UNIVERSIDADE TÉCNICA DE LISBOA
INSTITUTO SUPERIOR TÉCNICO

Social Networks Modeling and Evaluation of Organizational Relational Capital Using SNARE

Alexandre Humberto dos Santos Barão

Supervisor: Doctor Alberto Manuel Rodrigues da Silva

Thesis approved in public session to obtain the PhD Degree in Information Systems and Computer Engineering
Jury Final Classification: Pass

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Doctor Alberto Manuel Rodrigues da Silva, Professor Associado do Instituto Superior Técnico, da Universidade Técnica de Lisboa;
Doctor Maria Eduarda Silva Mendes Rodrigues, Professora Auxiliar Convidada da Faculdade de Engenharia, da Universidade do Porto;
Doctor Miguel Leitão Bignolas Mira da Silva, Professor Auxiliar do Instituto Superior Técnico, da Universidade Técnica de Lisboa.

2012

Tese orientada por:

Prof. Doutor Alberto Rodrigues da Silva

PROFESSOR ASSOCIADO NO
DEPARTAMENTO DE ENGENHARIA INFORMÁTICA DO
INSTITUTO SUPERIOR TÉCNICO DA UNIVERSIDADE TÉCNICA DE LISBOA

Resumo

O conhecimento pode ser tácito ou explícito. A Gestão do Conhecimento identifica e potencia o conhecimento colectivo das organizações e permite acompanhar e manter o conhecimento tácito existente nas mesmas. O valor das organizações tende a ser maior que a soma dos seus activos tangíveis. O capital humano, estrutural e relacional é conhecimento essencial nas organizações. Este conhecimento existe em diferentes indivíduos e organizações, mas é difícil de avaliar porque é tácito. Como conhecimento tácito, não é possível capturar o valor do capital relacional a partir de sistemas puramente contabilísticos nas organizações. Apesar dos diversos modelos de avaliação referidos na literatura, existem poucos modelos para avaliar o capital relacional das organizações numa perspectiva de rede, i.e. considerando o valor do capital relacional estritamente relacionado com relações de *oferta-procura*. O SNARE ("Social Network Analysis and Reengineering Environment") é um sistema que tem componentes para representar e construir redes sociais, permitindo o desenvolvimento de cenários reais e análise do respectivo capital relacional. Neste âmbito, a nossa questão-chave é saber qual o valor de uma rede social. Assim, desenvolvemos três componentes: *SNARE-Language*, *SNARE-RCO*, e *SNARE-Explorer*. *SNARE-Language* é um perfil UML para descrever estruturalmente redes sociais. O *SNARE-RCO* é um modelo para determinar o capital relacional das organizações. Finalmente, o *SNARE-Explorer* é uma ferramenta para visualização de redes sociais, capaz de simular ou utilizar cenários reais que utiliza o modelo *SNARE-RCO* para calcular o valor do capital relacional de uma organização. Para uma abordagem organizacional, propomos ainda a *SNARE-Methodology*. A validação do sistema SNARE foi realizada com base em vários casos de estudo.

Palavras-chave: Análise de Redes Sociais, Análise Organizacional de Redes, Modelação de Redes Sociais, Valor da Rede Social, Valor do Capital Relacional, Monitorização de Redes Sociais, SNARE-Language, SNARE-RCO, SNARE-Explorer, SNARE-Methodology

Abstract

Knowledge may be tacit or explicit. Knowledge Management (KM) refers to the identification and enhancement of the collective knowledge in an organization. KM information systems are a way to track and keep tacit knowledge inside organizations. The overall value of organizations tends to be greater than their tangible assets. Human capital, structural capital and relational capital are essential knowledge of organizations. This knowledge is present in organizations through different individuals, but it is difficult to evaluate it because it is tacit. The relational capital value of a social network represents a contribution to meet demands, which are satisfied by social entities. As tacit knowledge, it is not possible to capture the relational capital value from accounting systems of organizations. Despite there being several evaluation models referred to in the literature, there is a lack of models to evaluate the relational capital of organizations in a network perspective, i.e. considering the relational capital value strictly related to *offer-demand* relations. The SNARE ("Social Network Analysis and Reengineering Environment") is an engineering framework with components to represent social networks and to design and build real scenarios for social networks relational knowledge discovery. In this scope, our key research question is how to value a social network. Considering we aim at evaluating the relational capital of organizations, we developed three SNARE components: *SNARE-Language*, *SNARE-RCO*, and *SNARE-Explorer*. The *SNARE-Language* is a UML profile that describes social network structures. The *SNARE-RCO* is a model to determine the relational capital of organizations. Finally, the *SNARE-Explorer* is a tool for social networks visualization, able to simulate or use real social network scenarios that uses *SNARE-RCO* model to compute the value of the organizational relational capital. For an organizational approach using SNARE components, we propose the *SNARE-Methodology.* The SNARE validation was made through several case studies.

Key-words: Social Network Analysis, Organizational Network Analysis, Social Network Modeling, Social Network Value, Relational Capital Value, Social Networks Monitoring, SNARE-Language, SNARE-RCO, SNARE-Explorer, SNARE-Methodology

Notation

2D	TWO DIMENSIONAL
3D	THREE DIMENSIONAL
API	APPLICATION PROGRAMMING INTERFACE
ASCII	AMERICAN STANDARD CODE FOR INFORMATION INTERCHANGE
BSC	BALANCED SCORECARD
CASE	COMPUTER-AIDED SOFTWARE ENGINEERING
CMS	CONTENT MANAGEMENT SYSTEM
CPU	CENTRAL PROCESSING UNIT
CSV	COMMA-SEPARATED VALUES
CW	CALIBRATION WEIGHTS
DIC	DIRECT INTELLECTUAL CAPITAL
DNA	DYNAMIC NETWORK ANALYSIS
ERGM	EXPONENTIAL RANDOM GRAPH MODEL
ERP	ENTERPRISE RESOURCE PLANNING
ETL	EXTRACT TRANSFORM AND LOAD
EVA	ECONOMIC VALUE ADDED
HC	HUMAN CAPITAL
HCP	HUMAN CAPITAL PROPERTIES
HR	HUMAN RESOURCES
IAM	INTANGIBLE ASSETS MONITOR
IC	INTANGIBLE CAPITAL
ID	IDENTIFICATION
IDE	INTEGRATED DEVELOPMENT ENVIRONMENT
I-O	INPUT-OUTPUT
IP	INTELLECTUAL PROPERTY
IS	INFORMATION SYSTEM
IT	INFORMATION TECHNOLOGY
JPEG	JOINT PHOTOGRAPHIC EXPERTS GROUP
KM	KNOWLEDGE MANAGEMENT
KMS	KNOWLEDGE MANAGEMENT SYSTEMS
MCM	MARKET CAPITALIZATION METHOD

MCS	MINIMUM CONNECTION STRENGTH
MDI	MULTIPLE DOCUMENT INTERFACE
MVA	MARKET VALUE ADDED
NP	NETWORK PROPERTIES
NTA	NODE TYPE ANALYSIS
NVF	NETWORK VALUABLE FACTOR
NVI	NETWORK VALUABLE ITEM
NW	NETWORK WEIGHT
ONA	ORGANIZATIONAL NETWORK ANALYSIS
OVF	ORGANIZATIONAL VALUABLE FACTOR
OVI	ORGANIZATIONAL VALUABLE ITEM
OW	ORGANIZATIONAL WEIGHT
PC	PERSONAL COMPUTER
PIXEL	PICTURE ELEMENT
RC	RELATIONAL CAPITAL
RCO	RELATIONAL CAPITAL OF ORGANIZATION
RCV	RELATIONAL CAPITAL VALUE
RLV	RELATIONAL LEVEL VALUE
ROA	RETURN ON ASSETS
RTV	RELATION TYPE VALUE
RV	RELATIONAL VALUE
RW	RELATIONAL WEIGHT
SC	STRUCTURAL CAPITAL
SCM	SCORECARD METHODS
SE	SOCIAL ENTITY
SEVF	SOCIAL ENTITY VALUABLE FACTORS
SEW	SOCIAL ENTITY WEIGHT
SMES	SMALL AND MEDIUM-SIZED ENTERPRISES
SNA	SOCIAL NETWORK ANALYSIS
UML	UNIFIED MODELING LANGUAGE
URL	UNIFORM RESOURCE LOCATOR
VNA	VALUE NETWORK ANALYSIS
XML	EXTENSIBLE MARKUP LANGUAGE

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To my daughter Ana

Alexandre Barão
Lisbon, October 2012

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Chapter 1

Introduction

Writing is nothing more than a guided dream.

Jorge Luis Borges

This research proposes a way to compute and monitor the relational capital value of an organization's social network. Monitoring the relational capital value is important to better understand aspects such as interpersonal relationships that happen in organizations. This knowledge can help an organization to understand its own network in order to better achieve its objectives and improve aspects such as: human relations, organizational efficiency, quality, and innovation. However, the relational capital of organizations tends to include intangible factors and, consequently, it is not always possible to determine this value from traditional business oriented accounting systems. Thus, our main challenge is to find a network evaluation metric to compute and monitor this capital and answer the question: "*What is the value of this social network?*"

The remaining of this chapter introduces the research context and main background definitions in Section 1.1, identified problems in Section 1.2, research questions and thesis statement in Section 1.3, research goals in Section 1.4, research method in Section 1.5, main results in Section 1.6, and, finally, document organization in Section 1.7.

1.1. Context

Knowledge may be tacit or explicit and can refer to an object, a cognitive state, or a capability. Moreover, knowledge may reside in individuals or social groups. Knowledge can be stored in documents, processes, or computer repositories [AL 01].

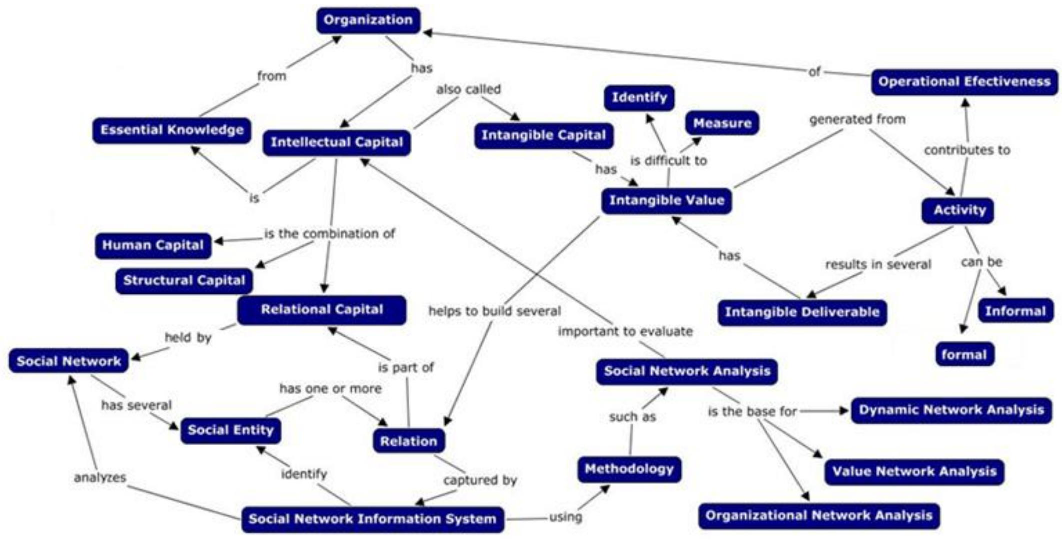

Figure 1.1 Context Conceptual Map

Knowledge management (KM) refers to identifying the collective knowledge in an organization to help the organization compete [Kro 98]. *Knowledge management systems* (KMS) refer to a class of information systems applied to managing organizational knowledge and are developed to specifically support the organizational processes of knowledge creation [AL 01].

We consider the *organization* definition as: "A social unit of people, systematically structured and managed to meet a need or to pursue collective goals on a continuing basis. All organizations have a management structure that determines relationships between functions and positions, and subdivides and delegates roles, responsibilities, and authority to carry out defined tasks. Organizations are open systems in that they affect and are affected by the environment beyond their boundaries" [Business 12]. The value of organizations tends to be greater than their tangible assets. In this sense, KM and KMS are a way to help tracking and keeping tacit knowledge inside organizations. It is important to refer that *human capital*, *relational capital* and *structural capital* are essential knowledge of organizations [Pat 07]. Thus, *human capital* can be defined as people's knowledge, skills and experience. *Structural capital* can be defined as the set of procedures, processes and internal structures that contribute to the implementation of an organization's objectives, and, finally, the *relational capital* is the value of social relationships in a given organization, which contributes to achieve its objectives, i.e. the value of internal and external relationships of an organization [Pat 07].

The *intangible value* of the organization is "generated from informal, noncontractual activities that help build business relationships and contribute to operational effectiveness" [ValueNetworks 10]. *Intangible deliverables*, which are the knowledge and benefits delivered by an individual or group, can result from these noncontratual activities, thus, they have value for the organization. "The combination of all intangibles of an organization, i.e. *human*, *structural* and *relational capital*, is called *intangible capital* or *intellectual capital* (IC)" [AO 10].

The *value of intangibles* might be difficult to identify and the use of several indicators is a way to provide intellectual capital measurement [AO 10]. Moreover, it is not always possible to capture intellectual capital in accounting systems of organizations [AO 10]. Also, there is a lack of standard metrics to evaluate the relational capital of organizations [ZWH 08].

Measurement can be seen as a result of observations that quantitatively reduce uncertainty. "A reduction, not necessarily elimination of uncertainty will suffice for a measurement because it is an improvement on prior knowledge" [Hub 10]. Thus, even when some amount of error is unavoidable, it can be useful as prior knowledge of a given system [Hub 10]. A measurement system does not have to eliminate uncertainty, for that we consider the measurement definition by Hubbard: "A quantitatively expressed reduction of uncertainty based on one or more observations"[Hub 10].

Organizations have social networks. The *value* of a social network represents a contribution to satisfy a given *demand*. This *demand* is satisfied by its social entities. In this sense, the *value* of a relation reflects the link between a *thing* (a good or service) and the social entities that are connected to it in a given context.

Social network information systems identify relations between social entities and provide a set of automatic inferences on these relations, promoting better interactions and collaborations amongst these entities. *Social Network Analysis* (SNA) [FF 94] is the basis for several areas such as: *Organizational Network Analysis* (ONA) [CP 04], *Value Network Analysis* (VNA) [Ale 08] and *Dynamic Network Analysis* (DNA)[CDRT 07]. For example, they provide methods for studying communication in organizations with quantitative and descriptive techniques for creating statistical and graphical models of the individuals, tasks, groups, knowledge and resources of organizational systems. In this sense, SNA approaches are important to discover individuals' roles in organizations and evaluate the value of intellectual capital.

Figure 1.1 shows a conceptual map with the key concepts and relations referred above.

1.2. Problems

Organizations have social networks. Using specific metrics for monitoring organizational social networks is important to better understand aspects such as interpersonal relationships. This knowledge can help an organization understand its own network in order to better achieve its objectives regarding aspects such as: human relations, efficiency, quality, process improvement, and innovation. However, we found that it is difficult to measure social phenomena with anything close to scientific accuracy because social networks are complex systems[1]. This implies that participants' behavior is unpredictable. Therefore, which measurement system should be used to find a social network value? To find this value it is important to monitor organizational social networks because it will enable us to analyze the relational capital evolution during time and perform network comparative analysis as well.

Thus, the main problem of our research is to answer the question *"What is the value of this social network?"*. The state of art analysis led us to conclude that any metric for assessing the relational capital of an organization should include aspects of human capital and structural capital. As stated before, the relational capital is an attribute of social networks, which are complex systems. Thus, if we were able define a metric to measure the relational capital, it would be possible to monitor it during a given period, but it is not possible to accurately predict its variation. However, a monitoring system can help analysts track relational capital and predict its variation using suitable metrics and correlations when observing: organizational seasonal phenomena, merging of organizational units, organizational downsizings, hiring employees, identifying key individuals, and team performance.

There are several evaluation approaches for studying aspects such as economic impact or operational impact in organizations. However, there is a lack of methodologies for organizational assessment that combines techniques derived from social network analysis with organizational aspects and its relation with intellectual capital. We also found that there are no standard IC measures. This means that organizations need a unique understanding of which intangible assets are really valuable for them [Bon 01]. Regarding the nature of the organization, many intangible capital indicators can be found, and the challenge for the manager is to choose the appropriate indicators to build an evaluation system.

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[1] "A complex system is a system composed of interconnected parts that as a whole exhibit one or more properties (behavior among the possible properties) not obvious from the properties of the individual parts" [JR 00]

When analyzing the various techniques for social networks representation, graph, matrix representations, and mathematical forms are universal and also easily understood. The reading of this kind of representations is simple if data comes from a network with few nodes. E.g., in matrix representations, if the number of nodes and their connections is high, matrices are good tools for algorithmic processing through specific software tools, but their reading becomes more difficult for human beings. Statistical models are also very rich in semantic aspects but their reading requires a thorough knowledge of mathematics and statistics. Thus, this is not a form of representation with a fast learning curve for most of analysts. These techniques are transversal, and hence, highly suitable to describe the entities of a social network and their connections. However, to represent social networks in the scope of consulting and software engineering environments, an object-oriented model focused from scratch in organizations can be a complementary tool to specify and create visual models of real-world systems, such as organizational social networks. Even when considering existing XML-based languages to represent networks, it is pertinent to have an object-oriented complementary and specific system to model social networks to be applied in organizational contexts, combining graphic features with semantic aspects of relationships, including the representation of social entities roles as well.

Finally, when studying the various approaches for social network analysis, namely Social Network Analysis (SNA)[FF 94], Organizational Network Analysis (ONA)[CP 04], Value Network Analysis (VNA) [Ale 08] and Dynamic Network Analysis (DNA)[CDRT 07], we found complementarities between them. On the one hand, SNA focuses primarily on analyzing networks using graph theory metrics. For this reason, it has the advantage of allowing automatic analysis procedures. However, given its nature, SNA does not focus on organizational aspects of networks. On the other hand, the ONA approach has the benefit of focusing its study in organizations. ONA assessments make it possible to emerge organizational factors such as contexts and roles but the results obtained by the ONA approach are strongly related with the classical analysis techniques from SNA. VNA focuses on analyzing transactions between entities based on organizational roles. After studying other techniques for social networks evaluation, VNA is a more comprehensive approach to model and evaluate the intellectual capital of organizations. However, for each analysis, VNA still requires a previous mapping to a specific model based on roles and transactions. Still, the SNA, ONA and VNA approaches are typically to be applied in a given moment and are not focused on allowing the continuous monitoring and dynamic aspects of a social network whereas DNA is highly suitable for continuous network monitoring.

As stated, the main challenge and central problem is to answer the question *"What is the value of this social network?"*in order to capture an overall relational capital metric to specifically represent the value of a social and organizational network.

1.3. Research Questions and Thesis Statement

Based on social network modeling and analysis, this research proposes a new approach to evaluate and monitor the relational capital of organizations, considering and integrating human and structural capital as well.

After analyzing the state of art, we identified several limitations, which are discussed in Chapter 2. As previously referred, IC measuring indicators are not standard and are not widely used in organizations, although, in some models, the real asset values of different types of intellectual assets are not clearly defined. Thus, a new and flexible model can emerge and be used to achieve a relational capital metric to evaluate and monitor the relational capital of organizations.

We also concluded that the approaches we studied to describe social networks are essential to analyze existing social networks but, as previously mentioned, we argue that new visual models can help infer and represent new or established relational patterns. Thus, our approach proposes a specific way for object-oriented graphic representation of organizational social networks. In order to understand how an individual is influenced by an organizational structural environment, it is necessary to identify the semantic of relations in a given social network. This process helps researchers conceptualize and identify social structures as patterns of relations.

We found XML-based languages to describe and represent networks' structure and semantics. When using these languages, there are interoperability advantages that allow importing or exporting hierarchical social structures in a more understandable way when compared with social network matrix-based representations. Using complementary social network UML-based models focused on describing and visually representing organizational entities, such as departments or employees, and relations, roles and attributes, surely helps the structural network design process. Nevertheless, when comparing techniques, such as SNA [FF 94], ONA [CP 04], VNA [Ale 08] and DNA [CDRT 07], to analyze and describe networks, we found strong complementarities between them and we also concluded that for continuous network analysis, DNA is the most suitable approach. However, as referred in the previous section, an overall relational capital metric to specifically represent the value of an organizational network is needed.

Thus, the key question that drives our research is: *how to define and measure the value of a social network?* Focused on organizations, an evaluation system for the relational capital allows us to answer this question. Moreover, due to its flexibility (i.e. configuration parameter features), the resulting evaluation system can also be applied to distinct organizational KMS, such as: content management systems (e.g. Moodle[2], LOP[3]) or social media platforms (e.g. LinkedIn[4], Facebook[5]). To follow the key question, we have defined a set of additional questions to be addressed in this research, namely:

RQ1: Which model is needed to define organizational social network descriptions using a set of contextual views, during the evaluation process of the relational capital in organizations?

RQ2: Using a set of organizational parameters, how can we measure the relational capital of social networks and its organic units, content management systems and social media platforms?

RQ3: How to monitor the relational capital value of an organization?

RQ4: How to approach an organization with the aim of analyzing and evaluating its relational capital?

As a result of these questions, the **thesis statement** of this research is the following:

The relational capital value of a network can be defined by taking into account the effects of tangible and intangible organizational variables, analyzed and monitored through an engineering framework.

1.4. Research Goals

As stated in the above section, our research proposes a new approach to evaluate the relational capital of organizations. This section overviews the research goals identified during the initial phase of our study. Thus, the starting goals that drive our research were:

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[2] http://www.moodle.org (accessed on July 26th, 2012)

[3] http://www.vemaprender.net(accessed on July 26th, 2012).Note: an instance of the LOP system [SS 07][SDF+ 08][SS 09].

[4] http://www.linkedin.com(accessed on July 26th, 2012)

[5] http://www.facebook.com(accessed on July 26th, 2012)

RG1. Define a language to represent social network structures focused on organizations, respective relations, entities, and roles (See Chapter 3);

RG2. Define a model to evaluate the relational capital of organizations but to be applied with KMSs, such as content management systems and social media platforms (See Chapter 4);

RG3. Design and implement a prototype system to support the experiences, cases studies performed, and better validate the thesis research (See Chapter 5);

RG4. Define a methodology to drive and help other researchers and analysts to monitor the relational capital value of organizations (See Chapter 6).

RG5. Validate the results through controlled case studies using the developed prototype tool and follow the proposed method (See Chapter 7).

To better support this thesis, we defined the SNARE-Framework which in the scope of this research includes:

- **SNARE-Language:** A flexible and extensible *UML-based* language for modeling social networks (See Chapter 3);

- **SNARE-RCO:** A model from which we can extract the relational capital value (RCV) of organizational networks (See Chapter 4);

- **SNARE-Explorer:** Based on SNARE-Language concepts and using SNARE-RCO model, it is a tool to edit social networks, simulate, evaluate and monitor its relational capital value (See Chapter 5); and

- **SNARE-Methodology**: It is a methodology to help analysts perform a systematic evaluation approach in organizations (See Chapter 6).

1.5. Research Method

The research method used in our work is the *Action Research* [Lew 46] because it is grounded on practical action and involves systematic and iterative stages as well as participants' collaboration. Also, *Action Research* is step structured and suitable for organizational environments (See Appendix A for more information).

Action Research involves a process which includes the identification of the problem within a social context. Thus, the data collection, analysis and interpretation, and the discovering of possible solutions, encompass research and action simultaneously. In addition, *Action Research* assumes that people involved in it constitute a group with common objectives and goals, interested in a problem that emerges in a given context[6]. This way, *Action Research* is essentially a participatory research, in which participants interact in the production of new knowledge. In addition, more than including the identification of a problem in a social context, *Action Research* should start from a concrete social situation to solve or change it. Moreover, based on defined hypotheses, actions must be chosen, and the methodology becomes then centered on practice and on the improvement of the strategies used.

Regarding these principles and the research key questions (See Section 1.3), we developed a starting *hypothesis* stated as: *a social network can be valued based on the "offer-demand logic"*, i.e. a service based paradigm. In other words, *assuming demands from social network entities, the value of a social network can represent the level of satisfied demands.* If our starting hypothesis is correct, the value of a given relation should reflect the link between a thing (e.g. a good or service) and at least two social entities connected in a given context. In general terms, within the scope of our hypothesis, it should be possible to evaluate *offers* made by network social entities with *producer* role and demands from social entities with *consumer* role. After that, other hypotheses quickly emerged during the iterative research process, e.g. *considering a group of social entities, if there are no connections between them, strictly regarding to relations, the relational capital value of the network should be zero.* If so, *in organizational contexts, a social network and its entities must be valued using also non-relational dimensions, such as human and structural, because even when some of its members are isolated, the potential of relational capital can be predictable. Thus, it must be possible to combine these dimensions to achieve a metric that monitors an organizational network.* However, *the human capital value must be strictly connected to the relational capital and vice versa because the type and relational level are not the same for all network members.*

Knowing that our hypotheses should be verifiable by experiments, surveys and analyses, and with the aim of developing a framework to monitor the value of organizational social networks, we started our research by defining the domain variables to apply in the scope of the methodological hypotheses. Thus, in our research we developed theoretical assumptions about the nature

[6] E.g. SNARE-Language and SNARE-RCO model were widely discussed with external experts, and during the SNARE-Explorer development, interface features to monitor RCV were developed considering insights from the Vodafone Manager (See Chapter 5).

of relations in several organizations, which involved participatory and self-interpretation of organizational problems to evaluate relational capital. An organizational network is a complex system that has emergent phenomena, which makes it difficult to predict its behavior. In the starting diagnosing phase we defined our problem domain: *how to value a given organizational network?* In the action planning phase, based on theoretical assumptions, we started developing SNARE-Framework to solve primary problems and we used it in several organizational contexts. This allowed us to refine our models and prototype tool with the help and useful insights of external participants. As a consequence of these steps, we have analyzed how the effects of actions conducted using SNARE-Framework contributed to determine the value of organizational networks, and we cyclically identified our general findings in order to develop new problem domain assumptions. For the case studies, stakeholders' collaboration was fundamental to produce and refine SNARE-Framework.

To investigate phenomena in its environment we also used other qualitative research methods such as: case study (e.g. to identify and observe relational flows at work, thus, helping develop real scenario validations), ethnography and interviews (hence capturing external insights and framework expectations). Moreover, these two techniques also adopt social perspectives, which were relevant to our research area.

As previously mentioned, SNARE-Framework is the result of the iterative *action-research-action* process, in which we developed assumptions about organizations and their problem domains. Also, we helped solve organizational problems and, along with the stakeholders involved, we have discovered general findings. SNARE-Framework was developed in an iterative and participative process, through which, as stated before, we had the opportunity to test our models, tools and techniques. Following an *Action Research* approach we also contributed to scientific knowledge by creating concepts and theories about the research problems.

The adopted research method had the objective of addressing research problems. To solve these problems we choose an engineering-oriented approach by making use of technology to create a prototype tool to validate proposed models in the field. In the scope of our work we also used the analysis of the state of the art to identify features relevant to our research, and we wrote and submitted articles to international conferences in order to obtain validation and feedback from the scientific community.

1.6. Main Results

Our research goals and main contributions are materialized in a framework which is useful for monitoring and understanding an organizational network. In the scope of this research, this framework includes an extensible language to define and model social networks; a model to evaluate the relational capital value of organizations; a computational analysis tool for monitoring the relational capital value; and a methodology to approach organizations aiming at evaluating and monitoring its relational capital value.

Next, SNARE-Framework architecture overview is presented in Section 1.6.1. SNARE-Language, SNARE-RCO, SNARE-Explorer, and SNARE-Methodology are introduced in Sections 1.6.2, 1.6.3, 1.6.4, and 1.6.5, respectively. Finally, Section 1.6.6 indicates the publications that have been produced during this doctoral research.

1.6.1. SNARE-Framework Architecture Overview

Based on the research goals, we developed SNARE-Framework, which is an acronym for "Social Network Analysis and Reengineering Environment". The SNARE-Framework is able to describe and visualize social networks and allow researchers to design and analyze real scenarios of social networks extraction and analysis. Specifically, SNARE-Framework has engineering artifacts to: (1) describe and visualize social network structures; (2) define relations, social entities, and properties; (3) define surveys to uncover organizational relations; (4) store, manage and visualize the information required for social network analysis; and (5) monitor the relational capital of an organization.

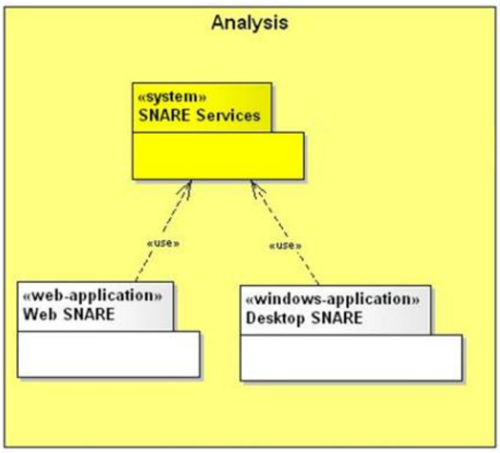


Figure 1.2 SNARE-System Packages

SNARE-Framework's architecture provides mechanisms to extract data sets from other systems by mapping data extraction components. As depicted in

Figure 1.2, SNARE-System involves a set of packages. Each package has a specific function, making it possible to distinguish several stereotypes in SNARE components such as: *web application, windows application*[7]*, and system*.

Web SNARE [8] is a web application designed to help managers and consultants construct social communities, define social entities, define the type of relationships and their instances, and enrich relationships and social entities with customized properties. Managers can also define surveys to apply to the network in order to infer relationships from the answers given. Every social entity can have a unique system login, so users can update their personal data or answers to surveys after seeing their personal results. In addition to these functions, Web SNARE can be used like usual Social Networking Systems: social entities can connect to each other and define what they do together. Each user is able to search the organization by a context or name and retrieve the content required. Users can also organize and join groups (e.g. groups based on interest or communities of practice inside the organization). Users are able to publish and retrieve content in their profiles or network pages.

1.6.2. SNARE-Language

The SNARE-Language is a UML profile to describe social network structures [UML 12] as a descriptive method. With the SNARE-Language it is possible to model social entities and the multiple relations among them. SNARE-Language main concepts are: *SocialEntity, Relation*, *Role*, *Action and Event* (See Chapter 3 for further detail).

Conceptualizing structures of a social network is a process that requires the definition of social entities, roles, relations, actions and events. The richness of this language to model social networks comes from the flexibility to combine these concepts stereotypes. E.g. a social entity can play several roles in the same relation, and this situation should be achieved through the meta-instantiation of several concepts (stereotypes), such as *social entity*, *relation*, and *role*. Regarding the connection patterns, SNARE-Language captures most of the possible social network relations. SNARE-Language ensures that relations, actions and events can have multiple social entity extremes. Thus, SNARE-Language is flexible enough to fit the needs of modeling social networks. When compared with other social networks representation techniques, SNARE-Language includes an appropriate set of diagrammatic

[7] The SNARE-Explorer prototype is the *Desktop SNARE-System* package component

[8] After the development of *SNARE-Language,Web SNARE* packages and services were developed in the scope of [Fre 08].

model elements, again based on UML stereotypes, and which are unambiguous and supported by UML tools.

SNARE-Language does not intent to replace other social network representation techniques, such as XML-based languages. However, it intends to help the social network design by using UML-based CASE tools. These models are effectively ready to represent organizational networks and are focused on describing entities such as departments or employees, and inherent relations and attributes among them.

Additionally, the SNARE-Language meta-model is used as the common ground for SNARE-Explorer main data structures, i.e. is the conceptual root of SNARE-Explorer and SNARE-Services as well.

1.6.3. SNARE-RCO Model

Our research is focused on finding and defining a new approach to compute the value of a social network. In this sense, several formulas to measure the value of an organizational social network - regarding its distinct dimensions - have been defined and presented to the scientific community. As described in Chapter 4, the SNARE-RCO model integrates human and structural capital factors that are inputs for the computation of the network relational capital, using metrics from social network analysis as well, thus proposing a new definition for the concept of relational capital of organizations (RCO). To analyze the *relational capital value* (RCV) of a given organization, SNARE-RCO model proposes distinct kinds of assessment inputs, namely: *organizational factors*, *network factors*, *social entity factors*, and *relational factors*. These inputs are dynamic, i.e. defined by the *Analyst*[9] because they depend on the target organization.

1.6.4. SNARE-Explorer

SNARE-Explorer is a desktop-based interface, for rich visualization data analysis developed with Java technology (See Chapter 5). This system is able to define, manage and visualize the information required to dynamically define real scenarios for social network visualization and analysis.

This tool is based on the SNARE-Language meta-model, supporting different types and instances of social entities (e.g. people, organizational-units, and organizations), social roles, and social relations. Also, it supports different integration approaches and it is able to manage and automatically collect social networks data from information systems, through *transparent* or *intrusive* approaches. Target systems are accessed through this tool, which includes

[9] See Section 6.1 which provides the *Analyst* role definition.

specific vectorial heuristics to address the different types of data analysis required, and a set of spatial graphics and diagrams able to depict network data views.

SNARE-Explorer is able to simulate scenarios and implement the SNARE-RCO model to compute the organizations' RCV and visualize it through real-time monitoring diagrams.

There are many available tools to analyze social networks. A good survey can be found at the Center for Computational Analysis of Social and Organizational Systems [CASOS 11_a], and a gallery of high quality visualization techniques can be found at *Visual Complexity* [VIS 11] as well. Despite the existence of social network tools to support high quality network visualizations and analysis procedures, in the scope of this research, we decided to develop this prototype tool to specifically implement the SNARE-RCO model. The main motivation was to use and test a system to monitor the RCV of a network regarding specific organizational scenarios. For this reason, this tool is unique and allows us to create or edit networks (e.g. by adding, changing or removing network components, such as social entities and relations) and compute and monitoring the RCV in real-time. With these features the SNARE-Explorer enabled visual simulations to analyze and monitor the RCV behavior during business events or activities, such as merging or splitting organizational networks, obtain RCV for each relational action, simulate the absence of central elements or analyze the removal of peripheral elements and measure the impact on network RCV.

1.6.5. SNARE-Methodology

SNARE-Methodology was designed to perform a systematic relational capital evaluation approach at organizations (See Chapter 6).Thus, several roles were defined for participants, namely: *Analyst*, *Sponsor*, *Manager*, and *Team*. SNARE-Methodology is based on four main processes in which participants are players: *Diagnosing*; *Designing*; *Executing*; and *Reporting*. During these processes, several artifacts to help understand the relational capital value of organizations are produced.

1.6.6. Publications

The following publications have been produced during this doctoral research:

- "Aplicação de Técnicas de Redes Sociais para o Sucesso Educativo", IBERIAN CONFERENCE ON CITIZENSHIP EDUCATION. Barão, Alexandre; e Silva, Alberto Rodrigues (2007), Faculdade de Ciências, Universidade de Lisboa, Portugal

- "SNARE - Social Network Analysis and Reengineering Environment: Architecture Overview". Barão, Alexandre; e Silva, Alberto Rodrigues (2008), WEBIST, Funchal, Madeira

- "A Iniciativa VemAprender". Silva, Alberto Rodrigues; Dinis, Patrícia; Ferreira, David; Saraiva, João; e Barão, Alexandre (2008), *Actas do Seminário Ibero-Americano SOLITE*, Madrid

- "Social Networks in Information Systems: Tools and Services". Freitas**,** Hernâni Borges; Barão, Alexandre; e Silva, Alberto Rodrigues (2009). Book chapter. In Handbook of Research on Social Dimensions of Semantic Technologies and Web Services, Idea Group Inc (IGI), ISBN-13**:** 978-1605666501

- "The SNARE Language Overview". Barão, Alexandre; e Silva, Alberto Rodrigues (2010). 12th ICEIS - International Conference on Enterprise Systems, *ICEIS 3*, SciTePress , p. 344-349.

- "A Model to Evaluate the Relational Capital of Organizations (SNARE RCO)". Barão, Alexandre; e Silva, Alberto Rodrigues (2011). CENTERIS - Conference on Enterprise Information Systems, Part I, CCIS, pp. 400-409. M.M. Cruz-Cunha et al. (Eds.), Springer-Verlag

- "What is the Value of Your Network?", Barão, Alexandre; e Silva, Alberto Rodrigues (2012). International Workshop on Social Networks and Data Processing (SNDP), IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology, Macau [forthcoming]

- "How to value and monitor the relational capital of knowledge-intensive organizations?". Barão, Alexandre; e Silva, Alberto Rodrigues (2012). Book chapter. In Handbook of Research on Enterprise 2.0: Technological, Social, and Organizational Dimensions, IGI Global [forthcoming]

- "Applying SNARE-RCO to Evaluate the Relational Capital of an Organization: The SH Case Study", Barão, Alexandre; e Silva, Alberto Rodrigues (2012). Book chapter. In Sociotechnical Enterprise Information Systems Design and Integration, IGI Global [forthcoming]

As invited speaker, the following presentation was made:

- "How to Value and Monitor the Relational Capital of Knowledge-intensive Organizations?", 5th Workshop on Statistics, Mathematics and Computation: Methods and Applications. Faro, Portugal. July 11-12, 2011.

1.7. Document Organization

This document is organized in eight chapters and six appendices. Chapter 1 introduces the context of our approach, problems identified, research questions and thesis statement, research goals, research method, and main results. Chapter 2 provides the research state of art, namely social networks modeling, social network analysis approaches, and relational capital evaluation. In Chapter 3, SNARE-Language is described through the meta-model definition and real scenarios application. In Chapter 4, SNARE-RCO model is presented. An overview of relational capital compute process is given, as well as necessary parameters definition. In Chapter 5, SNARE-Explorer is presented. In Chapter 6, the approach methodology to compute the relational capital of the organizations is defined and related roles and steps are described. In Chapter 7 we discuss the validation results, and three cases are exemplified. Finally, in Chapter 8, we present the conclusion.

For a complementary reading, this document contains six appendixes, namely: (A) Research Methods; (B) Social Network Analysis Concepts; (C) Uncovering Network Relationships and Individual Roles; (D) Project Charter Template; (E) Cases Studies - Supplementary Materials; and (F) SNARE-Explorer Features.

Chapter 2

State of the Art

I have always imagined that paradise will be a kind of library.

Jorge Luis Borges

This research is developed within the context of several areas. This chapter presents work that we consider relevant for our research, namely: on *Social Networks Modeling*, *Social Network Analysis Approaches*, and *Relational Capital Evaluation*. Thus, this chapter is structured into three sections. Section 2.1 covers social networks modeling. To reflect reality, models are needed to better capture and represent social networks. There are several modeling approaches for this purpose. The most common approach is the graphical representation of nodes and links. In fact, the first significant models representing social interactions are from the early 20th century and were designated as *sociograms*. A *sociogram* is a graphic representation of social links that an individual has with others. In 1932 Jacob Moreno first introduced group psychotherapy to the American Psychiatric Association and for the next 40 years he developed and introduced his Theory of Interpersonal Relations [Mor 11]. Still in Section 2.1, we present core social networks concepts such as: *social entity*, *relation* and *role*. In addition, this section also describes the most used models to represent social networks: graphical representations, mathematical analysis procedures and statistical models. Moreover, Section 2.1 reviews social networks modeling tools and frameworks.

The need to assess social networks interactions has become of extreme importance. Thus, various fields of study emerged. The main study area is Social Network Analysis (SNA) and Section 2.2 covers the most relevant related work. SNA represents a method for achieving analytical results about almost any group interaction in which social entities are present. Organizational Network Analysis (ONA) is based on the SNA methodology and its application focus is the organization. Management consultants use ONA methodology. However, ONA is not focused on analyzing how people create value in a given network. Value Network Analysis (VNA) fills this gap because it provides a network perspective into how processes and people create value. Also, VNA shows unique relationships and transactions with sequences of value flows. Complex systems such as social networks are dynamic. The dynamics result from multiple change processes and the data on these systems is often incomplete and difficult to collect. In order to accomplish a better group evaluation, there is another field of SNA: Dynamic Network Analysis (DNA). This section also points to the major DNA interest areas.

With knowledge of social networks dynamics, to assess the relational capital of an organization it is necessary to understand what organizational evaluation is. Section 2.3 presents organizational evaluation approaches and organization assessment steps. The relational capital definition is given. This section also describes what intellectual capital is. So, the main aspects that should be considered to assess the relational capital of an organizational social network are focused on. There are challenges associated with intellectual capital measurement and this section provides an overview of them. Trying to solve these challenges, the research into measuring the intellectual capital of organizations has produced several methods and theories over the last years. Thus, an overview of these methods is provided. Despite all identified measurement methodologies, this section shows that there is no dominant model for intellectual capital measurement.

2.1. Social Networks Modeling

In this section we introduce main concepts of social networks and we describe the most usual ways of modeling social networks: *Graphical Representations*; *Mathematical Analysis Procedures*; and *Statistical Models*.

2.1.1. Social Network Concepts

A *social network* consists of a "finite set of actors and the relations defined among them"[FF 94]. *Actors* are individuals or collective social units and are linked to one another by social *ties* [FF 94]. Actors may be referred to as *social entities*. A *dyad* is a linkage or relation between two actors. *Triads* are triples of actors and associated ties. A *group* is the collection of all actors on which ties are to be measured. A *subgroup* of actors is any subset of actors and all ties among them. The collection of ties of a specific kind of members of a group is called a *relation* [FF 94]. Appendix B provides *Social Network Analysis Concepts*.

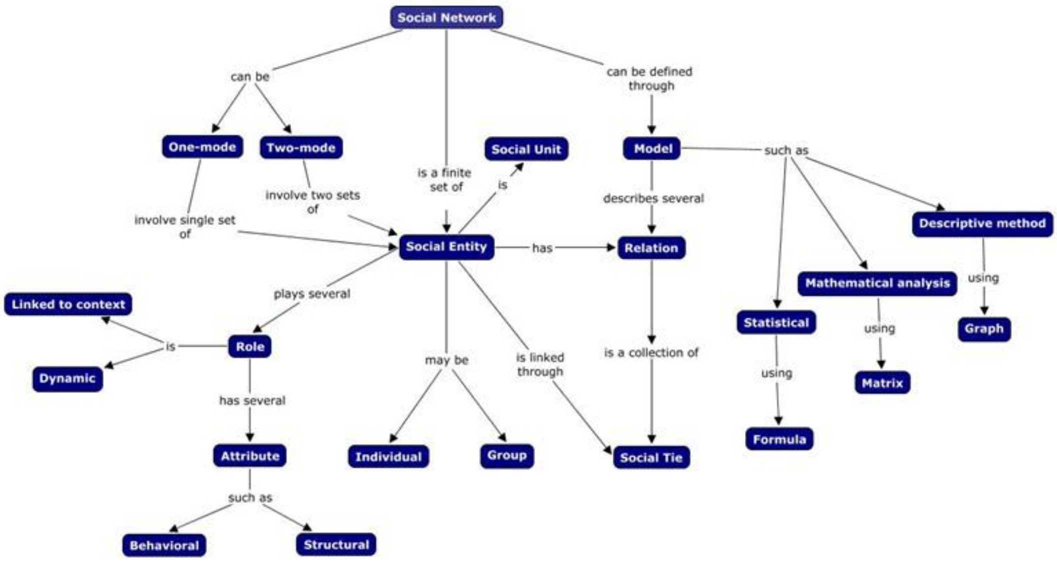


Figure 2.1 Social Network Concepts

An entity may be considered social if it involves a network of relations with other social entities as well [MVE+ 04]. In social network relations, a social entity plays several roles. A role may be seen as a combination of particular sets of behavioral, meaningful, and structural attributes [Wel 07]. There are several fields that discuss the nature of roles, specifically: knowledge representation, knowledge engineering, object-oriented and conceptual modeling, multi-agent systems, linguistics, and cognitive semantics [MVE+ 04]. Therefore, four common features about social roles can be found, namely: (1) roles are properties, e.g. different entities can play the same role; (2) roles have dynamic properties, e.g. an entity can play different roles simultaneously; (3) roles have a relational nature, i.e. roles imply patterns of relations; and (4) roles are linked to contexts. The term *context* can have different interpretations, e.g. metaphysical context, cognitive context or/and linguistic context. See [MVE+ 04] for further review.

There are different types of social networks. *One-mode networks* involve just a single set of social entities. E.g. analyze friendship relations using a single set of people. *Two-mode networks* involve two sets of actors, or one set of actors and one set of events [FF 94]. *Events* have an associated time property and it is possible for relations, positions and roles to change over time. Thus, events can occur at different times. E.g. the organizers of events change over time, and a different set of actors might participate in each event [LGR 05]. *Dyadic networks* and *affiliation networks* are particular cases of *two-mode* networks. The *ego-centered* network is a *network* in which a focal actor (termed "ego") has a set of alters who have ties to ego, and a measurement on the ties among these alters. E.g., it is used in personal network data analysis. "It is possible to consider three or more mode networks, but rarely have social network methods been designed for such data structures"[FF 94]. Figure 2.1depicts social networks main concepts.

After introducing these concepts, we explain how a social network can be modeled in the next sections. SN models allow researchers to conceptualize social structures and understand how an individual is influenced by a social environment [FF 94]. Thus, the aim of using methods to show social networks, such as mathematical and graphical techniques, is to represent the descriptions of networks compactly and systematically.

In the analysis of complete networks, three strategies for modeling social networks can be found: (1) descriptive methods, also through graphical representations; (2) mathematical analysis procedures, often based on a decomposition of the adjacent matrix; and (3) statistical models based on probability distributions [JH 06].

2.1.2. Graphical Representations

Graph theory gives a representation of a social network as a model consisting of a set of actors and the ties between them. When a graph is used as a model of a social network, points or nodes are used to represent social entities, and lines, connecting the points, are used to represent the ties between them. Adapted from [CH 05], Figure 2.2 is a graph that describes the structure of relations between entities A, B, C, D, E, F and G. In Figure 2.2, the circles are nodes and the lines between them are links. The links correspond to the "send mail to" mail messages act between entities. Entity A is linked to two subgroups and also to entity G. The arrows show direct connections (e.g. A sends mail to E)[CH 05]. Node *A* can be characterized as a boundary entity between two subgroups, and potentially a point of connection between them.

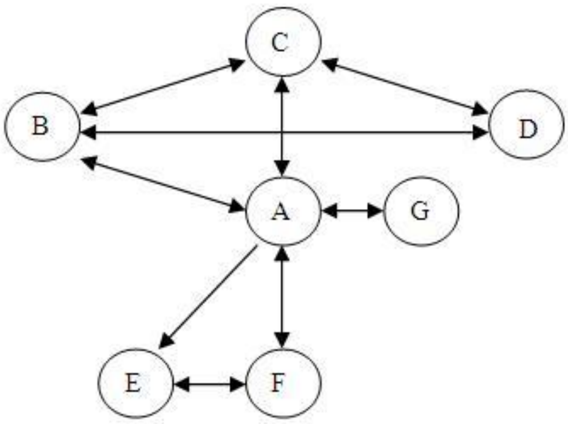


Figure 2.2 "Send Mail To" Graph

The visual representation of data that a graph offers allows researchers to uncover patterns that might otherwise go undetected. Graphs have been widely used in Social Network Analysis (SNA) as a mean of formally represent social relations and quantify social structural properties. See the work of Dawn Iacobucci for a wide review on this approach [Iac 94]. Inspired by social tagging mechanisms, Peter Mika has formulated a generic model of semantic-social networks in the form of a graph of person, concept and instance associations, extending the traditional concept of ontologies (concepts and instances) with the social dimension. His work showed how community-based semantics emerge from this model through a process of graph transformations [Mik 05].

