exists. Undocumented features cost developers significantly more time to work with, whereas these are typically highly marketable features, due to their novelty. Documentation platform architecture in general is weak in all four platforms, although it must be noted that the documentation in some cases specifically uses the concept of patterns to illustrate platform extension to developers" [22].

18. **Efficient use of system resources** [18]: "Due to the need for optimal resource utilization and low power consumption a direct control of the hardware is required" [18].

19. **Evolution/Evolvability** [03][29][32][37]: "Evolution inexorably causes it to incorporate functionality that earlier was developed by external developers" [3].

20. **Extensibility** [01][09][10][12][23][24][29][35]: "A good SECO architecture should allow different ecosystem actors to accommodate additions to the core capabilities" [35].

21. **Extension** [13][21][23]: "allows enhancing the functionalities of components in a layer, e.g., the evolution of Brechó platform from a component repository to a component marketplace environment, generating Brechó-VCM" [13].

22. **Flexibility** [09][10][18][24][37]: "Flexibility expresses how easy, cheap, and fast necessary changes to software systems, i.e. existing requirements, can be accomplished" [10]. "Good architectural design helps to attract new external developers, while a bad design can cause problems for them. Any change in the platform has an associated cost that can affect extensions within the ecosystem. Lower costs means more platform flexibility. To increase the degree of flexibility it is necessary to reduce the number of dependencies and the complexity of the interfaces making them more "translucent"" [37].

23. **Framework stability** [22]: "Frameworks tend to evolve through a number of iterations, leading to new versions, due to the incorporation of new or changed requirements, better domain understanding and fault corrections. New versions of a framework cause high maintenance cost for the products built with the framework. Because of this, it is important to assess the stability of a framework" (MATTSON & BOSCH, 1999).

24. **Hard real time requirements** [18]: "embedded devices have hard real time requirements, e.g. for audio playback and telephone conversations. Linux is a real time operating system that is widely used in embedded systems. It offers the developers the possibility to optimize on system resources and supports hard real time requirements" [18].

25. **Innovation** [18]: "The optimal definition of the boundaries depends on where the major innovation steps in the architecture take place. When innovation takes place across the boundaries of the platform the integrity of the platform is compromised and the complementors need to be involved thus slowing down the speed of innovation. Therefore, a wide scope allows for larger innovation steps more easily. The introduction of multi touch screens is such an example. Due to this innovation specialized hardware

was needed; the interface towards the user has changed and a new API towards the application developers was required" [18].

26. **Integration** [01][03][05][07][12][13[18][19][21][29][37]: "the level of integration between the platform and externally developed solutions. Depending on the type of domain, the integration may be limited to a common UI framework, but frequently the integration needs to include the workflow and the data stored in the system. In some cases, the architecture also needs to facilitate integration between two or more externally developed products which adds yet another layer of complexity" [03].

27. **Interface stability** [03][13][18][33]: "It is required that a platform interface is defined that external developers can use to develop against. In this case, obviously, the interface has to be sufficiently expressive that external developers can build relevant functionality. On the other hand, it also should decouple the platform organization from the external developer community to the extent possible. Achieving this allows the platform organization to release new version of the product or new products in the product line without having to be concerned with disabling the externally developed applications operating on top of the platform. No interface, however, can be static and consequently the platform interface needs to evolve over time. The architectural challenge is firstly to allow the interface to evolve in a predictable fashion and with significant time for external developers to adjust their applications or to prepare new functionality exploiting the new interface" [03].

28. **Interoperability** [24][28]: "Interoperability is about the ability of two systems to work together according to anticipated and desired usages. Such two systems are typically independent and fully functional systems, which provide an overall usage benefit when interoperating" [24].

29. **Licensing** [01][32]: "Traditional proprietary licenses allow a company to retain control of software it produces, and restrict the access and rights that outsiders can have. OSS licenses, on the other hand, are designed to encourage sharing and reuse of software, and grant access and as many rights as possible. OSS licenses are classified as academic or reciprocal. Academic OSS licenses such as the Berkeley Software Distribution (BSD) license, the Massachusetts Institute of Technology license, the

Apache Software License, and the Artistic License, grant nearly all rights to components and their source code, and impose few obligations. Anyone can use the software, create derivative works from it, or include it in proprietary projects. Typical academic obligations are simply to not remove the copyright and license notices" (ALSPAUGH et al., 2009).

30. **Learnability** [22][24]: "One of the main issues that affected developer experience regarded learnability. It emerged that the platform resources did not facilitate learning. A major example is that the third-party APIs, because of their structure, did not aid the learning process. As a general approach developers would have preferred that the APIs were structured in such a way that is straight-forward to perform basic operations. The more advanced options of those operations could have been learned and used over time. Instead, it was easy to end up using advanced options or operations, even deprecated ones, already at the beginning" (BIANCO, 2013).

31. **Maintainability** [15][35][37]: "One of the major requirements for SECO architecture is to support ecosystem actors through improving and evolving the original platform to be able to create new business value. It should be possible to perform cost - effective changes within the platform without inadvertently breaking extensions that depend on it" [35]. "Conversely, changes in an extension should not require adjustments in the platform. This is accomplished through partitioning the platform into standalone subsystems and linking hem using standardized interfaces that do not change often over time" [37].

32. **Modifiability** [01][07][13][26]: "allows replacing or modifying components in a layer, e.g., the evolution of a component trade mechanism to support pricing models" [13].

33. **Modularization** [12][13][19][37]: "Modularity consists in applying the traditional engineering principle related to decomposing a system in manageable modules, minimizing the technical coupling among its parts" [13].

34. **Niche creation** [13]: "describes the SECO capability in creating opportunities to new and old actors to explore new business chances" [13].

35. **Offline capability** [20]: "One common and important decision we often encounter is how to deal with limited or interrupted network connections. While it means definitely a much better user experience to offer the complete functionality of an app in offline mode, it has to be considered that adding this feature significantly increases complexity of synchronizing data between the different components of the app ecosystem. In the end this often leads to the tradeoff of reduced maintainability and extendibility. A compromise can be to implement offline support only for specific apps or particular features of the ecosystem, but finally it depends on the importance of the offline capability driver which approach should be taken" [20].

36. **Open interfaces (for components**) [32]: "The paper examines open interface for components in a case study analyzing Chromium. It appears that all the external components have open interfaces (i.e. public and standardized), so that Chromium can evolve by replacing components with others implementing the same interfaces, or shimmed to them, as long as the replacements are also under non-propagating OSS licenses" [32].

37. **Openness** [01][02][21][22][24][32][37]: "Openness is the degree to which a platform supplier allows the platform users to interact with the platform, view, extend or change its components and depends on different technical and commercial aspects" [01]. "Deals with the extensibility of products and processes, including management and the technical aspects involved" [02]. "Openness is the property of a system architecture to enable added-value services by incorporating third party contributions (typically unknown in advance) while retaining essential qualities. Explicit mechanisms for openness are established at development time and third party contributions utilize such mechanisms at runtime. The decision to open a system architecture is always based on business rationale" [24].

38. **Parallel development** [35]: "Ecosystem actors typically develop their platform additions independently. A good SECO technical platform should enable parallel independent development" [35].

39. **Performance** [11][21][24]: "An increase in the number of available features will usually result in an increase in the size of the products that extend the platform, often due to the use of a large number of plugins, can cause runtime performance and

memory problems" [11]. "Open systems need to ensure that system extensions do not prevent the system from fulfilling essential performance requirements. There might be risks of extensions that perform long running computations prolonging the response time of systems or allocating an inadequate amount of system resources" [24].

40. **Portability** [22][37]: "Portability provided by a platform makes it easy for developers writing extension to participate in the ecosystem, regardless of the technologies used in their applications. This means it is necessary to standardize the interfaces responsible for interactions with the platform. Portability describes the platforms that are required to install the main platform" [37]. "The difference between MSCRM and its Microsoft oriented stack immediately incurs all kinds of extra license fees, whereas Ruby can be deployed on so many different configurations, it is hard for developers to pick which underlying technology fits their extensions best" [22].

41. **Productivity** [13]: "describes the SECO activity level, i.e., how much business is created, how much value is earned and how many actors are joined" [13].

42. **Quality** [14][18][38]: "The overall product quality depends on the combination of software from the different contributors and failures often occur because of component interaction, unclearly documented Application Programming Interfaces (API) or unknown use of the system. A firm that controls a wide scope of the architecture can guarantee the product quality more easily. In the situation where multiple firms are involved, and especially when the interfaces are not clearly defined, the quality can easily break down and externally developed code could access data in the system, causing malfunctioning or security problems" [18].

43. **Quality of extensions** [29]: "it is crucial for platform suppliers to have a way of certifying the quality of extensions provided by external developers. Only in this way they can maintain a quality standard already established or to be established with final end-users. Moreover, only through the definition of such mechanisms platform suppliers might have the assurance that both defective and malicious extensions will not affect the entire ecosystem" [29].

44. **Rate of change** [22][37]: "As platforms are frequently updated, significant investments are needed from extenders to stay up to date and implement new features for the platform. Software platform developers typically fight on two fronts: on the one

hand developers want their platform to accommodate new technologies, on the other hand platforms must remain stable and reliable" [22].