Conceiving ontologies (explicit specifications of the conceptualization of a domain) as engineering artifacts allows their objectification, separation from their original social context of creation, transfer across the domain, and export to other sources [Mik 05]. GraphML (*Graph Markup Language*) [BEH+ 02][GP 11] is a language for modeling graphs that can be adapted to represent social networks. GraphML is a XML format for generalized graph structures, thus, suitable for representing social networks, which are structurally based on graphs. GraphML structure is based on *graph*, *node* and *edge* concepts, but it is also able to add modules that implement specific extensions or additional data. It is used by several graph analysis and drawing tools such as Gephi [Gephi 12] and NodeXL [NodeXL 12] (See Section 2.1.5). DyNetML [CASOS 11_b] is an *Interchange Language for Rich Social Network Data*. More specifically, DyNetML is an XML format specialized in the needs of social network data interchange. Figure 2.3 depicts the first proposed DyNetML hierarchical structure. A *DynamicNetwork* is used to unite all time periods in a single dataset. Each *Meta-Matrix* consists of a number of *Nodeset* elements that encompass node data, followed by a set of networks that specify edge data for a set of graphs involving the nodes. As depicted, a set of *Properties* or computed *Measures* can be associated to several DyNetML elements. DyNetML structure has evolved since the first proposal, and other elements were introduced, such as the *anthropac* element, which helps link network data to anthropological data [Tse 04]. See [CASOS 09] for a view of an updated DyNetML 2.0 specification schema. DyNetML is used by social network analysis tools, such as ORA (See Section 2.1.5).

FOAF [MB 00] is a machine-readable ontology describing people, their activities, and their relationships to other people and objects. hCard [CS 04] is a format for publishing contact details of people, companies, organizations, and places. It is used to import and export data in social networking websites.

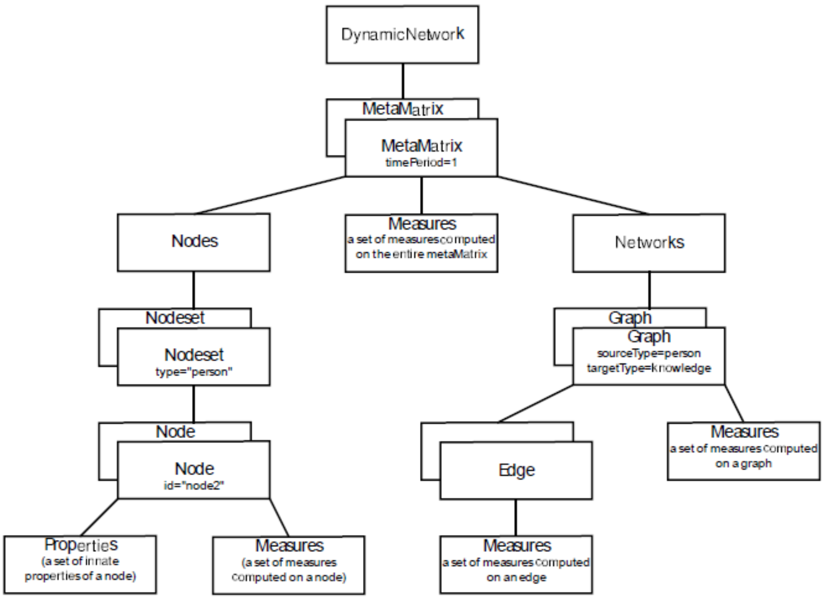


Figure 2.3 Structure of DyNetML (Extracted from [TRC 03])

Graphical representations such as graphs are useful to study the relational capital of networks because they clearly depict entity connections, i.e. the relations among them. Also, graphs may represent entities according to their network centrality (e.g. nodes with higher relational capital value in the center of the graph) or weight (e.g. nodes with higher relational capital value can be depicted with a large diameter or a different color). These characteristics help the *Analyst* to better understand the importance of network entities. Furthermore, a graph clearly depicts several network phenomena such as *bottle necks* (e.g. a network entity that reduces the possibility of increasing the relational capital of other network entities) or *isolate nodes* (e.g. an entity with no connections to other network entities). When combined with XML-based languages, graphical representations are a powerful tool to depict networks and related semantic and structural aspects.

2.1.3. Mathematical Techniques

Matrices are another way to represent networks. "A matrix contains the same information as a graph, but it is more useful for computer analysis, because matrix operations are widely used for definition and calculation in SNA"[FF 94]. The adjacency matrix is used in SNA, usually referred as a *sociomatrix* [Iac 94]. The entries in the matrix indicate whether two nodes are adjacent or not. The incidence matrix registers which line coincides with which node [Iac 94]. Figure 2.4 (adapted) shows a matrix representing Figure 2.2's connections [CH

05]. In the matrix, value 1 indicates the presence of a connection and value 0 the absence. The absence of a link between A and D is represented by the zero value in both cells of the matrix. Entity A is related to E via a directed link and E is not directed to A [CH 05].

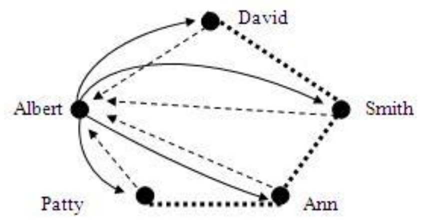
	A	B	C	D	E	F	G
A	0	1	1	0	1	1	1
B	1	0	1	1	0	0	0
C	1	1	0	1	0	0	0
D	0	1	1	0	0	0	0
E	0	0	0	0	0	1	0
F	1	0	0	0	1	0	0
G	1	0	0	0	0	0	0

Figure 2.4 "Send Mail To" Matrix (Extracted from [CH 05])

Using mathematical and graphical techniques to describe a network, consider a scenario with multiple relations (e.g. more than one relation defined on pairs of actors from group $\mathcal{N}$), R represents the number of relations. Each relation can be represented as a graph and has a set of arcs $\mathcal{L}_r$ containing L_r ordered pairs of actors with $1 \leq r \leq R$. Each set R defines a directed graph with nodes in $\mathcal{N}$. These graphs can be seen in one or more pictures. Each relation is defined by the same set of nodes, and each has a different set of arcs. A relation r is given by $(\mathcal{N}, \mathcal{L}_r)$ with $r = 1, 2, \ldots, R$ .Figure 2.5describes a scenario for three possible relations defined with mathematical and graphical techniques.

$\mathcal{N} = \{Albert, Smith, David, Patty, Ann\}$					
R	r	Description		Type	$\mathcal{L}_r$
3	1	"Supervises work of..."	$\longrightarrow$	Directed	$\mathcal{L}_1 = 4$
	2	"Write report to..."	$- - - - \rightarrow$	Directed	$\mathcal{L}_2 = 4$
	3	"Work with..."	....	Undirected	$\mathcal{L}_3 = 6$

Entity Relations



$\mathcal{L}_1$	$\mathcal{L}_2$	$\mathcal{L}_3$
<•, •> Directed relations connections		(•, •) Unidirected relations connections
<Albert, Smith> <Albert, David> <Albert, Patty> <Albert, Ann>	<Smith, Albert> <David, Albert> <Patty, Albert> <Ann, Albert>	(Smith, David) (Smith, Ann) (Patty, Ann)

Figure 2.5 Multiple Relations Scenario (Mathematical/Graphical)

2.1.4. Statistical Techniques

Statistical methods for SNA were introduced by Wasserman and Faust [FF 94], but in recent years there has been a growing interest in exponential random graph models (ERGMs) called the p^* class of models. The exponential random graph models describe a general probability distribution of graphs on n nodes. The possible ties among the nodes of a network are regarded as random variables, and assumptions about dependencies among these random tie variables determine the general form of the ERGM for the network. The Markov random graphs are a particular class of ERGMs (see [RKL 07] for a summary of the formulation and application of ERGMs for social networks). Mathematical and graphical SNA techniques allow representing the descriptions of networks compactly and systematically. “For small populations of actors (e.g. the people in a neighborhood, or the business firms in an industry) it is possible to describe the pattern of social relations that connect the actors using words. However, to list all logically possible pairs of actors, and describe each kind of possible relations, if the number of actors and number of relation types is large, formal representations ensure that all the necessary information is systematically represented, and provides rules for doing so in ways that are much more efficient than lists”[Han 10]. Robert Hanneman considers that social network analysis is more of a branch of "mathematical sociology” than a “statistical or quantitative analysis", though networkers most certainly practice both approaches [Han 10]. He argues that the distinction between the two approaches is not clear. In his words: “Mathematical approaches to network analysis tend to treat the data as deterministic. That is, they tend to regard the measured relationships and relationship strengths as accurately reflecting the real or final or equilibrium status of the network. Mathematical types also tend to assume that the observations are not a sample of some larger population of possible observations; rather, the observations are usually regarded as the population of interest. Statistical analysts tend to regard the particular scores on relationship strengths as stochastic or probabilistic realizations of an underlying true tendency or probability distribution of relationship strengths”[Han 10].

In reviewing the main results of the analysis and modeling of networks, Watts describes the main network modeling approaches, regarding structure, connectivity, search ability, and degree distributions. He concludes that “the current generation of network-related research is a rapidly emerging, and a highly interdisciplinary synthesis occurs, with new analytical techniques with greater computing power, and an unprecedented volume of data” [Wat 04]. The scope and use of statistical approaches have been extended in recent years through methods for SNA, focusing on longitudinal network data, which is understood as two or more repeated observations of a graph on a given node set. Longitudinal network data is the most frequently used network data format in social sciences. Several articles discuss models designed to analyze such data, as proposed in Snijders [Sni 01] and Snijders, Steglich & Schweinberger [SSS 07]. There is little difference between conventional statistical approaches and SNA approaches. According to Hanneman [Han 10], "univariate, bi-variate, and even many multivariate descriptive statistical tools are commonly used to describe, explore, and model social network data. Social network data is easily represented as arrays of numbers". For Hanneman, algorithms from statistics are used to describe characteristics of individual observations and the network as a whole. Those algorithms are very heavily used in assessing the degree of similarity among social entities, and in finding patterns in network data [Han 10].

2.1.5. Tools and Platforms

Several software packages to support, represent, and analyze social networks are available. The packages can range from complete software to analyze and visualize social networks to systems that allow the design and execution of surveys and then use the data obtained to perform a full network analysis. Other systems allow the automatic discovery of network information via mining a data repository or a communications gateway. As depicted in Figure 2.6, based on the referred models, there are different approaches for capturing a social network. Next we present an overview of representative methods, tools and platforms to support and analyze social networks.

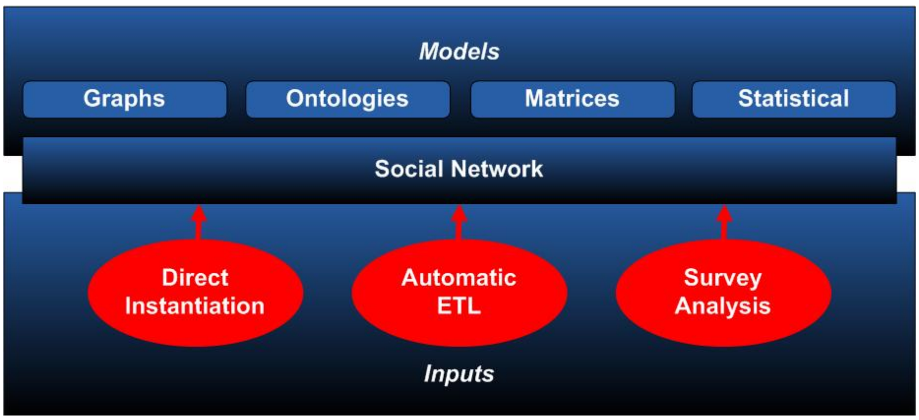


Figure 2.6 Capturing and Representing a Social Network

The common way to extract a social network is by instantiating it directly through SNA software packages. However, using these tools and platforms it is also possible to automatically extract social networks from information gateways or through automatic survey analysis.

Most of the software packages share common features to extract, analyze, and visualize social networks. **UCINET** [BF 02] is "probably the best-known and most frequently used software package for the analysis of social network data"[FF 94]. It is a commercial product developed by Steve Borgatti's team, but an evaluation version is available for 90 days. UCINET uses datasets as collections of matrices, it can import data in various formats and has a spreadsheet editor to authorize data manipulation. UCINET works as a graphical application and is distributed with a user manual and reference guide for social network analysis. UCINET supports uni-modal and bi-modal networks and contains a large number of network analysis methods, such as analysis procedures for computing centrality degree, ego network analysis, and the detection of subgroups and structural holes in the entire network or only in parts of the network. UCINET does not contain graphic procedures or visualization techniques, but it can export directly to **NetDraw** (developed by the same team and included in its package) or other formats.

Pajek [BM 98] is free software developed by the University of Ljubljana and is designed to handle large data sets (from tens to hundreds of thousands of nodes) of uni-modal and bi-modal networks. It is distributed with a reference manual containing a list of commands and operations, but there is also a textbook about SNA theory, applications, and the use of Pajek in network analysis [NMB 05]. Data can be entered directly into the program by 1) importing ASCII network data from network files, 2) importing data with other formats (e.g. UCINET), or 3) opening a Pajek project file (.paj) that combines all the data structures supported in one file. Pajek allows the manipulation of all of its structures (e.g. of the transposition of networks, change of directionality in graphs, or extraction of networks). Visualization techniques are present in Pajek: default network drawing is based on the principle that distances between nodes should reveal the structural pattern of the network. Pajek uses spring-embedding algorithms that seek a configuration of the bodies with minimal local energy, thus a position for each body is such that the sum of the forces (on each body) is zero [BETT 99]. The algorithms from Kamada-Kawai [KK 88] and Fruchterman-Reingold [FR 91] are good examples of this kind of technique. Graph images can be exported to traditional image formats. In Pajek, descriptive methods are also present and examples include: the computation of degrees, closeness, betweeness, paths detection, structural holes, and other operations in two-mode networks [CSW 05]. Statistical procedures are also available, and Pajek can invoke directly statistical software.

Netminer [Cyram 12] is a commercial product developed by Cyram and supports network analysis and network visualization. With the increasing complexity of social network data, SNA tools and platforms had to support networks with multiple node types (multi-modal), multiple edge types (multi-relational), and multiple descriptive features (multi-featured). Sing et al. refer to this approach as *M*3* (i.e. multi-modal, multi-relational, and multi-featured) [SBGB 07]. NetMiner has a data model composed of a dataset of various unit data designed to support uni-modal and multi-relational networks with a graphical interface. Constructing new datasets of nodes and links can be achieved by mouse-dragging on the network map. Network-drawing can be based on spring-embedding algorithms, multidimensional scaling, analysis procedures (e.g. centrality), and simple procedures (circle, random). Built-in standard statistical procedures and charts are also integrated in NetMiner.

Another commercial product is **Sentinel Visualizer** [FMS 12]. This tool provides 2D and 3D network link charts which automatically identify network central players with the help of SNA algorithms. Sentinel Visualizer provides a time range interface that hides or shows data based on a time slider control. Thus, with temporal analysis, the *Analyst* can observe how networks form, change, and interact with each other over time. Moreover, this tool has geospatial features such as: visualize entities and relationships on a map; data integration with Google Earth[10]; geo-query operations to find data by region; and data filter operations by geographical area. Sentinel Visualizer provides sharing data features, namely: export data to several formats, including Word, Excel, PDF, and web pages.

Also with temporal analysis and geographic visualization features, **ORA** is a network analysis tool developed by CASOS at Carnegie Mellon that detects risks or vulnerabilities of an organization's design structure [CRSC 11]. I.e., it analyzes the relationship among its personnel, knowledge, resources, and tasks entities. These entities and relationships are represented by the Meta-Matrix (See Section 2.2.4). This tool contains over a hundred measures categorized by which type of risk they detect. ORA has been used to examine how networks change through space and time, it can handle multi-mode, multi-plex, and multi-level networks, identifying key players, groups and vulnerabilities. This software has been tested with large networks (e.g. 10^6 nodes per 5 entity classes). ORA reads and writes networks in multiple data formats to be interoperable with other network analysis packages.

Gephi [Gephi 12] is an open source network exploration and manipulation software for exploratory data analysis[11] and the main goal is to help data

10 http://www.google.com/intl/EN/earth/index.html(accessed on July 26th, 2012)

11 Exploratory data analysisis an approach to analyzing data sets, often with visual graphs, without using a statistical model or having a previously defined hypothesis.

analysts make intuitive hypothesis, discover patterns, and isolate structure singularities or faults during data sourcing [BHJ 09]. Gephi can import, visualize, spatialize, filter, manipulate and export several types of networks. Through games visualization techniques, Gephi uses a 3D render engine to render graphs in real-time. Nodes can be personalized (e.g. the shape can be a texture, a panel or a photo) and real-time adjustments such as speed, gravity, repulsion, autostabilize, inertia or size can be made to Gephi layout force-directed algorithms. The user interface is structured into workspaces, and for each one, sets of nodes or edges can be obtained manually or by using the filter system. Gephi architecture supports graphs whose structure or content varies over time, i.e. dynamic network visualization. As a result a timeline component was developed, and a dynamic network can be played as movie sequences. Network data can be gathered either from acompatible graph file format (e.g. GEXF, GDF, GML, GraphML, Pajek NET, GraphViz DOT, CSV, UCINET DL, Tulip TPL, Netdraw VNA, and Spreadsheet) or from external data sources (e.g. a web-crawler can be connected to this software in order to see the network construction over time). The architecture is interoperable and data source can be created to communicate with existing software, third parties databases or web-services.

Another platform for exploratory data analysis on relational data sets is **JUNG** (Java Universal Network/Graph)[JUNG 12]. JUNG Framework is a free, open-source software library that provides a common and extendible language for the manipulation, analysis, and visualization of data that can be represented as a graph or network [MFS+ 05]. I.e., JUNG is a graph toolkit that serves as a framework for building social networks and for graph analysis. JUNG supports a variety of representations of entities and their relations, directed and undirected graphs, multi-modal graphs, and hypergraphs. JUNG main features provides: 1) mechanisms for annotating graphs, entities, and relations with metadata; 2) routines for clustering, decomposition, optimization, random graph generation, statistical analysis, and calculation of network distances, flows, and ranking measures; 3) a visualization framework for the interactive exploration of network data; and 4) filtering mechanisms to extract subsets of a network. Graphs can be imported from other formats such as: Pajek and GraphML.

SocialAction [SocialAction 12] is also an interactive exploratory tool for social network analysis that integrates visualization and statistics to improve analytical processes [PS 06]. SocialAction is a non-commercial software package. It supports large, multi-relational, uni-modal and bi-modal networks, and users can iterate through visualizations of measures, filter nodes, find cohesive subgroups, focus on communities of interest, or find patterns across different edge types using overview visualizations. For each operation, a node layout is maintained in the network visualization in order to allow users to make comparisons. "Instead of presenting statistical results in typical tabular interface, SocialAction results are depicted in a visual system that provides meaningful computed attributes of the nodes and edges, thus, users can dynamically filter nodes and edges to find interesting data points"[Per 10]. The visualization interface simplifies statistical results, helping the user to discover features such as distributions, patterns, trends, gaps, and outliers. "With SocialAction visual analytic system, users are focused on insights and generating hypotheses rather than managing a medley of software packages" [Per 10]. Networks can be imported into SocialAction from a variety of popular formats, such as Pajek and GraphML.

Invenio is a visual mining tool for social network data mining [SBGB 07]. This tool is a JAVA application and it was developed using Prefuse [Prefuse 12] and JUNG [JUNG 12] libraries. The major feature of Invenio is the ability to provide visual mining and systematic analysis of M*3 networks. "With Invenio the user can interactively explore this type of social networks, creating views (which represent multiple abstraction levels of a single social network) to support visual analytics, and using both database and graph mining operations" [SBGB 07]. "Common social network tools read a specially formatted input file in order to generate visualizations. In contrast, Invenio supports the loading of data directly from a relational database. I.e. this tool reads all the relations in a database and lets the user select the desired relations for visual analysis, as well the number of nodes and edges"[SBGB 07].

NodeXL (Network Overview, Discovery and Exploration) [NodeXL 12] is a free, open-source template for Microsoft Excel to explore network graphs. Networks are represented in the form of edge lists. Each edge list is, at least, a pair of entity names that indicate the presence of a relationship which may be directed or not. Additional columns to contain data about relationships can be added. With NodeXL, the user can enter a network edge list in a worksheet and a graphical representation of relationships of complex networked data is produced, because it provides a canvas for displaying and manipulating network charts and data, which include display options to specify the appearance of individual edges (e.g. different thickness, color, and level of transparency) and nodes (e.g. location, size, color, transparency, shape or image) as well as the overall layout of the network. NodeXL includes software routines for statistics about individual vertices, including indegree, outdegree, clustering coefficient, closeness, betweenness, and eigenvector centrality, but other analyses features can be integrated by advanced users. According to Smith et al. [SSF+ 09], "reliance on a spreadsheet does limit the scale of NodeXL data sets to small and medium size networks with thousands to tens of thousands of nodes, but most networks even when composed of billions of elements will ultimately need to be reduced to a limited set either by aggregation or by selectively focusing on a sub region of the larger network".

NodeXL data can be imported from Pajek files, other spreadsheets, comma separated value files, or incidence matrices. NodeXL also extracts networks from other data sources (examples include email *reply-to* information from personal e-mail messages,which can be extracted from the *Microsoft Windows Desktop Search Index*, and data imported from *Twitter* user subscriptions).

Netvis [NetVis 09] is a web-based tool distributed as an open-source program to analyze and visualize social networks using data from comma-separated value files (CSV) and surveys. The software allows the registration of actors present in the network, and then it lets users define a survey and use the data received from the answers to perform a social network analysis. Netvis can also export data to more common formats.

Network Genie [Genie 12] is an online application developed by Tanglewood Research for designing and managing social network projects. It includes the design of surveys and survey questions, the management of social network projects, the collection of social network survey data, and the import/export of data to SNA software. The main objective of this kind of software is to gather information from surveys and automatically export data to the most common software applications for SNA.

A team at University of Virginia's McIntire School of Commerce headed by Research Director Rob Cross developed an application called **The NetworkRound Table** [RoundTable 12]. Most of the content and documentation is not public and it is only available to clients who subscribe by paying an annual fee. However, its features, steps, and procedures are available on the website. Based on an organizational perspective, the software allows an analyst to register or import all of the actors into the system, join them into teams or groups, and assign them roles. After that, the analyst can create a survey with questions to infer all of the social relationships in the network as well as their strength or frequency. The software is powerful enough to direct specific questions and answers to specific actors or groups, and questions can be open-ended, rating scale type, multiple-choice, order importance choice, or nested in groups. The analyst can explain how each question is important and what he wants to infer from the analysis of the answers. After the survey's activation, the registered users receive an email directing them to visit a web address and properly complete the survey. The analysts can check the status of the survey; when they have a satisfactory amount of answers, they can close it. After closing the survey, an individual action plan is available to all actors with the analysis of their own answers. The analysts can then view and analyze the results of the complete network. There are options available to export the data to the most common formats, but simple direct analyses are also present in the software. The analysts can also view, edit, annotate, or delete individual answers and filter them by parameters. The team states that the personal network feedback by itself enables each actor to assess his or her connectivity within the network and improve it by planning changes. The feedback is delivered either on paper, which can be analyzed in group meetings, or in an online action plan that allows actors to annotate and plan actions to increase connectivity.

Although the Web itself is an example of a social network and the formation of communities is one of its most important achievements, the Web 2.0 boom made group information sharing possible to users via the spread of wikis, forums, blogs, and social networking communities. While these websites feature much of the same content that appears on personal Web pages, they provide a central point of access and bring structure in the process of personal information sharing and online socialization [JH 06]. People can register or be invited to these websites. After uploading information about themselves, they can upload photos, join groups of people, and connect to other friends or people with similar interests. People become organized in networks or groups and can see each other's profiles, relationships, and actions in the network. Most of these websites allow people to upload and tag photos, share files, post in blogs, and interact in other ways with their peers.
With the growth of large social communities on the Web, the development of more sophisticated data collection methods, social analysis procedures, and visualization techniques is still a challenge.

2.1.6. Discussion

When analyzing the various techniques for social networks modeling, the most prevalent are: graph representations, matrices, and statistical models. These techniques are effective in most situations. They describe the core entities of a social network and their connections.

Typically, graphical representations only show nodes and network links. To minimize this problem, graph visualization systems provide zoom and clustering mechanisms to view information of a particular node, context or role. When combined with XML-based languages (such as GraphML and DyNetML) graphical representations are a powerful tool to depict networks and related semantic and structural aspects. However, since they are interchangeable languages for network data, it is always possible to define meta-data to enhance the relational knowledge about network entities.

For matrix representations, mathematical forms are universal and also easily understood. The reading of this kind of representations is simple if data comes from a network with few actors. If the number of entities and their connections is high, matrices are good tools for algorithmic processing through specific software, but its reading becomes difficult for human beings. Imagine a symmetric matrix that reflects the possible relationships between 250 people.

In this case, reading the relational information would become challenging for human being. Moreover, typically in this type of representation, the value of each matrix cell only means the presence or absence of a given connection. These are two-dimensional arrays and for this reason, to represent the semantic aspects in actors' relations, *n*-dimensional data structures are needed.

Statistical models are very rich in semantics aspects, but their reading requires a thorough knowledge of mathematics and statistics and it is not a form of representation with a fast learning curve for most analysts. Table 2.1provides a comparison of the analyzed social network modeling techniques.

Table 2.1 Social Network Modeling Techniques Comparison

Concepts / *Methodology*	**Social Entity Visualization**	**Relation Visualization**	**Semantic Descriptions** *E.g. role*	**Network Macro-View Facility**	**Mapping facility for computer processing**	**Ease of Interpretability**
Graphs	+++	+++	+++	+++	++	+++
Matrices	++	++	++	++	+++	++
Statistical procedures	+	+	++	+	+	+

Legend: + low, ++ medium, +++ high

Regarding tools and platforms, from free applications to commercial ones, or from stand-alone applications to web-based, the user's choice depends on the expected functionalities to fit specific needs. Tools and platforms comparison criteria can be based on issues, such as: platform type, input/output formats, custom attribute handling, graph analysis and statistical specific functions, or visualization features. A good survey of social network data analysis and visualization tools can be found at the Center for Computational Analysis of Social and Organizational Systems [CASOS 11_a]. Also, a gallery of high quality visualization techniques can be found at *Visual Complexity* [VIS 11]. However, INSNA, the recognized International Network for Social Network Analysis, holds a public list of its member's software in [INSNA 12]. Moreover, an updated website about social networks tools and platforms regarding main functionalities, technical issues, license types and related costs can be found at [SNA 12].

2.2. Social Network Analysis Approaches

Every organization has a social network made up of smaller networks and knowledge is dispersed throughout the network, i.e. it is not converged in the managerial class [AO 10].

Theorizing about networks can generally be thought of as coming from two complementary perspectives: "the view from the individual organization and the view from the network level of analysis"[PFS 07]. Interorganizational networks are also referred to as "whole networks". A typology demonstrates the possibility of four different types of network research approaches [PFS 07]: (1) the impact of organizations on other organizations through dyadic interactions; (2) the effect of a network on individual organizations; (3) the impact of individual organizations on a network; and (4) whole networks/network level interactions.

Considering an organizational environment, network-level theories use many of the behavior, process, and structure ideas and measures developed by organization-level researchers. However, as stated by Provan et al., "the focus is not on the individual organization but on explaining properties and characteristics of the network as a whole"[PFS 07]. There are common network properties and processes associated with whole networks, such as structure, development/evolution, governance, and network outcomes [PFS 07]. To uncover these properties, evaluate and analyze social networks, there are four major areas: *Social Network Analysis*, *Organizational Network Analysis*, *Value Network Analysis* and *Dynamic Network Analysis*. The scope of them is described in the next sections.

2.2.1. Social Network Analysis

Social Network Analysis (SNA) represents a method for achieving analytical results about almost any group interaction in which social entities are present. This section introduces SNA, its most common measures[12] and explains its use in the organizational context.

In SNA scope, group dynamics are studied to identify relations and interactions among their members. Thus, from these interactions it is possible to identify social patterns [Hay 05]. Also, it is possible to detect or propose social or organizational changes that reveal how networks grow or should change. Typically, SNA scenarios are strategic alliances and collaborations, flows of information, communication, affect, goods and services, and influence

[12] See also Appendix B - Social Network Analysis Concepts.

[BGT 04]. Network research represents a different paradigm, which requires new concepts and methods [Bor 03].

Traditional SNA studies use a lot of information residing in archives that were not created expressly for social research. Sometimes, such data provide measures of social ties and trace relations of social entities that are reluctant to do interviews. Archival data are often inexpensive, especially when in electronic form [CSW 05]. The data comprising social networks tend to be heterogeneous, multirelational, and semi-structured. In this sense, link mining is a relevant example, showing a confluence of research in social networks, link analysis, hypertext and web mining, graph mining, relational learning, and inductive logic programming [HK 06].

To perform SNA it is necessary to define measures that can be used to compare actors or networks, "Measures in SNA can be distinguished as those that evaluate the entire network and those that evaluate only a specific node"[FF 94].

At an individual level, the most frequently analyzed measure is *centrality*. This measure evaluates the actor's position in the network and can be interpreted as the prominence of an actor in a social group. It can be measured using metrics such as: *nodal degree, betweeness, and closeness*. Other important concepts are the *geodesic distance* (the shortest distance between one node and another in the graph) and the *structural equivalence* (the extent to which an actor shares the same set of links with another).

At the network level, it is important to understand how the network is structured. *Centralization* is directly connected with the central nodes concept: a more centralized network indicates that most ties are dispersed around one or a few nodes. *Path Length* is defined as the average distance between all pairs of nodes. *Cohesion* measures the percentage of actors directly connected to each other by cohesive ties. Directly linked with this concept are the members who would disconnect the group if they were removed. This kind of node is called *cutpoint*. Ties that disconnect parts of the graph when removed are called *bridges.*

SNA can be used in organizations to better understand the social capital [BF 03], support partnerships and alliances [CP 04], measure the degree of the actors' embeddedness in the network, support knowledge management policies, and identify *who* really knows *what* in the company [HB 05]. Finally, SNA is a tool that makes the patterns of relationships within and across strategically important networks visible [CP 04].

2.2.2. Organizational Network Analysis

Organizational Network Analysis aims at integrating networks across core processes, promote innovation and organizational changes, by supporting the development of informal communities of practice, improving leadership effectiveness, replicating high performance, and understanding connections between groups in the organization or between groups outside [CP 04].

The need for more agile, flexible, dynamic, and polyvalent organizations and employees in locations where organizational change is a daily routine, and the rise of new ways of working, collaborating and interacting has caused Social Network Analysis to become a "must-have" tool for analyzing communities and groups. Management consultants use this methodology with business clients and refer to it as Organizational Network Analysis (ONA). As Cross and Parker states in his book, "real organizations are typically different from those expressed in organizational charts"[CP 04]. A company's hierarchy topology is represented in Figure 2.7along with the relationships extracted by internal questionnaires. Looking at the network diagram[13], we can understand that actors in lower hierarchical positions can have great importance inside the organization due to their knowledge, role, or personal relationships with other peers. This figure is based on an example given by Cross and Parker [CP 04].

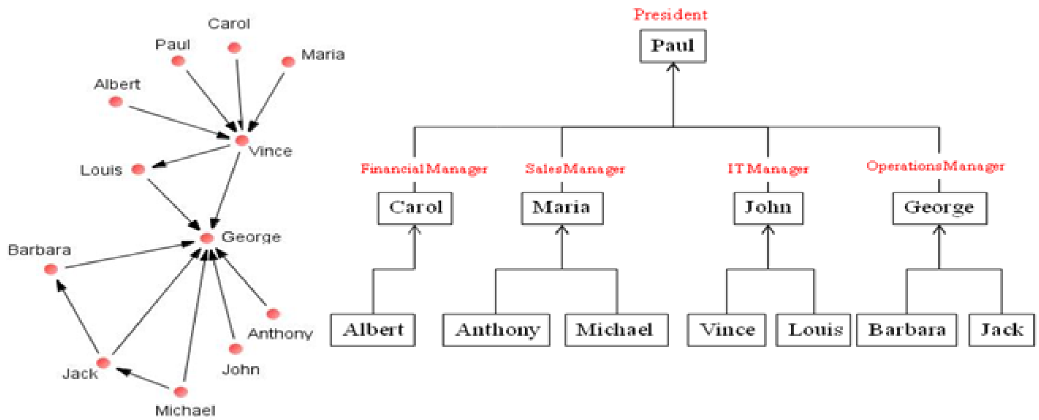


Figure 2.7 Network Diagram and Organizational Chart

The ONA methodology begins with a problem statement (e.g. "How easy is it for new members to overcome isolation?"), a list of names (e.g. the community list), and a set of survey questions, e.g.: "When and how often do each of these other members provide you with information to accomplish your work?", "How well do you know each of these members now?", "How likely are you to call each of these people when you have an idea that you want to

[13] Produced with SNARE-Explorer.

brainstorm?”. The questions are designed to elicit insights into the current state of the relationships of the people named, and to map tools that process survey data to produce a snapshot of the patterns of connection and knowledge flow in the network [Pat 07].

Factors like gender, age, ethnicity, and education can drive people to communicate primarily with peers who do not have formal relationships with them in the organizational chart or are not connected to their organizational role. For the same reasons, when introduced into a department and project separation, it can produce a lack of communication, lack of resources awareness, and lack of collaboration between actors within a company. Conversely, the excessive importance of an actor can bottleneck an entire organization.

In a real scenario experiment, carried out with Vodafone Portugal[14][SDF+ 08], SNARE-Explorer was used to analyze the relationships and roles of actors in the context of a specific business area. After an ONA survey approach, Figure 2.8 depicts the resulting sociogram produced with SNARE-Explorer. It is a social network graph derived from the question "Who helps you more to achieve your objectives?”. The actors are managers from Vodafone Portugal and their names are omitted for confidentiality reasons.

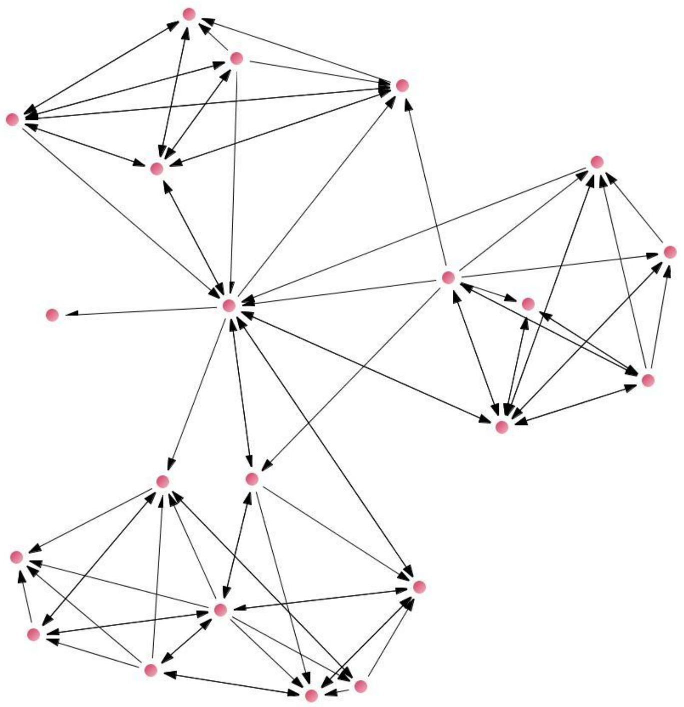


Figure 2.8 SNARE-Explorer Social Network Graph

[14] This experiment has triggered several findings which led to a new research cycle where the need to monitor the relational capital of organizations started.

Finally, ONA methodology can be helpful to uncover network value questions, namely [Pat 07]: "Does the network have adequate resources to create value, both tangible and intangible?", "Does the network produce appropriate value for its stage in its development cycle?", "Are there performance metrics for tangible value produced?", "Is the network's value-producing model sustainable?", and "Are all stakeholders receiving the value they are expecting?". Naturally, focused on organizational relations, ONA is a particular case of SNA.

2.2.3. Value Network Analysis

Value Network Analysis (VNA) is focused on [Ale 08]: (1) Providing a perspective for understanding value by creating roles and relationships, both internal and external, upon which an organization depends; (2) Offering dynamic views of how both financial and non-financial assets can be converted into negotiable forms of value that have a positive impact on those relationships; (3) Explaining how to more effectively produce value for each role and how to use tangible and intangible assets for value creation; and (4) Providing a systematic analysis of how one type of value is converted into another.

Alee argues: "Participants in a value network, either individually or collectively, *utilize* their tangible and intangible asset base by assuming or creating roles that *conver*t those assets into more negotiable forms of value that can be delivered to other roles through the execution of a transaction. In turn, the true value of deliverables received is *realized* by participants when they convert them into gains or improvements in tangible or intangible assets"[Ale 08].

Also, according to Verna Alee: "The emergent purpose and value dynamics of the network are revealed through the particular pattern of roles (contributing individuals or organizations) and their unique negotiated value exchanges in service to fulfilling an economic or social goal or output. Shared purpose and values may be *either* tacit or explicit but can be deduced from the network patterns and the nature of the exchanges. *Value* is continually being negotiated in this context of both individual and overall purpose and values" [Ale 09].

"Every network has a purpose, and every network creates value. The purpose is related to the value that network creates"[Pat 07]. A web of relationships that generates tangible and intangible value through a complex, dynamic exchange between individuals, groups, or organizations is a *value network* [Ale 03]. Also, "any organization or group of organizations, engaged in both tangible and intangible exchanges, can be viewed as a value network"

[Ale 03]. A value network approach takes a whole-system view of processes and the exchanges that occur among a network's stakeholders [Pat 07]. Thus, it is necessary to understand roles and relationships that generate value. This way "any purposeful organization can be seen as a value network"[Ale 03].

"VNA fills the analytical and managerial gap between other organizational tools because it provides a network perspective into how processes and people create value. Also, it shows unique relationships and transactions and sequences of value flows" [ValueNetworks 10]. This implies a transaction analysis of deliverables originated by specific network roles [Ale 08].

In organizational networks, value interactions are of two types [ValueNetworks 10]: (1) *tangible deliverables*, which are contractual interactions between participants; and (2) *intangible deliverables* that are informal interactions (e.g. exchanges of knowledge, favors, and benefits). The roles and deliverables are made visible through a visual mapping technique and the diagrams link a variety of tools to support cost/benefit analyses [ValueNetworks 10]. In the VNA diagram typical mapping elements are: (1) *roles*; (2) *transactions*; and (3) *deliverables*. These elements are depicted in Figure 2.9. Nodes represent participants with the roles they play. Solid lines show tangible (formal, contractual) deliverables being provided while dashed lines show intangible or informal deliverables being offered. The arrow represents a completed transaction or delivery and the label shows the deliverable name [ValueNetworks 10]. Notice that roles can be performed by individuals, teams, business units, and organizations [ValueNetworks 10].

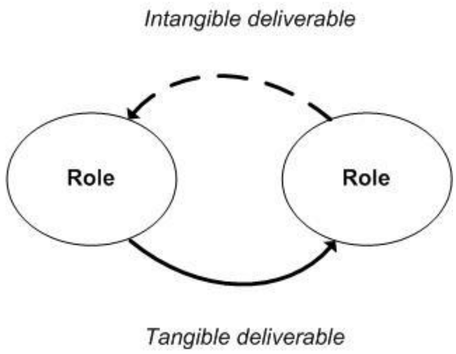


Figure 2.9 VNA Diagram Elements (Adapted from [Ale 08])

As an example of a VNA, Figure 2.10 shows the relationships among the beneficiaries of a nonprofit value network. The tangible types of value exchanged are: funding, reports on activities, guidance documents, policies, standards, economic improvements, and services. The others are intangibles (dash-dotted lines).

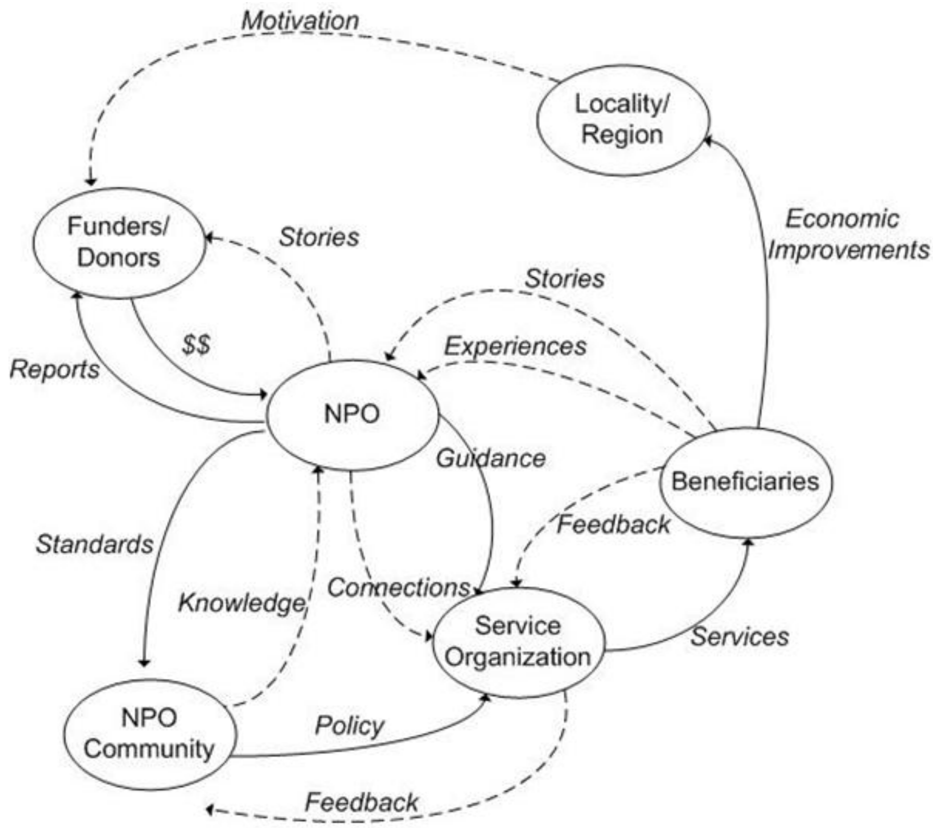


Figure 2.10 Value Network (extracted from [Pat 07])

When all of the critical roles, value exchanges, and transactions have been identified, it is possible to do perform value network analysis. Hence, analyzing a value network requires three steps [Ale 08]: (1) *Exchange analysis*, to know how is the network converting value; (2) *Impact analysis*, to know what impact each value input has on the roles involved in terms of value realization; and (3) *Value creation analysis*, to know how to create, extend and leverage value, either through adding value, extending value to other roles, or converting one type of value to another. Verna Alee's methods are based on some core assumptions about value networks, namely:

- Participants and stakeholders participate in a value network by converting what they know, both individually and collectively, into tangible and intangible value, which they add to the network;
- Participants accrue value from their participation by converting value inputs into a positive increase of their tangible and intangible assets, in ways that will allow them to continue producing value outputs in the future;

- In a successful value network, every participant contributes and receives value in ways that sustain both their own success and the success of the value network as a whole. When this is not true, participants either withdraw or are expelled, or the overall system becomes unstable and may collapse or reconfigure;
- Successful value networks require trusting relationships and a high level of integrity and transparency from all participants;
- Insights can be gained into value networks by analyzing: a) the patterns of exchange, b) the impact of value transactions, exchanges, and flows, and c) the dynamics of creating and leveraging value; and
- A single transaction is only meaningful in relation to the system as a whole.

Summarizing, there is a variety of business domains that VNA can address [ValueNetworks 10]:

- Relationship management: VNA considers relationships as two-way value creating interactions;
- Market space strategies and investments: VNA helps identify, analyze, evaluate, prioritize, and manage investments in market spaces;
- Business web development: resource deployment, delivery, market innovation, knowledge sharing, and time-to-market advantage depend on the quality, coherence, and vitality of the relevant value networks and business webs;
- Fast-tracking process redesign: product and service offerings are constantly changing (e.g. processes to innovate, design, manufacture, and deliver);
- Open innovation: success depends on the ability to creatively partner in innovation value networks around research, product development, and implementation or commercialization;
- Reconfiguring the organization: VNA helps reorganize roles and interactions to more effectively deploy existing resources; and
- Supporting knowledge networks and communities of practice: understanding transactional dynamics is vital for purposeful networks of all kinds.

2.2.4. Dynamic Network Analysis

According to Carley, SNA is focused on small, bounded networks with few types of links (e.g. *friendship* and *advice*) among one type of node (e.g. *person*), at one point in time [Car 03]. However, complex socio-technical systems are dynamic [CDRT 07]. The dynamics result from multiple change processes. Data on these systems is often incomplete, with errors, and difficult to collect, which further complicates the understanding and evaluation of these systems. Consequently, the need for tools that go beyond traditional SNA and link analyses arrived. In response to these needs a new sub-field of SNA has been proposed: *Dynamic Network Analysis* (DNA)[Car 03].

DNA is a scientific field that combines social network analysis, link analysis and multi-agent systems within network science and network theory [CDRT 07]. There are two aspects to be considered: statistical analysis of data and simulation to address issues of network dynamics. DNA networks vary from traditional social networks in that they are larger, dynamic, multi-mode (multiple types of nodes), multiplex networks (multiple types of links), and may contain varying levels of uncertainty [CDRT 07]. A difference of DNA to SNA is that DNA takes the domain of time into account. This is made by taking snapshots of the same network from different intervals and observing and analyzing its evolution.

Carley suggests an approach to DNA based upon the combined use of multi-agent modeling, machine learning and a meta-matrix approach to network representation [Car 03]. This meta-matrix is a multiplex representation of entities and connections that enriches the traditional one-dimensional representation. Carley combined knowledge management, operations research and social networks techniques together in order to create the notion of meta-matrix. The meta-matrix approach provides a representational framework and family of methods for the analysis of organizational data. With this model, organizations are conceived of as being composed of a set of elements, each of which belongs to one of five classes, as suggested in Table 2.2 [CASOS 07].

The organization is defined by the set of elements described in Table 2.2 together with the dyadic relationships among these elements. It is the analysis of these dyadic relationships that lies at the core of the meta-matrix approach. Considering this, meta-matrix specific metrics were developed. E.g. *cognitive load*: a metric to capture the overall importance of an individual, task, or resource in the group. This metric is used to measure the effort that an individual has to employ to hold his role in a terrorist group, and takes into account, “who he interacts with, which events he has been at, or, which organizations he is a member of” [Car 03]. *Cognitive load* is a complex measure and a core issue for DNA is to know what appropriate metrics for describing and contrasting dynamic networks are needed. A set of measures that are generally not correlated, but they scale well and are key in characterizing a network. E.g. the *size of the network*, *density*, *homogeneity* in the distribution of ties, *rate of change in nodes*, and *rate of change in ties* [Car 03].

Table 2.2 Meta-matrix Classes

Class	Description
Personnel	*Individual agents within the organization (human or otherwise) that are capable of supplying labour to task performance and form a locus for knowledge (procedural or declarative), social contacts, task assignments, and/or control of resources*
Knowledge	*Functionally coherent elements of procedural or declarative information (generally pertaining to organizationally relevant task performance) to which agents may have access (often the same as human capital)*
Resources	*Passive elements of organizational structure that act as inputs to task performance and which may be controlled by agents (often synonymous with physical capital)*
Tasks	*Organizational objectives that must be met by a specified agent performance (usually involving resources and/or knowledge)*
Organizations	*Organizational entities beyond the entity under immediate study (i.e., other organizations within the environment)*

DNA tools tend to provide more measures to the manager, because they provide measures that use data simultaneously drawn from multiple networks. Properties change over time and nodes can adapt. Table 2.3 adapted from [Car 03] shows basic change processes for nodes in the meta-matrix.

Table 2.3 Basic Change Processes for Nodes in the Meta-matrix

People	Knowledge/Resources	Events/Tasks	Organizations
Birth	Innovation	Goal change	Organizational birth
Death	Discovery	Re-engineering	Organizational death
Promotion	Forgetting	Development of new technology	Mergers
Mobility	Consumption	Stop usage of technology	Acquisitions
Recruitment			Legislation of new entity
Incarceration			
Isolation			

A company's employee can learn new skills and increase their value to the network. In complex systems, a change propagates from one node to the next and so on. Thus, identifying key individuals, locating hidden groups and estimating performance are some of the tasks that analysts might perform when applying DNA [CDRT 07].

Along with SNA and ONA, DNA tools include software packages for data collection, analysis, visualization and simulation. The process of data analysis includes tasks such as identifying relations among individuals and groups, characterizing the network's structure, locating the network elite or key actors, points of vulnerability, and comparing networks [CDRT 07].

Some of the problems that DNA covers are: developing metrics and statistics to assess and identify change within and across networks; validating simulations to study network change, evolution, adaptation, and decay; validating formal models of network development and evolution; developing techniques to visualize network change; developing statistical techniques to analyze differences observed over time in networks; developing algorithms to change links distribution in networks over time; developing algorithms to track groups in networks over time; developing tools to extract or locate networks from various data sources; developing statistically measurements on networks over time; examining; examining networks as probabilistic time-variant phenomena; identifying trails through time given a sequence of networks; and, identifying changes in multi-mode, multi-link, and multi-time period networks [DNA 10].

As previously mentioned DNA takes snapshots of the same network at different intervals and observes and analyzes its evolution in the network. When dynamically observing scale-free networks, they have power-law [15] degree distributions. A reference model to generate scale-free networks is the Barabási-Albert model, which uses two concepts: *growth* (which means that the number of nodes in the network increases over time) and *preferential attachment* (which means that the more connected a node is, the more likely it is to receive new links). Thus, the development of large networks is determined by robust self-organizing phenomena that go beyond the particulars of the individual systems [BA 99].

2.2.5. Discussion

When studying the various methodologies for social network analysis (SNA, ONA, VNA, and DNA), we found complementarities between them. SNA focuses primarily on analyzing networks using graph theory metrics. For this reason, it has the advantage of allowing automatic analysis procedures. However, given its nature, the SNA does not focus on networks' organizational details.

The ONA methodology, though, has the advantage of focusing its study on organizations. ONA assessments make organizational factors possible to emerge, such as contexts and roles, but the results obtained by ONA methodology are closely related with the SNA's classical analysis techniques.

[15] A power law is a mathematical relationship between two quantities. E.g. when the frequency of an event varies as a power of some attribute of that event (e.g. its size), the frequency is said to follow a power law.

VNA reverses the SNA and ONA methodology's logic. That is, the focus is on analyzing the existing transactions between entities based on the organizational roles entities. After studying other techniques for evaluating social networks, VNA has proved to be a more comprehensive methodology to model and evaluate the intellectual capital of organizations. However, VNA still requires a previous mapping to a specific model based on social entities roles and transactions.

The common evaluation systems SNA, ONA and VNA are typically applied at a given moment. The DNA methodology has the advantage of allowing the continuous monitoring of dynamic aspects of networks. Table 2.4 provides a comparison of the above methodologies.

Table 2.4 Network Analysis Methodologies Comparison

Concepts / *Methodology*	**Organizational Context**	**Intellectual Capital Analysis**	**Social Entities Transactions Analysis**	**Social Entities Roles Analysis**	**Automatic Analysis Procedures**	**Continuous Analysis Nature** *Timeshots*	**Appreciation for Relational Capital Analysis**
SNA	+	+	+	+	+++	++	+
ONA	+++	++	++	++	++	++	++
VNA	+++	++	+++	+++	+	+	++
DNA	++	++	++	++	+++	+++	++

Legend: + low, ++ medium, +++ high

SNA, ONA, VNA and DNA can be applied in organizational contexts. However, from our point of view and considering continuous analysis, they are not designed from scratch with the specific purpose of achieving an overall network metric to evaluate and monitor the relational capital of typical organizations.

2.3. Relational Capital Evaluation

As a part of the intellectual capital of organizations, the *relational capital* is the value of internal and external relationships for that organization. First, we will describe the need to assess organizations. Second, intellectual capital's main concepts are going to be presented. Third, we will discuss the current challenges for measuring the value of intellectual capital of organizations, and respective methods. Finally, we will talk about relevant aspects to create an assessment system for measuring intellectual capital.

2.3.1. Organizational Evaluation

An organization has objectives and goals to reach and evaluation helps understand if they are being achieved. In addition, an organization must be resilient to new environments and evaluation improves our understanding of adaptation processes (e.g. evaluating technologies change to face new environment scenarios in order to better use resources). Areas to be improved or modified as well as different ways to fulfill clients' needs can be identified by organizational evaluation processes [FAO 12].

According to [FAO 12], "evaluation information is an input for planning and establishing resource allocation priorities in organizations, and this information helps to justify the need for additional resources, helping to track key activities".

Several types of organizational evaluation approaches can be found, and a set of evaluation steps are defined. Thus, organizational evaluation can be focused on economic impact (e.g., cost-benefit analysis), basic evaluation (e.g. socio-economic, biological, physical, technical and institutional aspects), analytical evaluation (e.g., socio-economic analysis of adoption studies, productivity analyses, risk assessment, use of labour, marketing credit and prices and their effects on technical alternatives), operative evaluation (e.g., comparative analysis between materials and resources used, activities carried out and the results achieved), evaluation of results (e.g., quantitative and qualitative analysis, retribution factors and probabilities of adoption), traditional evaluation (e.g., reports, technical meetings, committees, courses and seminars), and personnel (e.g., analyzing the performance of professional, administrative and technical human resources in the organization) [FAO 12].

Notwithstanding, there are several steps to evaluate an organization and the evaluator must consider them [FAO 12]. Namely:

- Objectives of the assessment exercise: the sponsors of the assessment may have specific expectations and the evaluator must be aware of them;
- Size and nature of the organization: it is important to consider dimensions such as demographic variables, type of activities and nature of the organization;

- Areas to be covered during the assessment exercise: e.g., general administration, organization plan, staff, services, financial issues, organizational system and technical productivity;
- Potential users of the assessment results and recommendations: this implies the definition of the assessment users;
- Organizational model on which the assessment methodology is to be based on: theories commonly used are: (1) human relations; (2) open system; and (3) internal process. The evaluator must also consider observation factors such as: (1) nature of work; (2) characteristics of the individuals; (3) group functioning and nature of the group; (4) the dimension of organizational structure and processes; (5) environment outside the organization; (6) the characteristics of organizational effectiveness; and (7) the relationship among all the previous factors;
- Framework for conducting the assessment exercise: the organization is a complex social system which implies participants' behavior may be unpredictable. It is essential to develop an integrated framework to assess organizational performance at four levels: (1) overall organization level; (2) unit level; (3) individual job level; and (4) relationships between jobs and units within the organization as well as with other organizations.
- Data evaluation: includes three steps: (1) collecting information regarding organizational functioning and impact; (2) analysis and interpretation of the collected information; and (3) use of the information and its analysis;
- Methods of collecting data: methods such as: (1) interviewing (unstructured, structured but open ended; or structured and closed ended); (2) questionnaires; (3) observations; and (4) focused group interviews;
- Methodology for conducting the assessment exercise: according to a methodology, the evaluator writes a case study document; and
- Results, analysis and recommendations: a meaningful implementation of the recommendations is a relevant phase in the organizational assessment exercise.

Concerning an organizational evaluation approach, information measures can be used to evaluate any kind of organization, since an organization is based upon interrelations among parts. Thus, "the *state* of a system is the set of values on some scale, numerical or otherwise, which its variables have at a given instant" and "if two parts are interrelated either quantitatively or qualitatively, knowledge of the state of one must yield some information about the state of the other" [Mil 78]. Next section analyzes intellectual capital and organizational related concepts in order to further understand *what* to observe and *why* measure.

2.3.2. Intellectual Capital Concepts

The actual economy is supported by information and communication technologies. Nowadays, the processing of information and creation of knowledge are the main sources of productivity, e.g. knowledge management, intellectual capital and organizational learning [AO 10]. Intellectual capital is composed of human capital (HC), structural capital (SC) and relational capital (RC).

In order to better understand what intellectual capital is, it is necessary to first know if an organization has *tangible* and *intangible* capital (See Section 1.1). Summarizing, *tangible capital* is what can be measured (e.g., the value of a product or service), and *intangible capital* is the result of the organization informal and non-contractual activities, such as interpersonal relationships, which tend to be ignored by the organization accounting systems. As stated, these intangibles can help and contribute to the organization's operational effectiveness. Therefore, in fact, **they are not intangibles** if they can be: "detectable as an amount, thus observable and measured"[Hub 10].

"The combination of all intangibles of an organization is intangible capital, also called *intellectual capital*"[AO 10]. From the book *The Knowledge Evolution*[Ale 97], Anklam summarizes[Pat 07]:

- *Human capital* is the knowledge, skills, and experience of the individuals required to provide solutions to customers, its core competency;
- *Structural capital* can be viewed as the internal procedures, processes, and internal organizational structures that have evolved to enable the organization to function as it does, for example, standard methods or heuristics passed on from person to person; and
- *Relational capital* is the value of an organization's relationships with customers, suppliers, and others it engages with to accomplish its business, for example, its access to specific markets or resources.

Figure 2.11 summarizes these concepts. "Many intangibles (e.g. relations) are not owned by organizations and it is hard to separate them from the HC and SC" [AO 10]. Also, "the value of intangibles can be difficult to identify through a financial transaction, and the use of nonfinancial indicators is a way to provide intangible capital measurement" [AO 10].

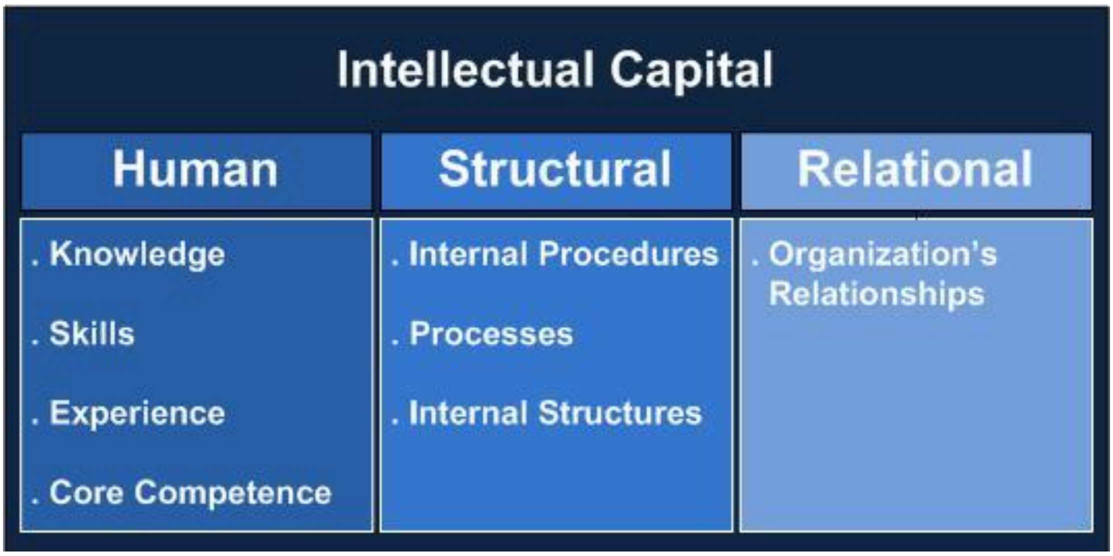


Figure 2.11 Intellectual Capital Types

"Knowledge is the critical resource in today's economy and is raw material. The raw materials of the knowledge era are knowledge-based intangibles" [AO 10]. Hence, HC, RC and SC are types of knowledge assets that become the raw material for innovation and value creation [AO 10]. As mentioned, an organization has tangible and intangible capital, but it is difficult to separate HC, RC and SC factors. The knowledge management (KM) captures these factors, which are necessary for the innovation and value creation processes. KM is an effort to benefit from the knowledge inherent to an organization by using it to achieve the organization's mission. "The transfer of tacit or implicit knowledge to explicit and accessible formats, the goal of many KM projects, is challenging, controversial, and endowed with ongoing management issues" [Mcl 02]. "The real promise of the knowledge economy comes in the creation of structural capital as the knowledge that is captured and institutionalized in an organization" [AO 10].Figure 2.12captures these concepts.

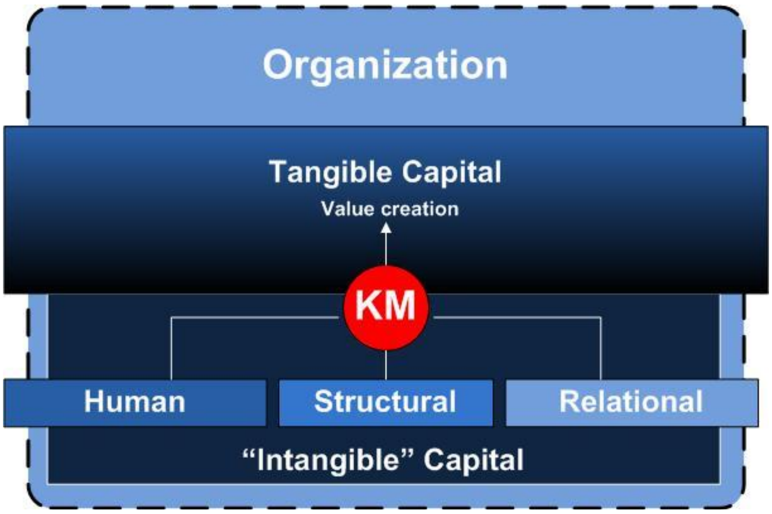


Figure 2.12 Organizational Tangible vs. "Intangible" Capital

KM started as "a core process and is becoming a core competence of all knowledge workers because they have to develop a better understanding of the information that they need at the work" [AO 10]. However, "knowledge assets are not captured in accounting systems and are almost invisible in other conventional forms of management information" [AO 10]. Another interesting perspective is: "Knowledge is an infinite asset, it can be a raw material or a very malleable product and a question may be: how to package this knowledge in a tangible form?" [AO 10]. Thus, "the future of manufacturing is less dependent on tangibles and more on intangibles such as trained workforce, a culture that supports continuous improvement, a network that maximizes the quality and cost of your total production process, and a structural knowledge that ensures consistency as well as serving as a launch pad for innovation" [AO 10]. We summarize intangible capital assets in organizations from [AO 10]:

Human Capital (People are an asset of the organization)

- **Competencies** (What is important in employees work)
- **Experience** (A guarantee of a high level of knowledge)
- **Longevity** (In employees it is no longer the norm, nor a requirement for stability and growth)
- **Attitude** (Makes the difference between effective and ineffective employees)
- **Management** (A manager's attitude can affect entire teams or the whole organization)

Structural Capital (Knowledge captured and institutionalized in the organization. A successful business has standardized processes and shared knowledge that stays in the company when people go home)

- **Culture** (Hard to define but everyone knows it is there. Can be a productive or a destructive force in organization)
- **Organizational Knowledge** (An explicit form of structural capital)
- **Intellectual Property** (Specific types of structural knowledge with a special legal status, e.g. patents, trademarks, copyrights, trade secrets)
- **Process** (E.g. capturing best practices is an automated process. A lot of process occurs inside of people's heads and can be harder to see and measure)
- **Knowledge Management** (KM become a core competence of knowledge workers. Social media can be seen as a tool for real-time knowledge access)

Relational Capital (Every company has a unique set of knowledge assets and this uniqueness extends to its combination of working and personal relationships)

- **Customers** (The shared understanding of each other's business; e.g. history, culture, product, service requirements, market position, and goals)
- **Partners** (Increased outsourcing, better linking of systems, the need for co-creation and innovation. Value creation partnerships are core business related. The relationship capital becomes part of knowledge capital)
- **Brands and Reputation** (Assets of the modern organization. Brand is how customers see products and reputation is how all stakeholders view the entire operation. Shared knowledge is part of the relationship capital)

After knowing *what* to observe and *why* to measure, based on current approaches, the next sections will describe *how* intellectual capital can be measured. In this sense, several challenges and limitations are uncovered.

2.3.3. Intellectual Capital Measurement Challenges

As strongly stated before, the focus of our research is related with the challenge of how to measure the relational capital of an organization. There are three basics challenges associated with intellectual capital [Buo 03][Gre 99]. In essence, how it is possible to:

- **Value** (measure) intangibles better;
- **Create more value** (i.e. invest and manage) from intangible capital; and
- **Retain** more (conversion) of this capital?

These questions are still a challenge. Mary Adams and Michel Oleksak [AO 10] argue that "In Europe and Asia, a number of tools have been created by governments as part of competitive initiatives to help training managers in small and medium-sized enterprises (SMEs) so that they can leverage their knowledge capital". However, to date, "there is no dominant model for intellectual capital assessment" [AO 10]. Also, Zadjabbari argues that "There is a lack of standard metric method to measure this kind of knowledge and assets" [ZWH 08].

So, when trying to solve this problem in order to create an IC assessment system, the main parameters are [AO 10]:

- **Scope**, after defining the scope (e.g., human, relationship or structural capital) it is possible to evaluate and measure intangibles;
- **Rating System**, this can be extremely valuable for transforming the data into actionable goals (e.g., using a rating scale from 1 to 10 or letter grades such as A, B, C, etc.); and
- **Standard of Measurement** in all the assessments within the organization in order to achieve a cohesive picture.

"Measurement can be seen as a result of observations that quantitatively reduce uncertainty. A reduction, not necessarily elimination of uncertainty will suffice for a measurement because it is an improvement on prior knowledge" [Hub 10]. Toward a universal approach to measurement intangibles in business, Douglas Hubbard recommends a five step framework [Hub 10]. We identify these steps as:

1. Define a decision problem and the relevant uncertainties (The first question is "What is your dilemma?"; Define all the variables relevant to the dilemma);
2. Determine what you know (Quantify uncertainty about unknown quantities in the identified question. E.g., ranges and probabilities);
3. Compute the value of additional information (Information has value because it reduces risk in decisions);
4. Apply the relevant measurement instruments (E.g., random sampling, controlled experiments);
5. Make a decision and act on it. Return to step 1 and repeat.

"Even when some amount of error is unavoidable, it can be an improvement on prior knowledge of a system" [Hub 10]. As stated, a measurement does not have to eliminate uncertainty [Hub 10] for that we consider the measurement definition from Hubbard: "A quantitatively expressed reduction of uncertainty based on one or more observations" [Hub 10].

2.3.4. Methods for Measuring Intellectual Capital

Researches of measuring the intellectual capital of organizations have produced several methods and theories over the last years. An overview of intangible measuring theories can be found in [Sve 10] and also in [Bon 01].

According to Sveiby, the main problem with measurement systems is that it is not possible to measure social phenomena with anything close to scientific accuracy. Thus, "all measurement systems have to rely on proxies, such as dollars, euros, and other indicators" [Sve 10]. Moreover, "the common reason for measuring and reporting is to improve internal performance, i.e. management control. However, the problem is that people don't like to be measured" [Sve 10].

Regarding Sveiby, we summarize four common approaches for measuring intangibles [Sve 10]:

- **Direct Intellectual Capital methods** (DIC) estimate the financial value of intangible assets by identifying its various components. Once these components are identified, they can be directly evaluated, either individually or as an aggregated coefficient;
- **Market Capitalization Methods** (MCM) calculate the difference between a company's market capitalization and its stockholder's equity as the value of its intellectual capital or intangible assets;

- **Return on Assets methods** (ROA) average pre-tax earnings of a company for a period of time divided by the average tangible assets of the company; and
- **Scorecard Methods** (SCM) the various components of intangible assets or intellectual capital are identified; indicators and indices are generated and reported in scorecards or as graphs.

Karl-Erik Sveiby method for measuring intangibles is the Intangible Assets Monitor (IAM). This is a method for measuring intangible assets and also a presentation format that displays a number of relevant indicators, which can be integrated in the management information system of the organization [Sve 01]. The choice of indicators depends on the company's strategy but the most important areas to cover are growth/renewal, innovation, efficiency and stability [Sve 01]. Figure 2.13 depicts the IAM adapted from [Sve 01].

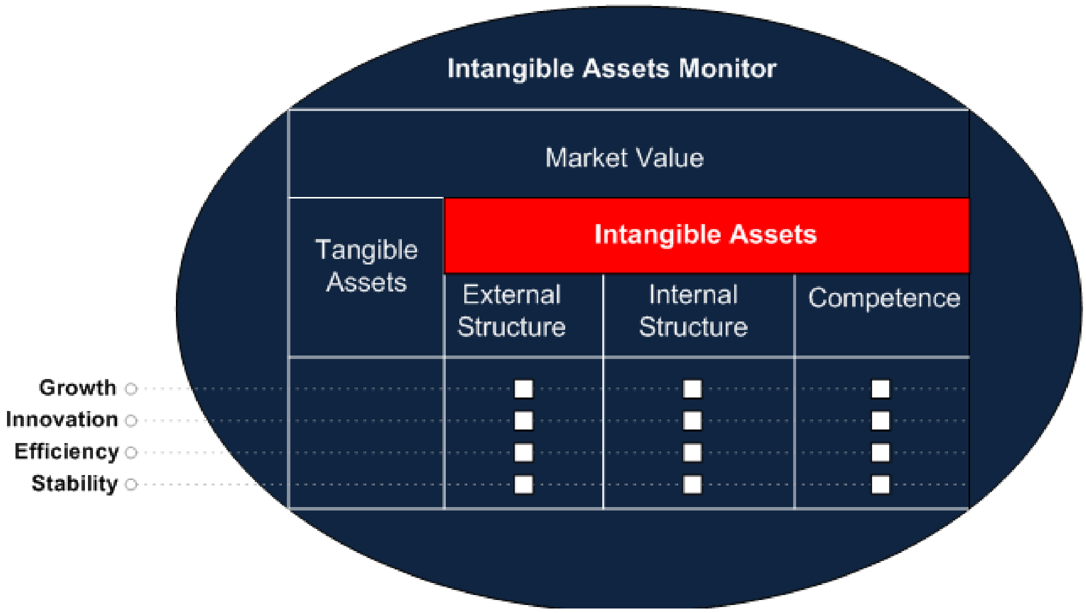


Figure 2.13 The Intangible Assets Monitor

For each area (*Growth*, *Innovation*, *Efficiency* and *Stability*), a set of indicators can be applied. "The idea is to peek into how the intangible assets are developing by designing indicators that correlate with the growth of the asset in question, its renewal rate, how efficiently we are using it, and the risk of losing it" [Sve 01]. The indicators of Table 2.5 are suggestions and examples to be applied in the IAM, which must be adjusted to the reality of each company.

Table 2.5 Sample of Intangible Assets Monitor (IAM) Indicators

	Intangible Assets		
	External Structure Indicators	**Internal Structure Indicators**	**Competence Indicators**
Growth	Organic growth	Investment in IT Investments in Internal Structure	Competence Index Number of years in the profession Level of education Competence turnover
Renewal/ Innovation	Image Enhancing Customers Sales to new customers	Organization Enhancing Customers Proportion of new products/services New processes implemented	Competence-Enhancing Customers Training and Education Costs Diversity
Efficiency/ Utilization	Profitability per Customer Sales per Customer Win/Loss Index	Proportion of Support Staff	Proportion of Professionals Leverage Effect Value Added per Professional Profit per Employee Profit per Professional
Risk/ Stability	Satisfied Customers Index Proportion of Big Customers Age Structure Devoted Customers Ratio Frequency of Repeated Orders	Values/Attitudes Index Age of organization Support Staff Turnover Rookie Ratio Seniority	Professionals Turnover Relative Pay Seniority

Alternatively, "Skandia is considered the first large company to have a truly coherent effort at measuring knowledge assets"[Bon 01]. In trying to use their experience to create a universal IC report, they recommend 112 metrics. As an example, we list a sample of Skandia IC measures [Bon 01]:

- Financial (Revenues/employee, revenues from new customers/total revenue, and profits resulting from new business operations);
- Customer (Days spent visiting customers, ratio of sales contacts to sales closed, and number of customers gained versus lost);
- Process (PCs/employee, IT capacity);
- Renewal and Development (Satisfied employee index, training expense/administrative expense, and average age of patents); and

- Human (Managers with advanced degrees, annual turnover of staff, and leadership index).

"There is no standard IC measures/metrics because every organization needs a unique understanding of which intangible assets are really valuable in the context" [Bon 01]. Some of the indicators are financial but it is possible to use nonfinancial indicators to provide the most basic parameters for intangible capital.

"The lack of a clear operating story in the financials means that is important to find nonfinancial indicators to enable an organization to track the progression of its work" [AO 10]. A sample of common nonfinancial indicators is listed [AO 10]:

- **Human Capital** (Number of full-time, part-time, and contract employees; employees' education level; training/certifications of employees; average tenure and/or turnover of employees);
- **Relational Capital** (For each key relationship type, such as with customers, vendors or partners: the size of relationship, relationship trend);
- **Structural Capital** (Process performance, intellectual property (IP) portfolio such as number of patents, grouped by areas of expertise or number of licenses).

"Depending of the nature of the business there are hundreds of other indicators, the most important question for the manager is choose the appropriate ones to build a unique performance measurement system" [AO 10].

"In the current business performance methods, e.g. European Foundation for Quality Management model, or Skandia model, measuring indicators are not standard and are not widely used in organizations, although, in some models, the real asset values of different types of intellectual assets is not clearly defined"[ZWH 08]. Table 2.6 adapted from [ZWH 08], shows a comparison between different business performance models. This table shows that there are several models to evaluate intellectual capital with distinct approaches. There is no dominant model because every company has specific IC evaluation purposes. Also, there is a lack of standard metric tools used in these approaches.

Table 2.6 Business Performance Models Comparison

Model	Approach	Standard metric tools used	Categories
BSC	Strategy	No	Customer, Finance, Training, Process
Skandia	Human	No	Process, Human, Technology, Finance, Customer
IC Audit	Market and Human	Yes	Market, Human, Intellectual Property, Infrastructure
IAM	Internal And External Structure	No	Employees, Internal data (management, structure, systems software), External data (brand, suppliers, customers relations)
MVA and EVA	Add Value	Yes	Value add for capital budgeting, Financial planning, Goal setting, Performance management, Shareholder communication
Intellectual capitals based model	Knowledge Sharing and Trust	Yes	Market capital Social capital, Human capital, Physical capital

2.3.5. Discussion

To evaluate the relational capital of an organization it is necessary to know various methods of assessment. There are several evaluation methodologies for studying aspects such as economic impact or operational impact. However, there is a lack of methodologies for an organizational assessment that combine techniques derived from social network analysis with organizational aspects and its relation with intellectual capital. As stated: "many intangibles (e.g. relations) are not owned by organizations and it is hard to separate them from the HC and SC" [AO 10]. Human capital is strongly connected with relational capital. For example, regarding interpersonal proximity levels, certain relations may enhance knowledge sharing, thus the participants' human capital (e.g. competences) may increase. Therefore, to evaluate the relational capital of an organization, it is necessary to combine metrics that also include assessments of human capital and structural capital. This is not an easy task because evaluating "intangibles" may sometimes be a subjective process of reflection dependent on the analysis type, and, as observed, the analysis type can be very diverse (e.g. *financial evaluation vs. assessment of the organization's human capital)*. Evaluation scenarios include independent variables from different sources (e.g. financial, process, human capital) and thus, as stated earlier, there is a lack of standard metric for relational capital evaluation and monitoring.

The relational capital is an attribute of social networks, which are complex systems, and this implies that the participants' behavior is unpredictable. Thus, if we can define a metric to measure the relational capital, it is possible to monitor a given time state, but it is not possible to accurately predict its variation. As referred, a framework to evaluate the organizational performance must be able to assess four levels: (1) overall organization level; (2) unit level; (3) individual job level; and (4) relationships between jobs and units within the organization and also with other organizations [FAO 12]. These levels can be used in a relational capital evaluation system. E.g., from individuals to organizations. Thus, using several evaluation levels, it is possible to focus on a given level and predict the relational capital value variation under specific circumstances (E.g. See Section 1.2 and Section 2.2.4).

To develop a framework to monitor the relational capital of an organization, techniques derived from social network analysis should be combined with aspects of organizational assessment and consider dynamic properties from the social entities intellectual capital as well.

The big challenge remains: a relational capital evaluation system to answer questions like: *What is the value of this social network?* This is not an easy answer. The state of art analysis led us to conclude that any metric for assessing and monitoring the relational capital of an organization should include aspects of human capital and structural capital.

Chapter 3

SNARE-Language

Human vocabulary is still not capable, and probably never will be,
of knowing, recognizing, and communicating everything
that can be humanly experienced and felt.

José Saramago

Models try to tell a story that some interested parties can understand. To reflect reality, models are needed to better capture and represent social networks. Which model is needed to support organizational social network descriptions using a set of pre-defined contextual views, during the evaluation process of the relational capital in organizations? When analyzing the various techniques for social networks descriptions, the three most prevalent are: graph representations, matrices, and statistical models. As described in Section 2.1.6, these techniques are effective in most situations because they describe the entities of a social network and their connections.

In this chapter, we present the SNARE-Language that provides a representation for the structure of social networks and is able to capture network semantics. As stated in Section 1.6.2, SNARE-Language does not intent to replace techniques such as XML-based languages, but it helps the structural network design by providing a set of models, which can be extended and instantiated to any organizational context. Besides, the SNARE-Language meta-model is used as the basis for SNARE-Explorer main data structures, and, thus, it becomes the common ground of SNARE-Explorer and SNARE-Services. SNARE-Language includes a set of diagrammatic model elements, expressive to capture social network semantic concepts, unambiguous, and supported by UML CASE tools.

In Section 3.1 we describe SNARE-Language meta-model concepts: *SocialEntity*, *Relation*, *Role*, *Action and Event*, *RelationExtreme*, *ActionExtreme* and *EventExtreme*. These concepts enable us to model social network systems. Section 3.2 briefly shows how to use SNARE-Language to model a well-known professional social network scenario. In this section we also exemplify SNARE-Language roles application (Section 3.2.1), relations application (Section 3.2.2), and, actions and events application (Section 3.2.3). Finally, in Section 3.2.4, using SNARE-Language, specific scenarios are instantiated.

Section 3.3 presents final discussion regarding the relevance of SNARE-Language.

3.1. SNARE-Language Meta-Model

SNARE-Language supports the representation of social network structures using UML. The SNARE-Language is a descriptive method and itis the common ground for SNARE-System.

Currently SNARE-Language is defined as an UML profile with several concepts (stereotypes in the UML terminology) and constraints, as suggested in Figure 3.1, namely: *SocialEntity, Relation, Role, Action and Event*. Three additional concepts to support multiplicity and give flexibility were engineered: *RelationExtreme, ActionExtreme* and *EventExtreme*. The SNARE-Language meta-model structure ensures that relations, actions, and events can have multiple extreme instances.

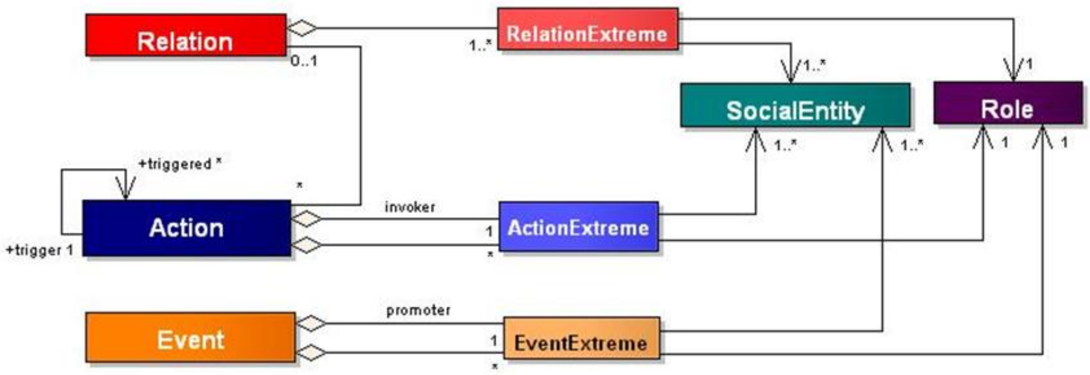


Figure 3.1 SNARE-Language Meta-Model

SocialEntity represents an entity, typically a person, but it can also represent an organizational unit, such as a department or even an organization in general terms.

Relation represents a kind of connection between two or more social entities and can be expressed in different ways, depending on the scope. For example, in the context of a family, we can consider relations such as *IsParentOf, IsChildOf, IsBrotherOf*. In an enterprise context other relations emerge, for example: *IsColleagueOf, IsManagerOf, IsCustomer* or *IsSupplier*. Still, in an academic context, we can find relations such as *Teaches*, *Mentors, IsStudentOf* or *ResearchWith*. The *Relation* concept encapsulates much of the semantic that characterizes the connection between social entities. However, it is not always a simple task to find the correct semantic to describe a relation. For example, if we consider the relation *IsColleagueOf*, the relation's semantic definition is easy since the relation is bidirectional. That is, if person A is a colleague of the person B, then B is also colleague of A. However, considering the family context, in the *IsParentOf* relation, we cannot concentrate all the semantics that characterizes the relation in a single class *Relation*. If A is the parent of B, we cannot say that B is the parent of A., i.e., the relation is not bidirectional. Each entity that participates in a *Relation* has a role. So, the *RelationExtreme* maintains the consistency of the connection as it allows us to differentiate roles in the same relation.

The *Role* concept supports semantic roles in a given context, e.g. *teacher*, *student*, *father*, *child*, *administrator or executive director*.

In social relations, there are sometimes different types of actions. The *Action* concept captures these flows between entities and the SNARE-Language makes it possible to keep track of the actions performed by social entities. For example, in an academic context, considering *ResearchesWith* relation, *WriteAnArticle* should be defined as an *Action.* Thus, the SNARE-Language allows us to keep track of all the articles written by participants on top of the *ResearchesWith* relation. The *Action* concept is applied to network actions, which we call *relational actions.* A *relational action* represents a flow triggered by social entities. An action instance can be viewed as an extension of Wasserman behavioral interaction concept, which is a relational tie [FF 94].

The *Event* concept describes events and associated entities. Social entities may attend social functions, participating in social activities, such as conferences and meetings. Events affiliate social entities depending on the type of entities involved [FF 94], e.g., *AnnualConference.*

As a final note, we would point out that associated to the key metaclasses *Relation*, *Action*, *Event*, *SocialEntity*, and *Role*, there is a correspondent metaclass, "…*Property*" (not represented in Figure 3.1 for the sake of simplicity), that can be used to further detail or enrich the specification of these classes.

3.2. Applying SNARE-Language

In this section, LinkedIn social network is used to show how to use the SNARE-Language. LinkedIn is a well-known online social network platform. It is used mostly for professional networking which allows registered users to maintain their own list of professional contacts they know and trust. The following figures show several SNARE-Language models regarding its application to the LinkedIn real scenario.

3.2.1. Entities and Roles

On LinkedIn several positions or educational issues may be described per person. A person can also have up to three references to personal web sites. In addition, a person can have several recommendations from other people (See Figure 3.2, which describes through SNARE-Language several LinkedIn social entity types).

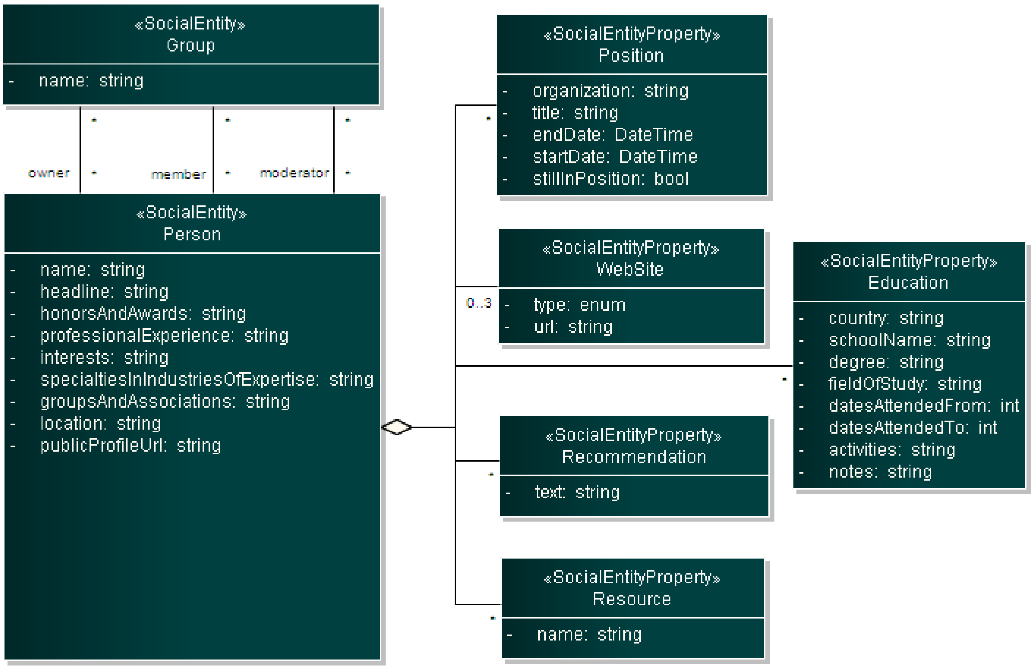


Figure 3.2 SNARE-Language LinkedIn Social Entities View

Besides, on LinkedIn people play different roles, commonly: *Friend* and *CompanyEmployee*. In most situations, the role of *Friend* is used when someone makes a direct invitation to another person. Typically, the person accepts a "Join to my network" request. Notwithstanding, the *CompanyEmployee* role emerges from the professional information profile of the person.

Figure 3.3 illustrates various roles that can be defined for LinkedIn. We can find more roles in this system. Let us consider a certain group within the network. Members can share the group without playing the *Friend* role as they just share the group and they have the common role *GroupMember*. A group is created by a member of the LinkedIn network. After inviting some friends or other people, this member can promote others to moderators of the group. Therefore, it is necessary to create two new roles in the system: *GroupOwner* and *GroupModerator*. As we can see, it is possible to extend the language in order to introduce these roles. Extend the role *GroupMember* to define *GroupOwner* and *GroupModerator* is a possible solution. Thus, the tasks performed by group owners and moderators can be characterized in their roles. Figure 3.3 depicts several hierarchical roles defined with SNARE-Language, which can be applied to LinkedIn.

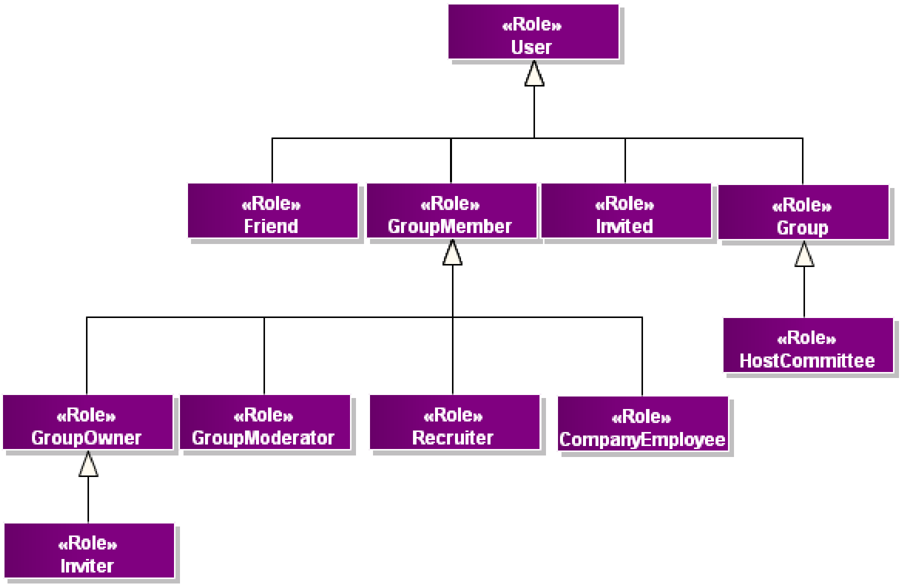
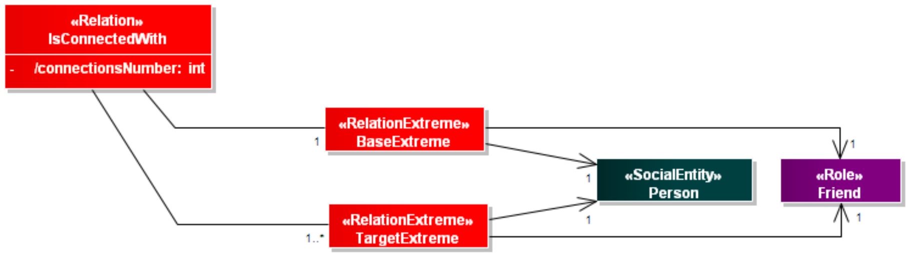


Figure 3.3 SNARE-Language LinkedIn Roles View

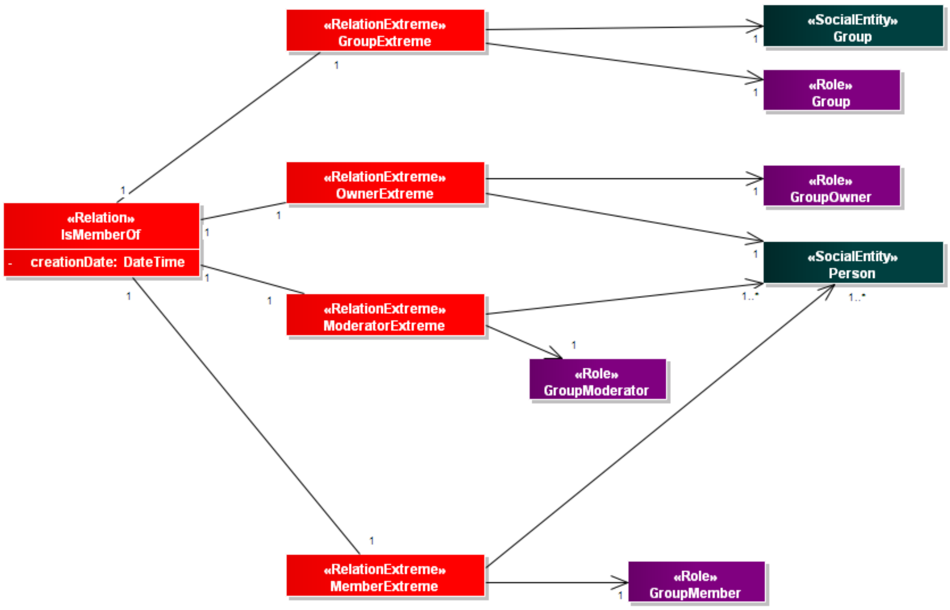
3.2.2. Relations

The *Relation* concept represents relations such as *Supervises*, *ResearchesWith*, or *Manages*. The *RelationExtreme* points to one or more social entities with the same role. In the same relation, it is possible to find entities with different roles and this is guaranteed through the multiplicities presented in the SNARE-Language. People have specific roles in the relation, e.g. one person can have the *Boss* role and one or more people are associated with the *Employee* role. With this language it is possible to add more *RelationExtreme* instances and, consequently, add new associated social entities and corresponding associated roles. Naturally, a social entity can play different roles in any social network.

A LinkedIn group may consist of one or more social entities. Figure 3.4 captures two of the core LinkedIn personal relations: a) *IsConnectedWith;* and b) *IsMemberOf*. In Figure 3.4 a), the usage of role *Friend* is depicted. In the example, all connected social entities are friends. In Figure 3.4 b) each member has a specific role. E.g., the figure shows a group, and several personal roles such as *GroupOwner*, *GroupModerator*, and *GroupMember*. Since all participants in the relation and respective roles are grouped under the *RelationExtreme* concept, this language ensures a high multiplicity level. No matter the number of group members, it is possible to specify a different role for each one. Then, the same person can play different roles according to the relation focus.



a)



b)

Figure 3.4 SNARE-Language LinkedIn Relations View

3.2.3. Actions and Events

When considering actions supported by LinkedIn, relevant *relational actions* are identified in Figure 3.5, Figure 3.6, and Figure 3.7. They correspond to: *InviteToJoinGroup*, *PostAJob*, and *RequestARecommendation relational actions*, respectively.

As mentioned earlier, a LinkedIn member can invite other members to join a particular group. In the following example, considering the invitation is addressed to a person, who does not belong to a given LinkedIn group, we apply the language to demonstrate the relational action *InviteToJoinGroup*. The

ActionExtreme invoker points to a person who has the *Inviter* role, i.e. a role derived from *GroupOwner* (see Figure 3.3). The target of this action points to a person who holds the *Invited* role (derived from *User).*

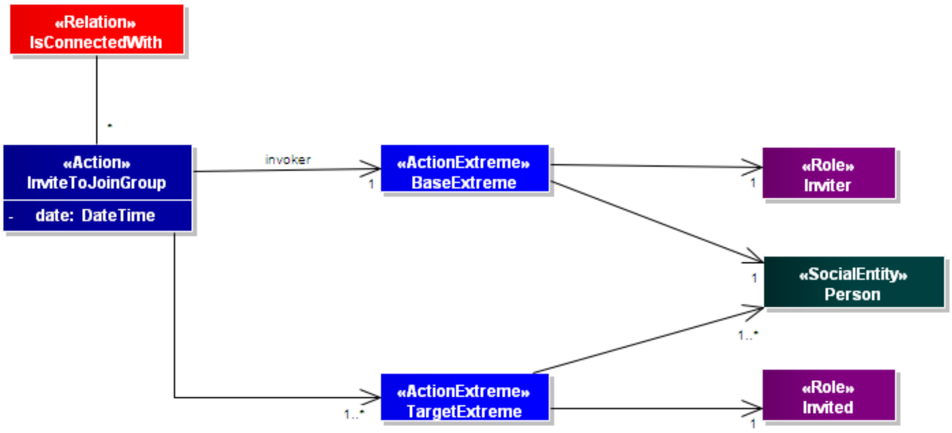


Figure 3.5 SNARE-Language Action "InviteToJoinGroup"

The LinkedIn network has a job board. Any member can submit an employment offer. A member may describe the job textually and submit the offer, or use the LinkedIn global job submission board. This board has a set of job information as described in Figure 3.6. When LinkedIn members submit the job, they do not know the potential candidates' identifications. The *PostAJob* action captures this concept.

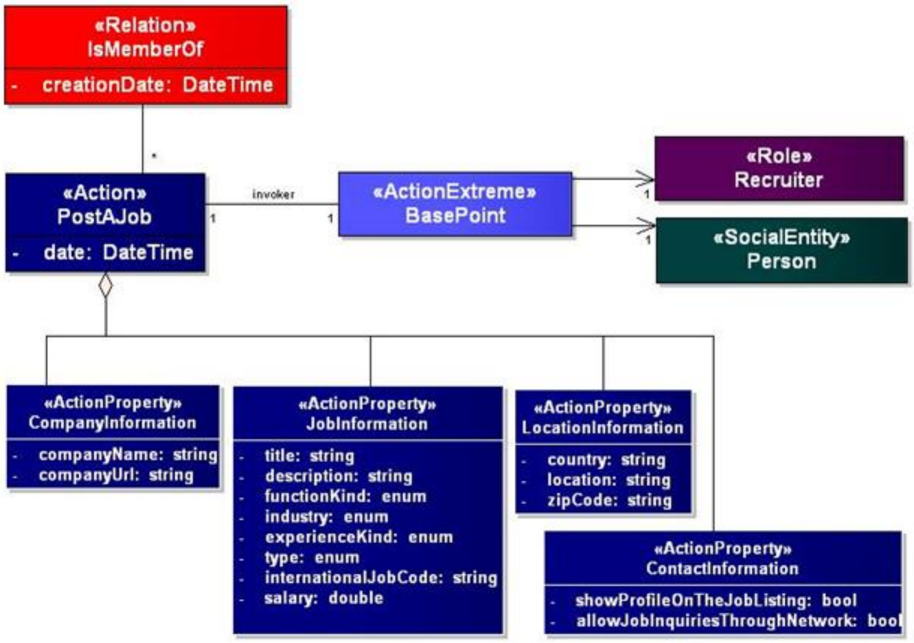


Figure 3.6 SNARE-Language Action "PostAJob"

Figure 3.7 depicts a recommendation request triggered by a social entity of type *Person* to all friends.