45. **Reliability** [03][24][26][33]: "Reliability of software is the capability of itself to maintain its level of stability under specified conditions for a specified period of time. The reliability of software is influenced by process and product factors. Among them, the design mechanism has a considerable impact on overall quality of the software" (SELVARANI & BHARATHI, 2017).

46. **Resiliency** [37]: "One defective extension should not cause the entire ecosystem to malfunction. The key here is to ensure that extensions are weakly coupled with the platform through the use of well-defined interfaces. This approach of keeping platform-extension dependencies to a minimum level also contributes to the stability of the entire ecosystem" [37].

47. **Reuse** [07][37]: "The lack of a common, shared, infrastructure to reuse forced companies to build all components themselves. Thus, small to medium sized business with expertise in e.g. home care were essentially excluded for the market due to lack of resources to develop and host server side solutions" [07]. "Platform modularization allows software reuse to be achieved both by the platform architecture and by external application, e.g., Apple does not allow applications to reuse" [37].

48. **Robustness** [13]: "Robustness describes how a SECO can recover from a major stress by itself, such as keystone loss, the "death" of some niche players, or a technological advance that affect the major part (community and/or platform) of the SECO" [13].

49. **Safety** [24][29]: "For certain system types, like machinery, safety is an essential concern. In such systems, attention has to be paid that behavior induced by extensions does not pose any threat to the safety of users or the environment" [24].

50. **Scalability** [09][10][11]: "Scalability is the effort required to adapt the system to new requirement that modify the size and scope of the computation" [10].

51. **Security** [03][21][24][26][33][37]: "Platform security potentially influence the increasing of confidence perceived by external developers, encouraging them to adhere to the ecosystem. Thus, some mechanisms are important to provide more security to the

platform, as authentication, usage limits, among other mechanisms to control or restrict access to applications and users" [37].

52. **Shared information** [38]: "This challenge concerns the kind of information that the platform providers can share with third-party developers. For privately ecosystems this issue involves questions about market strategies and business survival. The focus of our study is OSS ecosystems, which main characteristic is to keep open all information about the ecosystem. Normally, information are shared in the website and in periodical meetings to integrate the community. However, even in OSS ecosystems, sharing information faces challenges such as keeping website updated, organize and distribute information by appropriate means, sharing knowledge at the right time for all working well, manage information regarding schedule pressures and unknown needs of different clients, and so on" [38].

53. **Simplicity** [37]: "The platform architecture should be simple enough to be comprehensible at least at high level of abstraction. Interactions between the platform and extensions should be well defined and explicit. Platform functionality reused by any extensions should also be identifiable" [37].

54. **Stability** [14][37]: "As the ecosystem grows, external developers end up developing functionalities that are later incorporated into the platform, the platform might expose new features, some of the platform features may be underutilized, etc. In other words, the platform architecture needs to adapt to the ecosystem evolution, but the frequency of changes should be limited to a reasonable level" [37].

55. **Standardization across the platform** [22]: "Standardization across the platform is seen as Standardized user interface across different layers in the application, thereby providing end-users with the feeling that they are always working within one product, whereas it may be possible that the end user uses several products simultaneously. One other example of standardization that is frequently praised is the use of application templates, which can easily be altered to provide extension specific feature" [22].

56. **Support** [22]: "quick and high-quality support for extenders is seen as having a major positive effect on an extender’s experience and development speed with a platform" [22].

57. **Synchronization** [20][21]: "A crucial part of an MSE (Mobile Software Ecosystems) is also a reliable, performant and easy-to-use synchronization mechanism that takes care of the distribution of data between backend, apps and other involved components" [21].

58. **Testability** [35]: "a good SECO technical platform should support testing platform additions in the context of ecosystem actors" [35].

59. **Transparency** [13]: "Transparency consists in making all kinds of development information available, including design and code, development tasks, defects and interactions among SECO stakeholders" [13].

60. **User experience** [21][24]: "In order to provide a great user experience, the overall system has to make sure that the right data and functionality is available at the right point in time at the right place" [21].

61. **Understandability** [35]: "The ecosystem, and its underlying technological platform, should be easily comprehended by ecosystem actors. Important aspects to comprehend include nature of the ecosystem, business rules" [35].

62. **Variability** [06][11][18][19][26]: "Variability management handles the way the variable features and characteristic are managed in different product of the same SECO. Variability among products of a SECO is necessary because it makes them a separate business entity" [06].

63. **Version compatibility** [37]: "Compatibility between platform versions is important for extension developers stay up-to-date with the platform. Extension developers should be able to use new features launched by each platform release. Furthermore, the process of updating an application should occur a stable manner. A common practice is to offer developers the option to use a version o e released (in testing) so that they can adjust their extensions over time" [37].

64. **Working facilities** [38]: "Practically all members of the community are affected by the software architecture. They need work in a coordinated way and solve several conflicts. For this, the keystone organization must adopted different working facilities that allows support different views including modeling, business, communication and

knowledge management of the software architecture. These facilities should be accepted and used by community to facilitate the combined work in a harmonious relation" [38].

References for definitions outside the set of papers resulting of the mapping study:

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Appendix III - Survey forms

TERM OF CONSENT

STUDY GOALS
This survey aims to investigate if the presented critical factors are relevant to the technology selection in a SECO, as well as if their related attributes fairly characterize them.

AGE
I declare to be over 18 (eighteen) years of age and agree to participate in a study conducted by Thaiana Maria Pinheiro Lima (COPPE / UFRJ) under the supervision of Prof. Rodrigo Pereira dos Santos (DIA/UNIRIO) and Profa. Cláudia Maria Lima Werner (COPPE / UFRJ).

PROCEDURE
The research will be conducted in three stages. In the first step, we ask that you respond to your experience on some topics. In the second step, you will answer multiple choice questions about the topics involved in the survey. In the third step, you can provide your own impressions and aditional comments. It is estimated that you will spend 20-30 min.

CONFIDENTIALITY
I am aware that my name will not be disclosed under any circumstances. I am also aware that the data obtained through this study will be kept confidential, and the results will then be presented in an aggregated form, so that a participant is not associated with a specific data. Likewise, I accept not to communicate my results while the study is not completed, as well as to maintain confidentiality of the techniques and documents presented and that are part of the experiment.

BENEFITS AND FREEDOM OF WITHDRAWAL
The benefits I will receive from this study are limited to learning the material that is distributed. I also understand that I am free to ask questions at any time, request that any information related to me not be included in the study or report my withdrawal from participation without any penalty. Finally, I declare that I participate of my own free will with the sole purpose of contributing to the advancement and development of techniques and processes for Software Engineering.

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Survey: Critical Factors for Technology Selection in Software Ecosystems

Research summary

Software Ecosystems (SECO) can be described as a set of actors, software artifacts, a common platform, and their relationships. Keystone is the main actor in a SECO. An element that a keystone controls is the set of technologies used to maintain a SECO platform. The problem of choosing which technology to introduce, discontinue or replace affects the development process and its management centered in SECO platform.

In order to better understand and select a technology from some candidates, a set of attributes that characterize SECO, its platform and technologies were extracted from the literature as a baseline for comparing the candidates for acquisition or discontinuation. As a result, 64 attributes were identified and grouped into 11 critical factors (seen as generic attributes). The critical factors are attributes that can represent other attributes. Since they are generic, they can englobe other concepts, according to the perceived relations covering attributes that are more specific.

This survey aims to investigate if the presented critical factors are relevant to the technology selection in a SECOs, as well as if their related attributes fairly characterize them.

Participant Characterization

Tell us about you experience

Email *
Your email will not be published.

Your answer

Q1 - Experience with related topics *

	Don't know it	Don't know, but I've heard of it	I know	I know it and have some experience	I have much experience with it
Software Ecosystems	○	○	○	○	○
Technology selection (acquisition, replacement, or discontinuation)	○	○	○	○	○
IT Architecture and Management	○	○	○	○	○

Q2 - Academic background *

- ○ Postdoctoral
- ○ Ph. D. Degree
- ○ Ph. D. Student
- ○ Master Degree
- ○ Master Student
- ○ Bachelor Degree

Q3 - Workplace *

- ○ Industry
- ○ Academy
- ○ Both

Evaluation of Critical Factors

Q4 - For each critical factor below (CF1 - CF11), mark the relevance level it has when selecting technologies in software ecosystems.

0 = No relevance | 1 = Little relevance | 2 = Limited relevance | 3 = Some relevance | 4 = Highly relevant

	0	1	2	3	4
CF1 - Configurability	○	○	○	○	○
CF2 - Cost	○	○	○	○	○
CF3 - Extension	○	○	○	○	○
CF4 - Openness	○	○	○	○	○
CF5 - Quality	○	○	○	○	○
CF6 - Reuse	○	○	○	○	○
CF7 - Scalability	○	○	○	○	○
CF8 - Stability	○	○	○	○	○
CF9 - Support	○	○	○	○	○
CF10 - User experience	○	○	○	○	○
CF11 - Version compatibility	○	○	○	○	○
CF12 - Niche creation	○	○	○	○	○
CF13 - Robustness	○	○	○	○	○
CF14 - Productivity	○	○	○	○	○

Q5 - In your opinion, did you miss any critical factor not included in the list? *

○ Yes

○ No

Q5a - If you aswered 'Yes' for Q5, please include critical factors (or edit existing ones).

Your answer

Q6 - General comments about the critical factors

Your answer

Evaluation of associated Attributes

Q7 - Every attribute represents a different perspective of the critical factor associated. Therefore, a set of attributes characterizes an assotiated critical factor. For each attribute bellow, mark the level of relevance for the characterization of a critical factor

0 = No relevance | 1 = Little relevance | 2 = Limited relevance | 3 = Some relevance | 4 = Highly relevant

CF1 - Configurability

	0	1	2	3	4
Commonality	○	○	○	○	○
Variability	○	○	○	○	○

CF2 - Cost

	0	1	2	3	4
Licensing	○	○	○	○	○
Buildability	○	○	○	○	○
Openness	○	○	○	○	○

CF3 - Extension

	0	1	2	3	4
Buildability	○	○	○	○	○
Extensibility	○	○	○	○	○
Extensions' delivery	○	○	○	○	○
Extensions' deployment	○	○	○	○	○
Modifiability	○	○	○	○	○
Standardization across the platform	○	○	○	○	○

CF4 - Openness

	0	1	2	3	4
Accessibility	◯	◯	◯	◯	◯
Availability	◯	◯	◯	◯	◯
Flexibility	◯	◯	◯	◯	◯
Licensing	◯	◯	◯	◯	◯
Performance	◯	◯	◯	◯	◯
Reliability	◯	◯	◯	◯	◯
Safety	◯	◯	◯	◯	◯
Security	◯	◯	◯	◯	◯
Synchronization	◯	◯	◯	◯	◯
User experience	◯	◯	◯	◯	◯

CF5 - Quality

	0	1	2	3	4
Certification	◯	◯	◯	◯	◯
Efficient use of system's resources	◯	◯	◯	◯	◯
Hard real time requirements	◯	◯	◯	◯	◯
Testability	◯	◯	◯	◯	◯
Quality of extensions	◯	◯	◯	◯	◯

CF6 - Reuse

	0	1	2	3	4
Composability	◯	◯	◯	◯	◯
Cost	◯	◯	◯	◯	◯
Decoupling among components	◯	◯	◯	◯	◯
Dependability	◯	◯	◯	◯	◯
Extensibility	◯	◯	◯	◯	◯
Integration	◯	◯	◯	◯	◯
Modularization	◯	◯	◯	◯	◯
Open interface (for components)	◯	◯	◯	◯	◯
Transparency	◯	◯	◯	◯	◯
Understandability	◯	◯	◯	◯	◯

CF7 - Scalability

	0	1	2	3	4
Complexity	◯	◯	◯	◯	◯
Extensibility	◯	◯	◯	◯	◯
Interoperability	◯	◯	◯	◯	◯
Performance	◯	◯	◯	◯	◯

CF8 - Stability

	0	1	2	3	4
Framework stability	◯	◯	◯	◯	◯
Interface stabilityExtensibility	◯	◯	◯	◯	◯
Parallel development	◯	◯	◯	◯	◯
Rate of change	◯	◯	◯	◯	◯

CF9 - Support

	0	1	2	3	4
Documentation	◯	◯	◯	◯	◯
Shared information	◯	◯	◯	◯	◯

CF10 - User experience

	0	1	2	3	4
Consistent user interface	◯	◯	◯	◯	◯
Documentation	◯	◯	◯	◯	◯
Accessibility	◯	◯	◯	◯	◯
Simplicity	◯	◯	◯	◯	◯

CF11 - Version compatibility

	0	1	2	3	4
Backwards compatibility	◯	◯	◯	◯	◯
Maintainability	◯	◯	◯	◯	◯
Portability	◯	◯	◯	◯	◯

CF12 - Niche creation

	0	1	2	3	4
Innovation	◯	◯	◯	◯	◯
Work facilities	◯	◯	◯	◯	◯

CF13 - Robustness

	0	1	2	3	4
Availability	◯	◯	◯	◯	◯
Offline capability	◯	◯	◯	◯	◯
Resilience	◯	◯	◯	◯	◯
Stability	◯	◯	◯	◯	◯

CF14 - Productivity

	0	1	2	3	4
Extensions' delivery	◯	◯	◯	◯	◯
Deployability	◯	◯	◯	◯	◯
Learnability	◯	◯	◯	◯	◯

Q8 - In your opinion, is there any misplaced attribute, i.e., any attribute should be moved or copied to another critical factor? *

- ◯ Yes
- ◯ No

Q8a. If you answered 'Yes' for Q8, please include your suggestions bellow.

Your answer

Q9 - In your opinion, is there any other attribute not included in the list regarding any critical factor? If so, please include your suggestions and their respective relevance level according to the following scale. Do not forget to mention the associated critical factor.

0 = No relevance | 1 = Little relevance | 2 = Limited relevance | 3 = Some relevance | 4 = Highly relevant

Your answer

General comments about the attributes associated to the critical factors

Your answer

Appendix IV – Informed Consent Form (In Portuguese)

Investigação sobre Ecossistemas de Software **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 Thaiana Maria Pinheiro Lima da COPPE/UFRJ, sob a orientação do Prof. Rodrigo Pereira dos Santos e 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 3 (cinco) minutos e que para realizar a 2a etapa seja necessário, 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.

PESQUISADORA RESPONSÁVEL
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Data, nome do participante e rubrica

Appendix V - Participant Characterization Form (In Portuguese)

Investigação sobre Ecossistemas de Software **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

2. Experiência Profissional

a) Tempo de Experiência

Por favor, detalhe sua resposta. Inclua o número de anos e meses de experiência em atividades da gestão de TI.

Comentários:

Desde já, agradecemos a sua colaboração.

Thaiana Maria Pinheiro Lima
Rodrigo Pereira dos Santos
Cláudia Maria Lima Werner

Appendix VI - Theoretical Background on SECO (In Portuguese)

Exemplo

- ECOS Android
  - Atores: Google, usuários de apps, desenvolvedores da google, desenvolvedores externos
  - Artefatos: apps, api de dev, kernel android, documentação
  - Relacionamentos: compra, utilização, dependência

3

Contexto

- Existe um conjunto de tecnologias que suportam as aplicações
- Assim, o gerenciamento de tecnologias de suporte é mais complexo
- A manutenção da plataforma depende da arquitetura de TI
  - Conjunto de especificações técnicas (**Weils & Ross, 2004**)
  - Tecnologias padrão da organização, geralmente categorizadas.

4

Contexto

- Inserir ou remover uma tecnologia impacta as relações ECOS, incluindo de projetos em desenvolvimento e suporte a projetos desenvolvidos

- Uma das mais bem sucedidas ações é ter um procedimento bem definido para aquisição de TI (Lagerström et al, 2014)

- Parte da definição consiste em ter critérios de avaliação para os candidatos da aquisição (Shafia et al, 2015).

5

Problema

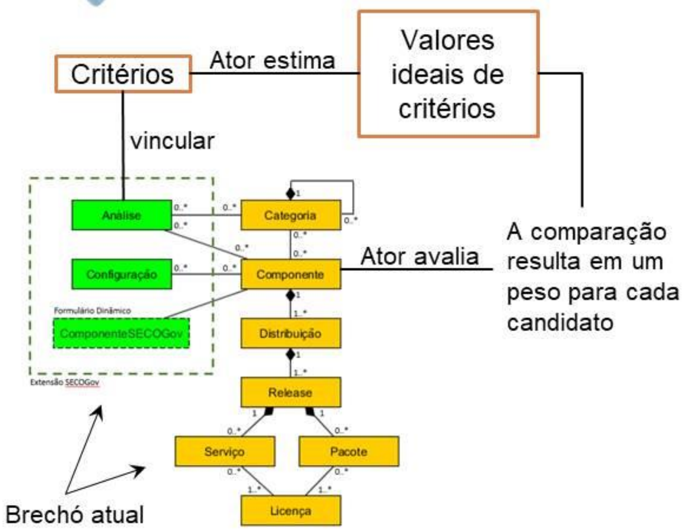
- Existem várias tecnologias candidatas, selecionar a mais apropriada é um desafio

- Cada candidata altera o ECOS de uma maneira diferente

- É necessário estabelecer critérios explícitos ao invés de usar o conhecimento tácito do arquiteto

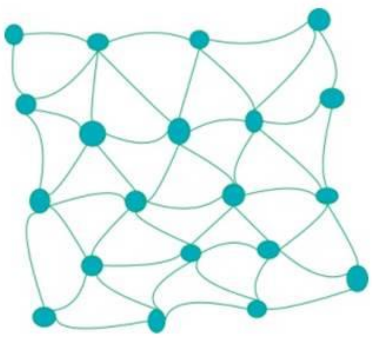
6

Funcionalidades da ferramenta



7

Funcionalidades da ferramenta



- Usando os atores, artefatos e as relações que os ligam, formam-se redes.
- A rede é criada e indicadores são calculados considerando cada candidato separadamente