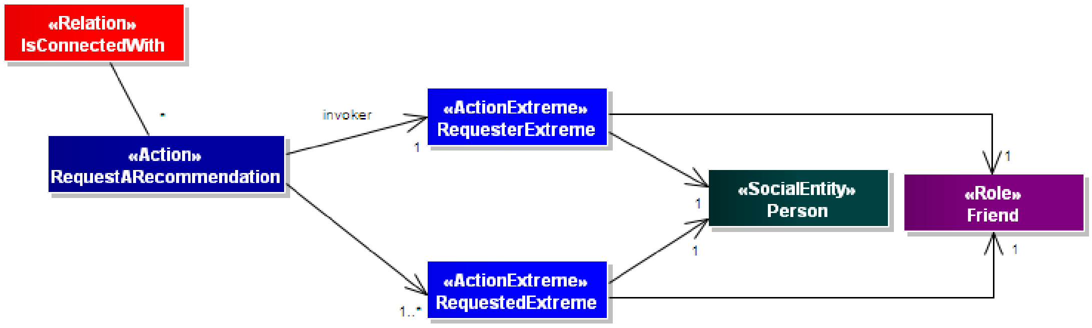


Figure 3.7 SNARE-Language Action "RequestARecommendation"

The *Event* concept describes events and associated entities. LinkedIn's entities may attend social functions, or belong to groups or subgroups. In SNARE-Language, an event must have an associated type and the language holds other user-defined attributes such as name, description, location, start date, and end date. One or more social entities with the same or different roles are aggregated by *EventExtremes*. Figure 3.8 represents an annual conference event. In this scenario, the event *promoter* is an organization group with the *HostCommittee* role. People are invited to the annual conference event by the host committee, which is a *Group* social entity.

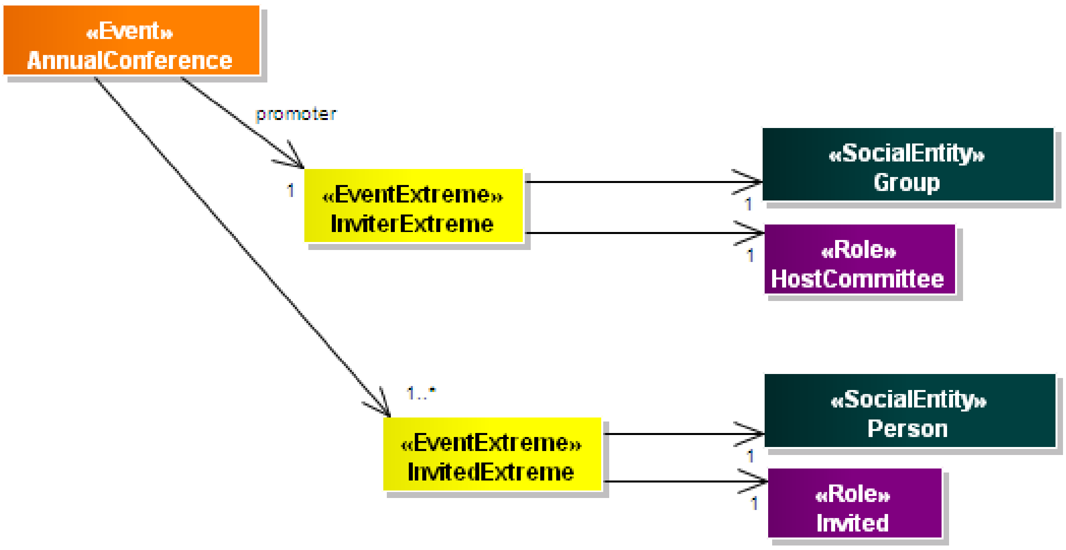


Figure 3.8 SNARE-Language Event
Example of "Group Annual Conference" Event

3.2.4. Specific Scenarios

Two specific social network scenarios are presented using SNARE-Language. First, there is a typical *IsMemberOf* relation scenario. Secondly, we have a set of actions triggered by social entities in a *IsConnectedWith* relation.

Figure 3.9 shows an example of the relation *IsMemberOf*. Several people share the same group, namely the *InformationSystems* group. This is described through several *RelationExtreme*, which points to different people who have specific roles in the relation. As depicted, in the same relation, it is possible to find entities with different roles, and this is guaranteed through relation extremes. With this language, it is possible to add more *RelationExtreme* instances and, consequently, add new associated social entities and their respective associated roles.

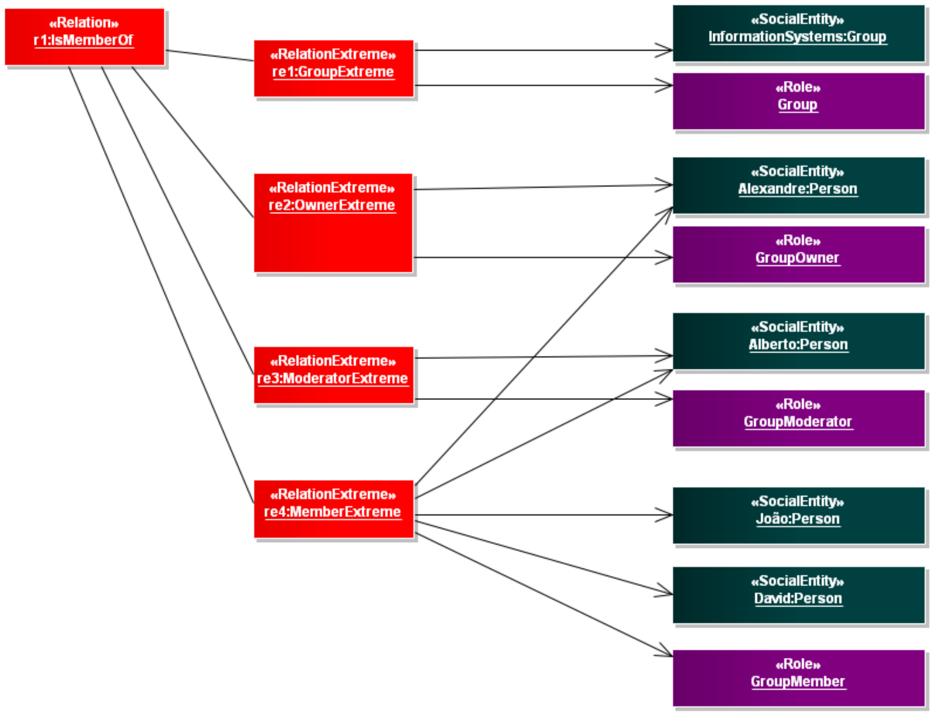


Figure 3.9 SNARE-Language "IsMemberOf" Relation Scenario

There are actions associated to specific relations, which we call *relational actions* as previously stated. An *Action* can be triggered by a social entity *invoker* to an unbounded group of social entities, i.e. a collection of all entities to which ties are to be considered. Consequently, relational data analysis algorithms may be applied to *Action* instances. Multiple actions may be part of some kind of relation and the *ActionExtreme* associates social entities with a role. Considering a specific relation *IsConnectedWith*, Figure 3.10 shows the *RequestARecommendation* triggered action. Multiple actions

RequestARecommendation are part of *IsConnectedWith* relation. The *invoker* of *RequestARecommendation* action is the person *David* who holds the *Friend* role. The relation extremes point to all people who have submitted to the *invoker* action, in this case *Alberto*, *Alexandre*, and *João* social entities, who will write a recommendation for *David*. Note that it is possible to include more *Action* instances in this particular *Relation*.

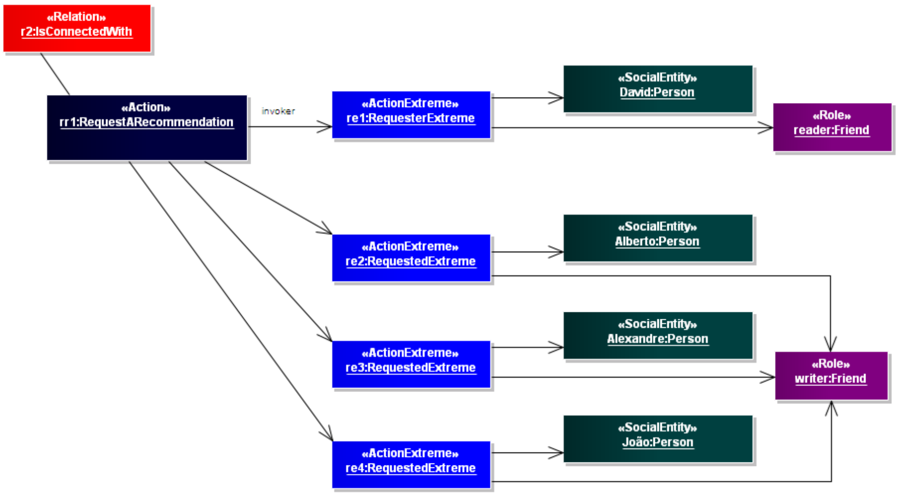


Figure 3.10 SNARE-Language "RequestARecommendation" Scenario

3.3. Discussion

As an informal descriptive method, the SNARE-Language is the common ground of SNARE-Framework, and includes a collection of diagrammatic elements. These elements are able of capturing social networks. The SNARE-Language is defined as an UML profile and can be applied to several organizational domains.

With the SNARE-Language's main concepts - *SocialEntity, Relation, Role, Action and Event* -, it is possible to graphically design social entities (e.g., people, organizational units, or even organizations) and the relations among them, i.e. any type of connection between two or more social entities. The *Relation* concept not only sums up much of the semantics that characterize the connection between social entities, but also provides a solution to support the representation of any real-world connection due to the *RelationExtreme* concept. This concept gives flexibility to define any type of relation, and maintains the connection's consistency as it allows us to differentiate roles in the same relation.

In social relations, different types of actions are performed by participants, and through the *Action* concept, SNARE-Language makes it possible to keep track actions performed by social entities. Additionally, social entities also participate in events, and to support modeling this kind of facts, the SNARE-Language includes the *Event* concept.

As mentioned, SNARE-Language is defined as an UML profile.UML is a standard general-purpose modeling language in the field of object-oriented software engineering, and it is used to specify visual models of real-world systems, through a set of graphic notation techniques, such as class diagrams. Class diagrams can be used for conceptual modeling of object-oriented applications as well as for data modeling. SNARE-Language diagrams describe the structure of a social network by showing the system's classes, their attributes, and the relationships among the classes. Through several views - such as *Social Entities View*, *Roles View*, *Relational View*, *Actions View, and Events View* - SNARE-Language describes organizational social network structures. In addition, object diagrams can be used to show a partial view of the system's instances at a specific time, i.e. they are suitable for describing specific scenarios, as exemplified in Section 3.2.4.

As stated in Chapter 2, XML languages support defining and using data formats. Aiming to exemplify a comparative discussion of these languages and the SNARE-Language, we chose two XML-based languages used specifically to describe networks, namely: GraphML [GP 11] and DyNetML [CASOS 11_b] (these languages were both introduced in Section 2.1.2).

When compared to other social network matrix-based representations, representing social network data with XML-based languages allows us to import or export hierarchical structures in a more understandable way. Thus, GraphML and DyNetML are good approaches to represent social network data. SNARE-Language models are ready to stand for all network relations, and they are focused on describing entities, such as departments or employees, as well as inherent organizational relations and the attributes between them.

As mentioned earlier, the richness of the SNARE-Language to model social networks comes from the flexibility to combine its stereotypes. The flexibility is expressed by all possible links that may exist in a network. Thus, in the context of a *LinkedIn* network, consider the SNARE-Language *IsConnectedWith Relation View* example previously depicted in Figure 3.4 a). Figure 3.11 depicts the *GraphML Metamodel*. Each *GraphML* entity holds several graphs. A *Graph* contains a list of nodes and edges. What's more, each *Node* and *Edge* can have *Data* elements to support specific attributes; e.g., each *Node* has an ID and each edge connects two nodes with *source* and *target* attributes. The relation *IsConnectedWith* can be encapsulated in the *Graph* concept and social entities may be represented using the GraphML *Edge/Node* elements. Moreover, each edge can hold data for describing the role of *source* and *target* nodes respectively.

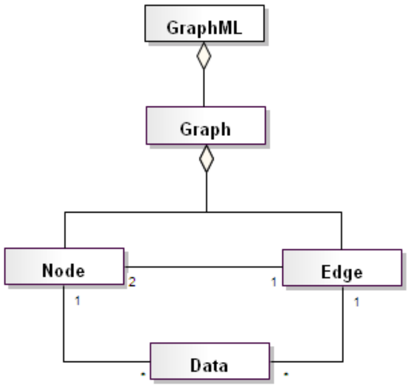


Figure 3.11 GraphML Metamodel

Figure 3.12 depicts the *DyNetML metamodel*[16]. Each *DynamicMetaNetwork* entity holds several *MetaNetworks*. Each *MetaNetwork* holds a list of *PropertyIdentity* elements, *Nodes*, and *Networks*. While *a Nodes* element points to one or several *NodeClass* elements that may have type attributes (e.g. *Agent*), each *NodeClass* element holds a set of *Node* elements to represent social entities. *Networks* hold a list of *Network* elements, which can be used to support the *Relation* concept, i.e. each *Network* instance can represent a specific relation through a set of *Link* elements, each of which pointing to two *Node* elements by using *target* and *source* attributes.

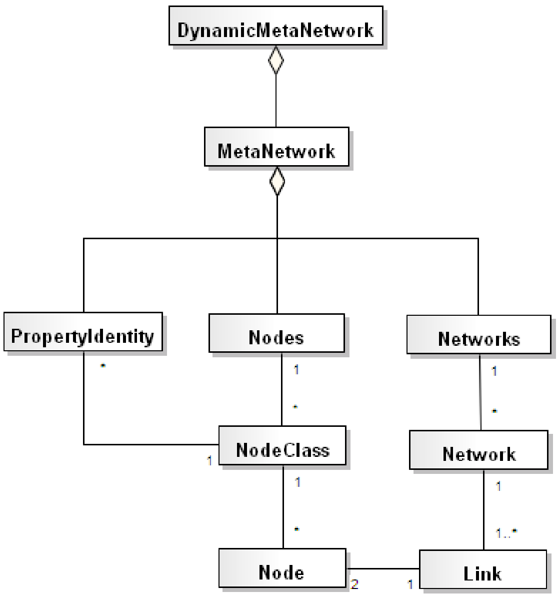


Figure 3.12 DyNetML Metamodel

[16] It is a good practice to use singular nouns for class names. However, the UML example strictly represents *DyNetML* structural elements with original names. For further information about general UML class diagram guidelines visit:
http://www.agilemodeling.com/style/classDiagram.htm(accessed on July 26th, 2012)

When using SNARE-Language to model a social network structure, the starting conceptual focus is the *Relation, SocialEntity* and *Role* concepts. From our point of view, these are the basic concepts to better *think* a social network. On the one hand, to model a social network structure, languages such as GraphML and DyNetML (as depicted in Figures 3.11 and 3.12) focus correspondingly on the *Graph* and *Network* concepts, which are naturally inspired on graph theory description approaches. On the other hand, regarding the presented XML structural views, concepts such as social entities and roles can be described within nodes or edges element data attributes.

Despite there being XML-based languages, with SNARE-Language it is possible to better visualize and describe real-world social networks, especially when regarding relational semantics first hand, through the *Relation, SocialEntity* and *Role* concepts and other diagrammatic extensible elements.

As introduced in the beginning of this chapter, SNARE-Language does not intent to replace existing languages for social network representation, such as XML-based languages. However, it does intend to improve the visualization of these social network designs by using UML-based CASE tools.

Considering the focus on relational concepts, the SNARE-Language is suitable to specifically describe and visualize social networks structures based on three modeling levels: 1) *meta-model level* (as depicted in Figure 3.1); 2) *type level* ; and 3) *instance level*.

Chapter 4

SNARE-RCO Model

Every problem has a gift for you in its hands.

Richard Bach

In Chapter 3, we present the SNARE-Language, which provides a representation for the abstract structure to model social networks and is able to capture network semantics. The relational capital is an attribute that can be derived from social networks. As referred in Section 2.3.5, there is a lack of methodologies for organizational assessment that combine techniques derived from social network analysis with organizational aspects and its relation with intellectual capital. Namely, techniques that help us answer questions like: *What is the value of this social network?* That is how to measure the relational capital of social networks that are already a part of the organizational units of an organization, content management systems, or social media platforms? To answer such questions, we present in this chapter the SNARE-RCO model from which it is possible to extract the relational capital value (RCV) of organizational networks.

After an introduction in Section 4.1, the process of defining and classifying parameters is described in Section 4.2. The RCV compute process and RCV formulas are presented in Section 4.3. Finally, in Section 4.4, a discussion about SNARE-RCO key-concepts is given, and, for analysts who do not have a deep SNA knowledge, a set of guidelines is provided to help SNARE-RCO model instantiation in organizations.

4.1. Introduction

Organizations have social networks. The value of a social network represents a contribution to satisfy a given *demand*. This demand is conducted by its social entities. In this sense, the value of a relation reflects the link between a thing (a good or service) and at least two social entities that are connected in a given context. Then, in general terms, there is an offer made by a social entity with *producer* role and a demand from a social entity with *consumer* role.

Figure 4.1 shows, using the SNARE-Language, an example for the "*Ask For Help*" relation. Each *AskForHelp* relation points to one or more *BaseMember*, and to a *TargetMember*. A *BaseMember* refers to a social entity *Person* with the *Consumer* role while a *TargetMember* is a social entity *Person* with the *Producer* role. Each *Person* has *tangible* and *intangible* value.

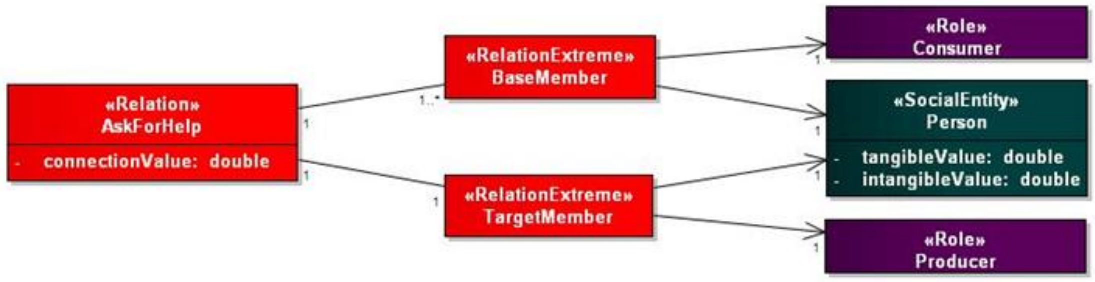


Figure 4.1 SNARE-RCO AskForHelp Relation Model

Considering Figure 4.2, in the social link *r1*, social entity A has a *consumer* role and social entity B has the *producer* role. SNARE-RCO has a function to compute the connection value between social entity A and social entity B. The value of the connection is formed from the *demand,* i.e. from the satisfaction that the good or service represents to the social entity A *consumer*. Naturally, social entity B can assume a *consumer* role and social entity A can play a *producer* role. The social link *r2* in Figure 4.2 depicts this concept.

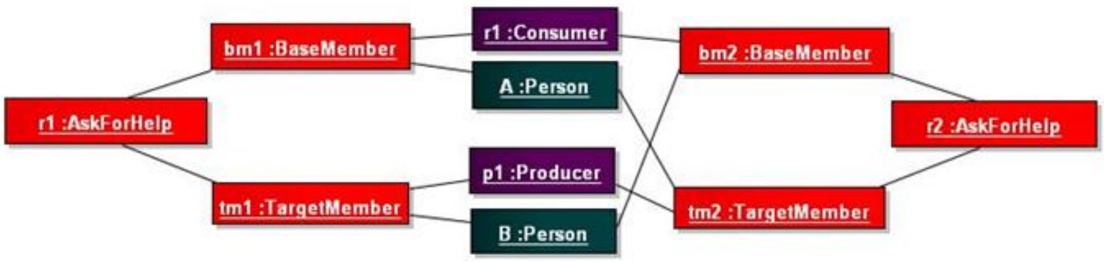


Figure 4.2 SNARE-RCO AskForHelp Specific Relation

To identify and assess the relational capital of an organization, it is necessary to identify the value of all its relations among all its social entities, which are social network members. Even when a social entity is isolated in the organization network, it holds tangible (e.g., goods or services) and/or intangible (e.g., competences or skills) value that can stimulate future connections (*demands*), thus contributing to the whole relational capital value of the organization.

Monitoring is understood as the act of measuring or being aware of the status of a given system, and the aim of measuring and evaluating is to reduce the uncertainty of the value of a given social network based on one or more observations. To observe and evaluate the Relational Capital Value (RCV) of a given organization, this model proposes distinct kinds of assessment inputs, namely: *organizational factors*, *network factors*, *social entity factors*, and *relational factors*. These inputs are dynamic parameters, i.e. they are defined by the *Analyst*. In Section 4.2 we describe the process of defining and classifying these inputs and, in Section 4.3, regarding *tangible* and *"intangible"* parameters, we describe the method to evaluate the relational capital of an organization, i.e. to compute the relational capital value of an organization.

4.2. Defining and Classifying Parameters

First, the SNARE-RCO model considers the following set of parameters: Organizational Valuable Factors (OVF), Network Valuable Factors (NVF), and Social Entity Valuable Factors (SEVF). These factors depend on the target organization. For each factor, weights can be defined according to their importance to compute a final sum. These weights are multiplied by the values of the parameters. OVF, NVF and SEVF weights ranges are defined by the *Analyst* (To illustrate the following examples, we considered weights ranging from 1 to 5).

Organizational Valuable Factors (OVF) are attributes of the organization, for example: the number of active customers; number of partners; and number of brands. Table 4.1 exemplifies the applied system of weights and the calculation of its total (OVF)

Network Valuable Factors (NVF) are properties of the organization's social network. These properties can be derived from analysis of social networks, for example the *size* and *density*[17] (See Table 4.2). Network size is measured by the number of nodes: if there are n nodes, then the maximum possible number of undirected links is n (n-1)/2. We considered n = 200 employees. Network density is the proportion of ties in a network compared to the total number possible.

Social Entity Valuable Factors (SEVF) are properties that are assigned to each social entity. The *Analyst* can use properties from the analysis of social networks, such as *centrality indegree* or *centrality outdegree*. The *Analyst* can also consider human capital properties. These properties are role dependent and

[17]Considering Kathleen M. Carley, a set of measures such as the *size of the network and density* are generally not correlated, but they scale well, and are key in characterizing a network [Car 03].

may result from previous HR management analysis, like questionnaires or other evaluation techniques.

To illustrate this application (See Table 4.3), we consider 5 human capital properties: analytical problem solving, creativity and innovation, problem diagnosis and solution, technical expertise, and time management.

After defining organizational valuable factors, network valuable factors, and the social entity valuable factors, we have to outline a weighting system to compute the relations value. It is necessary to define the **Relation Type Values (RTV)** and the **Relational Levels Values (RLV)**. These relations must be actionable for analysts after the results are disclosed. To illustrate this, we chose two types of collaborative relations, as described in Table 4.4. These questions were extracted from Cross and Parker [CP 04] (see Appendix C) and for each relation type between two social entities, we defined values to be used to compute the relational capital. A relational level is a classification to characterize the proximity between two social entities. The average value (*Regular*) can be assumed by default. A higher relational level between two entities can enhance the relational capital of the organization. Table 4.5 describes the relational levels' values from our framework to be used in order to compute the relational capital.

Table 4.1 Organizational Valuable Factors

Organizational Valuable Item	Value	Weight
Number of active customers	275	1
Number of partners	15	5
Number of brands	4	5
OVF =412500 (275*1)*(15*5)*(4*5)		

Table 4.2 Network Valuable Factors

Network Valuable Item	Value	Weight
Size	19900	1
Density	0.32	5
NVF = 31840 (19900*1)*(0.32*5)		

Table 4.3 Social Entity Valuable Factors

Social Entity Valuable Item	Value	Weight
Network properties (np)		
Centrality indegree (Absolute)	23	5
Centrality outdegree (Absolute)	16	2
		np=147 (23*5)+(16*2)
Human capital properties (hcp)		
Analytical Problem Solving	8	1
Creativity and Innovation	7	2
Problem Diagnosis and Solution	8	2
Technical Expertise	10	3
Time management	2	2
		hcp=72 (8*1)+(7*2)+(8*2)+(10*3)+(2*2)
SEVF=10584 (np*hcp)		

Table 4.4 Relation Type Values

Relation Type	Value
Collaboration/Information relation type *E.g. "From whom do you typically seek work-related information?"*	2
Collaboration/Problem solving relation type *E.g. "Who do you typically turn to for help in thinking through new challenging problem at work?"*	1

Table 4.5 Relational Levels Values

Relational Levels	Value
Very near	5
Near	4
Regular	3
Far	2
Very far	1

Finally, to allow calibration processes, the SNARE-RCO defines four weights: **Organizational weight (Ow)**; **Network weight (Nw)**; **Social Entity weight (SEw)**; and **Relational weight (Rw).** See Formula F.1 in the next section.

4.3. Evaluating relational capital

In this section we present the RCV computation process and its associated formulas.

4.3.1. Overview of RCV Compute Process

Figure 4.3 depicts an overview of SNARE-RCO organizational and network flows to compute the relational capital of an organization. From human capital (blue flows), SEVFs are computed using HCP and NP inputs. From relational capital (red flows), RVs are computed using RTV, RLV and SEVF inputs. Structural capital from the organization is strongly related with human and relational capital (blue and red flows). Finally, the RCV is computed using OVF (grey flow), NVF (red flow), SEVFs (blue flows), and RVs (red flows). RCV units are the RCO measurement units.

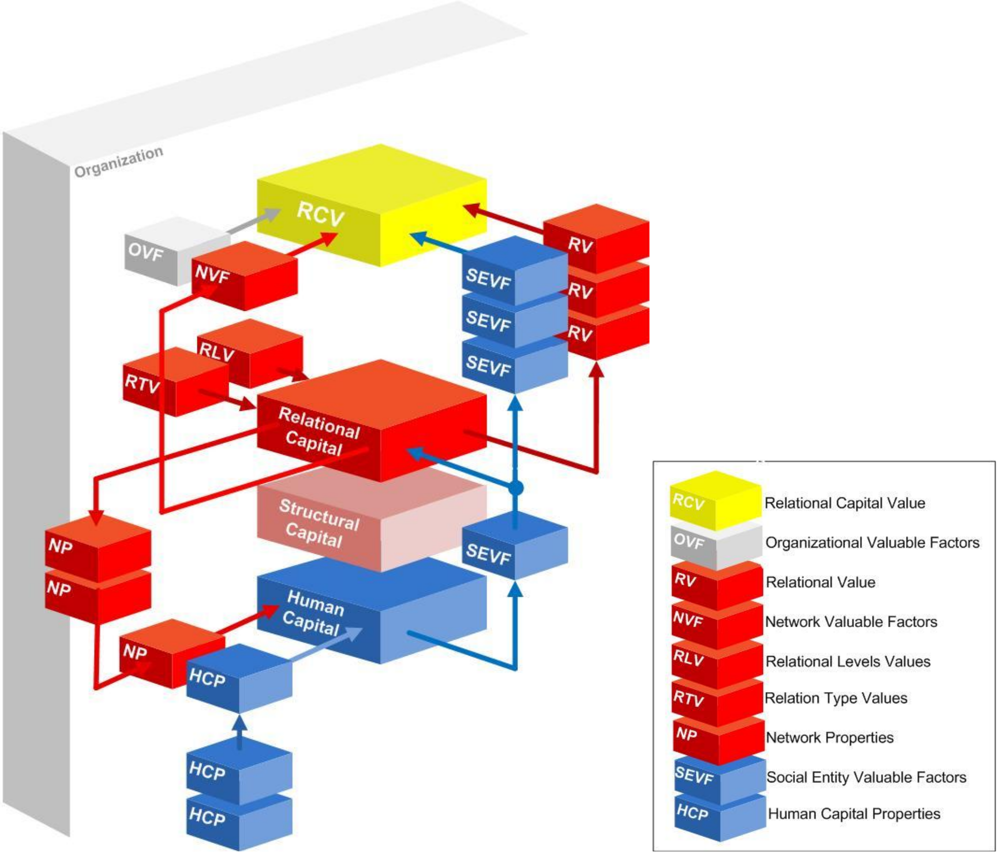


Figure 4.3 SNARE-RCO Flows to Compute RCV

4.3.2. RCV Formulas

The **Relational Capital Value (RCV)** of an organization is computed according the formula:

$$\boldsymbol{RCV} = Ow * \boldsymbol{OVF} + Nw * \boldsymbol{NVF} + SEw * \boldsymbol{SEVFsum} + Rw * \boldsymbol{RVsum} \qquad \text{(F.1)}$$

(Ow= organizational calibration weight, OVF= organizational valuable factors product, Nw= network calibration weight, NVF= network valuable factors product, SEw=social entities calibration weight, $SEVFsum$=social entities valuable factors sum, Rw=relational calibration weight and $RVsum$ = relational value from all network connections)

Where:

$$\boldsymbol{OVF} = \prod_{\boldsymbol{i=1}}^{\boldsymbol{totalOVF}} \boldsymbol{vOVI_i} * \boldsymbol{wOVI_i} \tag{F.2}$$

(totalOVF = total of organizational valuable factors, vOVI = value of organizational valuable item and wOVI = weight of organizational valuable item)

$$\boldsymbol{NVF} = \prod_{\boldsymbol{j=1}}^{\boldsymbol{totalNVF}} \boldsymbol{vNVI_j} * \boldsymbol{wNVI_j} \tag{F.3}$$

(totalNVF = total of network valuable factors, vNVI = value of network valuable item, and wNVI = weight of network valuable item)

$$\boldsymbol{SEVFsum} = \sum_{\boldsymbol{s=1}}^{\boldsymbol{totalSE}} \left(\boldsymbol{SEVF_{(s)}}\right) \tag{F.4}$$

(totalSE = total of social entities from the network and$SEVF_{(s)}$= network and human capital valuable factors from social entity s)

$$\boldsymbol{SEVF_{(X)}} = \left(\sum_{\boldsymbol{n=1}}^{\boldsymbol{totalNP_x}} \boldsymbol{vNP_n} * \boldsymbol{wNP_n}\right) * \left(\sum_{\boldsymbol{h=1}}^{\boldsymbol{totalHCP_x}} \boldsymbol{vHCP_h} * \boldsymbol{wHCP_h}\right) \tag{F.5}$$

($totalNP_x$= total of network properties of social entity X,$totalHCP_x$= total of human capital properties of social entity X, vNP = value of social entity network property item, wNP = weight of social entity network property item, vHCP = value of social entity human capital item and wHCP = weight of social entity human capital item)

$$\boldsymbol{RVsum} = \sum_{\boldsymbol{c=1}}^{\boldsymbol{totalC}} \left(\boldsymbol{RTV_c} * \left(\boldsymbol{RLV_c} * \boldsymbol{SEVF_{SocialEntity_{Producer}}}\right)\right) \tag{F.6}$$

For any connection $\boldsymbol{C}$ ($\boldsymbol{SocialEntity}_{\boldsymbol{Consumer}}$, $\boldsymbol{SocialEntity}_{\boldsymbol{Producer}}$)

(totalC = total of network dyadic connections, RTV_c = relation type value of connection c, RLV_c = relation level value of the connection c, $SEVF_{Social\ Entity\ Producer}$ = network and human capital valuable factors from connection social entity with role producer)

4.4. Discussion

SNARE-RCO is a relational capital evaluation model that allows us to measure the relational capital of social networks from organizational units to organizations, content management systems, or social media platforms (See the discussion provided in Section 7.4.1). Thus, using RCV measure units helps answer the question: *"What is the value of this social network?"* because it combines techniques derived from social network analysis with organizational aspects and its relation with intellectual capital.

Three key-concepts to compute the network RCV are: (1) *the value of a social network represents a contribution to satisfy a given demand; (2) this demand is conducted by its social entities*; and (3) *the value of relations in a given context reflects offers and demands from social entities*.

To compute the RCV, the definition and classification of parameters, such as OVF, NVF, NP, RTV, RLV, and HCP, may change depending on the type of analyzed network. This way, SNARE-RCO is flexible because it allows adapting model parameters definitions and classifications. Also, any of these parameters can be calibrated (even neutralized) depending on the *Analyst*'s analysis purposes.

Besides computing the overall network RCV, this model allows us to identify and compute other network aspects, such as the existing human capital value. This feature is important to perform human capital and relational capital comparative analyses. SNARE-RCO model shoulders a dependency between RV sum and SEVF sum; Figure 4.4 depicts this. Assuming NP neutral, and SEVF sum constant, if SEVF sum increases (A), then RV sum increases as well (A′). In addition, if SEVF sum decreases (B), then RV sum decreases (B′). Consequently, this affects the network RCV. Therefore, besides increasing OVF or NVF factors, if an organization aims at increasing its RCV value, there are ways to do so, such as: to increase SEVF sum, i.e. increase the social entity value from the network, or increase the RV sum, i.e. the network's relational capital. Naturally, SEVF is dependent on NP and HCP factors, thus, increasing these factors will also increase SEVF, and, consequently, the organizational RCV. Moreover, if the number of network connections increases, the network RCV will increase if *producer* entities, i.e. the *target* entities of directed relations, have positive SEVFs.

To start using SNARE-RCO model, analysts who do not have a deep SNA knowledge may follow a set of application guidelines to perform specific model instantiation at organizations. See Table 4.6 and Tables C.1 and C.2 from Appendix C. As described in Table 4.6, SNARE-RCO application guidelines are divided into four main groups: *Organizational Analysis*; *Network Analysis*; *Social Entity Analysis*; and *Relational Analysis*.

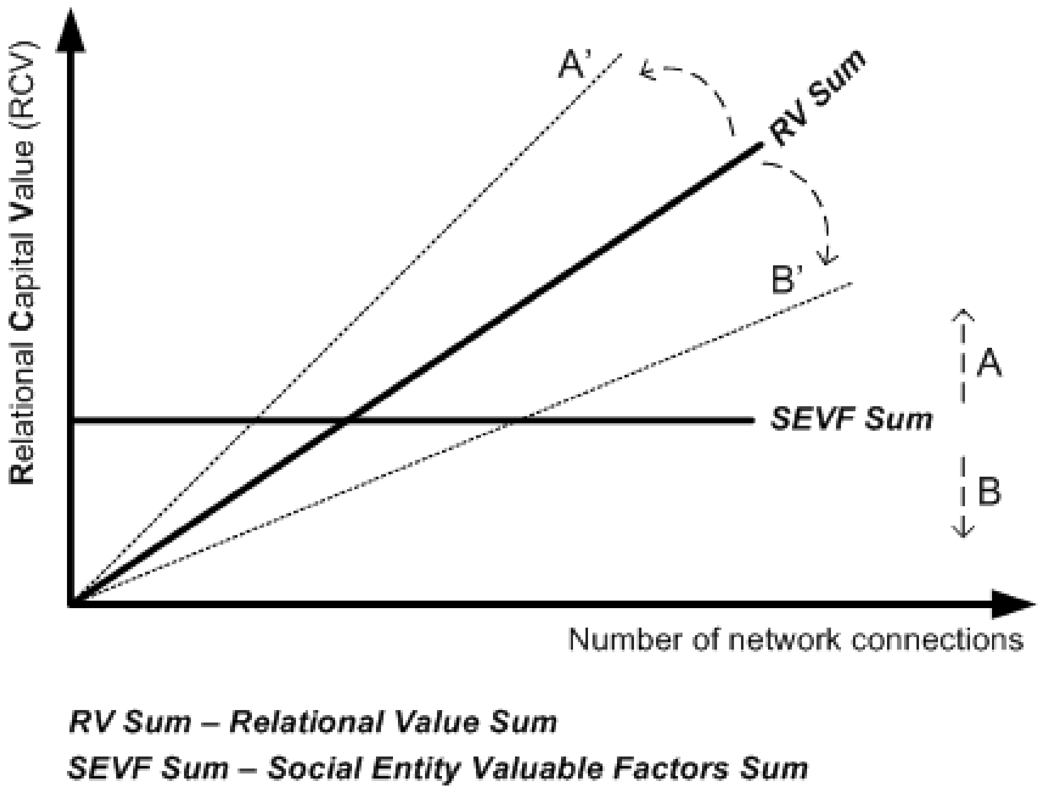


Figure 4.4 SNARE-RCO Relational Dependency from SEVF Value

Each organizational approach to perform network analysis is a specific case, nevertheless SNARE-RCO application guidelines provide several specific insights and suggests how to: (1) Identify the value of organizational attributes, so as to compute OVF; (2) Identify the value of members within a network regarding SNA metrics to compute NP; (3) Identify the value of network characteristics using SNA, in order to compute NVF; (4) Identify and measure the human capital value within a network, to compute HCP; (5) Analyze the value of human capital within a network also regarding its activity, centrality, and position, using SEVF; (6) Identify what relational flow types are to be valued and analyzed within a network, to define and set RTV; (7) Identify interpersonal relation levels that should be valued within a network, to define and set RLV; (8) Measure and analyze the value of network flows within a network, using RV; and (9) Identify the global relational capital value within a network, through RCV.

Table 4.6 SNARE-RCO Application Guidelines

Analysis Dimension	Application Guidelines
Organizational Analysis	
OVF	**Identify the value of organizational attributes.** Use global organizational indicators and structural capital properties such as: • Demographics • Culture • Organizational Knowledge • Intellectual Property • Process • Knowledge Management
Network Analysis	
NP	**Identify the value of members within a network regarding SNA metrics.** Use SNA metrics[18] to set NP and reveal individual aspects,like: *How highly connected is an entity within a network?* *What is an entity's overall importance in a network?* *How central is an entity within a network?* Compute SNA metrics for each network member such as: • Degree Centralities • Betweenness Centrality • Closeness • Eigenvalue • Hub and Authority
NVF	**Identify the value of network characteristics using SNA.** Use SNA metrics to set NVF and identify aspects such as: *How many members are within a network?* *What is the communication level within the network?* *How large is the network?* Use properties of the organization's social network, such as: • Number of network members • Network density • Network diameter
Social Entity Analysis	
HCP	**Identify and measure the human capital value within a network.** Use human capital evaluation indicators for each network member in dimensions,like: • Competencies • Experience • Longevity • Attitude • Management

[18] Please consult *Table C.2* - SNA Metrics to Detect Individual Roles *in Appendix C*.

Analysis Dimension	Application Guidelines
SEVF	**Analyze the value of human capital within a network regarding also its activity, centrality, and position.** Use computed metrics based on NP and HCP.
Relational Analysis	
RTV	**Identify what relational flow types are to be valued and analyzed within a network.** Define key relation types to analyze in areas, such as[19]: • Communication • Information • Problem Solving • Innovation • Access • Engagement • Decision making • Task flow • Power or influence • Liking • Friendship • Career support • Personal support • Energy • Trust
RLV	**Identify interpersonal relation levels to value within a network.** Define key relational levels values for each relation, such as: • Very near • Near • Regular • Far • Very far
RV	**Measure and analyze the value of network flows within a network.** Using computed metrics based on RTV, RLV, and SEVF settings.
RCV	**Identify the global relational capital value within a network.** Based on computed SNARE-RCO RCV top-level input parameters: OVF, NVF, SEVF Sum, and RV Sum.

Despite its application guidelines, regarding our experience, SNARE-RCO parameter weights may be defined using the following criteria:

- OVF, NP, NVF, HCP (Absolute values, weight=1. Relative values[20] weight =100);
- SEVF (NP, weight=1. HCP, weight=1);
- RTV (For each relation type value, set RTV=0,1. Use multiples of 0,1 to increase the relation type value regarding its importance[21]);

[19] See Table C1 - Questions to Uncover Important Network Relationships in Appendix C.
[20] Such as normalized or other indicators.
[21] E.g. $RTV_{ProblemSolving} = 0{,}1$ and $RTV_{\text{Innovation}} = 0{,}2$.

- RLV (Five range RLV[22], e.g. from 1 to 5, or consider RLV=1 if no relational levels are used to differentiate relational proximities);
- RCV (For each top-level parameter, weight=1. Use a complementary normalization of model parameters when comparing distinct networks).

When using SNARE-RCO, and considering specific contexts, the *Analyst* may develop specific criteria procedures to extract the relational capital value (RCV) of organizational networks. Moreover, the suggested application guidelines, may be employed in the scope of SNARE-Methodology (Described in Chapter 6), namely in the *Designing Process*, and more precisely, in the definition of *organizational analysis metrics*.

[22] More levels allowed.

Chapter 5

SNARE-Explorer

The machine does not isolate man from the great problems of nature but plunges him more deeply into them.

Antoine de Saint-Exupery

In Chapter 3, we presented the SNARE-Language, which provides an UML profile to visualize and describe structures of social networks and is able to capture network semantics. In Chapter 4 we proposed the SNARE-RCO model from which it is possible to determine the relational capital value of organizational networks. The next challenge is to find a way to analyze and monitor that relational capital value. To analyze and monitor is important for it allows us to better understand aspects, such as interpersonal relationships (informal or not), of an organization's social network. Thus, as previously stated, this knowledge can help organizations understand their own network and better achieve their objectives, concerning aspects such as: human relations, efficiency, quality, process improvement, and innovation. In this chapter we describe SNARE-Explorer, a prototype tool able to compute and monitor the relational capital value of organizational social networks, besides other features.

To analyze social networks, there are many tools and platforms and a review of those systems was provided in Section 2.1.5. However, despite there being social network tools to support high quality network visualizations and analysis procedures, in the scope of this research, we developed a prototype tool to specifically implement the SNARE-RCO model. The main motivation was to use and test a system to specifically analyze and monitor the relational capital of several networks, regarding precise organizational scenarios. Thus, this prototype tool is unique.

A detailed description of SNARE-Explorer's main features is provided in Appendix F. However, this chapter overviews technical aspects, such as components architecture and specific features to help analyze RCV. Section 5.1 presents the *Architecture Overview*; Section 5.2 summarizes the SNARE-Explorer's main features while Section 5.3 presents the RCV Monitor overview. Finally, in Section 5.4, a discussion is given on architectural and RCV prototype analysis and on monitoring issues.

5.1. Architecture Overview

SNARE-Explorer is developed with Java technology, throughNetBeans [23], which is an open-source IDE and an application platform that enables developers to create web, enterprise, desktop, and mobile applications using the Java platform.

Figure 5.1 overviews the SNARE components architecture. SNARE-Explorer is the Desktop-SNARE windows application and uses SNARE-Services system. SNARE-Services include a library and a database as showed in Figure 5.1. SNA algorithms are provided by SNARE Library, i.e. they are a set of algorithms which may analyze social networks to compute RCV.

Components interact with each other through provided and required interfaces. SNARE-Services provide two main interfaces: (1) interfaces to support external data integration; and (2) interfaces to support web and windows-based applications. SNARE-Language meta-model defines the data integration, and SNARE-Services has a built-in XML parser to handle social networks relational data, including relations, actions, events, social entities and roles. Through data integration mechanisms, SNARE-Explorer is able to extract and analyze social networks from information systems that were not originally designed with relational capital analysis features.

There are two approaches in SNARE architecture corresponding to two boundaries: (1) *Transparent,* to support the analysis of an information system without needing to change it; and (2) *Intrusive,* to support analysis depending on full access to a generic information system source code, thus needing to change it.

As suggested in Figure 5.1, in the *Transparent* approach, two components are connected: SNARE-Services and Information System (IS). The IS denotes a generic information target system. Thus, to extract *meta-data* and *data files* to be further processed, SNARE-Explorer is dependent on ETL procedures triggered by the IS side[24].

The *Intrusive* approach connects the Extended Information System (IS*), which is an IS refinement, to SNARE-Services. The IS* includes a SNARE-Plugin component to provide access to SNARE-Services operations[25].

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[23] Netbeans.org

[24] E.g. the *Analyst* must access the IS (with the IS *Manager*'s help) and perform ETL procedures using relational knowledge bases or other organizational databases, such as from ERP systems (See Section 6.4.4).

[25] Using web-services technology to provide database connection for information retrieval, SNARE-Web [Fre08] was the first target system to be accessed through SNARE-Explorer.

Besides these two approaches, SNARE-Services can be executed autonomously, i.e. through SNARE-Explorer user interface, it is possible to perform relational capital analysis tasks without the need of external information systems integration.

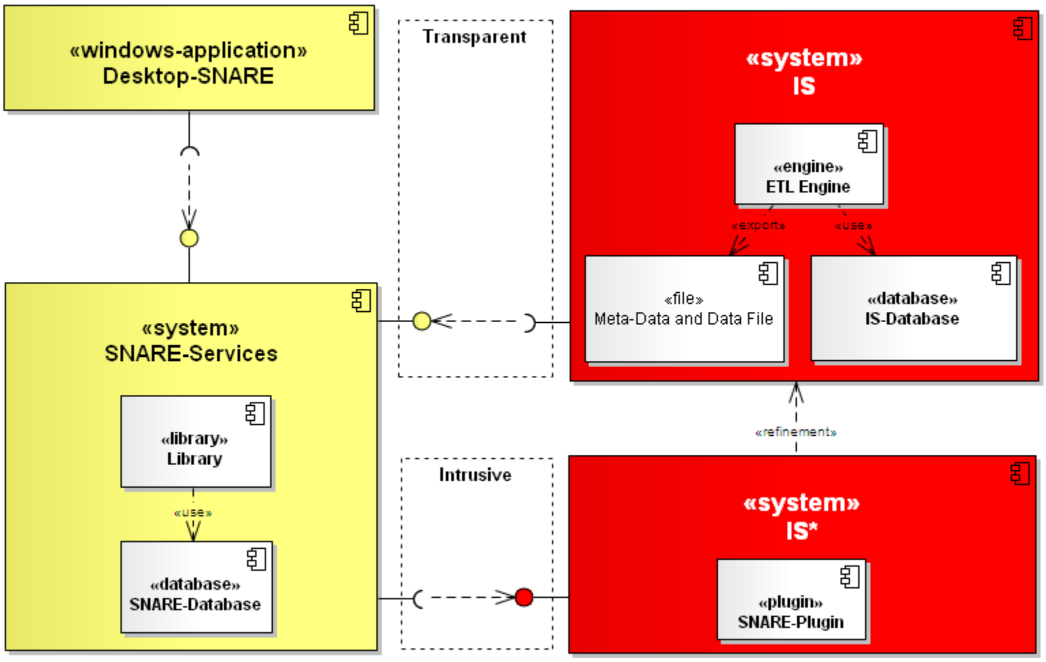


Figure 5.1 SNARE Components Architecture Overview

5.2. Features Overview

SNARE-Explorer allows editing, analyzing and monitoring multiple social networks. Thus, for each opened network, the *Analyst* can perform several operations. See Figure F.1 in Appendix F for a summary of the SNARE-Explorer's features, which are based on the following issues:

- Drawing selectors: to choose node type, edge type or relation level type;
- Drawing operations: to adjust the network layout manually or automatically;
- Edit/find tools: to select and edit nodes or edges, as well as to find, copy, paste and cut nodes or edges from a network;
- Analysis operations: to perform SNA operations, network statistics, and compute RCV; and
- I-O operations: to perform data import/export operations.

These features are supported by a multiple document interface (MDI) environment. A MDI system is the one whose windows reside under a single parent window, i.e. it allows child windows to embed other windows inside them as well. As an example see Figure 5.2 where the SNARE-Explorer MDI interface is depicted. Networks "Net 1" and "Net 2" were merged and, as a result, "Net 3" network was produced. Rotation operations were then applied and a new connection was added (from Node 105 to Node 4). MDI features help the *Analyst* edit and perform network simulations, such as splitting or merging scenarios to analyze the network RCV.