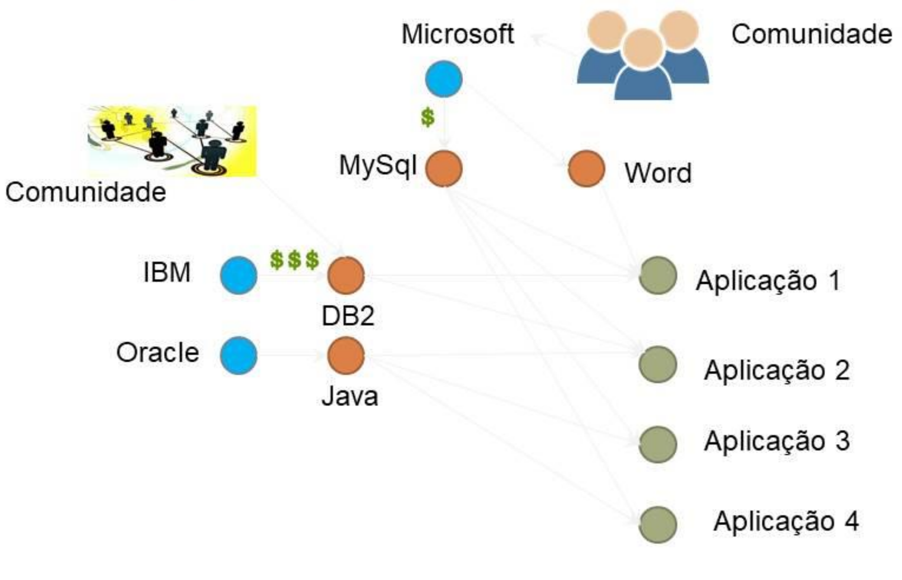
8

Funcionalidades da ferramenta

- A análise considera as relações dependência, produção e cadidatos.
- Cada tecnologia candidata é analisada simulando sua entrada ou saída no ECOS atual. A estrutura do ECOS gera observações para o usuário, como:
  - Tecnologias que são **HUBS**. Estas tecnologias afetam uma porção maior do ECOS
  - Tecnologias das quais muitas aplicações **dependem**. Estas tecnologias podem gerar esforços extras para manter as aplicações funcionando com sua saída. Outros tipos de centralidades podem ser calculados
  - Fornecedores principais/centrais

9

Exemplo simples de resultados da visualização da rede



10

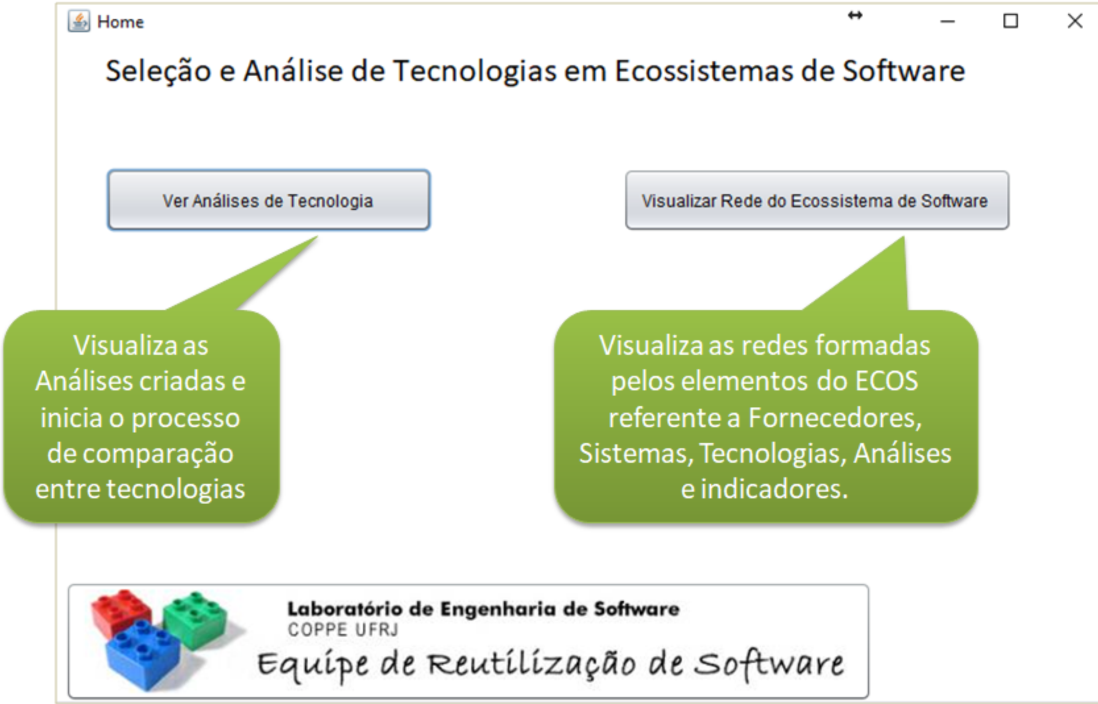
Estudo

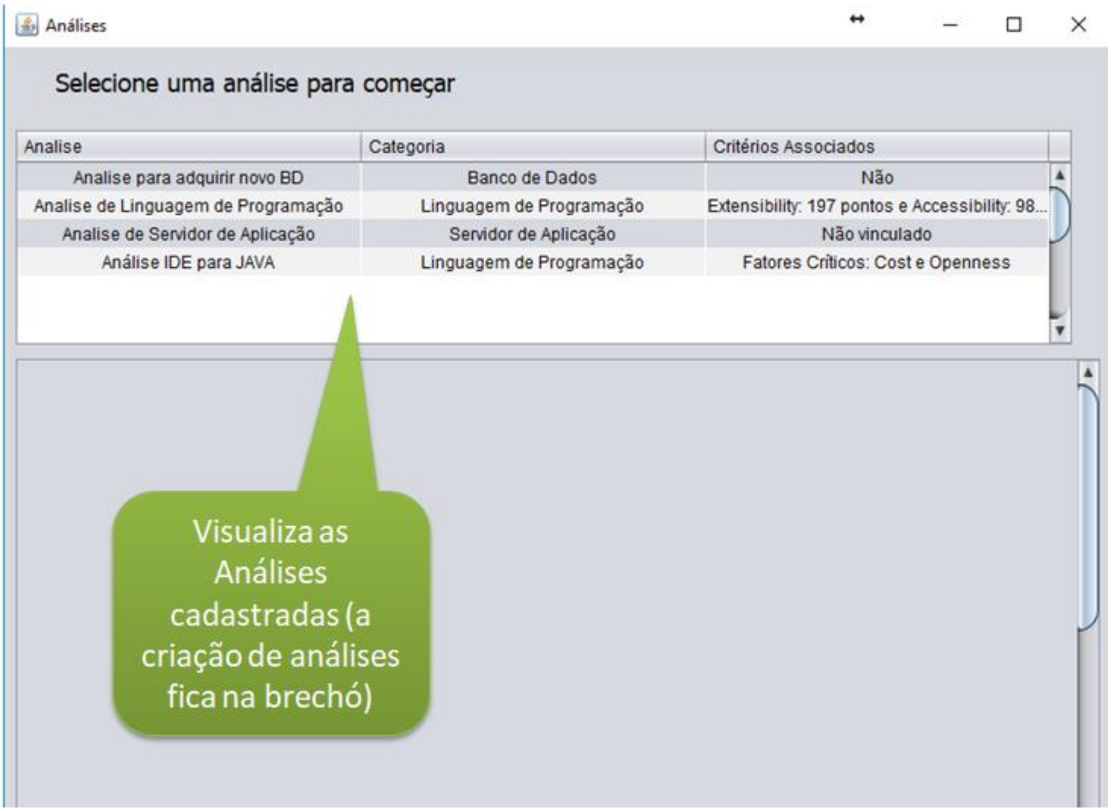
Você é um gestor de TI na sua e parte das suas atividades é realizar a seleção de tecnologias de suporte aos seus sistemas.

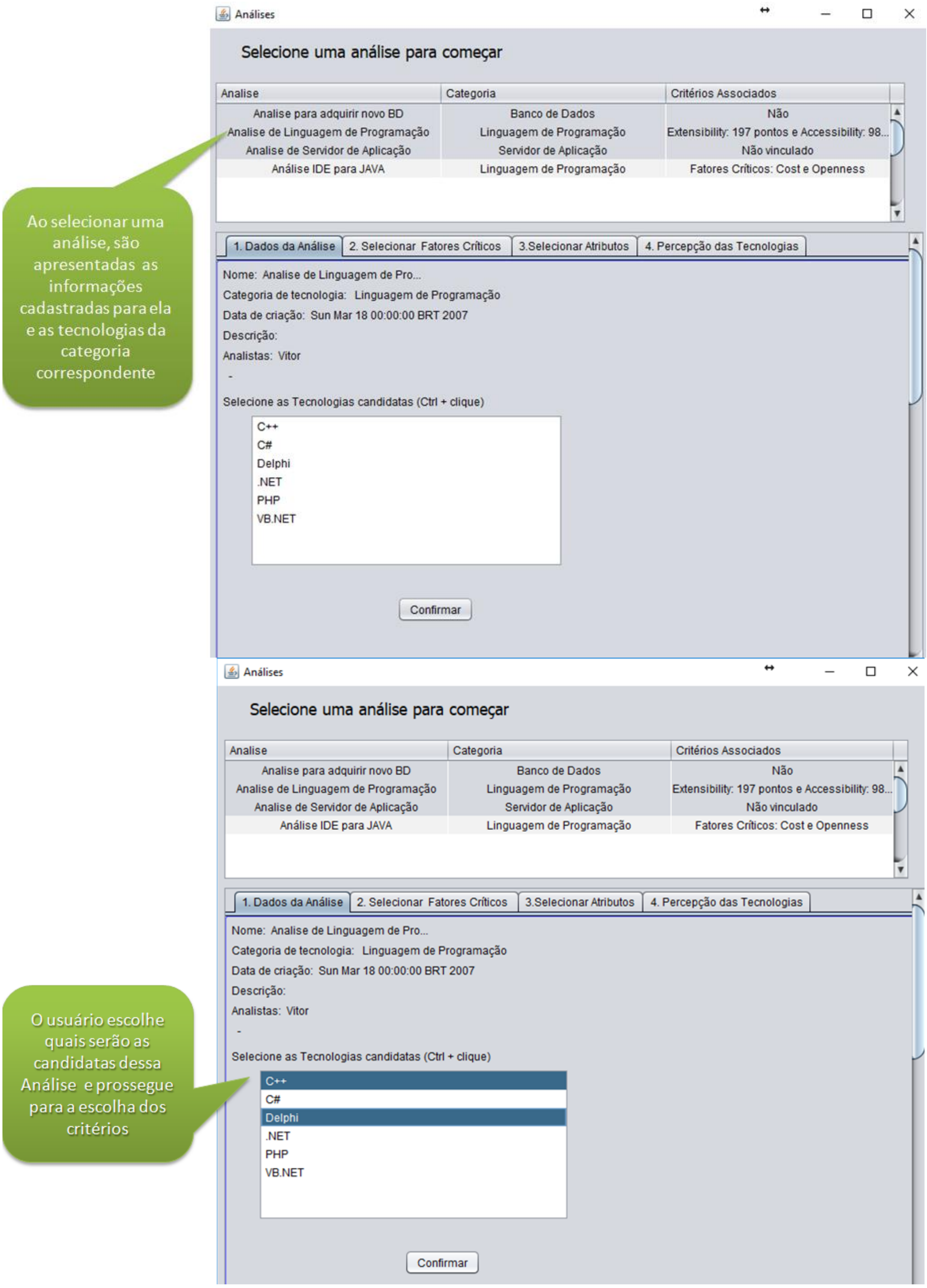
A ferramenta utiliza um repositório contendo o Ecossistemas da DPGE formado por usuários tecnologia, sistema e fornecedores.

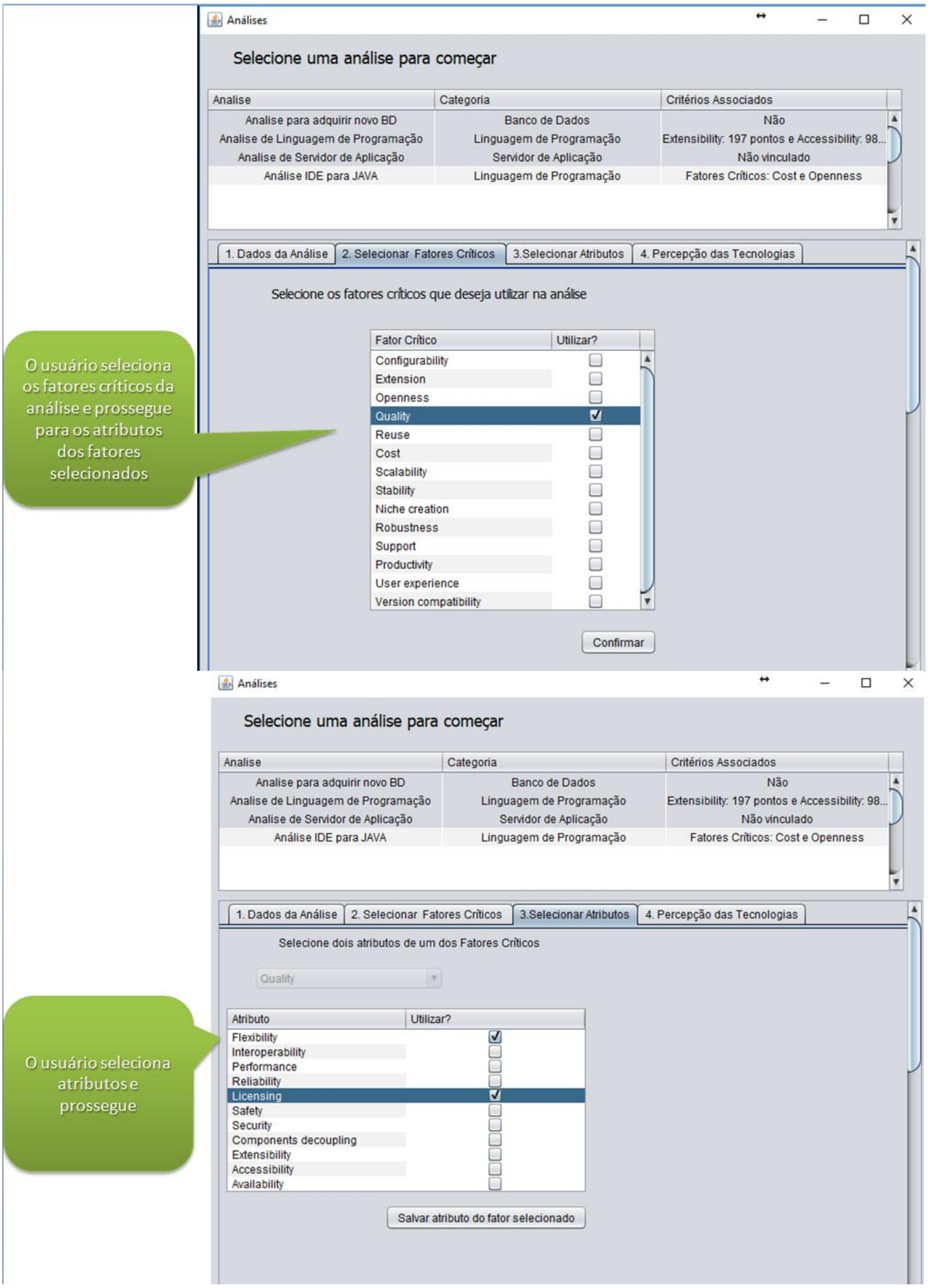
11

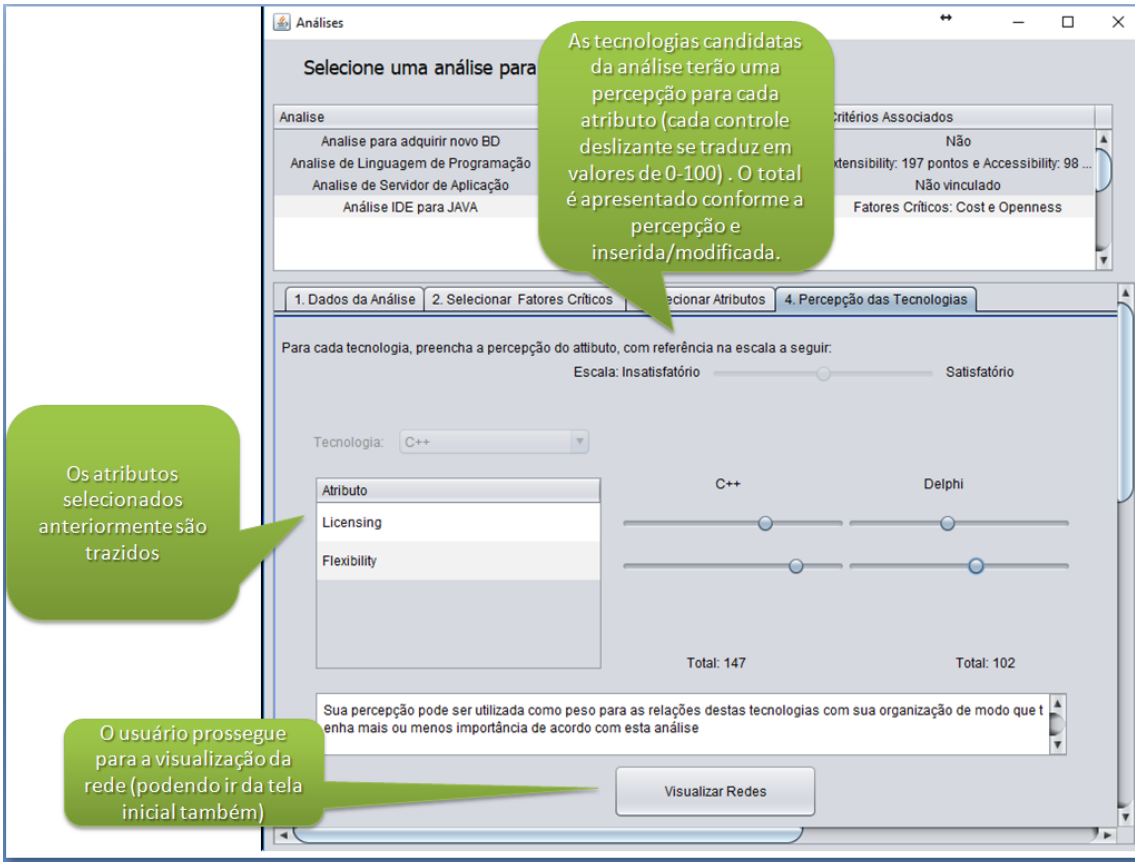
Appendix VII – Tool's Instructions (In Portuguese)