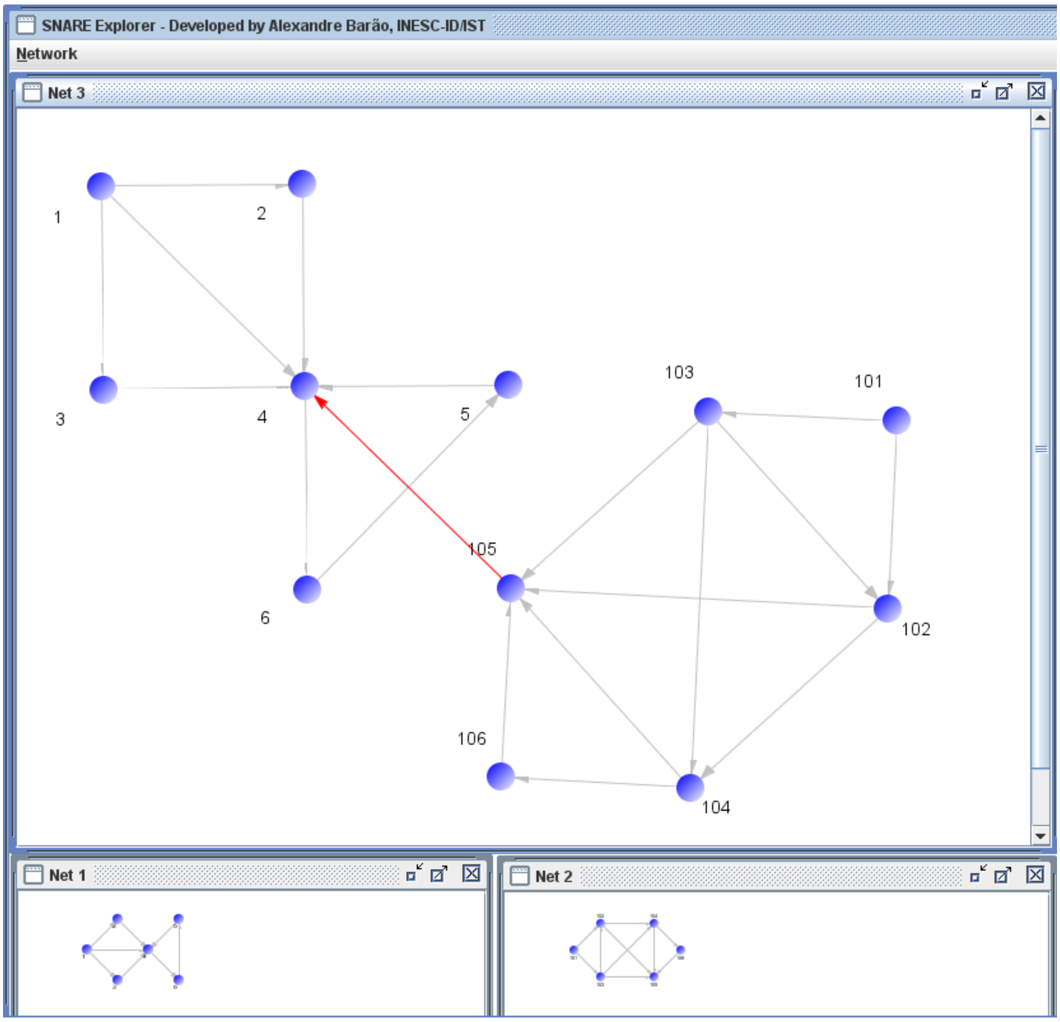


Figure 5.2 SNARE-Explorer MDI Interface

The SNARE-Explorer MDI system implements a vectorial system[26] and is able to automatically produce network views. When reading a network from a database, for example with hundreds of nodes, it is necessary to draw a graph automatically. The graph must meet aesthetic standards, minimizing crossing lines and representing nodes according to its centrality in the network. To achieve this, the Fruchterman-Reingold algorithm was used [FR 91]. The Fruchterman-Reingold algorithm is a force-directed layout algorithm[27], and SNARE-Explorer shows network nodes in space with as few crossing edges as possible, leaving the user (e.g., the *Analyst*) free to visually drag, cut, copy, insert or remove network nodes and edges to analyze RCV.

Besides reading a network from a database, it is possible to add nodes and edges directly, i.e. create organizational scenarios interactively in a given network window.

5.3. The RCV Monitor Overview

SNARE-Explorer implements the SNARE-RCO model to compute the relational capital value of organizational networks.

Regarding a target network, the SNARE-Explorer monitoring system, traces in real-time a log and a linear chart of computed RCV values to monitor RCV over time. The monitor log has the following information: *Date; Time; RCV value; OVF value; NVF value; SEVF Sum; RV Sum;* and *Ratio (RV/SEVF)*. Also, the monitor keeps information about the maximum values reached for each referred value[28]. Moreover, using SNARE-Explorer interface, the *Analyst* can define relation type values (RTV), relation level values (RLV), calibration weights (CW), organization valuable factors (OVF) and network valuable factors (NVF)[29]. SNA properties, such as network density and node indegree/outdegree, are computed by SNARE-Explorer. Human capital properties may also be customized by the *Analyst*.

Figure 5.3 depicts the RCV interface for monitoring the network “Net 1”. Besides the tool box (on the left), the window “Net 1” shows a graphical representation of the network (e.g., in a relation *Ask For Help*, six nodes and

[26] A vectorial system makes use of geometrical primitives such as points, lines, curves, shapes or polygons, which are based on mathematical formulas, to represent images in computer graphics. This kind of system has the advantage of image scalability without loss of image quality (resolution).

[27] The SNARE-Explorer uses a specific and modified version of this algorithm, namely to support the *cluster node* concept, which implied a change in attraction/repulsion heuristics. See *Automatic Graph Layout* and *Finding Homomorphic Cluster* topic in Appendix F.4.

[28] See *Starting the Relational Capital Monitor* in Appendix F.5

[29] See *SNARE-RCO Settings* in Appendix F.5

directed edges are represented). On the bottom, the window "RC Monitoring System" traces a line chart for network and a log for "Net 1"[30]. On the right, for each network node, the "Nodes" dialog window shows NP, HCP, and SEVF parameters. Moreover, the SEVF percentage strength for each node, regarding network SEVF Sum, is computed as well as the Minimum Connection Strength (MCS)[31].

The MCS is an indicator of *how much* RV Sum will increase (in percentage) <u>if</u> a new connection is specifically added to that node. Thus, to perform this kind of simulations, the *Analyst* can specifically set the RTV and RLV to compute and understand the MCS of distinct network members. E.g., in Figure 5.3, considering RTV = 1.0 ("t=1.0") and RLV = 1.0 ("l=1.0"), the Node ID 4 has MCS (%) = 40,541. Thus, if a new connection to Node ID 4 occurs, the network RV Sum will increase 40,541%. Figure 5.4 depicts the same network with a new *Ask For Help* connection from Node ID 7 to Node ID 4.As showed, the RV Sum has increased from 740 RCVs to 1040 RCVs and node properties were updated (including new MCS percentages).

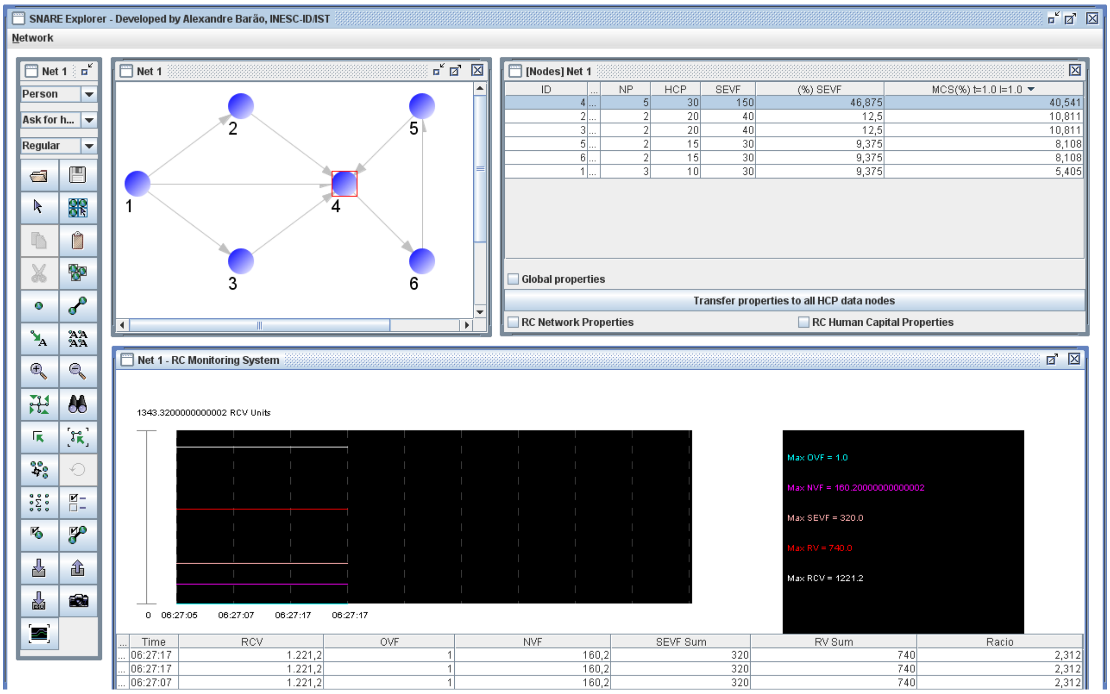


Figure 5.3 SNARE-Explorer RCV Monitor Interface

[30] For each opened network, a real-time monitoring system can be triggered.

[31] NP, HCP, SEVF, SEVF (%), and MCS (%) attributes can be sorted with ascend or descend criteria. This feature enables us to identify nodes concerning their network centrality or attribute strength. In the window "[Nodes]", in Figure 5.3, nodes are sorted from higher to lower MCS and NODE ID 4 is selected, which is also highlighted in the network window "Net 1".

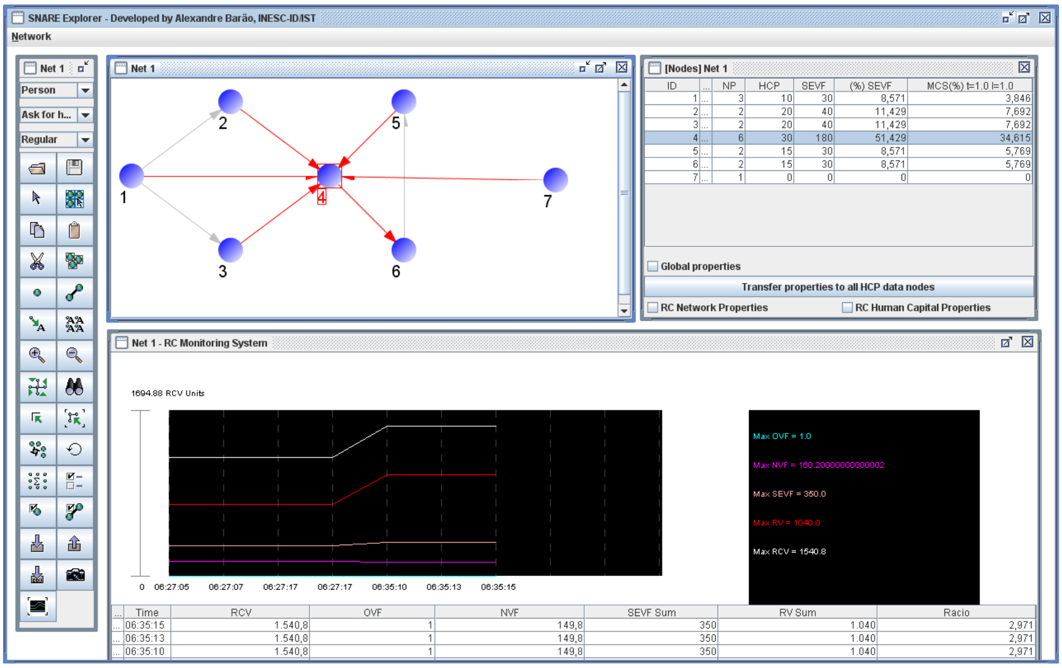


Figure 5.4 Network RCV After a New Network Connection

5.4. Discussion

The prototype architecture is based on two SNARE components: the SNARE windows application - which is the SNARE-Explorer tool - and the SNARE-Services system. SNARE-Services includes a library, a database, and provides interfaces to support external data integration from information systems (*Transparent* approach) and to access other information systems through web and windows-based applications (*Intrusive* approach[32]). Thus, with these SNARE architectural approaches, the prototype tool is able to extract, analyze and monitor social networks from information systems that were not originally designed with relational capital analysis features. In addition, these tasks can be executed autonomously, which means that through SNARE-Explorer's user interface it is also possible to perform relational capital analysis tasks without the need of external information systems integration.

SNARE-Explorer's MDI features help the *Analyst* edit and analyze several social networks at the same time. Besides network design features, the *Analyst* can use SNARE-Explorer to perform SNA operations, network statistics, and compute RCV. Despite the SNARE-RCO model's full implementation, this tool includes additional algorithms to be used when analyzing the relational capital of organizational networks, such as the *Minimum Connection Strength*

[32]A SNARE-Plugin component must be installed on the target information system.

algorithm, which was introduced to predict RCV variations when adding hypothetical connections to specific network members.

The SNARE-Explorer monitoring system traces in real-time a log and a linear chart of computed RCV values to monitor RCV top-level parameters over time. Moreover, the *Analyst* can dynamically change RCV parameter settings using SNARE-Explorer interface.

SNA properties such as network *density* and node *indegree/outdegree* are computed by SNARE-Explorer. Still, other SNA algorithms such as *betweenness*, *closeness*, or *eigenvalue* (See concepts in Appendix B) can be further computed. Meanwhile, the *Analyst* may use also other tools, such as *Pajek* (See Section 2.1.5), to perform these algorithms and import the results through SNARE-Explorer input mechanisms.

As stated in the beginning of this chapter, to analyze social networks there are many available tools. However, despite the existence of social network tools to support high quality network visualizations and analysis procedures, in the scope of this research, we developed this tool to specifically implement and validate the SNARE-RCO model. The main motivation was to use and test a system to monitor and visually edit the relational capital of a network regarding specific organizational scenarios. For this reason, this tool is unique. Moreover, SNARE-Explorer features - such as the relational capital monitoring system or editing features, like visually splitting and merging networks to analyze RCV, or removing central network members – have been developed incrementally throughout time with insights from the different experiments, in particular with Vodafone's Manager participant in Case A's validation (See Section 7.1).

This tool has been tested in several real contexts and has proved that it is possible to compute and monitor the relational capital of organizations.

Chapter 6

SNARE-Methodology

The meaning of things lies not in the things themselves,
but in our attitude towards them.

Antoine de Saint-Exupery

In previous chapters, we presented: the SNARE-Language to modeling social networks; SNARE-RCO model from which it is possible to extract the relational capital value of organizational networks; and SNARE-Explorer, which is able to compute and monitor the relational capital value of organizational social networks. Concerning our experience, we felt the need to define a methodology for conducting the relational capital assessment approach in organizations. Thus, after analyzing relational capital evaluation issues, as described in Section 2.3, we decided to develop SNARE-Methodology.

SNARE-Methodology was designed to perform a systematic evaluation approach in organizations, thus, several roles were defined for participants, namely: *Analyst*, *Sponsor*, *Manager*, and *Team*. SNARE-Methodology is based on four main processes in which participants are players: *Diagnosing*; *Designing*; *Executing*; and *Reporting*. During those processes, several artifacts to help understanding the relational capital value of organizations are produced. An artifact example is the *Analysis Pack* that includes the *Relational Capital Value Report*.

This chapter presents the SNARE-Methodology to be applied in order to evaluate the relational capital of organizations. Methodology roles are described in Section 6.1.Methodology artifacts are introduced in Section 6.2 while the methodology tool and used models are identified in Section 6.3. Finally, SNARE-Methodology processes are described in Section 6.4, and a discussion is given in Section 6.5.

6.1. Roles

In organizational context *stakeholders* are participants who are normally associated with specific roles such as [Pat 07]: sponsors, employees, customers, and suppliers. In social terms, sponsors are *network investors* or *funders* whereas employees are *network core group members*, customers are *members of the network*, and suppliers are *partners* [Pat 07]. Employee roles are dependent on the target organization, which has a specific organizational structure. This structure expresses allocation of responsibilities for different functions and processes to diverse entities, such as departments, workgroups and individuals. The figure bellow shows four roles we have chosen to define the SNARE-Methodology: *Analyst*, *Sponsor*, *Manager*, and *Team*.

Figure 6.1 Methodology Roles

The *Analyst* is the SNARE-Framework expert. The *Analyst* can bring shifts in management thinking and improvements in the relational capital value of the organization. The *Sponsor* is a role whose primary objective is the preservation of organizational investments. In the organization, the *Sponsor* can be an individual or group, assuming strategic responsibilities and decisions. The *Manager* serves as an agent to provide access to the organization's private information systems. The *Team* involves all the individuals of the organization. Typically there are people who work part-time or full-time under an employment contract.

6.2. Artifacts

The SNARE-Methodology considers the development and use of several artifacts (Figure 6.2), namely: *Organizational Context*, *Organizational Structure*, *Project Charter*, *Analysis Pack*, *Evaluation Report* and *Evaluation Presentation*.

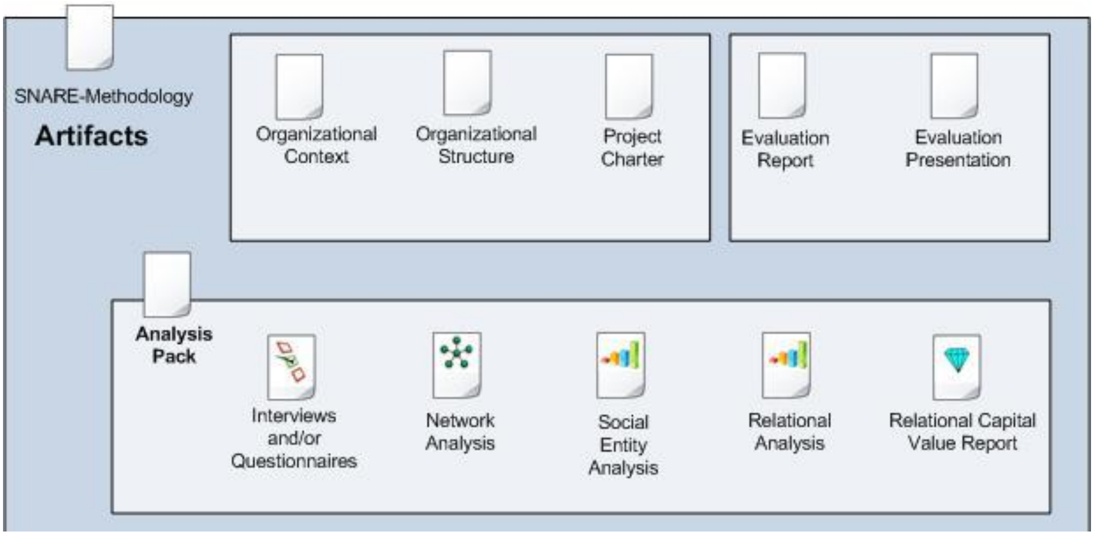


Figure 6.2 Methodology Artifacts

The *Organizational Context* is a document that results from the organization's elicitation and contains an introductory description of the organization.

Based on SNARE-Language, the *Organizational Structure* is a document that identifies the organization's social entities, roles and social relations to be analyzed.

The *Project Charter* (See Appendix D) contains four sections: (1) *General Information*; (2) *Overview*; (3) *Project Approach*; and (4) *Project Approval*. The *General Information* section contains the identification of: project, organization, *Sponsor*, and *Analyst*. The *Overview* section contains a brief project description, with goals' description, sponsorship expectations, and the analysis project ownership. In the *Project Approach* section, project deliverables and quality objectives are defined as well as responsibilities, dependencies, facilities and resources, risk management issues, project stages, project control issues, project schedule, and project cost estimative. Finally, the *Project Approval* section contains *Sponsor* and *Analyst* agreement signatures.

Interviews and/or Questionnaires are instruments of analysis.

The *Analysis Pack* is a set of analysis documents, namely: *Interviews and/or Questionnaires*, *Network Analysis*, *Social Entity Analysis*, *Relational Analysis*, and *Relational Capital Value Report*.

Interviews and/or Questionnaires contain *Team* answers that help the *Analyst* identify organizational relations.

Network Analysis is a document which includes: *Network Layouts* (to depict network views with node type differentiation), *Network Properties* (to show social entity centrality degrees or other SNA applied measures), and *Network*

Valuable Factors (to identify overall network properties, such as density or number of social entities).

Social Entity Analysis is a document that includes: *Human Capital Properties Analysis* (to compare human capital properties), *Social Entity Valuable Factors Analysis* (to analyze the RCV contribution of each social entity), *Node Type Analysis* (to analyze social entities predominant network node types), and Organizational Valuable Factors (to identify attributes of the organization that may contribute to the evaluation system).

Relational Analysis is a document that firstly includes definitions for *Relation Type Values* (to differentiate relational action values) and *Relational Levels Values* (to differentiate proximity relational values). Secondly, this document comprises the *Relational Value Analysis*, which is a description to understand each relational action RCV contribution.

Relational Capital Value Report is a document that describes the global RCV of the network and may include simulated scenarios to analyze RCV changes.

Evaluation Report is a private document that may include insights and recommendations to improve the relational capital of the organization.

Evaluation Presentation is a public domain document with evaluation results.

6.3. Tool and Models

SNARE-Methodology makes use of a tool and two models as depicted in Figure 6.3.

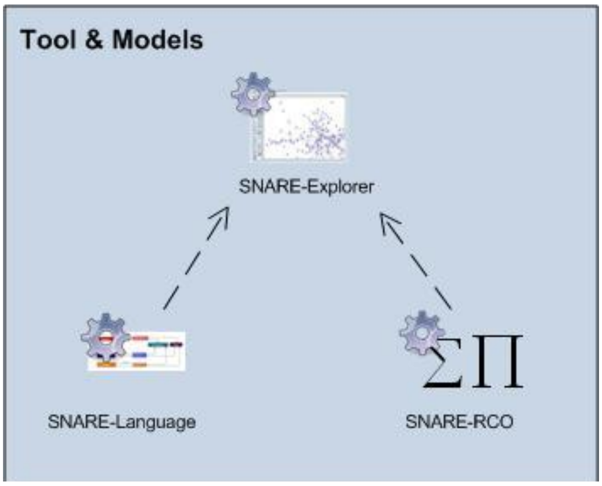


Figure 6.3 Tool and Models

The tool is *SNARE-Explorer* and the models are *SNARE-Language* and *SNARE-RCO*. The *SNARE-Language* model is used to produce the *Organizational Structure* document. *SNARE-RCO* model is employed to classify relational input parameters to compute the relational capital of the organization. Finally, *SNARE-Explorer* is the desktop tool application that uses *SNARE-Language* and *SNARE-RCO*. The *Analysis Pack* is produced using *SNARE-Explorer* tool, but other tools can be complementary used too, namely: ETL tools, spreadsheets and word processors.

6.4. Processes

In Section 6.4.1 an overview of SNARE-Explorer processes is given. In sections 6.4.2, 6.4.3, 6.4.4, and 6.4.5, the SNARE-Methodology processes *Diagnosing*, *Designing*, *Executing*, and *Reporting* are respectively presented.

6.4.1. Overview

Starting with specific organizational needs, SNARE-Methodology is based on four main processes, namely: *Diagnosing*, *Designing*, *Executing*, and *Reporting*. As suggested in Figure 6.4, these processes tend to be performed sequentially. The *Analysis Pack* is produced in the *Executing* process, and the *Evaluation Report* is produced in the *Reporting* process. See next section for a detailed description of each process.

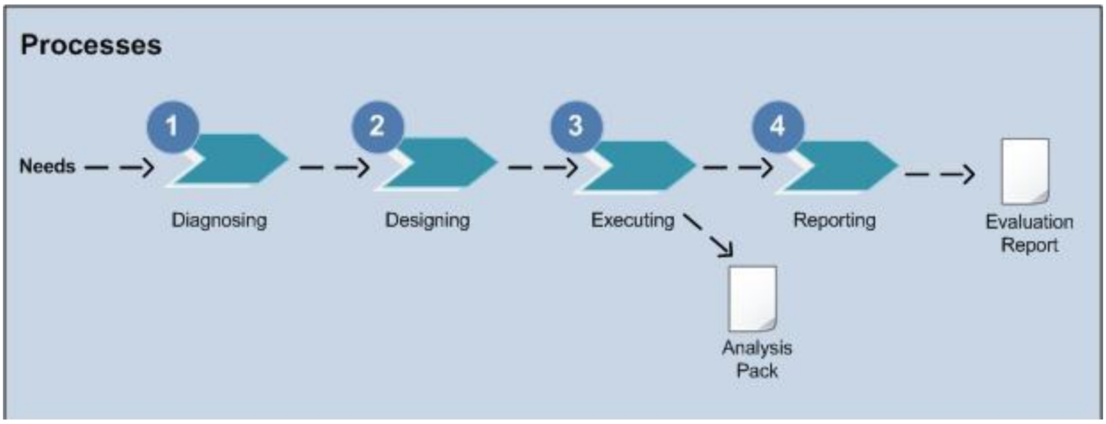


Figure 6.4 Processes Overview

6.4.2. Diagnosing

In the *Diagnosing* process (Figure 6.5), the *Analyst* presents the *SNARE-Methodology* to the *Sponsor* and the *Team* [33]. The *SNARE-Methodology*

[33] Based on our experience, this is may be a critical task, because, in order to participate in the relational capital evaluation process, the *Team* must be aware and clearly understand the intervention purposes. Regarding the results, monitoring and evaluating the relational capital

presentation includes an overview of the intervention purposes, and *SNARE-Language*, *SNARE-RCO*, *SNARE-Explorer* tool, as well. After the *SNARE-Methodology*'s presentation, the *Analyst* produces the *Organizational Context* document with the collaboration of the *Sponsor* and the *Team*. Then, using *SNARE-Language*, the *Analyst* writes the *Organizational Structure* document. Finally, the *Analyst* produces the *Project Charter*, which must be formally signed by him and the *Sponsor*.

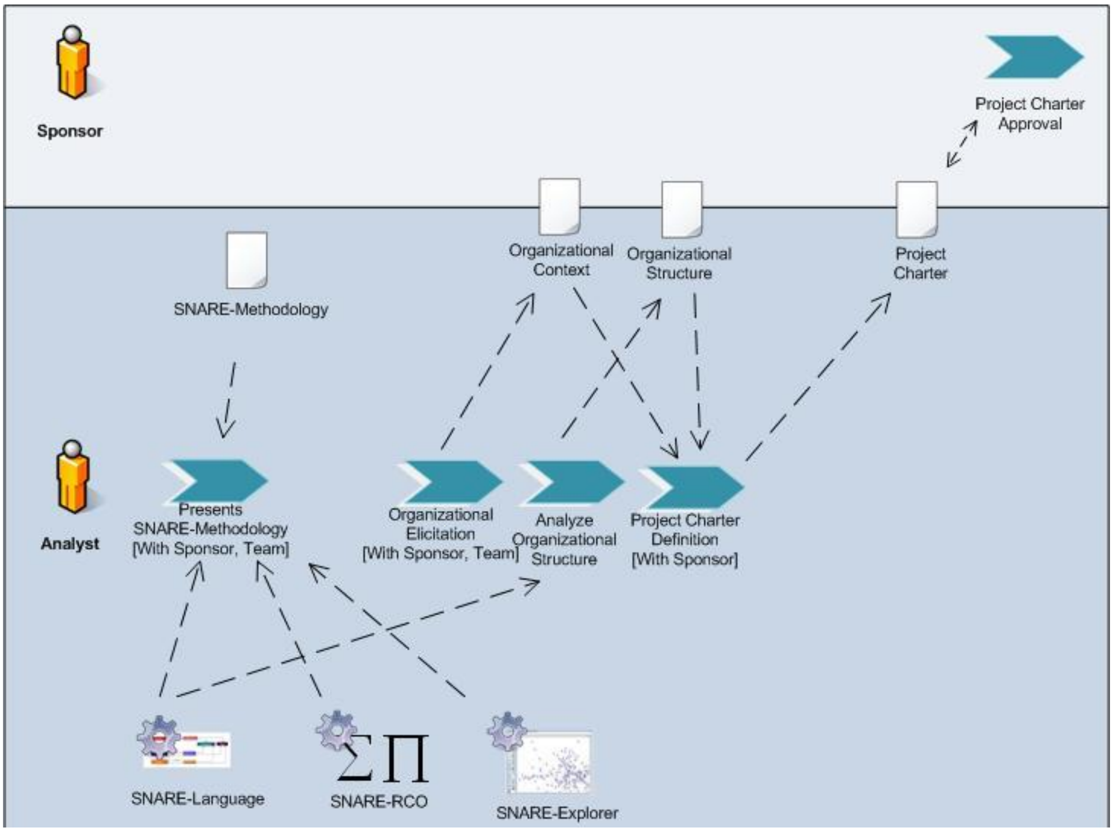


Figure 6.5 Diagnosing Process

6.4.3. Designing

In the *Designing* process (See Figure 6.6), by using the identified *Organizational Structure*, the *Analyst* starts to request information access to the *Manager*. After that, the *Analyst* can determine along with the *Manager* how organizational data will be gathered from the organization's knowledge base. In the next step the *Analyst* defines analysis metrics[34], which are SNARE-RCO metrics. Finally, when applicable, analysis instruments such as interviews and/or

value can further induce changes in organizational culture, and "culture can be a productive or a destructive force within an organization" [AO 10].

[34] The analyst may follow the SNARE-RCO application guidelines suggested in Chapter 4.

questionnaires are defined by the *Analyst*. These instruments must be approved by the *Sponsor*.

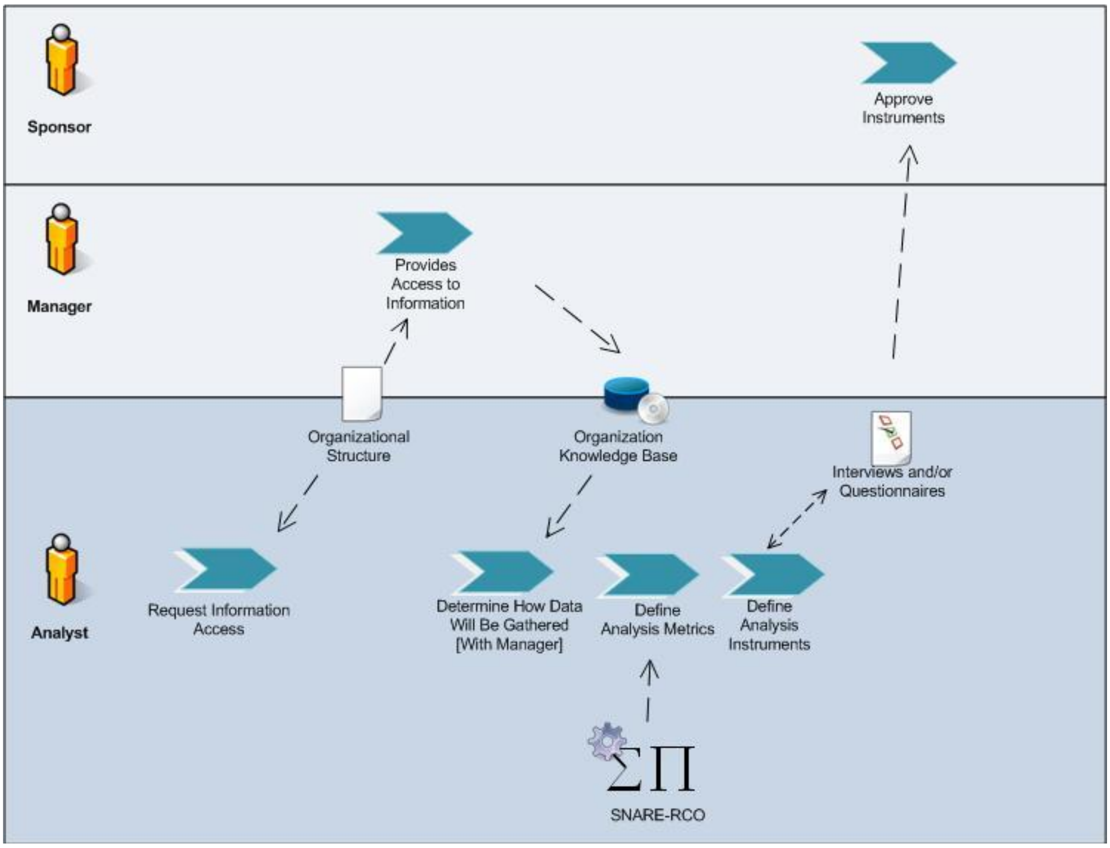


Figure 6.6 Designing Process

6.4.4. Executing

In the *Executing* process (see Figure 6.7), the *Analyst* starts making interviews and/or lunch questionnaires to the *Team*. Interviews and questionnaires will be analyzed next by the *Analyst*. The *Manager* grants *Analyst* access to all the necessary organizational information systems, such as: the relational knowledge base, social networks, or Enterprise Resource Planning[35] (ERP) systems. Having been given this access, the *Analyst* is able to start tasks like

---

[35] An ERP system integrates internal and external information of the organization, such as: Finance/Accounting (e.g., cash management or budgeting); Human Resources (e.g., payrolls, training programs or recruiting data); Manufacturing (e.g., orders, purchasing, supply chain planning, supplier scheduling, claim processing); Project Management (e.g., performance units or activity management); and Customer Relationship Management (e.g., sales and marketing, commissions, service, customer contact, call center support)

extract, transform, and load data[36]. These tasks will populate SNARE-Databases and, using *SNARE-Explorer*, the *Analyst* can start analyzing data, monitor, and evaluate relational capital. As a result of these tasks, the *Analysis Pack* is produced. This pack includes processed *Interviews and/or Questionnaires*, *Network Analysis*, *Social Entity Analysis*, *Relational Analysis*, and *Relational Capital Value Report*.

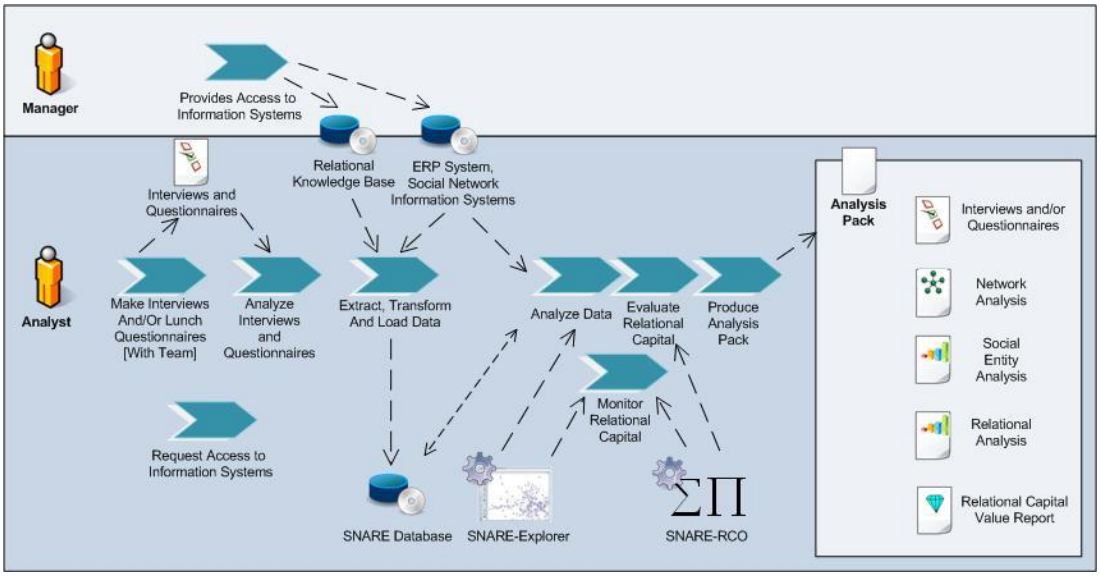


Figure 6.7 Executing Process

6.4.5. Reporting

In the *Reporting* process (Figure 6.8), the *Analyst* starts reviewing the *Analysis Pack* with the aim of produce the *Evaluation Report*. This report will be delivered to the *Sponsor*. The *Evaluation Report* contains data, some of which may be private, and it is necessary to define the *Evaluation Presentation* approach with the *Sponsor*, i.e. define what kind of results can be presented to the *Team*. At last, the *Analyst* prepares the final presentation, which will be performed to the *Sponsor* and the *Team*.

[36] The SNARE-Methodology was tested considering a *non-intrusive* technical approach, i.e. a *transparent* approach (See Section 5.1).

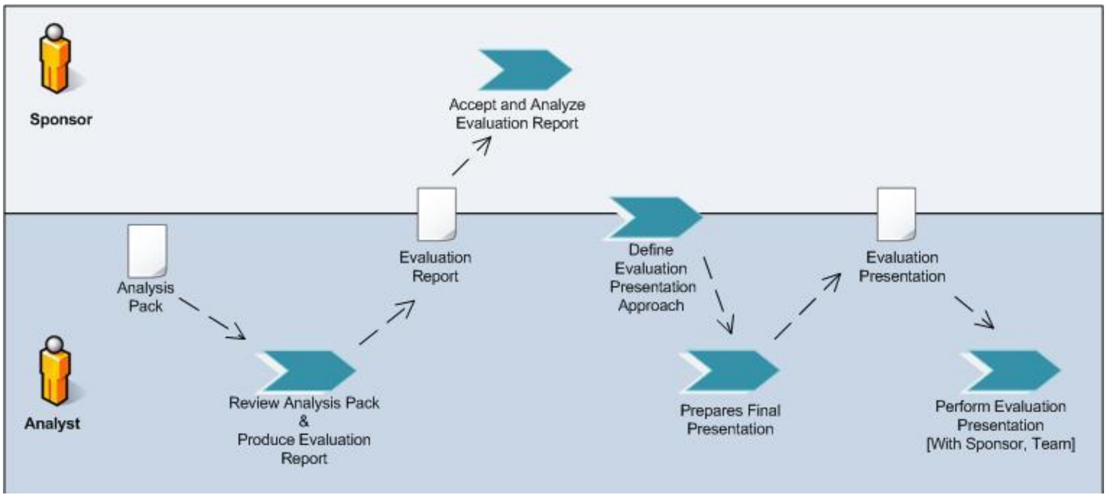


Figure 6.8 Reporting Process

6.5. Discussion

When evaluating the relational capital of organizations, the SNARE-Methodology can be used for an organizational evaluation approach, and several roles were defined for participants, namely: *Analyst*, *Sponsor*, *Manager*, and *Team*.

Starting with organizational needs, SNARE-Methodology is based on four main processes: *Diagnosing*; *Designing*; *Executing*; and *Reporting*. The aim is to produce several artifacts, such as an *Analysis Pack*, which includes the *Relational Capital Value Report*.

Considering our experience, this methodology helps promote a collaborative analysis environment. More specifically, when analyzing the relational capital value of organizational networks, participants work together with the aim of finding ways to improve this value.

When using SNARE-Methodology, the *Analyst*'s presence can probably affect the situation on the experiment field because it allows direct intervention into organizational dynamics. During the evaluation approach, the *Analyst* can be seen as a co-worker and an active player in the organization. Therefore, the *Analyst*'s intervention must be carefully prepared and teams must be aware of the evaluation purposes.

Finally, we must say that the *Analyst* and the *Sponsor* participate in iterative and reflective processes. As a result, besides the improvement of SNARE-Methodology roles, processes, and artifacts[37], SNARE-Framework models, tools and techniques can be bettered as well.

[37] During this research, we have discussed and refined SNARE-Methodology *roles, artifacts, and* processes, with Case A and B participants.

Chapter 7

Validation

The only source of knowledge is experience.

Albert Einstein

In previous chapters, we presented: the SNARE-Language to modeling social networks; SNARE-RCO model from which it is possible to extract the relational capital value of organizational networks; SNARE-Explorer, which is able to compute and monitor the relational capital value of organizational social networks; and SNARE-Methodology for conducting the relational capital assessment approach in organizations. This chapter presents the validation efforts that were performed to determine the viability of these research results. Thus, to validate results through controlled cases, we have chosen to apply the relational capital evaluation in the context of two organizations and also in a web-based collaborative and social platform. In particular, we validate our findings in the following cases: (1) Case A - Services Support Group at Vodafone Portugal (GSS), a group responsible for the operation and support in networking services, which is composed by more than half-hundred collaborators, most of them allocated to the different functional areas; (2) Case B - A Secondary School in Lisbon that employs over 200 people, namely teachers, technical assistants and operational assistants; and (3) Case C – the LOP[38] platform, which has hundreds of users [SS 09].

The three cases represent distinct and specific organizational scenarios. The aim was not to produce a comparative RCV benchmark evaluation between these three networks including OVF parameters. In fact, Vodafone has considered OVF as strategic and private data, thus OVF indicators were not provided. Naturally, we understand the privacy reasons invoked by the involved entities, and once more acknowledge their participation in helping trace common objectives in our research. OVF parameter was symbolically set to 1 RCV in cases A, B, and C.

Regarding validation results, we will discuss how it is possible to apply SNARE-RCO model to other CMS, or social media platforms.

[38] http://www.vemaprender.net

Sections 7.1, 7.2, and 7.3 present cases A, B, and C, respectively. Finally, in Section 7.4, a discussion about the analyzed scenarios, SNARE-Framework platforms application, SNARE-RCO parameter settings criteria, SNARE-RCO parameter weighting levels, the role of SNA metrics, and the challenge of comparing distinct networks is provided.

7.1. Case A

In this section, Case A validation results are shown. The organizational context is presented in Section 7.1.1, the organizational structure in Section 7.1.2, and the project charter summary is given in Section 7.1.3. Case A data gathering processes are described in Section 7.1.4. The evaluation report is given in Section 7.1.5, and finally, the case conclusion is presented in Section 7.1.6.

7.1.1. Organizational Context

The present study is focused on the analysis of the relational capital of six teams from a Vodafone Portugal Unit. The major goal is to explore the team's resilience using the relational capital as an input for team resilience diagnosis. Resilience has several means and can be explored in different perspectives. The perspective in the study analyzes team resilience as a function of a team's dependency of specific members[39]. The goal is to look for a balanced relational capital among team members, creating groups able to better react to the temporary or permanent absence of any of its members.

The social network in consideration is centered in the teams under analysis and has 14 main Units. Each Unit is divided into teams, as presented in Table E.1 of Appendix E. The 384 individuals identified in the study belong to different Unit teams.GSS Unit is an operations and support team, and this study lies in analyzing the GSS group members and their relationships with the remaining network. The relations are divided into two major types: *Business Processes* (*Incident*, *Change* and *Problem*) and *Information Sharing*. Taking this into account and, to proceed with the study, every GSS member was identified and associated with their team.

In general, GSS members have similar responsibilities and perform equivalent tasks, but over different equipment and technologies. As described above, the teams are involved in 3 major processes: *Incident*, *Problem* and *Change*. From the manager perspective, *Incident* and *Problem* are the main focus. Except for VOC Service Desk, all other teams are composed of specialists performing system administration, applications and services

[39] Regarding organizational context and needs, this perspective was suggested and discussed by a Vodafone Sponsor.

administration. In short, they guarantee that services, applications and systems are "up and running" according to expectations, and intervening if this is not so. The *Change* process is responsible for transformation, i.e. service evolution or new service deployment.

Each individual was given a unique identifier (ID) and sorted by its user name (not disclosed in the present report). Each GSS team has a Manager (See Appendix E for a description).

The study acknowledges the fact that the collected information is a limited view of reality, capturing it partially. Therefore the analysis, models, conclusions and actions forward must be included and interpreted in a broad nest of relations.

7.1.2. Organizational Structure

The organizational structure of this case is presented using three complementary SNARE-Language views: social entities view (Figure 7.1), roles view (Figure 7.2), and relational actions view (Figure 7.4).

In structural terms, Vodafone is a *Telecommunications Operator* that has several *Organization Members* (Figure 7.1). *Employees* and *Groups* are *Organization Members*. Each member is identified by an ID and a name. *Units* are groups which may have several *Teams*. Each *Team* can have several employees.

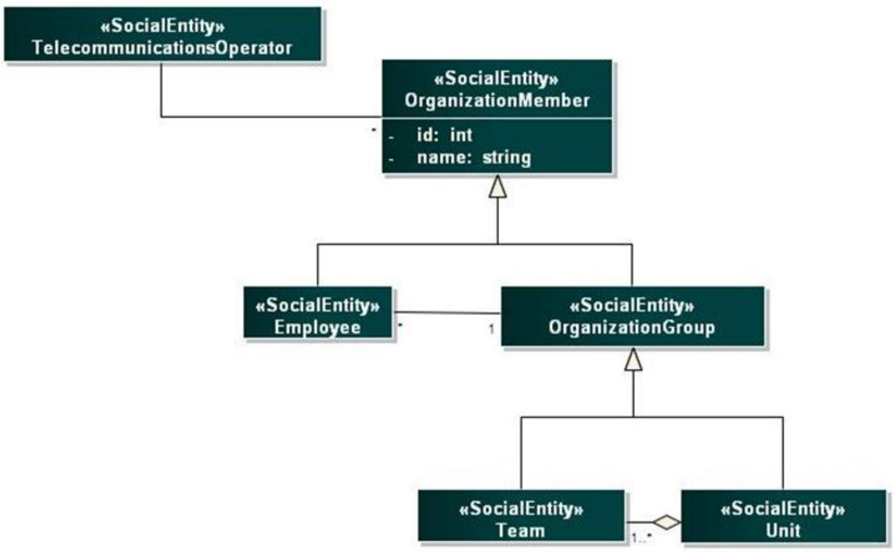


Figure 7.1 Case A - Social Entities View

In this study, we identify three main roles to be analyzed (Figure 7.2): *Technical Specialist*, *Manager*, and *Team Leader*. *Managers* and *Team Leaders* are also *Technical Specialists*.

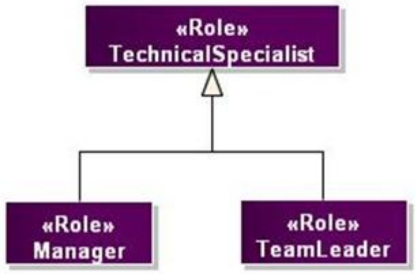


Figure 7.2 Case A - Roles View

In the *IsColleagueOf* relation, we have identified four relational actions to be considered (Figure 7.3): *Request Information*, *Incident Request*, *Problem Request*, and *Change Request*. An *invoker* triggers a request and, typically, for each request one or more replies may occur. Requests are sent by *Employees* who play *Technical Specialist* roles.

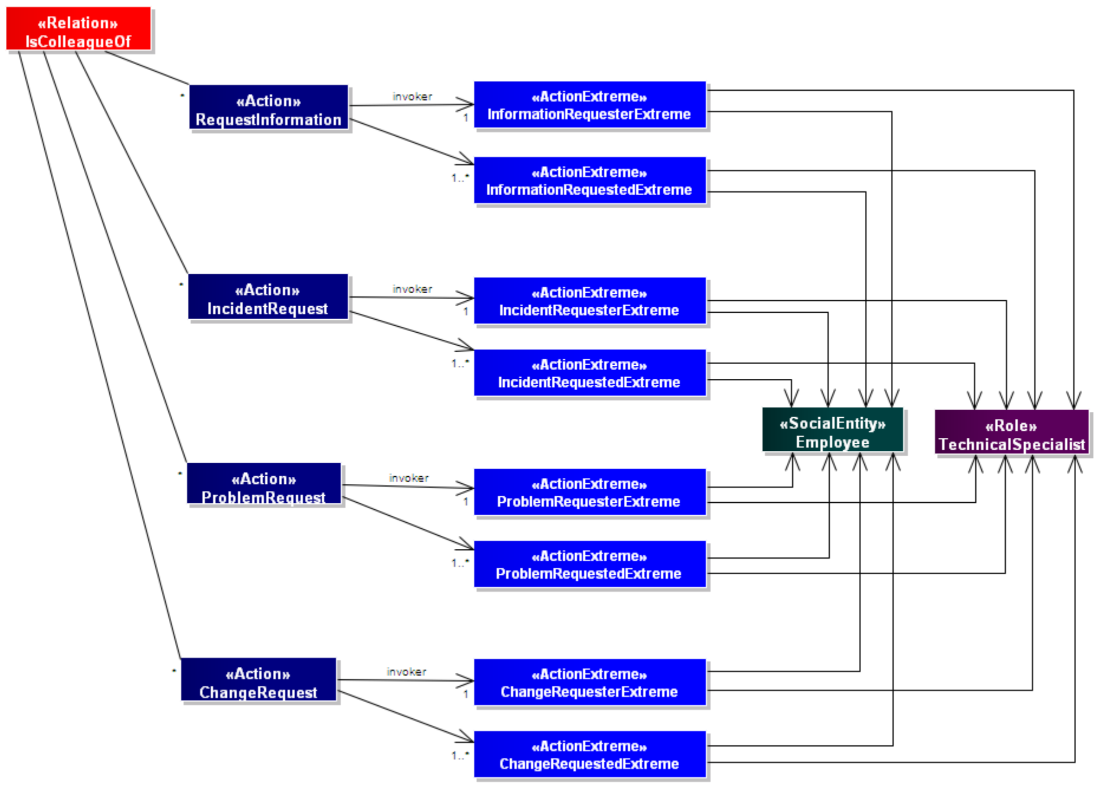


Figure 7.3 Case A - Relational Actions View

7.1.3. Project Charter Summary

After identifying the organizational context and structure, we summarized in this section three relevant issues of this project's charter:

- Identification - The present study is focused on the analysis of the Relational Capital of six teams from a Vodafone Portugal Unit: GSS. The study analyzes team resilience as a function of the team's dependency of specific members.
- Project Objectives - Centering the analysis on GSS Unit, the main objectives are to: identify central elements on each team; obtain the RCV of each team; and analyze how RCV varies depending on the type of relational action. Also, to verify the GSS network importance, three additional goals were defined: compute the global RCV of the network; simulate the absence of central elements and measure the impact on the network RCV; and simulate the removal of GSS Unit and measure the network RCV impact.
- Business Need - Answer the question: "How far do network properties and relational value translate team resilience?"and increase team resilience. The study will also try to validate these expectations: Homogeneous groups, in which all members execute similar functions, are expected to equally distribute effort among its members. If this is the case, Network Properties (NP) will also be equally distributed and groups are resilient; Members with NP higher than average can represent a risk of dependency; and Members with NP lower than average can represent elements not entirely integrated in the teams dynamics and jeopardize the team's "possible" resilience.

7.1.4. Data Gathering Processes

The entry point of this study consisted in collecting the manager's perception (See *Data Gathering Processes* in Appendix E.2), which was confirmed by this study. The data was collected from Vodafone's workflow tool from June 2011 to July 2011. Data allowed us to identify 384 individuals belonging to the 14 units described above. As stated, each individual was given a unique identifier (ID) and sorted by its user name.

Logs were collected from the Vodafone workflow system for two months, and allowed insight into the three main business processes in which the Units under study participate:

- Incident: (*Incident; DBA; Network*) - Processes used to identify and respond to events that fall outside normal operations, including the recording, analysis and categorization of these events, along with the measures taken to address the underlying causes, restore normal service operation as quickly as possible and minimize the adverse impact on business operations;
- Change: (*Change and Standard*) - Processes used to manage any kind of change to existing technology, including definition of procedures, capturing change requests, analysis and formal approval of change requests, testing of changes, authorization of changes, implementation and review of changes; and
- Problem: (*Problem*) - The process responsible for managing the lifecycle of all problems. Its goal is to of prevent *Incidents* from happening, and minimize the impact of incidents that cannot be prevented.

The analysis repository was enriched with the log information from the *Information Sharing* used by the Units under study. The logs collect information from January to the beginning of July 2011.

Both records belong to *Business Processes* and *Information Sharing* which were processed and analyzed with SNARE-Explorer Tool. The analysis gave origin to a network containing the total of records. The following table summarizes the analyzed records of colleague relational actions.

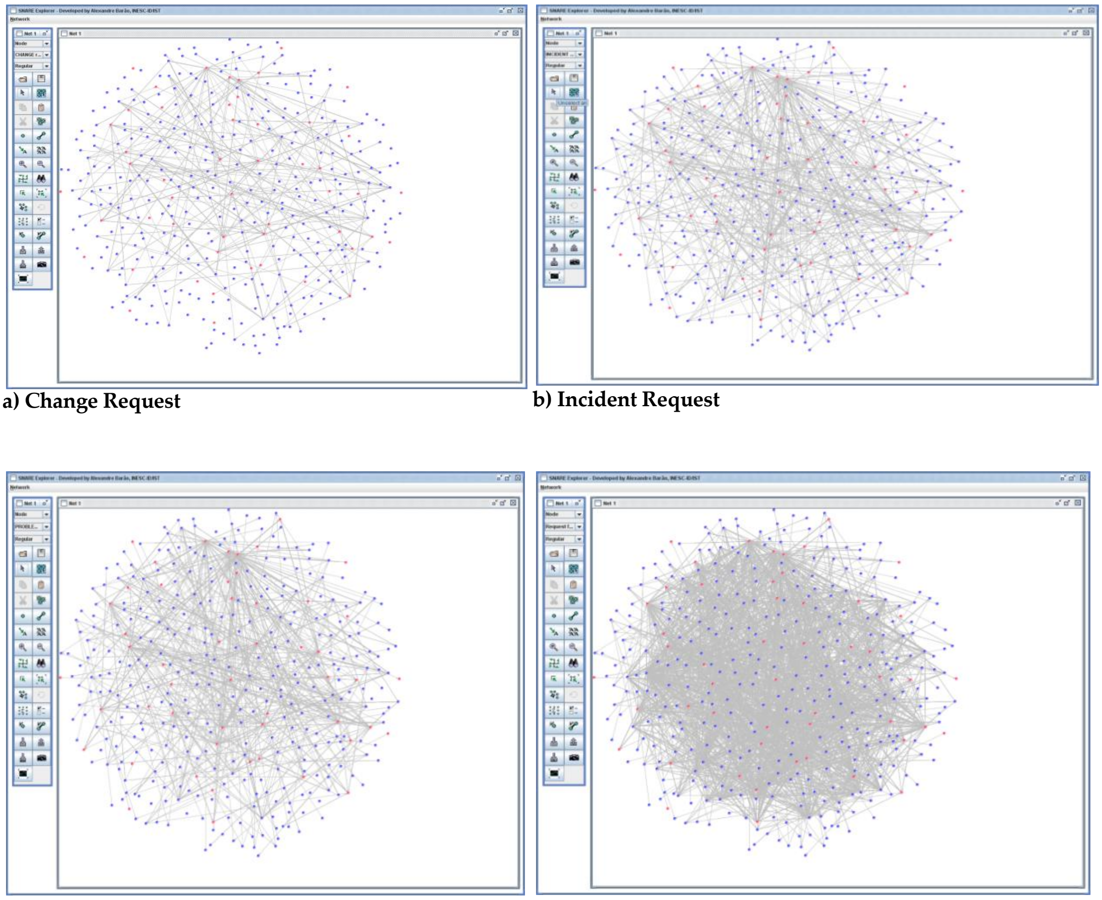
Table 7.1 Case A - Analyzed Relational Actions

Relation: Is Colleague Of

Actions	**Number of Analyzed Records**	**Number of Action Types**
Information Sharing Requests	4383	92
Change Requests	463	41
Incident Requests	464	37
Problem Requests	153	18
Total	**5463**	**188**

The network graph is directed, revealing the requester and recipient edges. Actions types were created dynamically in order to express different interactions between the Unit members.

Relational actions *Change*, *Incident*, *Problem* and *Information Sharing* were imported by CSV SNARE-Explorer mechanisms. Figure 7.4 illustrates each step of this process, respectively.



a) Change Request
b) Incident Request
c) Problem Request
d) Information Sharing Request

Figure 7.4 Case A - Relational Actions Import

7.1.5. Evaluation Report

The *Evaluation Report* is presented in this section and is composed by four methodological artifacts: *Network Analysis; Social Entity Analysis; Relational Analysis;* and *Relational Capital Value Report*.

7.1.5.1. Network Analysis

Network Analysis includes network layouts, network properties (NP) analysis, and network valuable factors (NVF) characterization. In this study, SNARE-Explorer automatic layout design feature was activated to produce a global network layout. The figure below shows an image of the analyzed Vodafone network. The red nodes are GSS members.

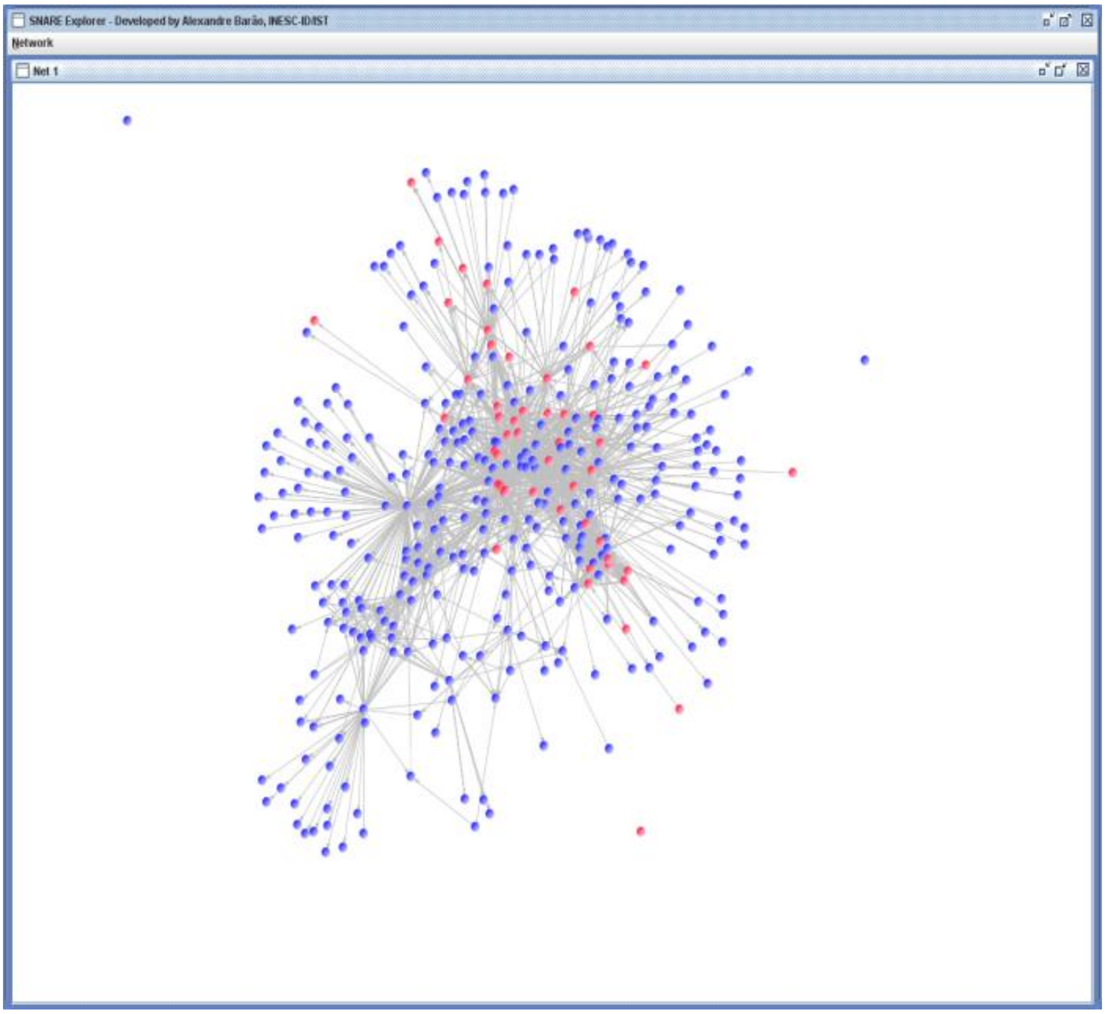


Figure 7.5 Case A - Network Layout

Different colors were associated to GSS teams as depicted in Figure 7.6. A GSS network layout was also produced (Figure 7.7).

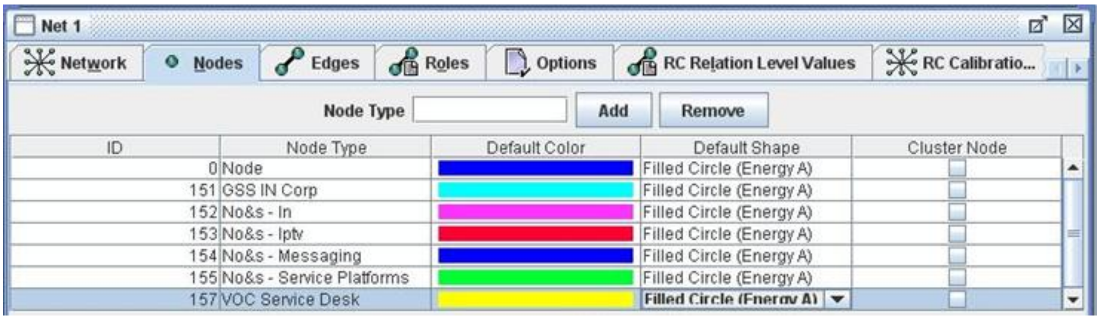


Figure 7.6 Case A - GSS Team Colors for Network Layout

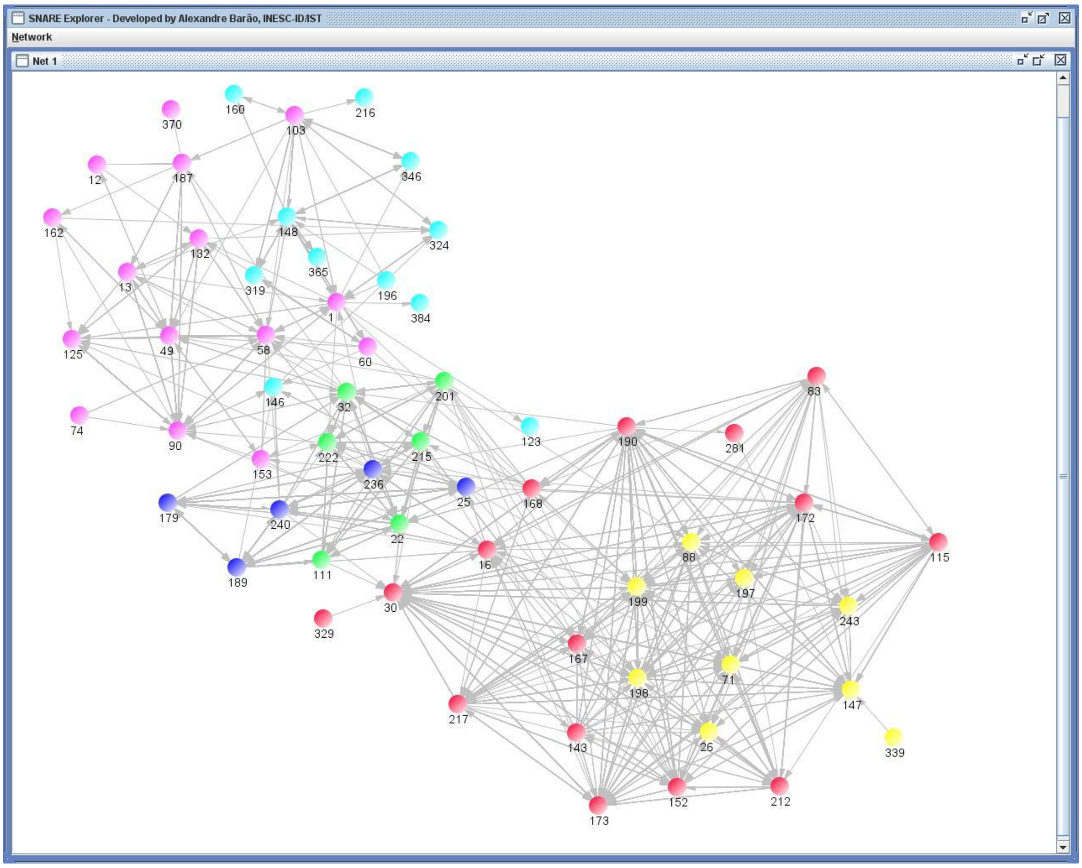


Figure 7.7 Case A - GSS Team Members Network Layout

The image above is tremendously rich and deserves the following comments:

- The layout reflects team communication proximities and GSS members degree centralities;
- VOC Service Desk (in yellow) is strongly connected to NO&S IPTV (in red). The IPTV team is responsible for all the procedures executed by VOC, and for knowledge transfer. VOC filters and solves incidents according to procedures and escalates (transfers) all incidents that they cannot handle with (the majority of these are transferred to IPTV);
- ID 25, being at Vodafone since 1999, is a key communication point for Messaging Team;
- Peripheral elements like ID 74, ID 370, ID 196 are consultants that cooperated with the team during a very short and limited period.

To start NP analysis, a network density analysis was performed for all imported relational actions. Throughout this density analysis isolated nodes were considered. Figure 7.8 depicts this process.

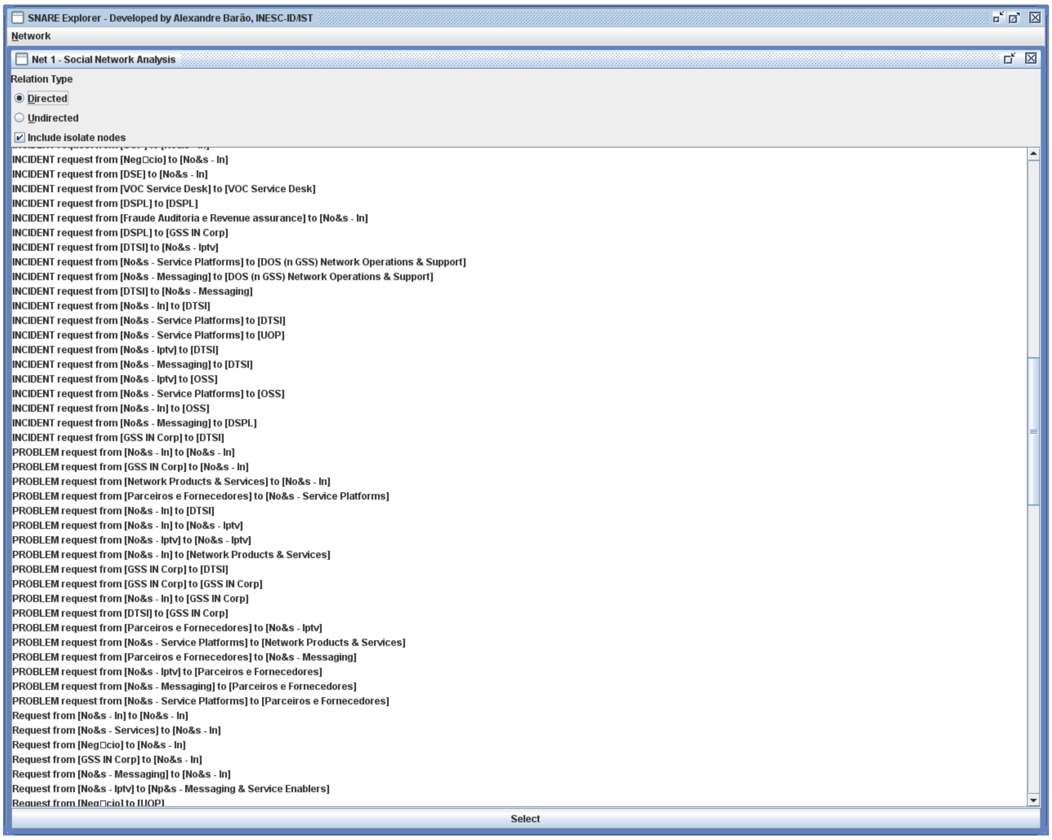


Figure 7.8 Case A - Network Density Analysis (Screen Shot)

Density analysis result[40]:

- Nodes analyzed: 384
- Isolate nodes included: yes
- Result: 0.011579362489120974

NP analysis was performed to find network centrality levels from GSS members (See *Table E.2 Case A - NP GSS Rank*). NP reflects the indegree/outdegree sum. We decided on this approach to measure the activity level of network members independently of being predominantly *senders* or *receivers*. Besides, regarding SNARE-RCO model, the RV Sum parameter reflects the *indegree* importance of network individuals. Figure 7.9 depicts the GSS network distribution ordered by NP rank of network members. This kind of picture provides instant information to understand the distribution of a network member's activity.

[40] Note: the density indicator obtained may be used in future studies based on the same parameters and, thus provides the basis for future comparisons.

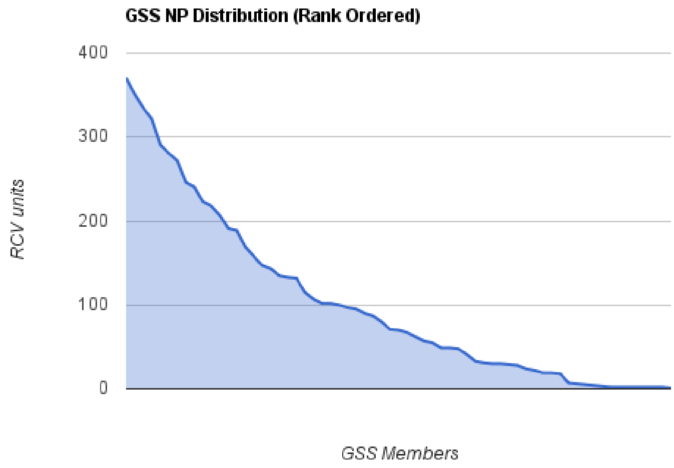


Figure 7.9 Case A - GSS NP Distribution (Rank Ordered)

Network Valuable Factor (NVF) is a SNARE-RCO input parameter to determine the network's RCV. The NVF value obtained was 444.65 RCV units. This value was computed using the number of network nodes (384) with weight 1, and the density of graph (0.0115793624891209774) with weight 100 (See *Defining and Classifying Parameters* in Chapter 4 for more information).

7.1.5.2. Social Entity Analysis

Social Entity Analysis includes Human Capital Properties (HCP), Social Entity Valuable Factors (SEVF), and Node Type Analysis (NTA). For confidentiality reasons, HCP was considered neutral for all network elements, i.e. equal to 1. SEVF was computed based on the degrees of centrality of each member in the network (NP). The SEVF computed for the entire network was: 10926 RCV. *Table E.7 Case A - Network SEVF (Organizational Units)* shows each group's contribution to network SEVF (absolute values expressed in RCV units). Figure 7.10 illustrates the SEVF distribution in the GSS Unit. *Table E.8 Case A - Network SEVF (GSS Teams)* shows absolute SEVF values for each GSS Team.

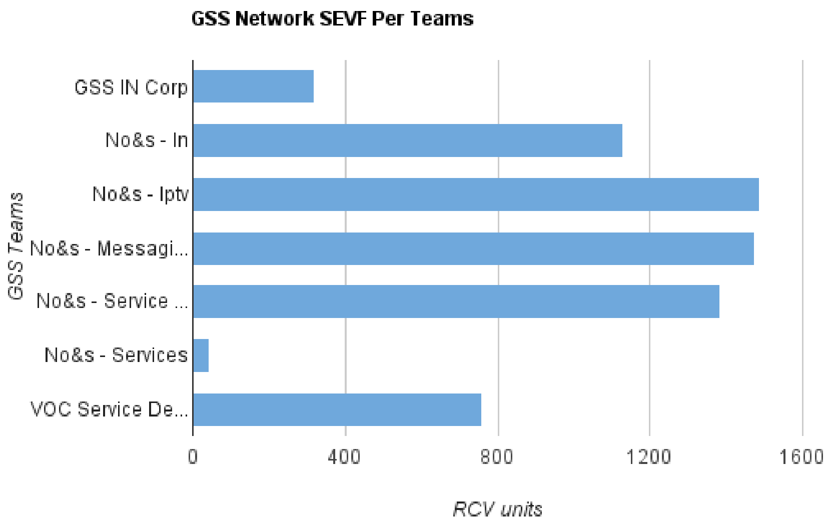


Figure 7.10 Case A - GSS Network SEVF per Teams

Network node types were characterized according their NP level. Node type concepts are: Isolate, Transmitter, Receiver, Carrier, and Ordinary Node (Refer to Table F.1 in Appendix F for more information). From the 384 analyzed nodes, statistical results were as follows: Isolate nodes = 7 (1%); Transmitter nodes = 76 (19%); Receiver nodes = 164 (42%); Carrier nodes = 4 (1%); and Ordinary nodes = 133 (34%). Figure 7.11 depicts these results.

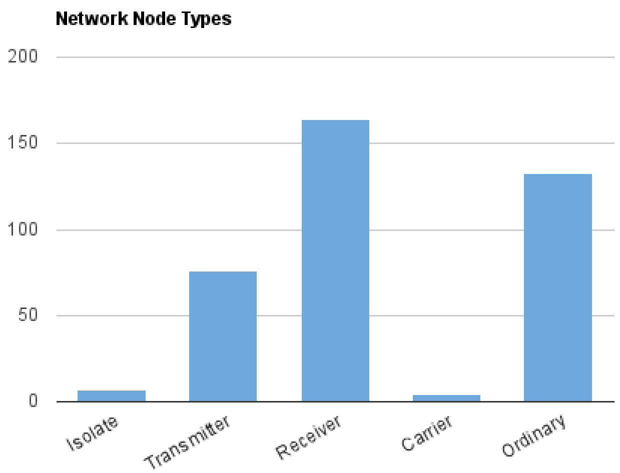


Figure 7.11 Case A - Network Node Types

Results of each Vodafone Unit node types are depicted in Figure 7.12. A list of these values is provided in *Table E.9 Case A - Node Types of Each Unit*.

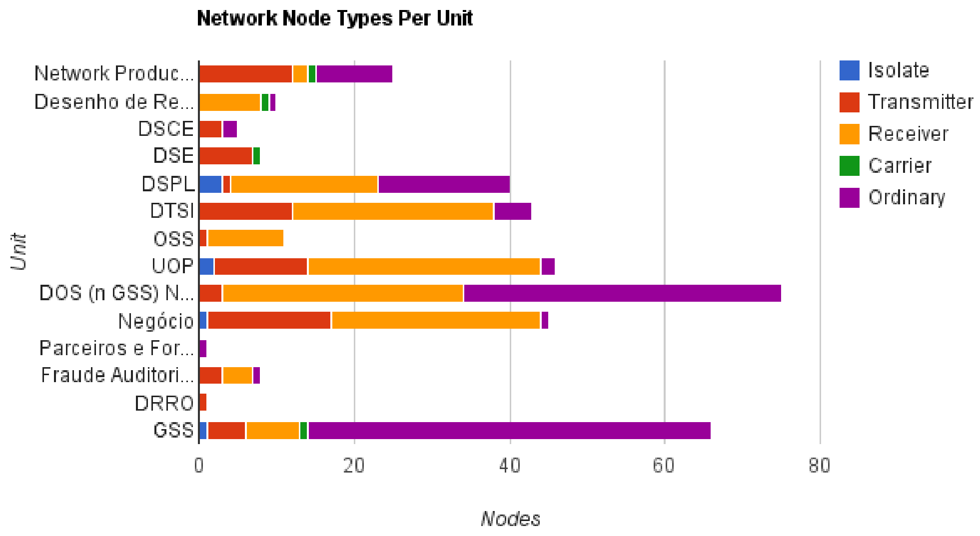


Figure 7.12 Case A - Network Node Types per Unit

The following figure shows nodes types for each GSS team.

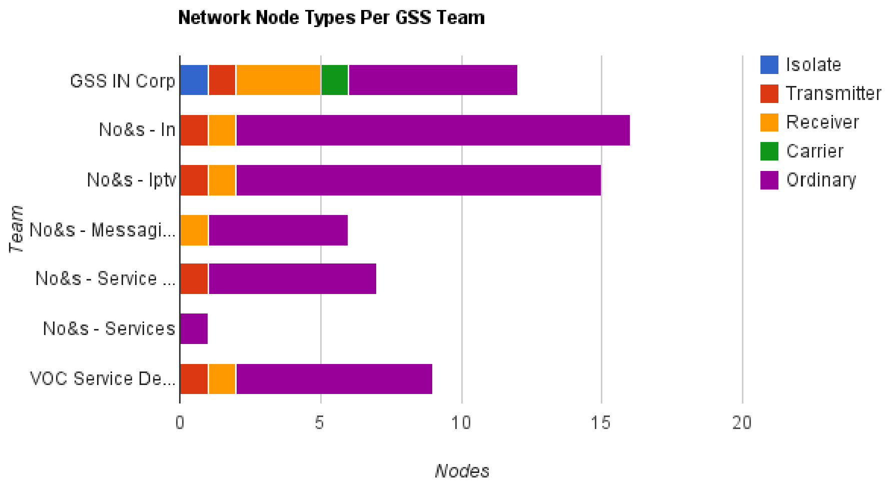


Figure 7.13 Case A - Node Types For Each GSS Team

7.1.5.3. Relational Analysis

To perform Relational Analysis, Relation Type Values (RTV) and Relational Levels Values (RLV) were firstly defined. RTV and RLV are SNARE-RCO parameters. In this study, RTV was defined as 0.1, and RLV was defined as 1.

Using these definitions, RV Sums for each relational action were computed. The following figure shows RV Sum values for each type of relational action (See *Table E.11 Case A - RV Sum per Relational Action*).

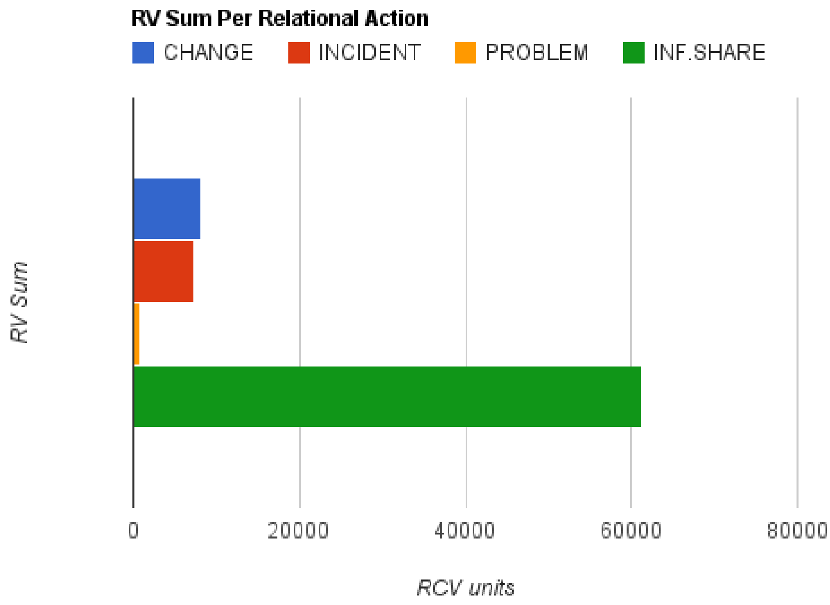


Figure 7.14 Case A - RV Sum per Relational Action

The predominant relational capital value refers to the *Information Share* relational action, and relational action *Problem* has the lowest RCV. The computed RV Sum for all relational actions is 77645,2 RCVs. This relational capital was produced by several Vodafone Units as detailed in Table 7.2. GSS RCV contribution is listed in Table 7.3.

Table 7.2 Case A - RV Unit Producers

RV Unit/Team Producer	**RV SUM**
Network Products & Services	41,2
Desenho de Rede	11,8
DSCE	0,6
DSE	0,2
DSPL	14102,7
DTSI	27,4
OSS	6,9
UOP	297,6
DOS (n GSS) Network Operations & Support	5225,4
Negocio	12,2
Parceiros e Fornecedores	32,5
Fraude Auditoria e RevenueAssurance	5,2
GSS	57881,5
Total	**77645,2**

Table 7.3 Case A - RV GSS Team Producers

Team	RV SUM
GSS IN Corp	2388,5
No&s - In	4775,2
No&s - Iptv	7502,7
No&s - Messaging	20149,3
No&s - Service Platforms	15683,3
No&s - Services	58,8
VOC Service Desk	7323,7
Total	**57881,5**

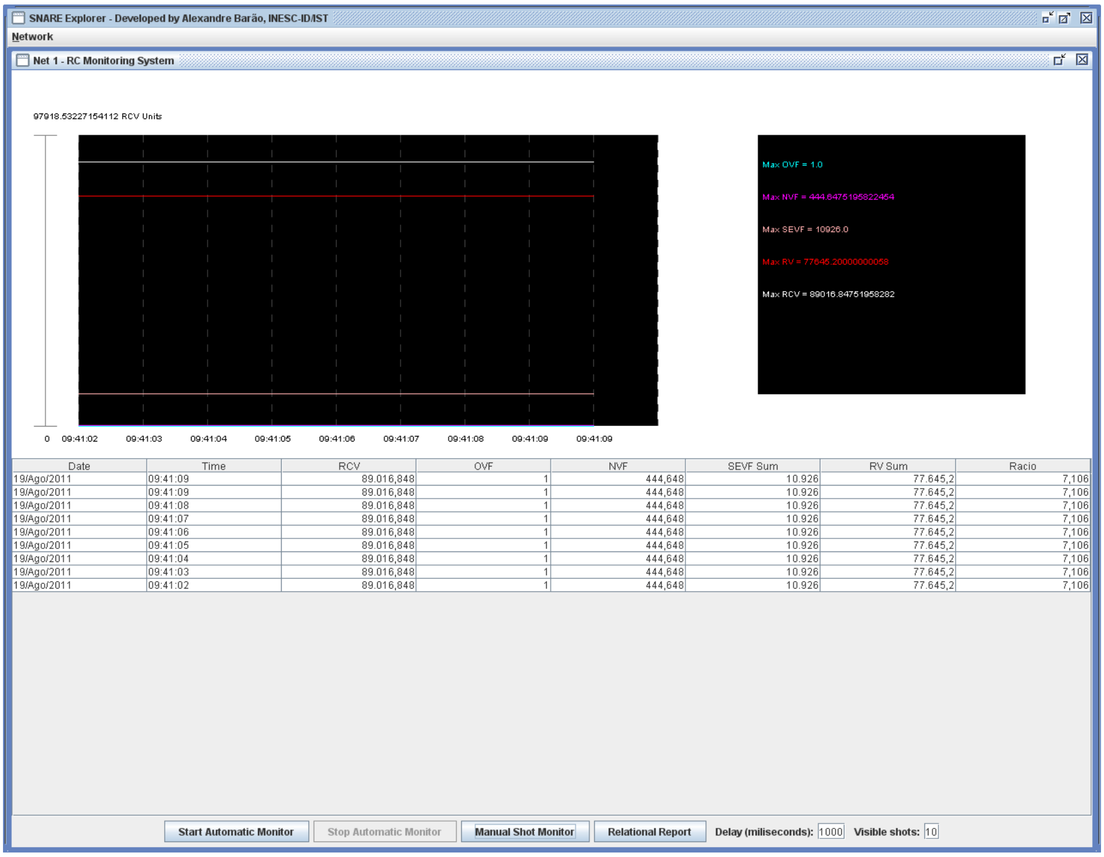
As previously mentioned, the analysis is focused on individual GSS teams[41]. When analyzing GSS teams, NP individual analysis is recalled and compared with the produced *RV Sum* of GSS teams. Each GSS team holds a RV contribution, which isused to compute the global network RCV (In *Table E.12 Case A - GSS Teams RV & Members Contribution* it is possible to analyze each team's RV contribution as well as each RV Sum of team members).

Results were compared with the Managers' perspective and with the members RV contribution in each respective team: GSS IN Corp; NO&s IN; NO&S IPTV; NO&S – Messaging; NO&S - Service Platforms; and VOC Service Desk (See *Relational Analysis* in Appendix E for a complete description). From the relational analysis, NP averages and each member team RCV contribution confirm most of the initial perceptions obtained when interviewing the manager. With this analysis, new and relevant insights were provided to managers in order to increase team resilience.

7.1.5.4. Relational Capital Value Report

Relational Capital Value Report includes procedures to compute the global RCV value as well as simulations regarding the study's goals. The analysis tool computed the global RCV of the organization: 89016.85 RCV units. Figure 7.15illustrates the process of RCV monitoring. Considering the SNARE-RCO model, RCV is computed with four input parameters: OVF, NVF, RV Sum, and SEVF Sum. As stated, *RV Sum* is the metric used to compute the RCV value of relational actions (RV Sum =77645.2).

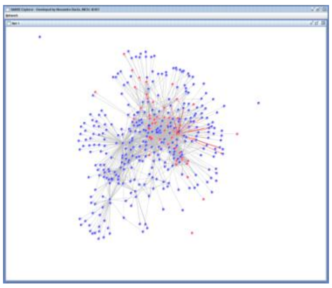
[41]ID 60, ID 1 and ID 103 are in transition from "No&s – In" to "GSS IN Corp". A decision was made to include them in the analysis for both groups, taking into account that they presently belong to "GSS IN Corp". No&s– Services were discarded from this analysis (Manager's decision).

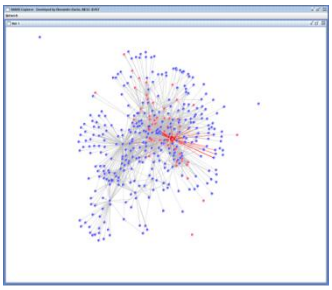


Date	Time	RCV	OVF	NVF	SEVF Sum	RV Sum	Racio
19/Ago/2011	09:41:09	89.016,848	1	444,648	10.926	77.645,2	7,106
19/Ago/2011	09:41:09	89.016,848	1	444,648	10.926	77.645,2	7,106
19/Ago/2011	09:41:08	89.016,848	1	444,648	10.926	77.645,2	7,106
19/Ago/2011	09:41:07	89.016,848	1	444,648	10.926	77.645,2	7,106
19/Ago/2011	09:41:06	89.016,848	1	444,648	10.926	77.645,2	7,106
19/Ago/2011	09:41:05	89.016,848	1	444,648	10.926	77.645,2	7,106
19/Ago/2011	09:41:04	89.016,848	1	444,648	10.926	77.645,2	7,106
19/Ago/2011	09:41:03	89.016,848	1	444,648	10.926	77.645,2	7,106
19/Ago/2011	09:41:02	89.016,848	1	444,648	10.926	77.645,2	7,106

Figure 7.15 Case A - RCV Monitoring

After computing the global RCV, a first simulation was conducted to assess the impact of the GSS most central three elements in the network. The following figures illustrate the process of selection and removal of these three network members using SNARE-Explorer. Red lines are connections between selected members.


a) Rank #1 Member Connections


b) Rank #2 Member Connections

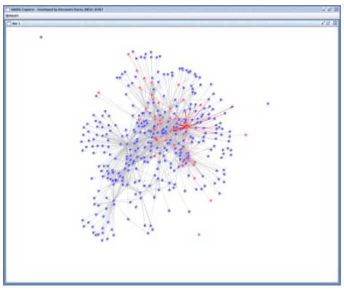

c) Rank #3 Member Connections

Figure 7.16 Case A - Removing GSS Members (Simulation)

When removing the above members, the SNARE-Explorer monitoring system had a significant reaction, and Figure 7.17 illustrates the three stages corresponding to these GSS elements' removal: a), b) and c).

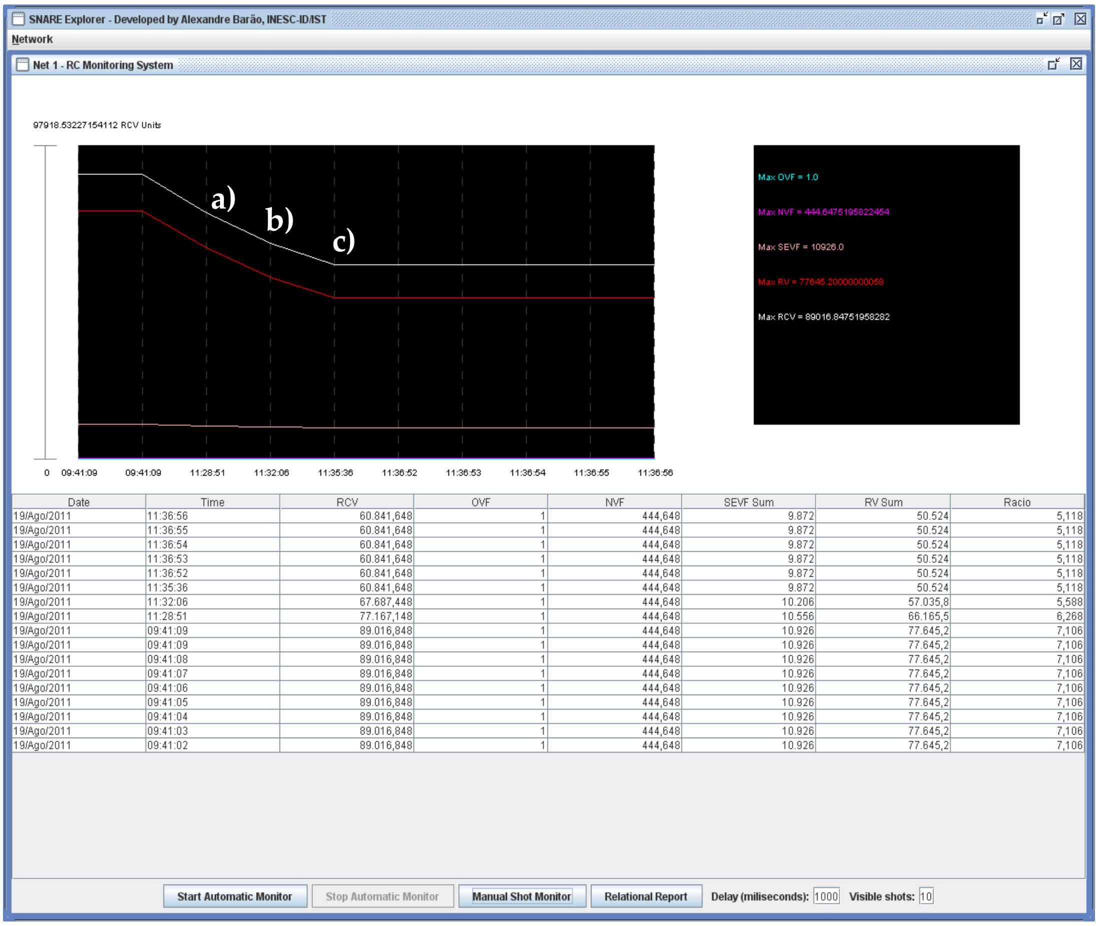
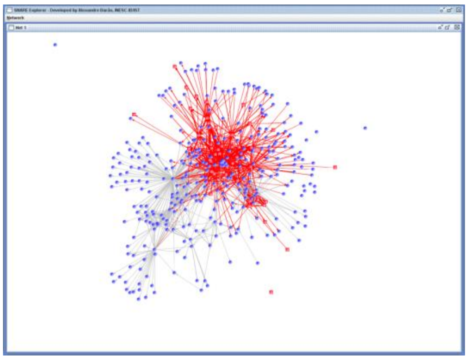
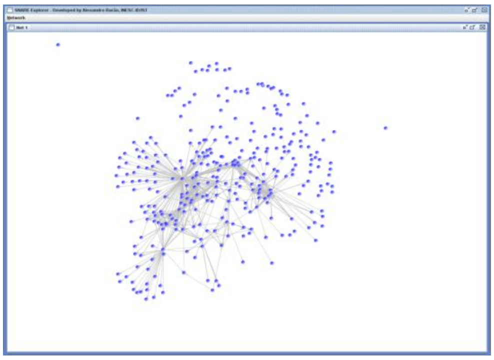


Figure 7.17 Case A - Monitoring GSS Elements Removal

A second simulation was performed: remove the entire GSS Unit from the network. Image a) from Figure 7.18 shows the network with GSS Unit selected. After GSS removal, a significant result can be seen in image b) where a significant number of Vodafone members were left as isolate nodes.



a) Vodafone Network before GSS removal



b) Vodafone Network after GSS removal

Figure 7.18 Case A - GSS RCV Impact on Vodafone Network

The GSS group has a high impact on the network's relational capital. When removing this group, the monitoring system showed a significant RCV value decline.

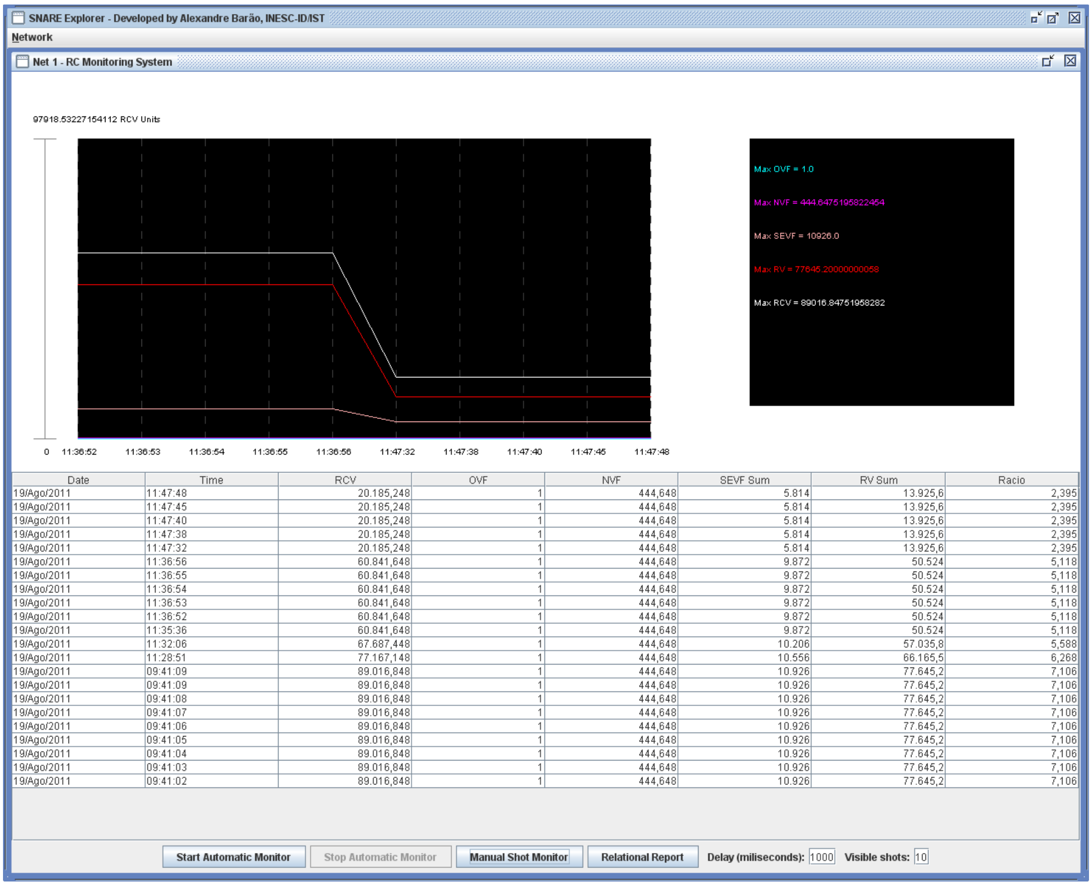


Figure 7.19 Case A - Monitoring the GSS Removal Impact

7.1.6. Case Conclusion

The performed study has the advantage of compiling manageable relational data and set forward a comprehensive mechanism to evaluate it.

When used to compare people with similar roles within a team, combined NP and RV analysis gives a perfect insight into the teams' ability to distribute work load and cooperate. Also, individual NP averages and related RCV contribution confirm most of the perceptions obtained when the manager was interviewed.

Using the SNARE-Framework, we successfully identified the central elements of GSS teams. Also, we determined the RCV of each team, and analyzed how RCV varies depending on the type of relational actions. Finally, we computed the RCV of the overall network, simulated the absence of central elements and measured its impact on the network RCV. We simulated the removal of GSS Unit and measured the network RCV impact.

From this study, we conclude that network properties and relational value can be a way to translate the team resilience in this specific case. Repeated over time, this study can help understand: what the impact of improvement measures is; what the impact of an individual absence is; and how long it takes to fully replace an individual.

7.2. Case B

In this section, Case B validation results are presented. The organizational context is presented in Section 7.2.1 and the organizational structure in Section 7.2.2. The project charter summary is given in Section 7.2.3. Case B data gathering processes are described in Section 7.2.4. The evaluation report is in Section 7.2.5, and finally, the case conclusion is discussed in Section 7.2.6.

7.2.1. Organizational Context

The present study is focused on analyzing communication levels from a school community. This community has over 200 employees and they are divided into three major categories: *teachers*, *technical assistants* and *operational assistants*. As a knowledge organization, the school has several organization members. These members are identified through an identification number and a name. Groups are organization members which contains employees. See Table 7.4 for a description of identified groups.

The study aim is to answer the question: “Is the organization optimized to produce and transmit knowledge?” To contextualize the reader, an example is given: every year, new teachers come to the school, and every year almost the same teachers leave the school. Those teachers take time to deeply know the local community. When they are fully integrated, the year is over. Every year, this school has an articulated and rich activities plan. If knowledge sharing is improved, then scientific articulations can be upgraded and this is better for students. To reach an answer for the above question, several main goals were defined, namely to: identify central elements in the organization; identify central groups in the organization; obtain RCV for each relational action; and compute the RCV of the network. Also, two additional goals were defined: (1) simulate the absence of central elements and measure the impact on network RCV; and(2) simulate the removal of peripheral elements and measure the impact on network RCV.