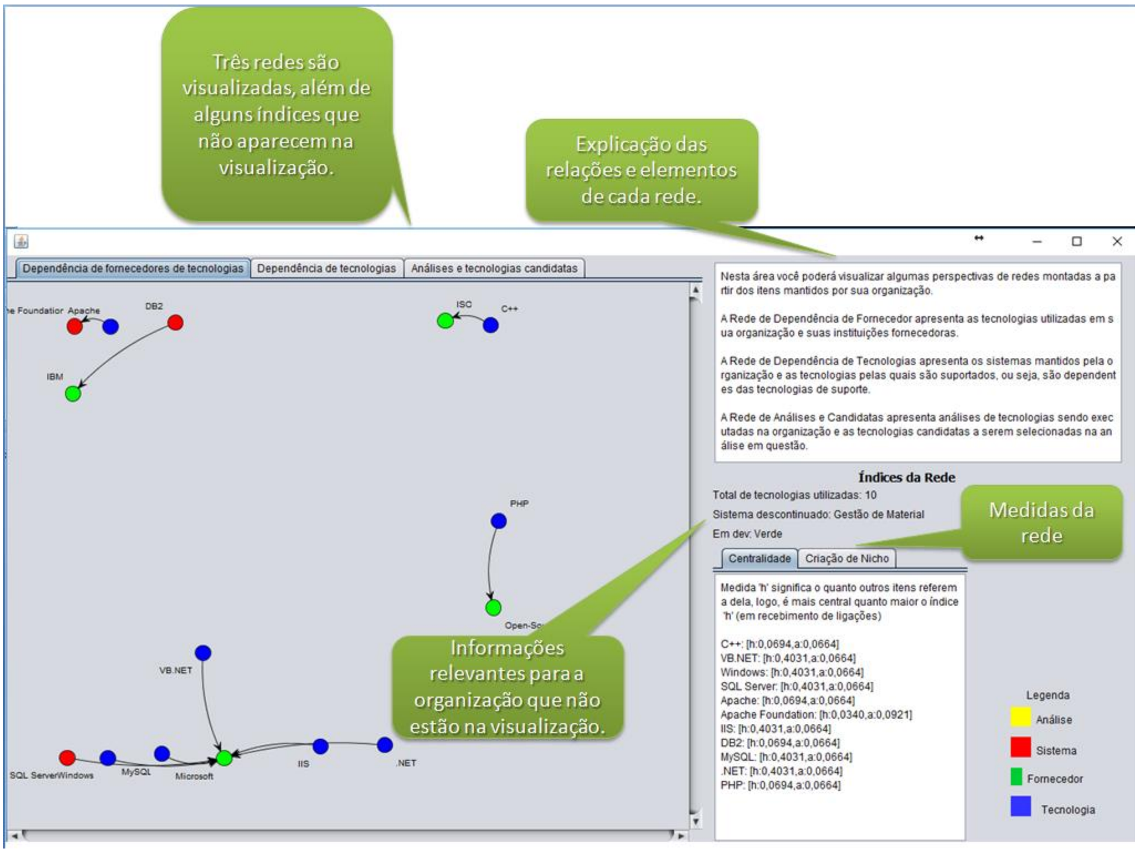


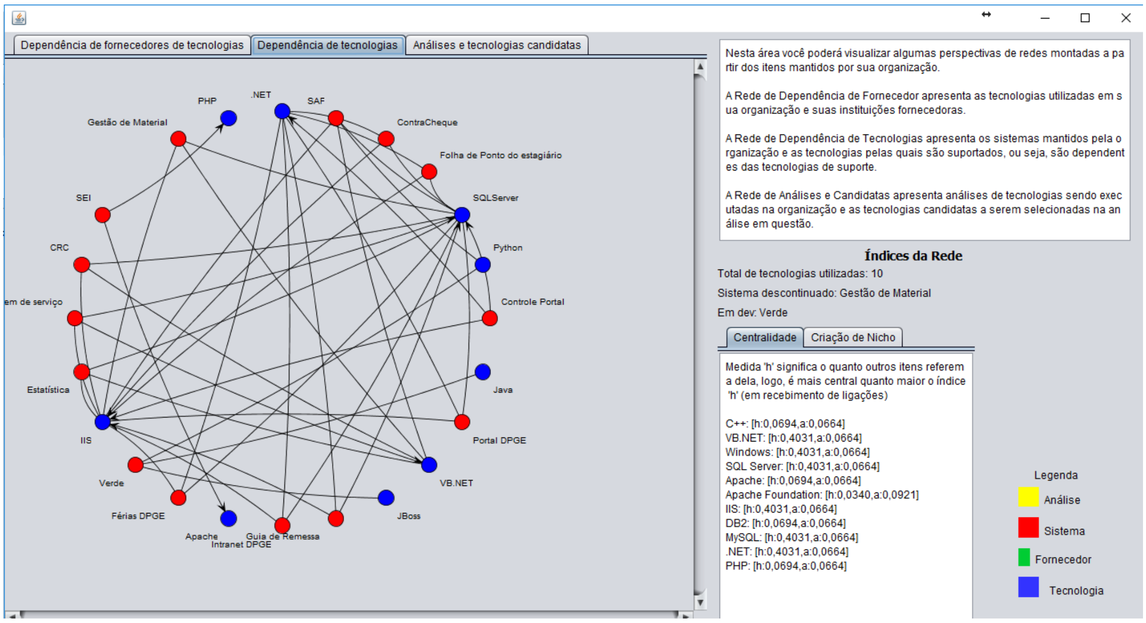


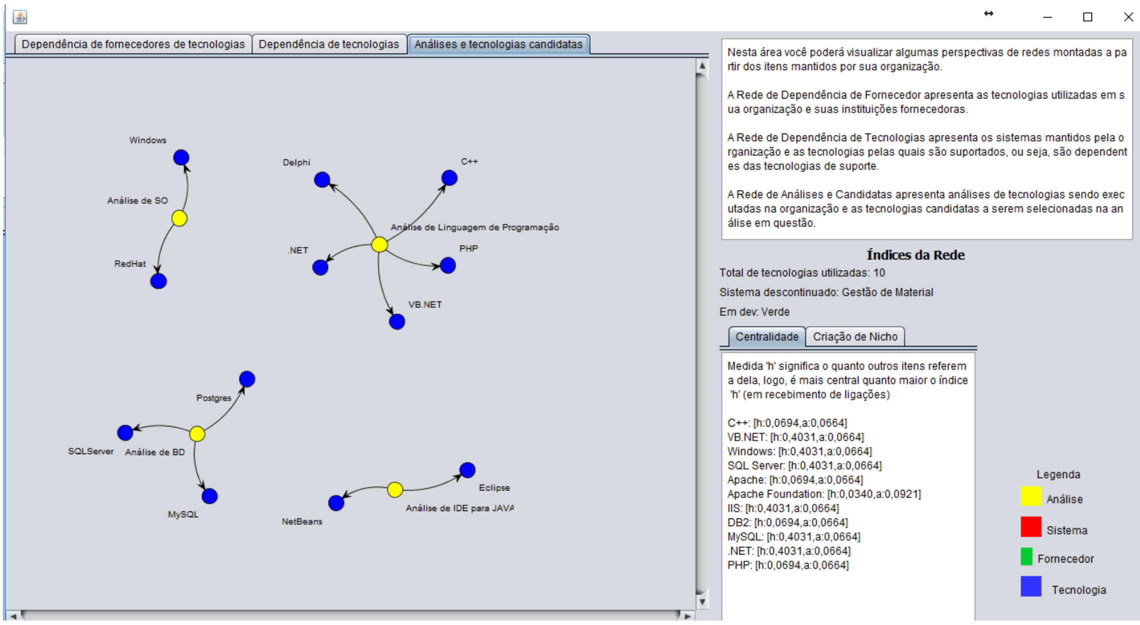

Análises
Selecione uma análise para começar
Analise
Categoria
Critérios Associados
Analise para adquirir novo BD
Banco de Dados
Não
Analise de Linguagem de Programação
Linguagem de Programação
Extensibility: 197 pontos e Accessibility: 98...
Analise de Servidor de Aplicação
Servidor de Aplicação
Não vinculado
Análise IDE para JAVA
Linguagem de Programação
Fatores Críticos: Cost e Openness
1. Dados da Análise
2. Selecionar Fatores Críticos
3.Selecionar Atributos
4. Percepção das Tecnologias
Nome: Analise de Linguagem de Pro...
Categoria de tecnologia: Linguagem de Programação
Data de criação: Sun Mar 18 00:00:00 BRT 2007
Descrição:
Analistas: Vitor
Selecione as Tecnologias candidatas (Ctrl + clique)
C++
C#
Delphi
.NET
PHP
VB.NET
Confirmar
Ao selecionar uma análise, são apresentadas as informações cadastradas para ela e as tecnologias da categoria correspondente
O usuário escolhe quais serão as candidatas dessa Análise e prossegue para a escolha dos critérios

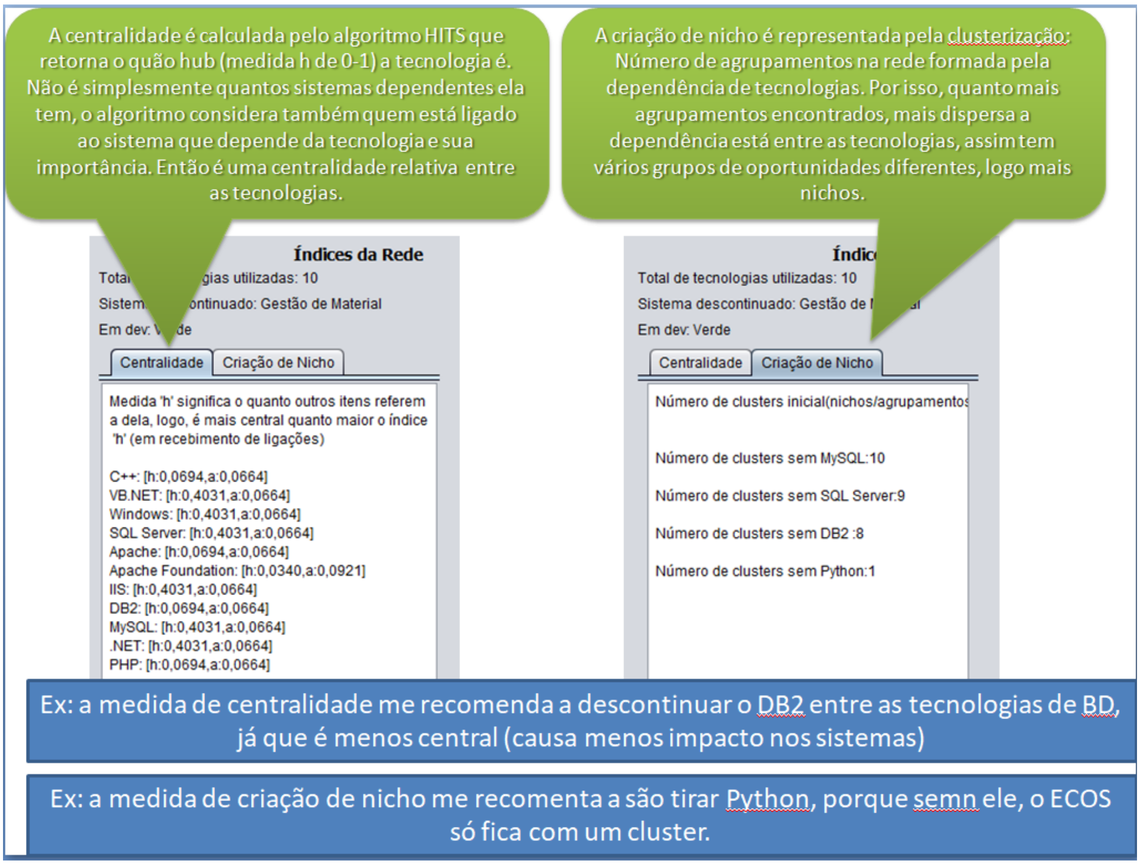

Análises
Selecione uma análise para começar
Analise | Categoria | Critérios Associados
Analise para adquirir novo BD | Banco de Dados | Não
Analise de Linguagem de Programação | Linguagem de Programação | Extensibility: 197 pontos e Accessibility: 98...
Analise de Servidor de Aplicação | Servidor de Aplicação | Não vinculado
Análise IDE para JAVA | Linguagem de Programação | Fatores Críticos: Cost e Openness
1. Dados da Análise
2. Selecionar Fatores Críticos
3.Selecionar Atributos
4. Percepção das Tecnologias
Selecione os fatores críticos que deseja utilizar na análise
Fator Crítico
Utilizar?
Configurability
Extension
Openness
Quality
Reuse
Cost
Scalability
Stability
Niche creation
Robustness
Support
Productivity
User experience
Version compatibility
Confirmar
O usuário seleciona os fatores críticos da análise e prossegue para os atributos dos fatores selecionados
Selecione dois atributos de um dos Fatores Críticos
Quality
Atributo
Utilizar?
Flexibility
Interoperability
Performance
Reliability
Licensing
Safety
Security
Components decoupling
Extensibility
Accessibility
Availability
Salvar atributo do fator selecionado
O usuário seleciona atributos e prossegue


Análises
Selecione uma análise para
As tecnologias candidatas da análise terão uma percepção para cada atributo (cada controle deslizante se traduz em valores de 0-100) . O total é apresentado conforme a percepção e inserida/modificada.
Analise
Analise para adquirir novo BD
Analise de Linguagem de Programação
Analise de Servidor de Aplicação
Análise IDE para JAVA
Critérios Associados
Não
xtensibility: 197 pontos e Accessibility: 98 ...
Não vinculado
Fatores Críticos: Cost e Openness
1. Dados da Análise
2. Selecionar Fatores Críticos
ecionar Atributos
4. Percepção das Tecnologias
Para cada tecnologia, preencha a percepção do attibuto, com referência na escala a seguir:
Escala: Insatisfatório
Satisfatório
Tecnologia:
C++
Os atributos selecionados anteriormente são trazidos
Atributo
Licensing
Flexibility
C++
Delphi
Total: 147
Total: 102
Sua percepção pode ser utilizada como peso para as relações destas tecnologias com sua organização de modo que t enha mais ou menos importância de acordo com esta análise
O usuário prossegue para a visualização da rede (podendo ir da tela inicial também)
Visualizar Redes


Três redes são visualizadas, além de alguns índices que não aparecem na visualização.
Explicação das relações e elementos de cada rede.
Dependência de fornecedores de tecnologias
Dependência de tecnologias
Análises e tecnologias candidatas
DB2
IBM
ISO
C++
PHP
VB.NET
SQL Server
Windows
MySQL
Microsoft
IIS
.NET
Nesta área você poderá visualizar algumas perspectivas de redes montadas a pa rtir dos itens mantidos por sua organização.
A Rede de Dependência de Fornecedor apresenta as tecnologias utilizadas em s ua organização e suas instituições fornecedoras.
A Rede de Dependência de Tecnologias apresenta os sistemas mantidos pela o rganização e as tecnologias pelas quais são suportados, ou seja, são dependent es das tecnologias de suporte.
A Rede de Análises e Candidatas apresenta análises de tecnologias sendo exec utadas na organização e as tecnologias candidatas a serem selecionadas na an álise em questão.
Índices da Rede
Total de tecnologias utilizadas: 10
Sistema descontinuado: Gestão de Material
Em dev: Verde
Medidas da rede
Centralidade
Criação de Nicho
Medida 'h' significa o quanto outros itens referem a dela, logo, é mais central quanto maior o índice 'h' (em recebimento de ligações)
C++: [h:0,0694,a:0,0664]
VB.NET: [h:0,4031,a:0,0664]
Windows: [h:0,4031,a:0,0664]
SQL Server: [h:0,4031,a:0,0664]
Apache: [h:0,0694,a:0,0664]
Apache Foundation: [h:0,0340,a:0,0921]
IIS: [h:0,4031,a:0,0664]
DB2: [h:0,0694,a:0,0664]
MySQL: [h:0,4031,a:0,0664]
.NET: [h:0,4031,a:0,0664]
PHP: [h:0,0694,a:0,0664]
Informações relevantes para a organização que não estão na visualização.
Legenda
Análise
Sistema
Fornecedor
Tecnologia


Dependência de fornecedores de tecnologias
Dependência de tecnologias
Análises e tecnologias candidatas
PHP
.NET
SAF
Gestão de Material
ContraCheque
Folha de Ponto do estagiário
SEI
SQLServer
CRC
Python
em de serviço
Controle Portal
Estatística
Java
IIS
Portal DPGE
Verde
VB.NET
Férias DPGE
JBoss
Apache
Guia de Remessa
Intranet DPGE
Nesta área você poderá visualizar algumas perspectivas de redes montadas a pa rtir dos itens mantidos por sua organização.
A Rede de Dependência de Fornecedor apresenta as tecnologias utilizadas em s ua organização e as suas instituições fornecedoras.
A Rede de Dependência de Tecnologias apresenta os sistemas mantidos pela o rganização e as tecnologias pelas quais são suportados, ou seja, são dependent es das tecnologias de suporte.
A Rede de Análises e Candidatas apresenta análises de tecnologias sendo exec utadas na organização e as tecnologias candidatas a serem selecionadas na an álise em questão.
Índices da Rede
Total de tecnologias utilizadas: 10
Sistema descontinuado: Gestão de Material
Em dev: Verde
Centralidade
Criação de Nicho
Medida 'h' significa o quanto outros itens referem a dela, logo, é mais central quanto maior o índice 'h' (em recebimento de ligações)
C++: [h:0,0694,a:0,0664]
VB.NET: [h:0,4031,a:0,0664]
Windows: [h:0,4031,a:0,0664]
SQL Server: [h:0,4031,a:0,0664]
Apache: [h:0,0694,a:0,0664]
Apache Foundation: [h:0,0340,a:0,0921]
IIS: [h:0,4031,a:0,0664]
DB2: [h:0,0694,a:0,0664]
MySQL: [h:0,4031,a:0,0664]
.NET: [h:0,4031,a:0,0664]
PHP: [h:0,0694,a:0,0664]
Legenda
Análise
Sistema
Fornecedor
Tecnologia