Using SNARE-Framework, this study was conducted with the collaboration of the School's Quality Observatory in April 2011. As a result, several recommendations to improve knowledge sharing emerged.

The target population was grouped[42]. See table below.

Table 7.4 Case B - Identified Groups

Group	Description
1	Visual Arts and Technological Education
2	Biology and Geology
3	Economics and Accounting
4	Sports
5	Philosophy
6	Physics and Chemistry
7	Geography
8	History
9	Information Technology
10	English
11	Portuguese, Latin and Greek, and Special Education
12	Mathematics
13	Technical Assistants
14	Operational Assistants

7.2.2. Organizational Structure

The organizational structure of this Case-B is presented using three complementary SNARE-Language views: social entities view (Figure 7.20), roles view (Figure 7.21), and relational actions view (Figure 7.22).

In structural terms, the *School* has several *Organization Members* (Figure 7.20). *Employees* and *Groups* are *Organization Members*. Each member is identified by an identification number and a name and each employee was modeled with five descriptors: *prestige, competence, experience, friendship*, and *proximity*.

In this study, we identified three main roles to be analyzed: *Teacher*, *Technical Assistant* and *Operational Assistant* (Figure 7.21). Derived from the *Teacher* role we identified four roles, namely: *Director*, *Sub-Director*, *Director Assistant* and *Coordinator*; from *Technical Assistant* we identified *Operational Assistant Chief*; and, from *Operational Assistant* we identified the *Technical Assistant Chief* role.

[42] Note: to preserve the confidentiality of the people involved a decision was made to join Visual Arts and Technological Education, and,in another group, Portuguese, Latin and Greek, and Special Education.

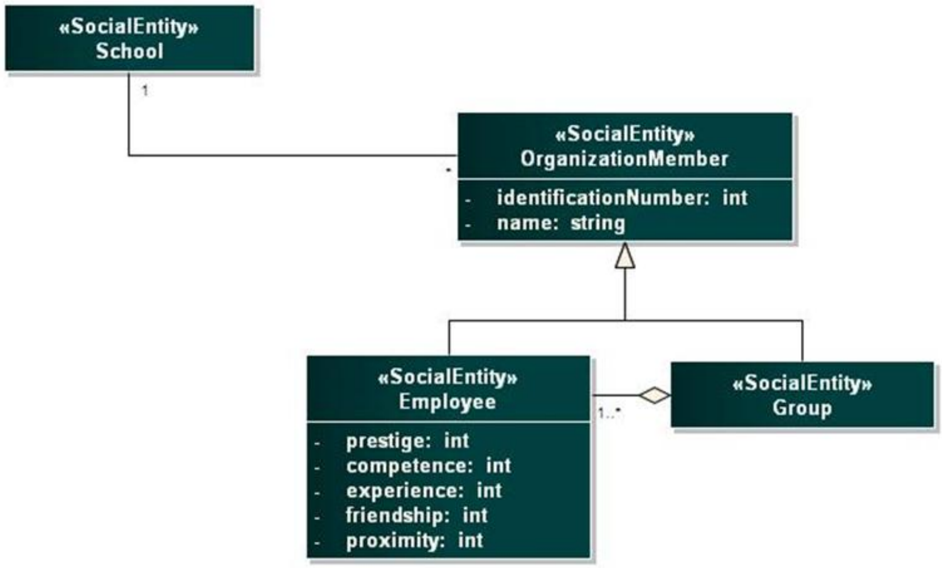


Figure 7.20 Case B - Social Entities View

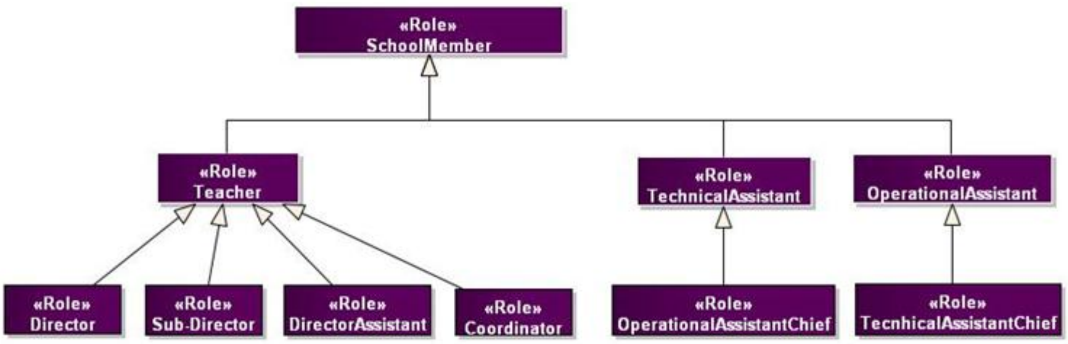


Figure 7.21 Case B - Roles View

In the *IsColleagueOf* relation, several relational actions were considered: *Evaluate Peer, Ask For Help, Communicate With IT, Transmit Information*, and *Who Recognize* (Figure 7.22). Those actions are triggered by social entities members (*invokers*) to organization peers. For each triggered action, there may be several target members.

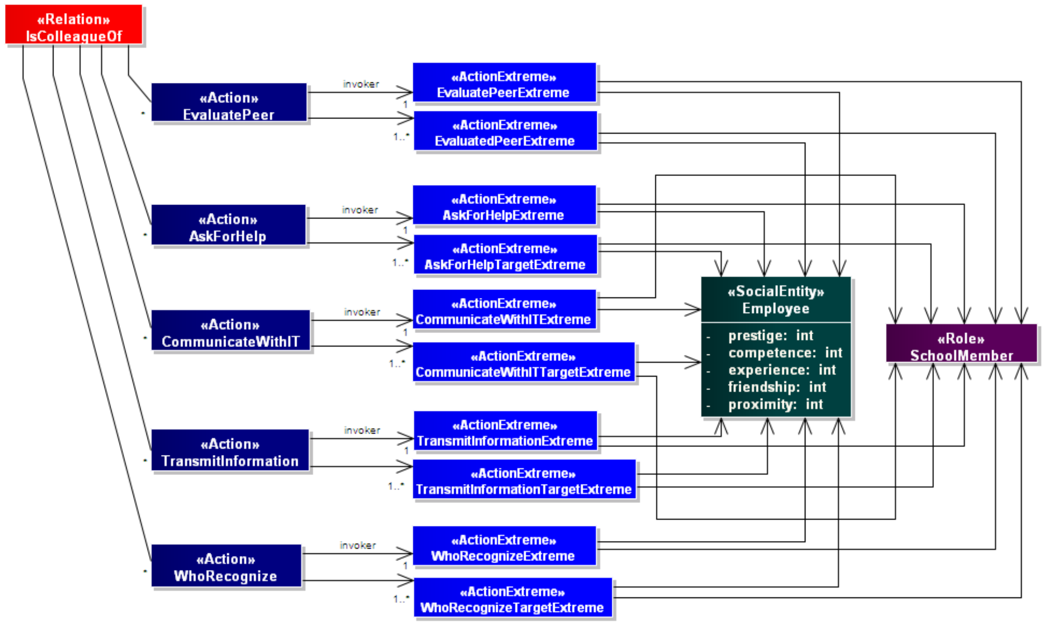


Figure 7.22 Case B - Relational Actions View

7.2.3. Project Charter Summary

After identifying the organizational context and structure, in this section we summarize three relevant issues of this project charter:

- Identification – The present study is focused on the analysis of communication mechanisms and information to transmit knowledge at the school.
- Project Objectives – To identify central elements in the organization; identify central groups in the organization; obtain RCV for each relational action; and compute the RCV of the network.
- Business Need – Answer the question: "Is the organization optimized to produce and transmit knowledge?" and improve the organizational sharing of knowledge.

7.2.4. Data Gathering Processes

With this study, a network analysis was first performed at school. With the aim of analyzing organizational mechanisms of communication and information to transmit knowledge, we raised, through a questionnaire, several questions to the local community (See *Questionnaire* in Appendix E). Data about employees was collected from the school's HR system (e.g., groups and members). The target universe contained 229 employees (*Teachers, Technical Assistants*, and *Operational Assistants*). 207 questionnaires were delivered and collected (162 *Teachers*, 11 *Technical Assistants* and 34 *Operational Assistants*).

The questionnaire contains several questions, and the closed-answer questions were defined as follows:

- Can you associate names to people in order to correctly identify your colleagues?
- Who transmits important information to carry out your functions?
- Who do you ask for help when you have to solve a new problem?
- Who do you particularly appreciate for professionalism and/or scientific knowledge?
- Who communicates with you using information technology?

These questions were inspired in Cross and Parker's work [CP 04] (For a review, see Table C.1 *Questions to Uncover Important Network Relationships* in Appendix C*)*. Using SNARE-Framework, four questions were analyzed, and for each relational action, a name was assigned according to the following table. The table also shows the analyzed records for each question.

Table 7.5 Case B - Relational Actions Analyzed Records

Name of Relational Action	**Questionnaire correspondence**	**Analyzed Records**
AskForHelp	2 b)	337
CommunicateWithIT	3 b)	296
TransmitInformation	2 a)	591
WhoRecognize	3 a)	481
	Total	1705

The above table shows that *TransmitInformation* captured a greater number of responses, and *CommunicateWithIT* a lower number. In addition, when answering the questions listed above, people were also asked to rate their peers in terms of five descriptors: *prestige, competence, experience, friendship*, and *proximity*.

All questions were firstly processed using a spreadsheet and imported by CSV SNARE-Explorer mechanisms.

7.2.5. Evaluation Report

The *Evaluation Report* is discussed in this section and is composed by four methodological artifacts: *Network Analysis; Social Entity Analysis; Relational Analysis;* and *Relational Capital Value Report*.

7.2.5.1. Network Analysis

Network Analysis includes network layouts, network properties (NP) analysis, and network valuable factors (NVF) characterization. In this study, SNARE-Explorer automatic layout design feature was activated to produce a global network layout.

The image bellow (Figure 7.23) was produced after the relational data import process, and community members and respective connections are depicted. Isolate nodes are also observable. In the second image (Figure 7.24), a network zoom is provided.

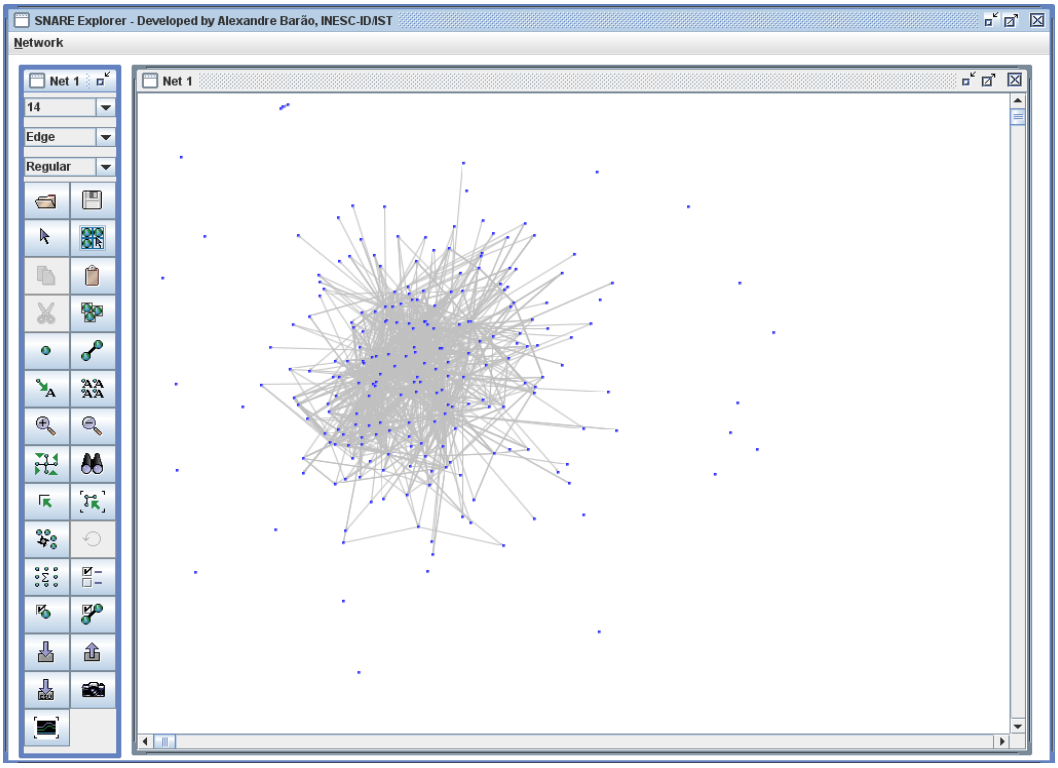


Figure 7.23 Case B - Network Layout

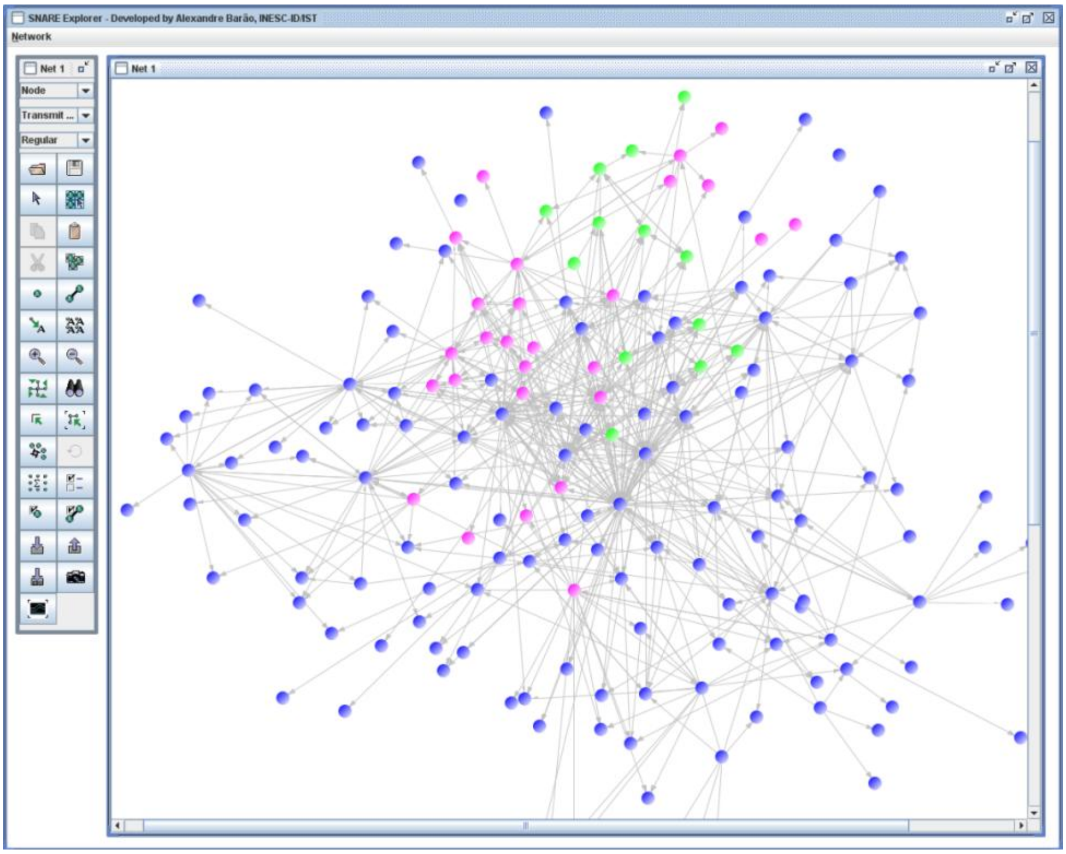


Figure 7.24 Case B - Core Network Members Zoom

In the image above, teachers are represented with blue nodes, technical assistants with green nodes, and operational assistants with pink nodes. The network image shows clusters of technical and operational assistants. Near these clusters we found a small group of high degree central elements. Some of them are board members and coordinators.

To start NP analysis, a network density analysis was performed for all imported relational actions. In this density analysis, isolated nodes were considered. Density analysis result:

- Nodes analyzed: 229
- Isolate nodes included: yes
- Result: 0,0192

In this study, the mean of *indegree/outdegree* of each relational action was analyzed. The following table analysis reveals that using IT to communicate has the lowest mean of *indegree/outdegree*. When analyzing *transmit information* relational action, it was observable that this mean is the highest. People are dependent of information transmission, but the use of IT with that purpose is not optimized in the organization.

Table 7.6 Case B - Mean of Nodal Indegree/Outdegree

Relational Action	Mean of Nodal Indegree/Outdegree
AskForHelp	1,471615721
CommunicateWithIT	1,292576419
TransmitInformation	2,580786026
WhoRecognize	2,100436681

Network Valuable Factor (NVF) is a SNARE-RCO input parameter to determine the network RCV. To set NVF value two parameters were included: the network total of members (229), and network density (0,0192). Weights were assigned from1 to 100, respectively (See *Defining and Classifying Parameters* in Chapter 4 for more information). The obtained NVF value was 439,68 RCV units.

7.2.5.2. Social Entity Analysis

Social Entity Analysis includes Human Capital Properties (HCP), Social Entity Valuable Factors (SEVF), and Node Type Analysis (NTA).

HCP data was captured from peer evaluation descriptors. As stated, these descriptors are: *prestige, competence, experience, friendship*, and *proximity*. Analyzing Table 7.7, *proximity* is a communication enhancer between people. By examining descriptors *friendship* and *prestige*, we can see they are lower than average, because people considered them as personal information. *Experience* and *competence* collected higher ratings. This is a recognized characteristic from professionals of the analyzed organization. Table 7.7 results are depicted in Figure 7.25.

The analysis shows that the community predominantly expresses the recognition of competence and experience among peers. The figure 7.26 shows that there is a strong correlation (0.956721444) between the recognition of *competence* and *experience* in the community.

Table 7.7 Case B - HCP per Group (RCV units)

Group	Prestige	Competence	Experience	Friendship	Proximity	HCP Sum
1	2	20	15	3	9	**49**
2	3	33	26	6	14	**82**
3	27	86	70	38	41	**262**
4	17	101	78	27	72	**295**
5	17	115	70	36	65	**303**
6	6	45	49	13	110	**223**
7	5	21	20	7	10	**63**

Group	Prestige	Competence	Experience	Friendship	Proximity	HCP Sum
8	2	19	11	12	15	**59**
9	11	83	81	29	38	**242**
10	9	41	30	25	33	**138**
11	30	151	122	73	92	**468**
12	43	152	108	70	88	**461**
13	17	77	72	19	56	**241**
14	50	110	107	47	84	**398**
Sum	**239**	**1054**	**859**	**405**	**727**	
Avg	17,07142857	75,28571429	61,35714286	28,92857143	51,928571	

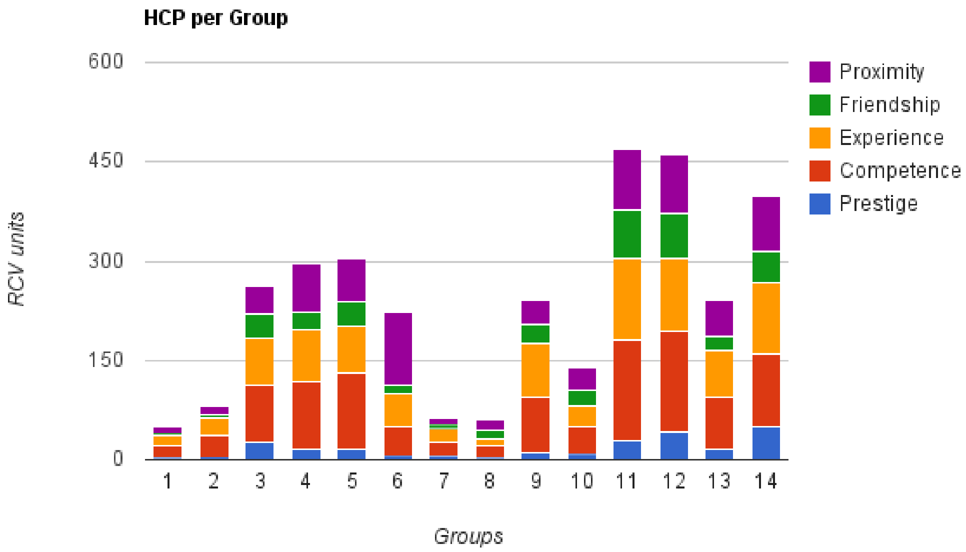


Figure 7.25 Case B - HCP per Group

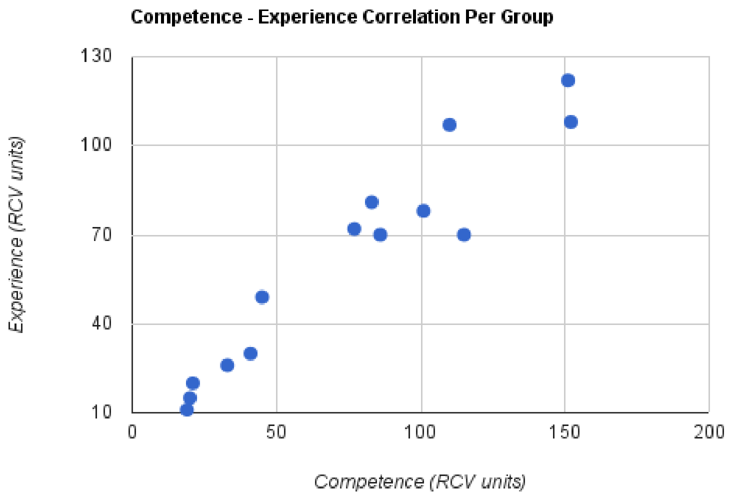


Figure 7.26 Case B - Competence/Experience Correlation

SEVF are properties associated to each entity. As stated in Section 4.2, to compute SEVF two types of properties are combined: NP and HCP. Figure 7.27shows SNARE-Explorer interface with the SEVF properties of a given network member[43].

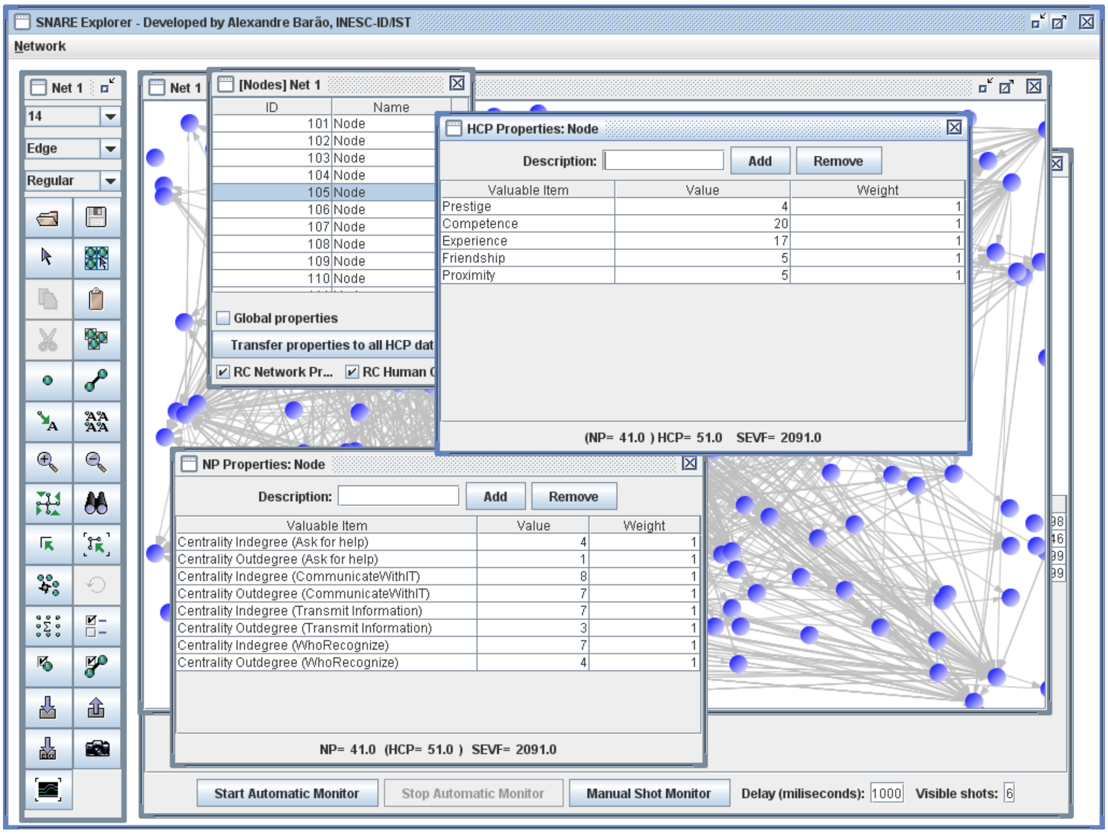


Figure 7.27 Case B - Network Member SEVF Properties

Table 7.8 shows the contribution of each group to the network SEVF. This table is ordered by SEVF computed values. Figure 7.28 depicts the related SEVF distribution per group.

[43] Identification number of network member disclosed with consent

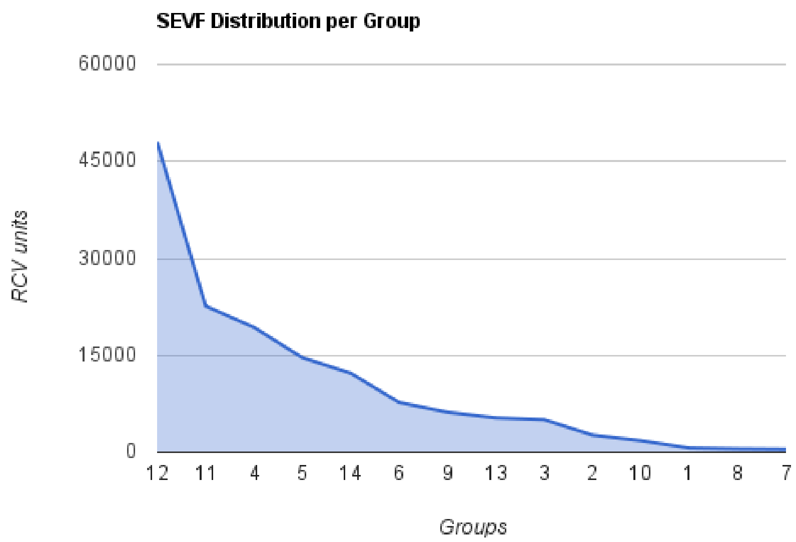


Figure 7.28 Case B - SEVF Per Group (RCV Units)

Table 7.8 Case B - Network SEVF (Groups)

Group	SEVF
12	47839
11	22471
4	19185
5	14493
14	12094
6	7562
9	6051
13	5180
3	4899
2	2513
10	1649
1	496
8	378
7	314
Total	**145124**

Table 7.9 uncovers a relevant finding: 50% of organizational SEVF are held by the first five network members, and 65% are held by the first ten. This means that the organization depends on those people and any change (e.g., a sick person) causes a high network RCV impact.

Table 7.9 Case B - Top 10 Network Core Members SEVF Weight

ID	NP	HCP	SEVF	SEVF (%)
Confidential	173	170	29410	20,3
Confidential	145	119	17255	11,8
Confidential	105	121	12705	8,7
Confidential	151	43	6493	4,5
Confidential	80	70	5600	3,8
Confidential	95	57	5415	3,7
Confidential	58	85	4930	3,4
Confidential	51	95	4845	3,3
Confidential	65	68	4420	3,0
Confidential	93	43	3999	2,7

Network node types per relational action were characterized. Refer to Table F.1 in Appendix F for a review of network node types' concepts. From 229 analyzed nodes, results were as described in Table 7.10, and depicted in Figure 7.29.

Table 7.10 Case B - Network Node Types per Relational Action

Relational Action	Isolate nodes	Transmitter nodes	Receiver nodes	Carrier nodes	Ordinary nodes	Total
AskForHelp	90	20	72	5	42	229
CommunicateWithIT	94	17	83	2	33	229
TransmitInformation	60	14	100	0	55	229
WhoRecognize	55	9	120	4	41	229

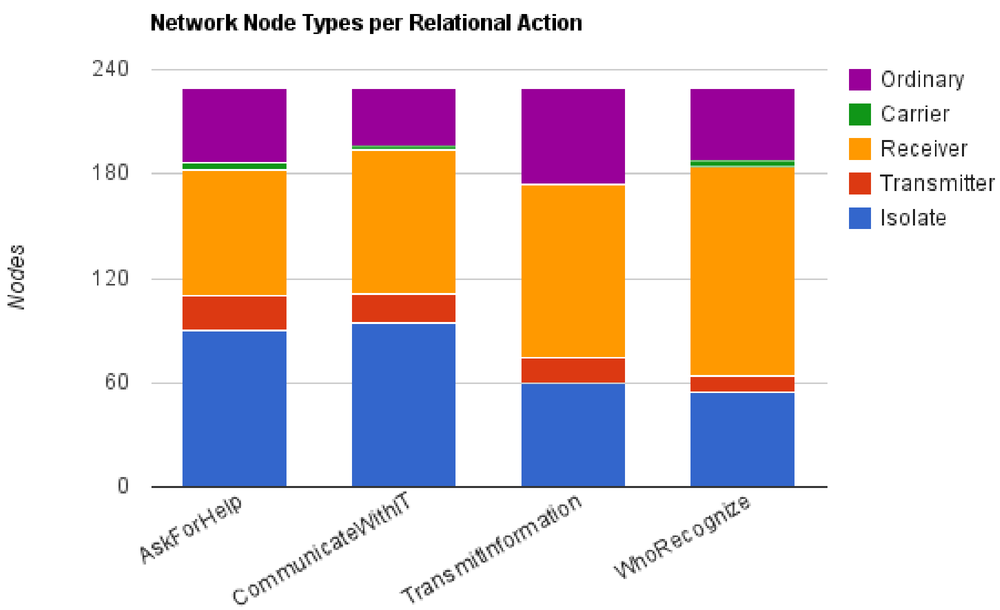


Figure 7.29 Case B - Network Node Types per Relational Action

CommunicateWithIT relational action has captured the higher number of isolate nodes. *Transmitter* nodes are predominant in *AskForHelp* relational action. *WhoRecognize* has captured the highest number of receiver nodes while *TransmitInformation* captured the highest ordinary nodes number.

7.2.5.3. Relational Analysis

To perform Relational Analysis, Relation Type Values (RTV) and Relational Levels Values (RLV) were firstly defined. RTV and RLV are SNARE-RCO parameters. In this study, RTV was set to 0.1 and RLV was defined as 1.

The following figure shows the RV Sum computed values (See Table 7.11) for each type of relational action.

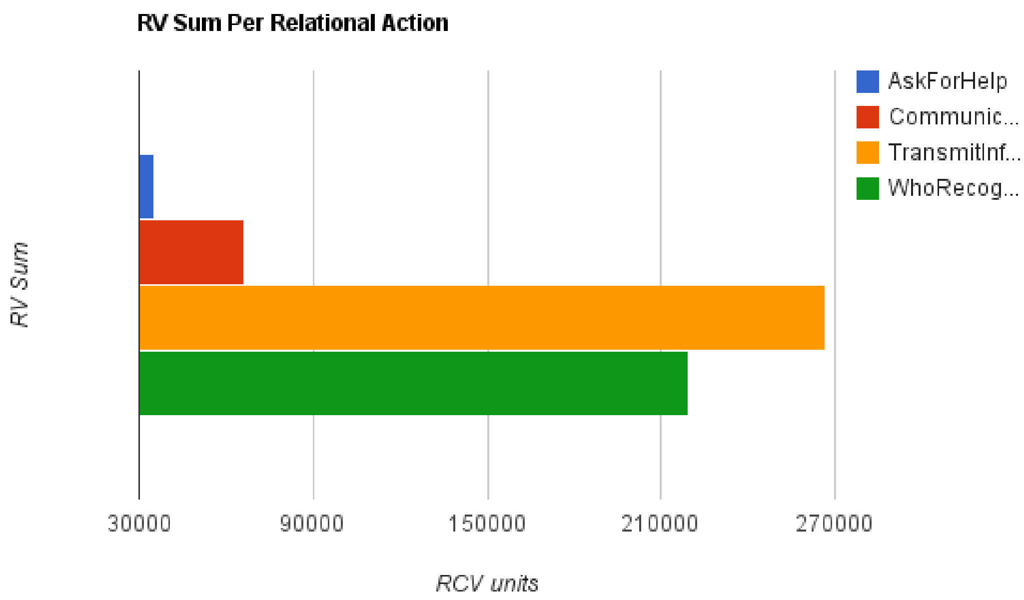


Figure 7.30 Case B - RV Sum per Relational Actions (RCV units)

Table 7.11 Case B - RV Sum Per Relational Action (RCV units)

	Ask For Help	**Communicate With IT**	**Transmit Information**	**Who Recognize**	**Total**
RV Sum	35348,6	66145,3	266652,9	219301,2	587448

The main responsible relational action for RCV increase is *TransmitInformation*. *AskForHelp* and *CommunicateWithIT* are the lowest RCV contributors. This is a remarkable fact, because it proves that communication and transmission of organizational knowledge can be optimized.

7.2.5.4. Relational Capital Value Report

Relational Capital Value Report includes procedures to compute the global RCV value and simulations, concerning the study goals. The analysis tool computed the global RCV of the organization: 733012,68 RCV units. This will be a reference value for future studies. Figure 7.31 illustrates the process of RCV monitoring. Regarding the SNARE-RCO model, RCV is computed with four input parameters: *OVF*, *NVF*, *RV Sum*, and *SEVF Sum*. As stated before, *RV Sum* is the metric to compute the RCV value of relational actions (RV Sum = 587448).

After computing the global RCV, a simulation was conducted to assess the impact of removing the three most central network members. Figure 7.32 depicts this process. Steps a), b) and c) correspond to the removal of people with SEVF rank#1, #2 and #3, respectively. The RCV impact is very substantial (white line). Step d) corresponds to a removal of a low ranked SEVF person, and the RCV impact is not significant.

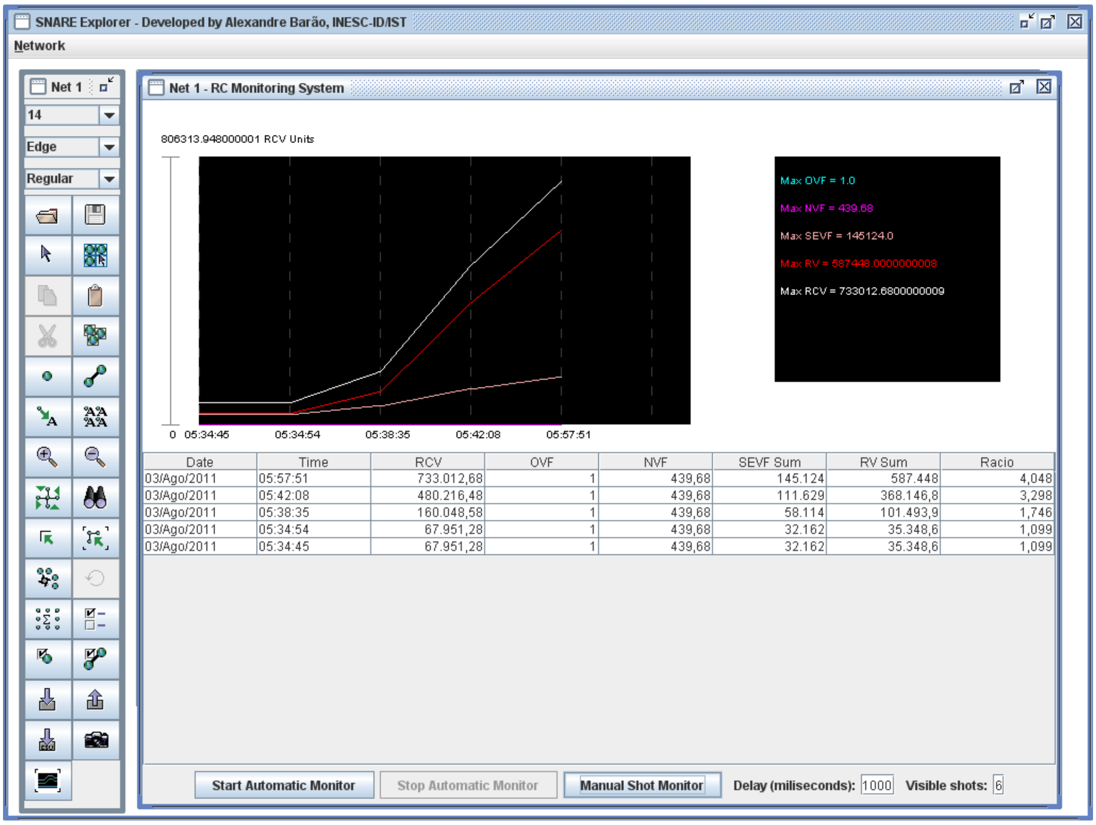


Figure 7.31 Case B - RCV Monitoring

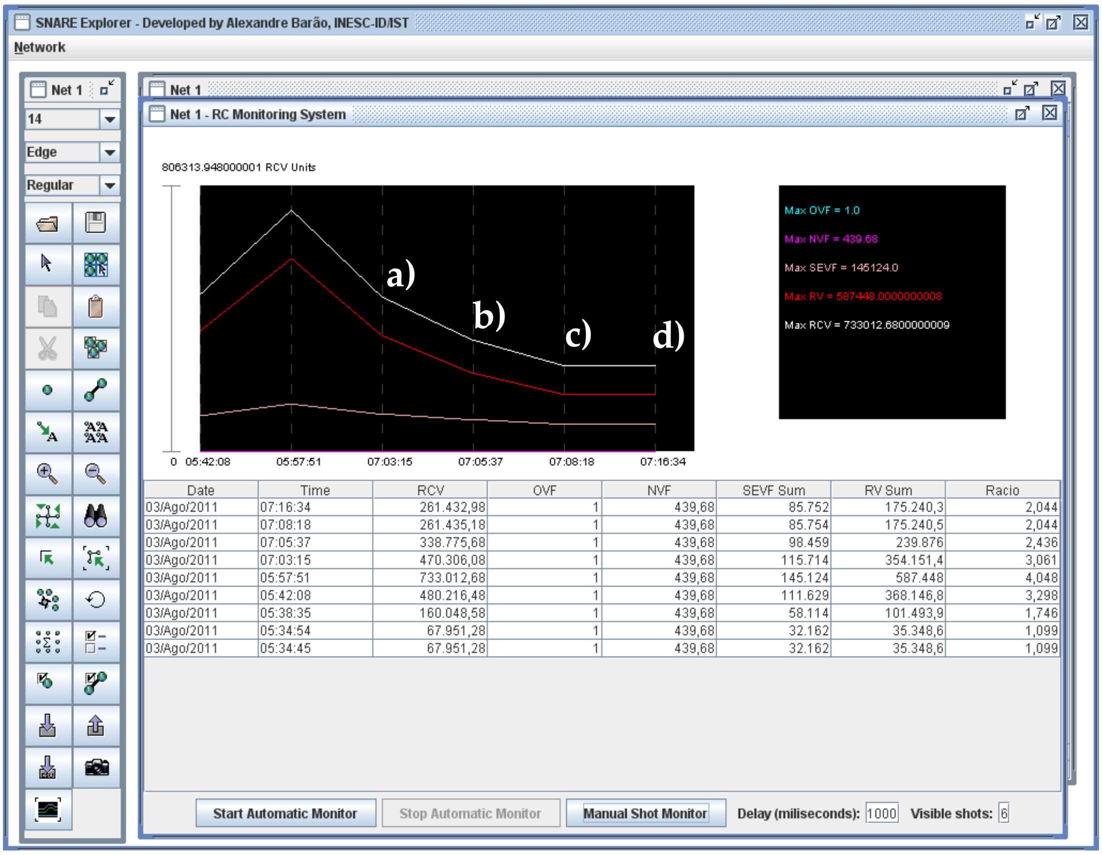


Figure 7.32 Case B - Monitoring Members Removal

The previous figure reinforces our findings: there is a restrict group of people who contribute significantly to the network RCV. The simulation allowed analyzing the RCV impact of those network members.

7.2.6. Case Conclusion

The study allowed collecting questionnaires from 204 people (89% of the expressive universe of 229 people). Moreover, this study captured ratings for people who did not participate in the questionnaire.

It was observed that a relatively small number of people play a central position in the organization. As the results showed, the information transmission relational action is the main responsible for network RCV. A problem was also detected: a significant number of people are dependent on the information provided by a restrict group. To increase this problem, communication with IT has captured low RCV values. This aspect reveals that to rationalize the information transmission using IT and redistributing workloads can release significant resources for other important tasks.

Even when using IT, senders are typically the network's core members. Besides, after analyzing questionnaire's open questions, we verified another problem: people receive the same information from several sources. Therefore, to avoid this and improve knowledge sharing, a CMS platform can be used, and a significant reduction of emails might be reduced. Also, to rationalize resources and increase IT communications, a workflow system would help the organization to know *who* does *what*, *how*, and *when*. This kind of system can release important resources, e.g. in the end of the year, board members and coordinators could spent less hours doing activity reports. Also, when improving these actions, it is possible to reduce operational costs (e.g. avoiding reprography services).

The SNARE-RCO model provides objective information to support decision making. Also, it can be used in order to compare several schools.

This study has showed that the school is not optimized to produce and transmit knowledge, and a change plan was recommended by the Observatory of Quality to the School board. This plan was accepted and change actions were started.

In the future, it would be interesting to involve students in order to capture their perception about the school community.

7.3. Case C

In this section, Case C validation results are presented. The organizational context is in Section 7.3.1 whereas the organizational structure is presented in Section 7.3.2, and the project charter summary is given in Section 7.3.3. Case C data gathering processes are described in Section 7.3.4. The evaluation report is presented in Section 7.3.5, and, finally, conclusions are discussed in Section 7.3.6.

7.3.1. Organizational Context

The present study is focused on analyzing a CMS platform, more specifically the Learning Objects Pool (LOP) system [SS 09]. This system is a repository of learning objects [CSS 09]. A learning object (LO) is defined as "any digital resource that can be reused to support learning" [Wil 00], and LOP is built around the "stock exchange" metaphor, pushing users motivation to produce good learning objects as well as cooperate with other users either by submitting suggestions, comments or rate existing learning objects [SS 07]. To achieve this level of motivation and interest, some kind of competition is promoted, assigning credits to users and setting a value cost for each learning object. This credit-based system allows us to create users and learning objects rankings, rewarding those who collaborate with the system.

As referred, LOP is built around the "stock exchange" metaphor, i.e. users are ranked through an *offer-demand* credit system, and the major aim is to compute its network RCV to understand if SNARE-RCO model is able to evaluate registered users with similar results. The analysis is made assuming that there is a "blind knowledge" about LOP user system credits algorithms in order to compare computed NP properties with original HCP properties, which will be imported from LOP database. If computed NP and imported HCP are expressively correlated, then, SNARE-RCO is suitable for evaluating this kind of system.

7.3.2. Organizational Structure

LOP system is a learning objects repository and has several users. Each user has an identification number, a name, and a password. People are users of the LOP system and have several attributes, namely: gender, birth date, email, homepage, phone number, address, zip code, country, and credits. Users can be authors of learning objects (which are resources). Each learning object has an identification number, creation date, submission date, and a state. It is possible to know how many visitors viewed a specific learning object, how many downloads were made, and what the classification of a given learning object is. The LOP system has groups of people (e.g., regarding a scientific area). This way, it is possible to filter learning objects that belong to a specific group. Figure 7.33 depicts these concepts.

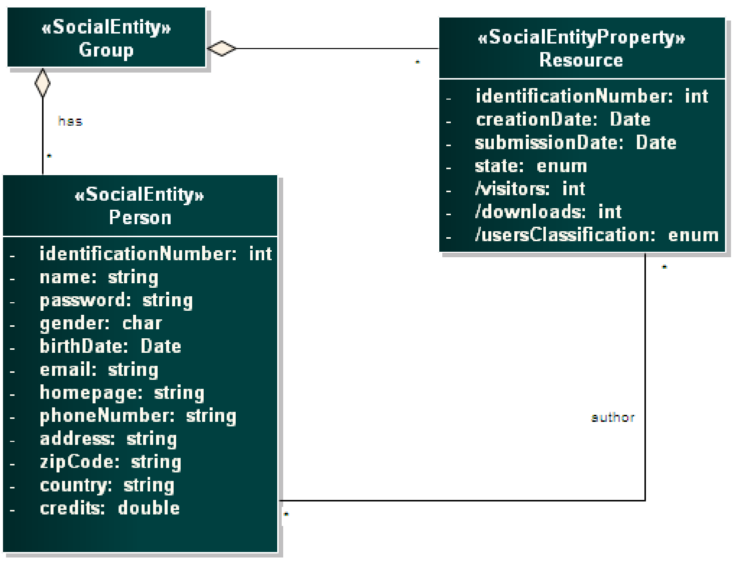


Figure 7.33 Case C - Social Entities Model View

LOP system users can have several roles, namely: *User*, *RegisteredUser*, *Administrator*, and *Reviewer* (See Figure 7.34). *AnonymousUser*s can browse the system, i.e. view learning objects (LOs) from other authors, but they cannot submit or download LOs. *RegisteredUser* can submit LOs, and also download LOs from other users as well as comment and rate them. The *Administrator* has total privileges on the platform. The *Reviewer* reviews LOs from authors and authorizes their submissions.

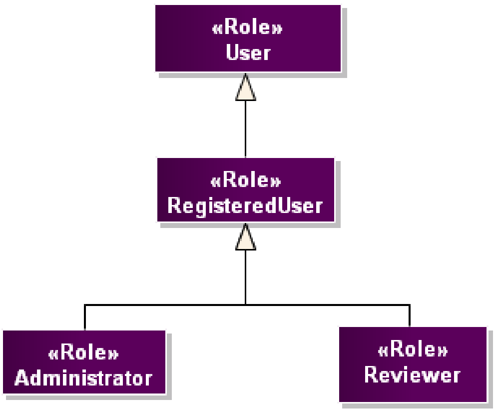


Figure 7.34 Case C - Roles Model View

This study is focused on two LOP system relational actions: *downloadLearningObject* and *commentLearningObject* (See Figure 7.35).

For each relational action, LOP registered users can make *downloads* or *comments* of LOs produced by other registered users.

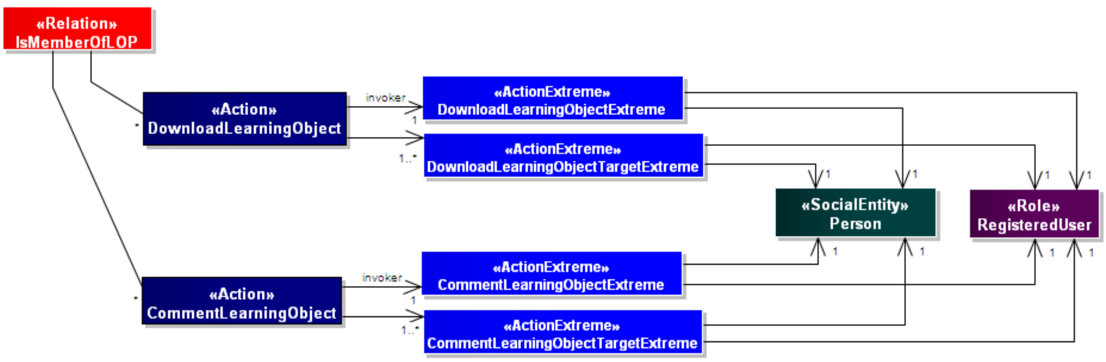


Figure 7.35 Case C - Relational Actions Model View

7.3.3. Project Charter Summary

After identifying the organizational context and structure, we summarize in this section three relevant issues of this project charter:

- Identification – The present study is focused on the analysis of the LOP's relational capital.
- Project Objectives – Compute the RCV of the network; Identify central elements in the network; Verify if NP properties enable similar user evaluations as produced by the actual LOP system; and obtain the RCV for each relational action.
- Business Need – Evaluate the RCV of the LOP system and understand how its relational capital is balanced.