Dependência de fornecedores de tecnologias
Dependência de tecnologias
Análises e tecnologias candidatas
Windows
Análise de SO
RedHat
Delphi
C++
Análise de Linguagem de Programação
.NET
PHP
VB.NET
Postgres
SQLServer
Análise de BD
MySQL
Eclipse
Análise de IDE para JAVA
NetBeans
Nesta área você poderá visualizar algumas perspectivas de redes montadas a pa rtir dos itens mantidos por sua organização.
A Rede de Dependência de Fornecedor apresenta as tecnologias utilizadas em s ua organização e as suas instituições fornecedoras.
A Rede de Dependência de Tecnologias apresenta os sistemas mantidos pela o rganização e as tecnologias pelas quais são suportados, ou seja, são dependent es das tecnologias de suporte.
A Rede de Análises e Candidatas apresenta análises de tecnologias sendo exec utadas na organização e as tecnologias candidatas a serem selecionadas na an álise em questão.
Índices da Rede
Total de tecnologias utilizadas: 10
Sistema descontinuado: Gestão de Material
Em dev: Verde
Centralidade
Criação de Nicho
Medida 'h' significa o quanto outros itens referem a dela, logo, é mais central quanto maior o índice 'h' (em recebimento de ligações)
C++: [h:0,0694,a:0,0664]
VB.NET: [h:0,4031,a:0,0664]
Windows: [h:0,4031,a:0,0664]
SQL Server: [h:0,4031,a:0,0664]
Apache: [h:0,0694,a:0,0664]
Apache Foundation: [h:0,0340,a:0,0921]
IIS: [h:0,4031,a:0,0664]
DB2: [h:0,0694,a:0,0664]
MySQL: [h:0,4031,a:0,0664]
.NET: [h:0,4031,a:0,0664]
PHP: [h:0,0694,a:0,0664]
Legenda
Análise
Sistema
Fornecedor
Tecnologia


A centralidade é calculada pelo algoritmo HITS que retorna o quão hub (medida h de 0-1) a tecnologia é. Não é simplesmente quantos sistemas dependentes ela tem, o algoritmo considera também quem está ligado ao sistema que depende da tecnologia e sua importância. Então é uma centralidade relativa entre as tecnologias.
A criação de nicho é representada pela clusterização: Número de agrupamentos na rede formada pela dependência de tecnologias. Por isso, quanto mais agrupamentos encontrados, mais dispersa a dependência está entre as tecnologias, assim tem vários grupos de oportunidades diferentes, logo mais nichos.
Índices da Rede
Centralidade
Criação de Nicho
Medida 'h' significa o quanto outros itens referem a dela, logo, é mais central quanto maior o índice 'h' (em recebimento de ligações)
C++: [h:0,0694,a:0,0664]
VB.NET: [h:0,4031,a:0,0664]
Windows: [h:0,4031,a:0,0664]
SQL Server: [h:0,4031,a:0,0664]
Apache: [h:0,0694,a:0,0664]
Apache Foundation: [h:0,0340,a:0,0921]
IIS: [h:0,4031,a:0,0664]
DB2: [h:0,0694,a:0,0664]
MySQL: [h:0,4031,a:0,0664]
.NET: [h:0,4031,a:0,0664]
PHP: [h:0,0694,a:0,0664]
Total de tecnologias utilizadas: 10
Em dev: Verde
Centralidade
Criação de Nicho
Número de clusters sem MySQL:10
Número de clusters sem SQL Server:9
Número de clusters sem DB2 :8
Número de clusters sem Python:1
Ex: a medida de centralidade me recomenda a descontinuar o DB2 entre as tecnologias de BD, já que é menos central (causa menos impacto nos sistemas)
Ex: a medida de criação de nicho me recomenta a são tirar Python, porque semn ele, o ECOS só fica com um cluster.

Appendix VIII - Form for Conducting the Study (Tasks in Portuguese)

Investigação sobre Ecossistemas de Software Formulário para Realização do Estudo	
Data:	
Código do Participante:	

CONTEXTUALIZAÇÃO

Você é um dos gestores de TI ou arquiteto de software/TI da sua organização, atuando na gestão de TI no seu dia a dia, mais especificamente na manutenção da arquitetura de TI selecionando tecnologias para inserção, descontinuidade e substituição. Sua organização possui uma variedade de atividades executadas, visando atender aos seus objetivos de negócio. Para tanto, ela prescinde de software do tipo sistema (e.g., Sistema Eletrônico de Informações – SEI, Sistema de Acompanhamento de Processos). Os sistemas, por sua vez, dependem de outros sistemas e de tecnologia de suporte (e.g., Java, Windows, DB2). As tecnologias que apoiam os processos de trabalho da organização e atendimento aos objetivos de negócio formam a arquitetura TI. A configuração desta arquitetura é alterada a cada nova aquisição, descontinuidade ou substituição de tecnologias de suporte.

Sua tarefa principal é avaliar a tecnologia prospectada, entre diversas candidatas, incluindo seus fornecedores e impacto no restante da organização. Assim, você realiza análises do ecossistema de software da organização e compara as tecnologias candidatas em critérios previamente definidos.

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

TEMPO	
Horário de Início:	
Horário de Término:	

Q1) Qual o nome da Análise da categoria Banco de dados registrados pela organização?

Q2)) Qual o principal critério (atributos de qualidade/arquitetura) envolvido na Análise de Sistemas Operacionais?

Q3) Quais fatores críticos são considerados na Análise IDE para JAVA?

Q4 Quantas tecnologias compõem o ecossistema de software da organização?

Q5) Com qual tecnologia as aplicações da organização possuem mais dependências?

Q6) Quais sistemas estão descontinuados e se mantêm registrados na organização? (Cite ao menos um sistema)

Q7) Qual tecnologia de linguagem de programação não deve ser selecionada para descontinuidade, caso se opte por não interferir em aplicações em desenvolvimento?

Q8) Qual tecnologia de banco de dados deve ser selecionada para aquisição para aumentar a criação de nicho (novos grupamentos) de aplicações em produção?

Q9) Caso a tecnologia de linguagem de programação .NET seja substituída por Python, qual o impacto gerado sobre a situação do ecossistema da empresa? Quer dizer, a organização torna melhor seus índices, i.e., melhora a criação de nicho, melhora a atividade da comunidade, suporta sitemas?

Q10) Qual fornecedor de tecnologia é central (HUB) na organização?

Obrigado pela sua colaboração.

Thaiana Maria Pinheiro Lima
Rodrigo Pereira dos Santos
Cláudia Maria Lima Werner

Appendix IX - Study Evaluation Questionnaire (In Portuguese)

FEEDBACK WITHOUT TOOL

Investigação sobre Ecossistemas de Software **Questionário 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 realizar todas as tarefas propostas?

( ) Sim ( ) Não

Comentários:

2) Você ficou satisfeito com o resultado final das tarefas?

( ) Sim ( ) Parcialmente ( ) Não

Comentários:

3) No seu ponto de vista, a visão de Ecossistemas de Software pode beneficiar ou apoiar atividades de Gestão de TI, mais especificamente a manutenção da arquitetura de TI e percepção do seu impacto na organização?

( ) 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 <u>comentários adicionais</u> (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.

Thaiana Maria Pinheiro Lima
Rodrigo Pereira Santos
Cláudia Maria Lima Werner

FEEDBACK WITH TOOL

Investigação sobre Ecossistemas de Software Questionário 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 realizar todas as tarefas propostas?

( ) Sim ( ) Não

Comentários:

2) Você ficou satisfeito com o resultado final das tarefas?

( ) Sim ( ) Parcialmente ( ) Não

Comentários:

3) No seu ponto de vista, é possível perceber como atividades de Gestão de TI, mais especificamente na seleção de tecnologias e análise do ecossistema de software, podem ser beneficiadas pela visão de Ecossistemas de Software usando as informações apresentadas?

( ) 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) Ferramenta SECO-AM

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 SECO-AM ?					
Consegui utilizar a SECO-AM da forma que eu queria?					
Entendi o que acontecia na minha interação com a SECO-AM ?					
Foi fácil executar as tarefas com o uso da SECO-AM ?					
Considero a SECO-AM útil para seleção de tecnologias e análise de ecossistemas de software?					
A SECO-AM permite perceber como as aplicações e tecnologias da organização consumidora se relacionam a elementos do ecossistema de software (e.g., fornecedores, clientes, usuários)?					
O uso da SECO-AM melhorou o meu desempenho durante a execução das tarefas em comparação com os procedimentos executados atualmente na organização?					
A SECO-AM apoia atividades de gestão de TI?					

Comentários:

7) Quais as <u>funcionalidades</u> da ferramenta SECO-AM que foram mais úteis na realização das tarefas?

Comentários:

8) De acordo com sua opinião, liste os <u>aspectos positivos</u> da utilização da ferramenta SECO-AM .
Comentários:

9) De acordo com sua opinião, liste os <u>aspectos negativos</u> da utilização da ferramenta SECO-AM .
Comentários:

10) Você possui alguma <u>sugestão para melhoria</u> da ferramenta SECO-AM ? Em caso positivo, por favor, especifique-a(s).

( ) Sim ( ) Não

Comentários:

11) Quais conclusões ou observações você pode extrair sobre a utilização da percepção dos gestores e arquitetos de TI sobre cada tecnologia candidata em critérios previamente definidos?
Comentários:

12) Quais conclusões ou observações você pode extrair sobre a análise do ecossistema de software da organização?
Comentários:

13) Este espaço é reservado para quaisquer <u>comentários adicionais</u> (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.

Thaiana Maria Pinheiro Lima
Rodrigo Pereira Santos
Cláudia Maria Lima Werner