7.3.4. Data Gathering Processes

Data was collected from LOP database corresponding to logs from June 2009 to July 2011. 268 users were imported by SNARE-Explorer using CSV mechanisms as well as associated relational actions: *download* and *comment* learning objects.

7.3.5. Evaluation Report

The *Evaluation Report* is presented in this section and is composed by four methodological artifacts: *Network Analysis; Social Entity Analysis; Relational Analysis;* and *Relational Capital Value Report*.

7.3.5.1. Network Analysis

Network Analysis includes network layouts, network properties (NP) analysis, and network valuable factors (NVF) characterization. In this study, SNARE-Explorer automatic layout design feature was activated to produce a global network layout.

The image bellow (Figure 7.36) was produced after relational data import process, and LOP members and their corresponding connections are depicted. Isolate nodes are also observable. In the second image (Figure 7.37), a network zoom is provided.

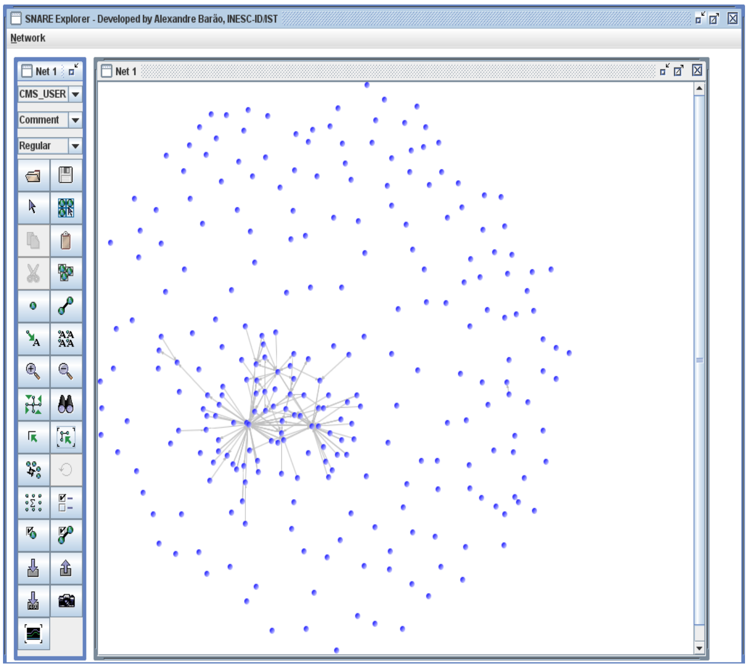


Figure 7.36 Case C - Network Layout

In the above image, a significant number of isolate nodes is observable. They are registered users, but they never make a unique LO *download* or *comment*. Besides, they have LOP starting credits to use the system. In the center of the network, most active users are depicted. The image reveals connections originated by relational actions such as *downloads* or *comments*.

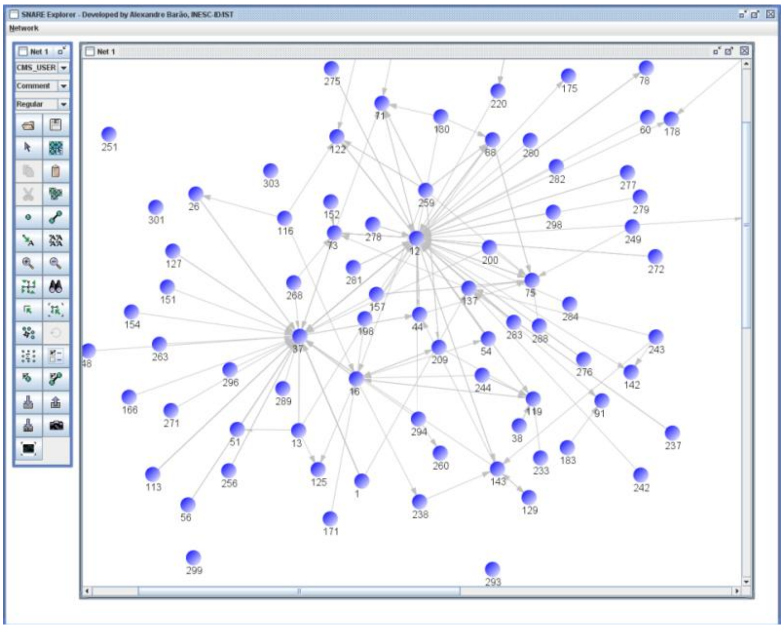


Figure 7.37 Case C - Network Core Members

In Figure 7.37, central members are depicted, revealing flows to most popular network authors.

To start NP analysis, a network analysis was performed for all imported relational actions (Figure 7.38). Isolate nodes were included. Density analysis result:

- Nodes analyzed: 268
- Isolate nodes included: yes
- Result: 0,00174688

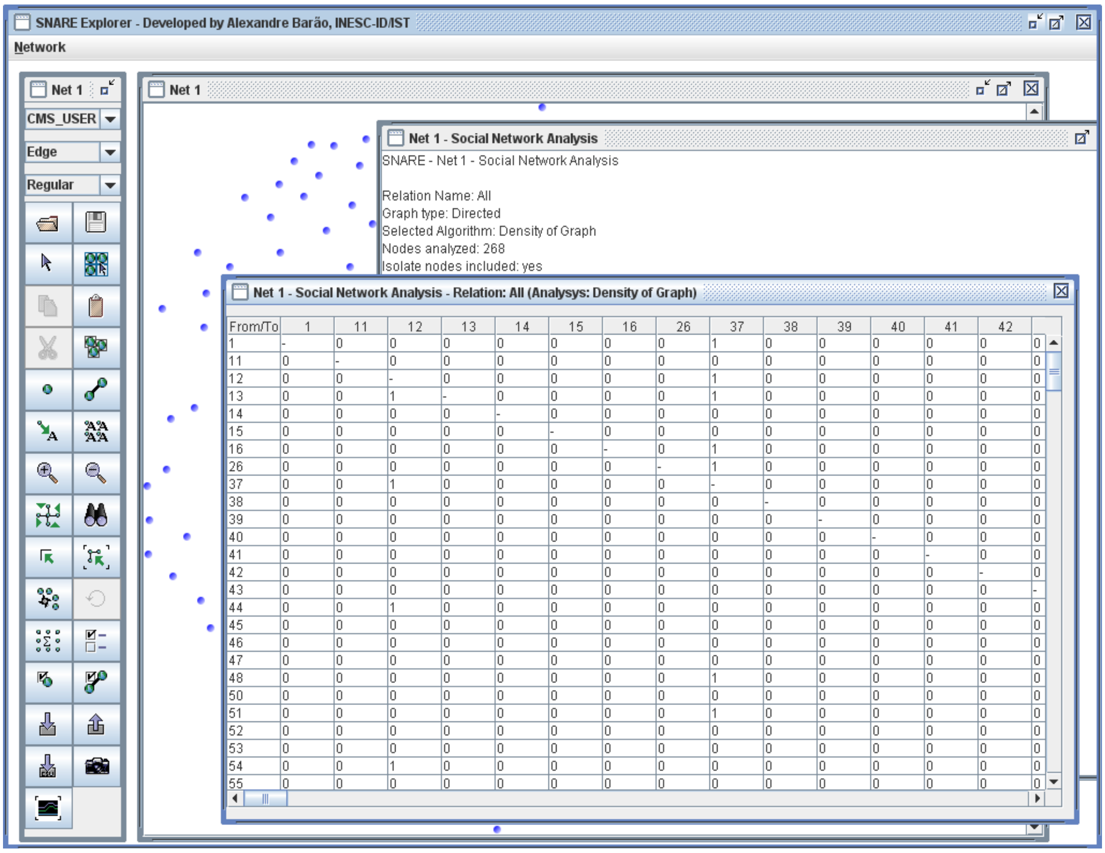


Figure 7.38 Case C - Network Density Analysis (Relational Matrix View)

NP analysis was performed to find network centrality levels from LOP registered users. Figure 7.39 depicts the LOP network distribution ordered by NP rank of network members.

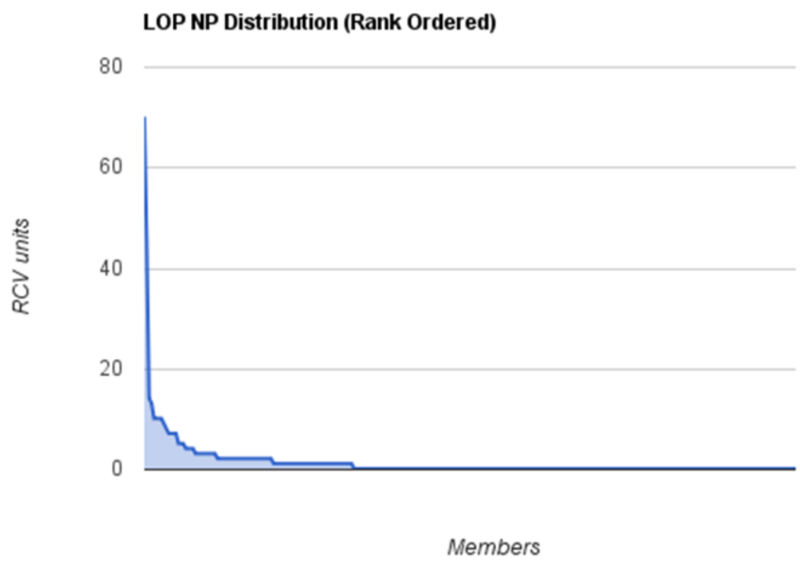


Figure 7.39 Case C - Network NP Distribution (Rank Ordered)

In the LOP platform, we have detected a small number of users with a high centrality degree (Figure 7.39). These results confirm the network layouts produced.

Network Valuable Factor (NVF) is a SNARE-RCO input parameter to determine the network RCV. The value obtained was 46.8 RCV units. This value was computed using the number of network nodes (268) with weight 1, and the density of graph (0,00174688) with weight 100 (See *Defining and Classifying Parameters* in Chapter 4 for more information).

7.3.5.2. Social Entity Analysis

Social Entity Analysis includes Human Capital Properties (HCP), Social Entity Valuable Factors (SEVF), and Node Type Analysis (NTA).

In this study, for each registered user, credits were imported as HCP properties. Figure 7.40 depicts HCP distribution. Using SNARE-RCO, user credits are now expressed in RCV units.

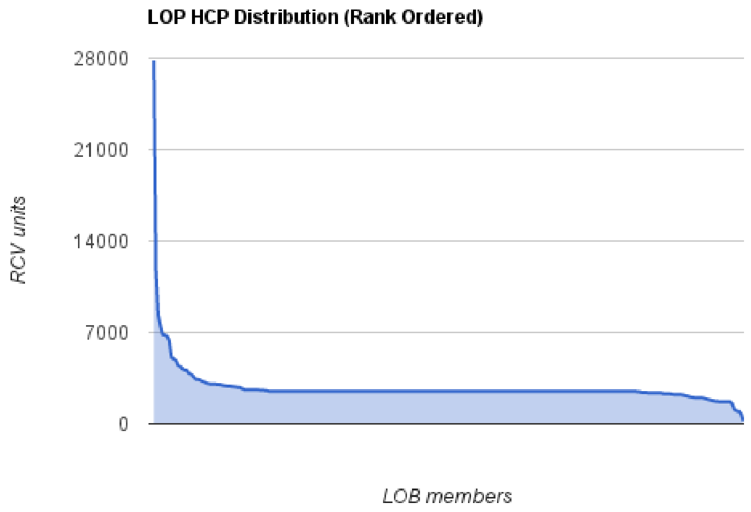


Figure 7.40 Case C - LOP HCP (Rank Ordered)

The SEVF was computed based on the centrality degrees of each network member (NP properties), and also computed from imported LOP user credits, which we assume as HCP properties, as stated before. Our first finding confirmed our expectations: there is a significant correlation between SNARE-RCO model computed NP properties and HCP properties imported from the LOP system. This correlation is: 0,862386017. Figure 7.41 depicts this correlation. Thus, taking NP results as a starting point, SNARE-RCO model is able to similarly evaluate LOP users. Results are correlated because LOP user credit algorithms are based on an *offer-demand* credit system. Hence, native algorithms used to compute LOP credits could be replaced by SNARE-RCO model RCV algorithms.

The computed network SEVF is 3309873,97 RCV units.

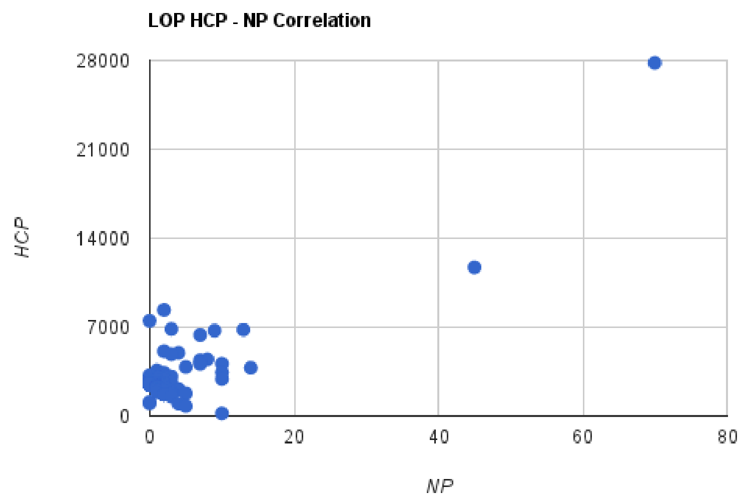


Figure 7.41 Case C - HCP-NP Correlation

Network node types were characterized according to their NP level (Refer to Table F.1 in Appendix F for more information). From the 268 analyzed nodes, statistical results were as follows: Isolate nodes = 182 (67%); Transmitter nodes = 53 (19%); Receiver nodes = 13 (4%); Carrier nodes = 5 (1%); and Ordinary nodes = 15 (5%). Figure 7.42 depicts these results.

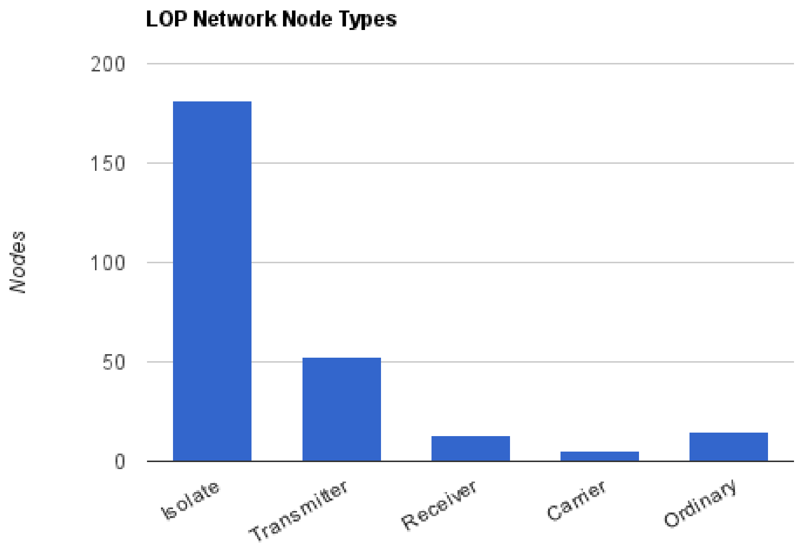


Figure 7.42 Case C - Network Node Types

From the above image, it is possible to verify that isolate nodes are predominant in this network. They are registered users who do not perform *comments* or *downloads*.

7.3.5.3. Relational Analysis

To perform Relational Analysis, Relation Type Values (RTV) and Relational Levels Values (RLV) were firstly defined. RTV and RLV are SNARE-RCO parameters.

In this study, RTV was set to 0,1 for relational action *downloads,* and set to 0,2 for relational action *comments*.RLV was defined as 1.

Using these definitions, RV Sums for each relational action were computed. The following figure shows the RV Sum for each type of LOP analyzed relational action, and Table 7.12 presents the computed values.

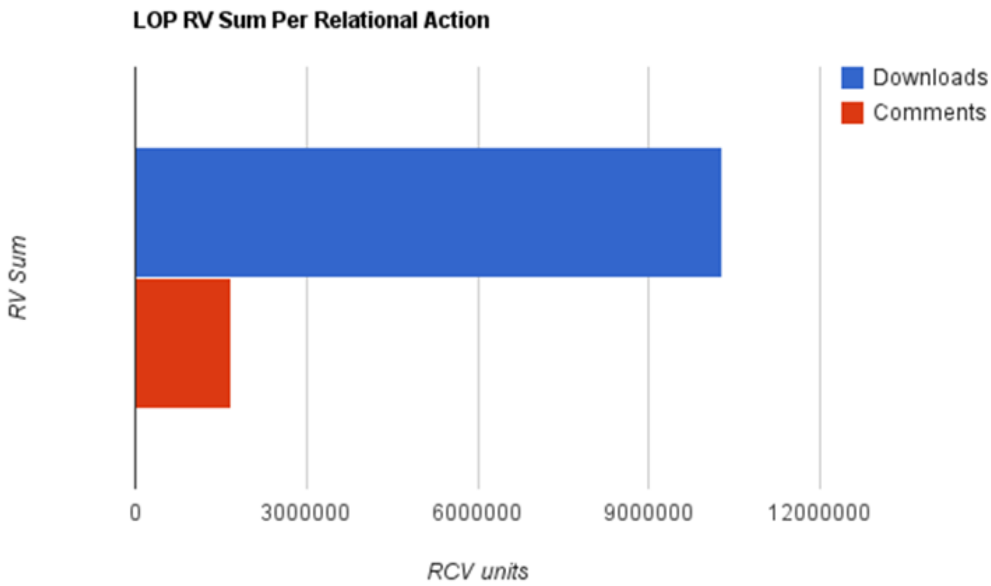


Figure 7.43 Case C - RV Sum per Relational Action

Table 7.12 Case C - RV Sum per Relational Action

	Downloads	Comments	Total (RCV units)
RV Sum	10276766,35	1675147,63	11951913,98

The predominant relational action to produce RCV capital is *Downloads*.

7.3.5.4. Relational Capital Value Report

Relational Capital Value Report includes procedures to compute the global RCV value and simulations regarding the study's goals. The analysis tool computed the global RCV of the organization: 15261835,77 RCV units (See Table 7.13). This will be a reference value for future studies. Figure 7.44 illustrates the process of RCV monitoring. Regarding the SNARE-RCO model, RCV is computed with four input parameters: *OVF*, *NVF*, *RV Sum*, and *SEVF Sum*. As stated, *RV Sum* is the metric to compute the RCV value of relational actions (RV Sum = 11951913,98).

Table 7.13 Case C - LOP RCV

	Downloads	Comments	Total (RCV units)
RCV	13153745,93	2108089,84	15261835,77

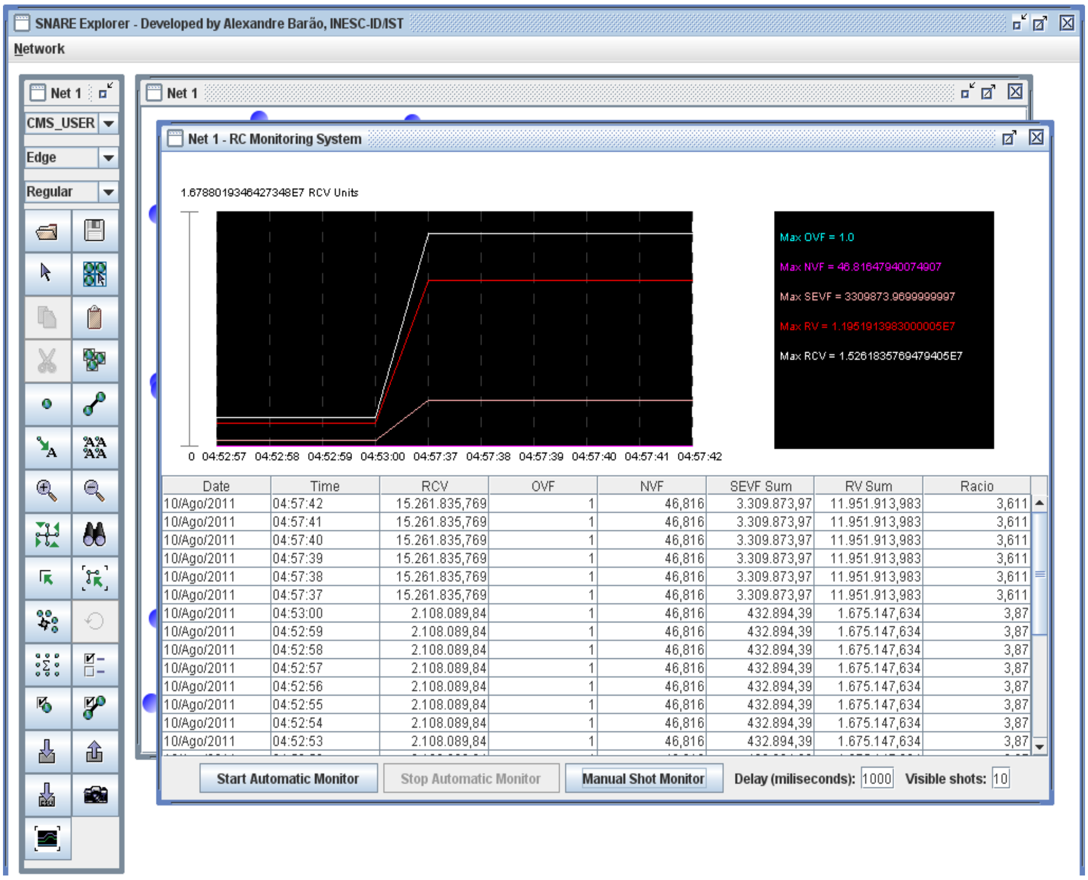


Figure 7.44 Case C - LOP RCV Monitoring

7.3.6. Case Conclusion

In the LOP system, a significant number of isolate nodes was observable. They are registered users but they never make a single LO *download* or *comment*. However, a small number of users with a high centrality degree were detected. These users are those most popular LO authors.

We found a significant correlation between NP computed properties and user credits imported from LOP system. This fact enforces that SNARE-RCO model is able to evaluate registered users with similar computed LOP results.

The study has also identified network central members, and proved that SNARE-Framework can be applied to monitor the relational capital of a CMS-based system. Relational actions were measured and the RCV was computed for the overall network.

7.4. Discussion

Case A is focused on the analysis of the Relational Capital of six teams from a Vodafone Portugal Unit: GSS, and analyzes team resilience as a function of team dependency of specific members. This validation was based on analyzing the workflow among Vodafone members. When used to compare individuals with similar roles within a team, combined NP and RV analysis shows the teams' ability to distribute workload and cooperate. We identified the central elements of teams. Also, we have computed the RCV of each team, and analyzed how RCV varies depending on the type of relational actions. Finally, we computed the RCV of the overall network, and we still simulated the absence of central elements and measured the impact on the network RCV. From this specific case, we conclude that network properties and relational value can be a way of translating team resilience. The study has validated expectations, namely: homogeneous groups, in which all members execute similar functions, are expected to equally distribute effort among its members; and if Network Properties (NP) are equally distributed, groups can be more resilient. However, members with NP higher than the average can represent a risk of dependency, and members with NP lower than the average can represent elements not entirely integrated into their teams.

Case B is focused on the analysis of mechanisms of communication and information to transmit knowledge in a given school. This validation was based on a delivered questionnaire. We identified central elements in the organization; identified central groups; computed the RCV for each relational action; and also computed the RCV of the overall network. It was observed that a relatively small number of people occupy a central position in the organization and a significant number are dependent on information provided by a restrict group of people. To increase the problem, *communication with IT* captured low RCV values. This aspect reflects one thing: to rationalize the information transmission using IT and redistributing workloads can release significant resources for other important tasks. Even when using IT, senders are typically the network core members. The study has showed that the school is not optimized to produce and transmit knowledge, and a change of plan was recommended to the School board. This plan was accepted and change actions were started. The SNARE-RCO model has provided objective information to support decision making, and it can be used in the near future for comparing the organization in different time points as well as to further compare several schools using similar OVF parameters.

Case C is focused on the analysis of the LOP relational capital. This validation was based on learning objects *offer-demands* analysis from users of the LOP CMS platform. Relational actions were measured and the RCV was computed for the overall network. LOP was analyzed and a significant number of isolate nodes was found. They are registered users, but they never made a single LO *download* or *comment*. A small number of users with a high centrality degree was detected. These users are the most popular LO authors. In this study, SEVF was computed based on centrality degrees for each network member (NP properties), and also from imported LOP user credits, which we assume as HCP properties. We found a meaningful correlation between NP computed properties and HCP properties imported from LOP system, which enforces the fact that SNARE-RCO model is suitable for evaluating registered users with similar computed LOP results. Hence, using SNARE-RCO model in the LOP system or other related CMS enable network comparisons using RCV metrics.

The study has also identified network central members, and proved that SNARE-Framework can be applied to monitor the relational capital of a collaborative platform (eventually supported by a CMS system).

7.4.1. SNARE-Framework Platforms Application

In our research questions (See Section 1.3) we stated: *"the resulting evaluation system can also be applied to distinct organizational KMS such as: content management systems (e.g. Moodle, LOP) or social media platforms (e.g. LinkedIn, Facebook)"*. In the platforms Moodle, LinkedIn, and Facebook *demands* are conducted by users, e.g., reading a document (Moodle), viewing a job description (LinkedIn), or viewing user photos (Facebook). These *demands* are relational actions and can be evaluated using SNARE-RCO model. Thus, Table 7.14 presents several scenarios to enforce SNARE-Framework's ability to evaluate the relational capital of those platforms.

Two contexts were considered, namely *CMS* and *Social Media* platforms, and several examples on how to apply SNARE-Framework are given. Aiming at computing RCV to evaluate the relational capital of the referred systems, Table 7.14 considers three analysis dimensions: *Network Analysis* (including *Network Layouts*, *NP*, and *NVF*); *Social Entity Analysis* (including *HCP Analysis*, *SEVF Analysis*, and *Node Type Analysis*); and *Relational Analysis* (including *RTV*, *RLV*, and *RV Analysis*).

From this study, as illustrated in Table 7.14, which compares the analyzed platform LOP application with distinct applications, it is possible to apply SNARE-Framework and, consequently, the SNARE-RCO model to other collaborative platforms.

Table 7.14 SNARE-Framework Platforms Application

Platform	LOP	Moodle	LinkedIn	Facebook
Context	CMS	CMS	Social Media	Social Media
Network Analysis				
Network Layouts Depict network views with node type differentiation	authors and readers	teachers and students	colleagues and friends	friends and relatives
NP Detect social entity centrality degrees	users	teachers and students	colleagues	friends
NVF Compare overall network properties	number of users	number of teachers and students	number of network members	number of friends
Social Entity Analysis				
HCP Analysis Compare human capital properties	user credits	students assessments	professional skills	activities and interests
SEVF Analysis Analyze the RCV contribution of each social entity	recognized authors	best students	skilled workers	friends interests
Node Type Analysis Analyze social entities network predominant roles	users	teachers and students	colleagues	friends
Relational Analysis				
RTV Differentiate relational actions value	downloads comments	forum replies submitted works	status post recommendation	like comment
RLV Differentiate relational levels value	users co-authors	users class mates	friends colleagues	friends family
RV Analysis Understand each relational action RCV contribution	download comments	forum replies submitted works	status posts recommendations	photo uploads comments
RCV Evaluate the relational capital of the network	LOP users network value	Classes value	Colleagues network value	Friends network value

7.4.2. SNARE-RCO Parameter Settings Criteria

When performing a relational capital analysis, SNARE-RCO parameter settings criteria must be defined. Section 4.4 suggests *SNARE-RCO Application Guidelines*, and, concerning our experience, parameter weights definition as well. To review the SNARE-RCO model application criteria strategy for cases A,B, and C, we present Table 7.15, which summarizes the model settings criteria used in validation. As stated before, the three cases represent distinct and specific organizational scenarios, and the aim was not to produce a comparative RCV *benchmark* evaluation between these three networks. For this reason, we symbolically set OVF=1 for all cases. In further studies, OVF items can be used as a RCV input parameters to compare different telecommunications operators, schools, or collaborative and content management systems. Nevertheless, we used homogeneous SNARE-RCO settings criteria for the three case studies. As showed in Table 7.15, similar criteria were applied for network analysis, social entity analysis, and relational analysis. More specifically, NP was computed using the *indegree/outdegree* sum criteria. As mentioned, we chose this sum to evaluate the activity level of network members. NVF was computed regarding the number of network members and also the network density, because these metrics scale well and are key when it comes to characterizing a network (See Section 4.2). The number of network members is a network size indicator and the network density expresses the communication level of a network, which enables to compare the communication level of different organizational units.

After several weighting tests using the SNARE-Explorer RCV monitoring system, the number of network members' weight was set to 1, and network density weight was set to 100.Computed NVF values were 444.65 (Case A), 439.68 (Case B), and 46.816 (Case C). Despite the use of similar criteria for HCP indicators weighting system, the results for this SNARE-RCO model parameter are less directly comparable than NVF values because the provided indicators (previously described in this chapter) and related data are different when regarding Case A, B, and C contexts. For this reason, SEVF sum computed values were as follows 10926 (Case A), 145124 (Case B), and 3309873.97 (Case C).In further studies, it is possible to develop and use alternative sets of HCP indicators, as suggested in *SNARE-RCO Application Guidelines*, to be used in distinct organizational contexts. Nevertheless, despite the SEVF sum different range computed values, the use of chosen indicators in distinct scenarios enforces SNARE-RCO model's flexibility to adapt to different realities. To choose a set of HCP adequate indicators, concerning the organizational context and the *Sponsor* expectations, will be always a challenge for the *Analyst*. However, the adopted criteria for social entity analysis can be further reused in the same organizations with the aim of comparing the relational capital evolution of those networks. E.g., this was suggested to Case B *Sponsor*, and accepted.

Regarding relational analysis, as described in Table 7.15, the settings criteria were homogeneous as well. All relation type values were set to 0.1 with the exception of *comments* relational action (from Case C), which was set to 0.2. Regarding Case C's characteristics, we decide to increase the relational type value *comments* to enforce the computed relational capital value of more interacting users. I.e. *downloads* is a less interactive relational action when compared with *comments*, thus, RTV was set to its double. RLV was equally set to 1 for the three cases. We must point out that RLV data for Cases A and C was not available. Hence, to keep the same RLV criteria, we decide not to differentiate Case B's RLVs (e.g., by using the available *friendship* and *proximity* indicators). However, in another case study, the *SH Software Company* [BS 12], we used and tested a large set of weighted RTVs combined with a five level RLV set to compute the organizational relational capital value for six months. More specifically, in the SH software company case study, we detected 40 RTV types such as: *technical assistance, suggestions, external service, specific development, planned development, web development, plug-in development, training request and software bug report*. According to the importance of requests and priorities of the software development team, each RTV was defined with a five range weight. High importance request was weighted with 0,5 and low importance request with 0,1. These weights were defined with the Sponsor agreement. Relational level values (RLV) were also defined and used to characterize the *proximity* between partners and the software-house, more specifically the partners-developers proximity. Not all partners have the same proximity to developers. Thus, in this case, *proximity* reflects the informal knowledge about a partner-developer relation. This knowledge is based on factors, such as *trust* and *informal communication*. For this reason, they are intangible assets with direct influence on the network relational capital value. Proximity weights were defined with Sponsor agreement (5 corresponding to *very near*, and 1 to *very far*).

RV Sum computed values were as follows: 77645,2 (Case A), 587448 (Case B), and 11951913,98 (Case C). One of the reasons that justified the lower value from Case A was the lack of provided HCP data. Notwithstanding, the computed higher values for case C are justified by the user credits data , which were used to fill HCP properties. Finally, the NVF, SEVF Sum, and RV Sum were weighted homogeneously, i.e. weight = 1.

RCV network values were computed as follows: 89016.848 (Case A), 733012.68 (Case B), and 15261835.77 (Case C).

Table 7.15 SNARE-RCO Validation Parameter Settings Criteria

Case	**A**	**B**	**C**
Scenario	Organizational Unit at Vodafone Portugal	School	LOP
Network Analysis Settings Criteria			
NP	Indegree/outdegree sum	Indegree/outdegree sum	Indegree/outdegree sum
NVF	Number of network Members (weight=1) Network density (weight =100)	Number of network Members (weight =1) Network density (weight =100)	Number of network Members (weight =1) Network density(weight =100)
Social Entity Analysis Settings Criteria			
HCP	Neutral=1 (Confidentiality reasons)	Valued Indicators for: Prestige Competence Experience Friendship Proximity	Valued indicators for: User system credits
SEVF	Based on NP (weight=1) and HCP (weight=1)	Based on NP (weight=1) and HCP (weight=1)	Based on NP (weight=1) and HCP (weight=1)
Relational Analysis Settings Criteria			
RTV	Change=0.1 Incident=0.1 Problem=0.1 Information Share=0.1	AskForHelp=0.1 CommunicateWithIT=0.1 TransmitInformation=0.1 WhoRecognize=0.1	Downloads=0.1 Comments=0.2
RLV	Set to 1	Set to 1	Set to 1
RV Input Parameters	RTV, RLV, and SEVF	RTV, RLV, and SEVF	RTV, RLV, and SEVF
RCV Input Parameters	OVF N/A Neutral (weight=1) NVF (weight=1) SEVF Sum (weight=1) RV Sum (weight=1)	OVF N/A Neutral (weight=1) NVF (weight=1) SEVF Sum (weight=1) RV Sum (weight=1)	OVF N/A Neutral (weight=1) NVF (weight=1) SEVF Sum (weight=1) RV Sum (weight=1)

7.4.3. SNARE-RCO Parameter Weighting Levels

SNARE-RCO model has two weighting levels for parameters calibration: a *fine tuning level* and a *large tuning level*.

For RCV's *large tuning*, the *Analyst* can define weights to calibrate OVF (Organizational Valuable Factors), NVF (Network Valuable Factors), SEVF Sum (Social Entities Valuable Factors), and RV Sum (Relational Values).For RCV's *fine tuning*, the *Analyst* can define weights for OVI (Organizational Valuable Items), NVI (Network Valuable Items), NP (Network Properties), and HCP (Human Capital Properties). Moreover, as previously described, the *Analyst* may also use and freely define RTV (Relation Type Values), and RLV (Relation Level Values). These features ensure that SNARE-RCO parameters can be weighted regarding any organizational analysis scenario. However, under this weighting system, two questions emerged during our research: *is the adopted weighting system adequate? What is the impact of using different weights in the model?*

Analyzing the *fine tuning* weighting system behavior, and taking parameters from SEVF Case A as an example, we made several simulations. As previously referred, the SEVF computed for Vodafone Network was 10926 RCVs, and more specifically, GSS Unit SEVF was measured with 6599 RCVs as showed in Table *E.3 Case A – Network SEVF (Organizational Units)*. Thus, focused on GSS members, Figure 7.45 shows four weighting simulation scenarios to compute Vodafone NP (See Tables E.2, E.3, E.4, and E.5 from Appendix E). Different weights were applied to Vodafone members *indegrees* and *outdegrees*, namely: *indegree=1* and *outdegree=1*; *indegree=1* and *outdegree=0*; *indegree=0* and *outdegree=1*; and, *indegree=0,5* and *outdegree=0,5*. As mentioned, our starting NP weighting criteria aim was to maximize SEVF, valuing network members' activity level. The study shows that weighting *indegree* and *outdegree* with 1 maximizes members NP, thus the network SEVF. For example, a member with ID 236 has NP=370 RCVs. When using weighting *indegree=1* and *outdegree=0*, i.e. valuing mostly who is accepting network requests, the same member with ID 236 decreases to NP=254 RCV units. However, valuing mostly who is making requests to other members, i.e. using the weighting *indegree*=0 and *outdegree*=1, the member with ID 236 has once more a lower NP=116 RCVs. Finally, valuing the weighting *indegree=0.5* and *outdegree=0.5*, results are exactly half of the ones obtained with the first scenario. In this case, ID 236 has NP=185. Figure 7.45 graphically depicts these differences.

When choosing to use the same *indegree/outdegree* integer weight (e.g. weight=1), NP values are maximized concerning the relational capital originators (typically members with high *outdegree*) and relational capital producers (typically members with high *indegree*). With these weighting criteria, SEVF is also maximized as depicted in Figure 7.46 (Case A – NP Weighting Impact In GSS SEVF).

The weighting system criteria depends on the organizational scenario, thus, a previously weight analysis must be considered to apply SNARE-RCO model.

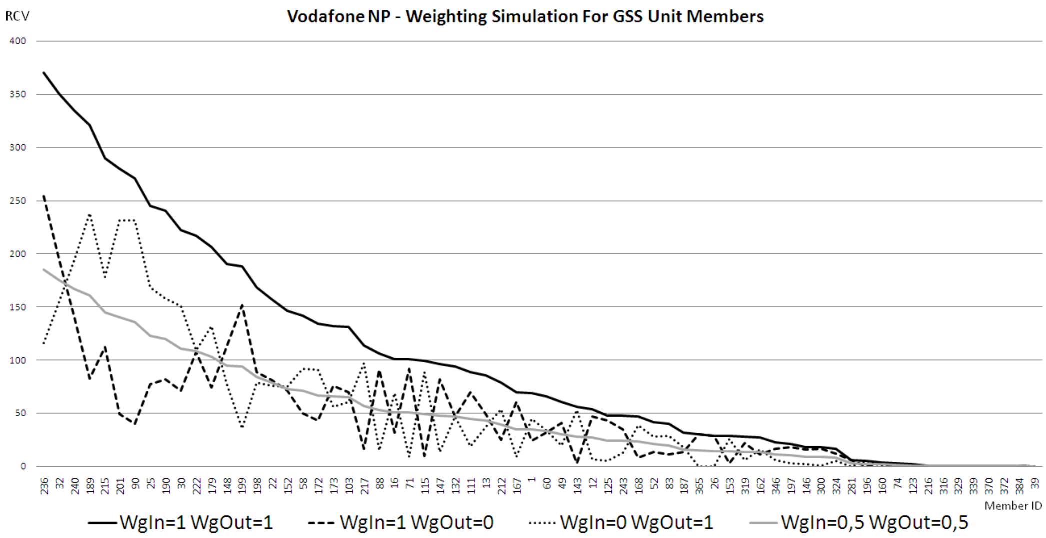


Figure 7.45 Case A – NP Weighting Simulation Scenarios

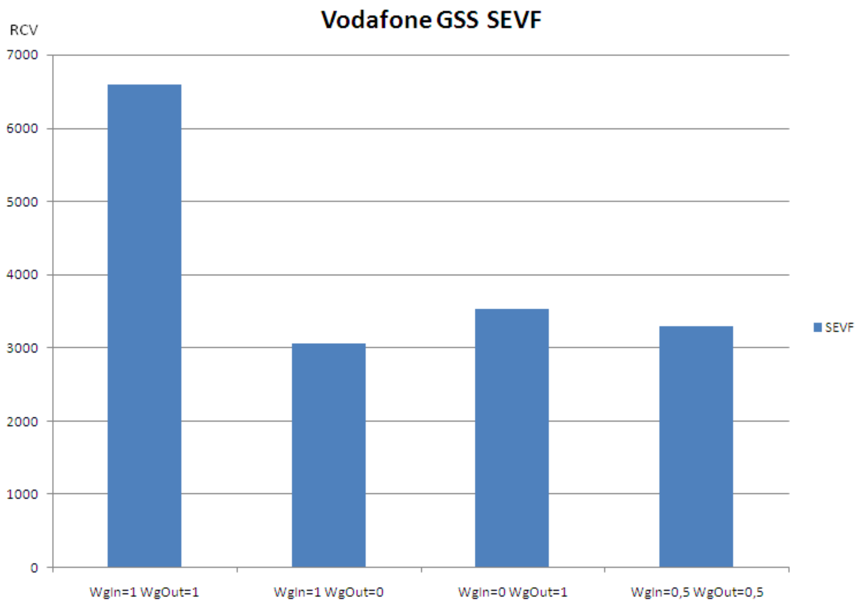


Figure 7.46 Case A – NP Weighting Impact In GSS SEVF

7.4.4. The Role of SNA Metrics

NP is the number of relationships that a network member has. Typically, a network member with high NP is generally an active player in the network, but not necessarily the most connected member in the organization. In validation scenarios, we used degree centralities for NP because they are *active* metrics, i.e. they are significant to reveal and count specific network members *from/to* actions.

Despite *degree centrality* metrics, other SNA metrics can be used to value and characterize network members, such as *betweenness*, *closeness*, *proximity prestige*, and *authority*. They reveal network members' positions, recognition, and possible abilities to reach or influence other members in the organization. E.g., high *betweenness* centrality identifies a network member with high ability to make connections with other members or groups in the organization and with a greater amount of influence over the organizational network. High *closeness* centrality means that an entity can quickly access more entities in a network, because it has a short path to other organization members. A *prestigious* member is one who is the object of extensive ties, focusing the member as a receiver; and, network members that many other members point to are called *authorities* and are typically a source of information, with high knowledge within a domain. NP metrics were computed by SNARE-Explorer. However, after choosing Case A validation scenario, we also used *Pajek* (See Section 2.1.5) to compute *betweenness*, *closeness*, *proximity prestige*, and *authority* for the overall Vodafone members as described in *Table E.6 Case A – SNA, Members Network Metrics (Normalized)* of Appendix E.

Figures 7.47, 7.48, 7.49, 7.50, and 7.51 depict the above referred computed values for Vodafone GSS members. It is visible that NP based on degree centralities are the less homogenous; hence, from our point of view, they are suitable to differentiate network members activity levels in the organization.

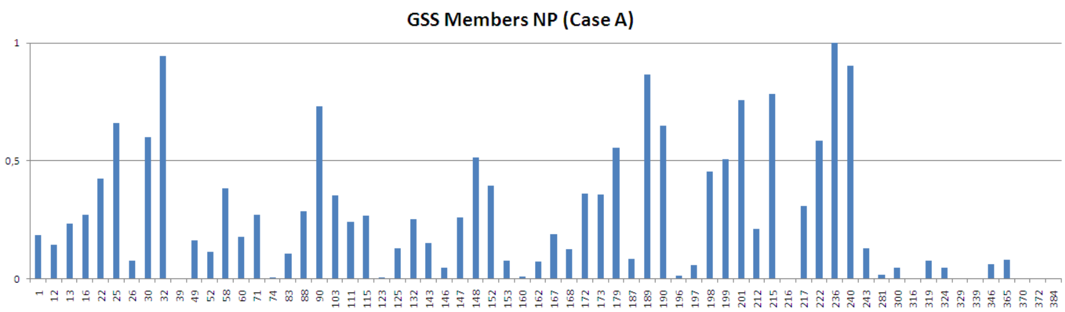


Figure 7.47 Case A - GSS Members NP

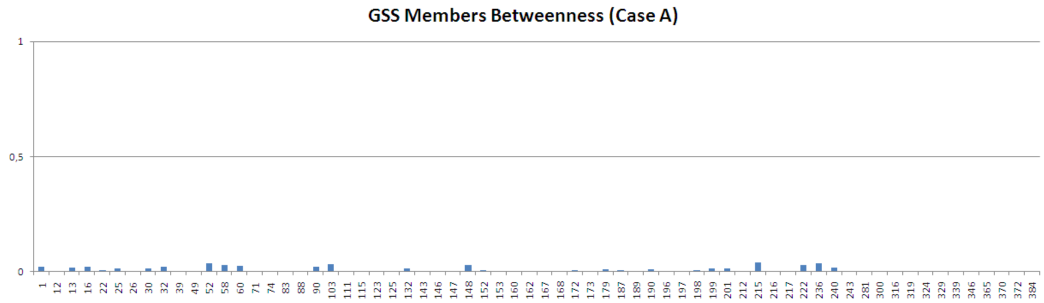


Figure 7.48 Case A - GSS Members Betweenness

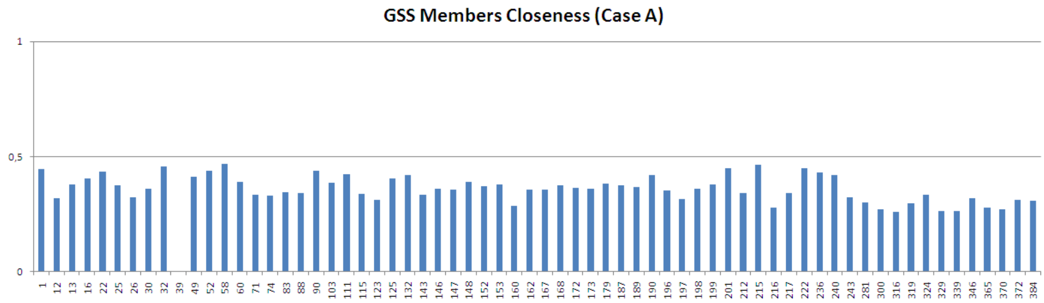


Figure 7.49 Case A - GSS Members Closeness

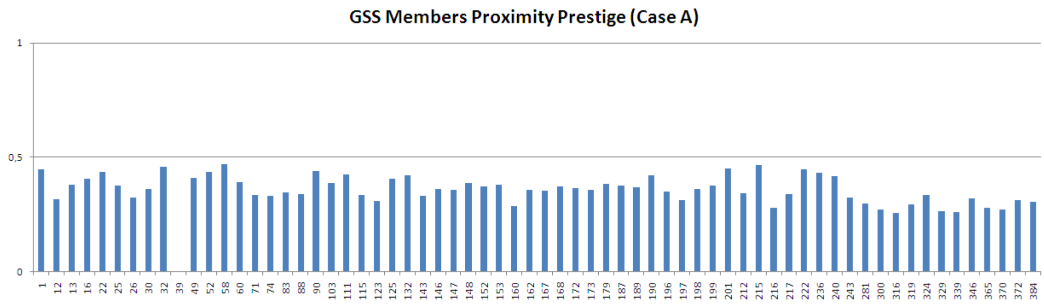


Figure 7.50 Case A - GSS Members Proximity Prestige

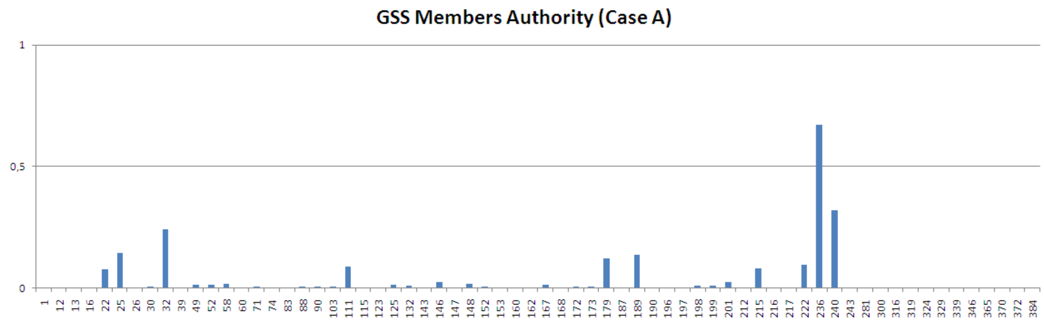


Figure 7.51 Case A - GSS Members Authority

However, taking the member *ID 16* from Vodafone case as an example, which belongs to the *No&s IPTV GSS* team, we found a low NP value for this member, as depicted in *Figure E.3 Case A – NO&S IPTV RCV per Process* (See Appendix E). On the contrary, from the previously interview to *NO&S IPTV* manager, we recorded the statement *"ID 168 and ID 16 (mostly this last one) connect the group Vodafone teams and are critical in guaranteeing and managing contacts and relations outside the IPTV 2nd Line and VOC"*. In fact, as depicted in Figure 7.52, which shows *NO&S IPTV* team computed values for *betweenness*, *closeness*, *proximity prestige*, and *authority*, ID *16* has the highest *betweenness* value and the second highest *closeness* and *proximity prestige* values, which confirms the manager's previous perspective of this network member. Moreover, *NO&S IPTV* Manager has also previously stated: *"Team is dependent on ID 172 and ID 190"*. From the RCV per process analysis (See *Figure E.3 Case A – NO&S IPTV RCV per Process in Appendix E*), we had confirmed this perspective regarding mainly ID 190.As showed in Figure 7.52, ID 190 has the highest team *closeness* and *proximity prestige* value.

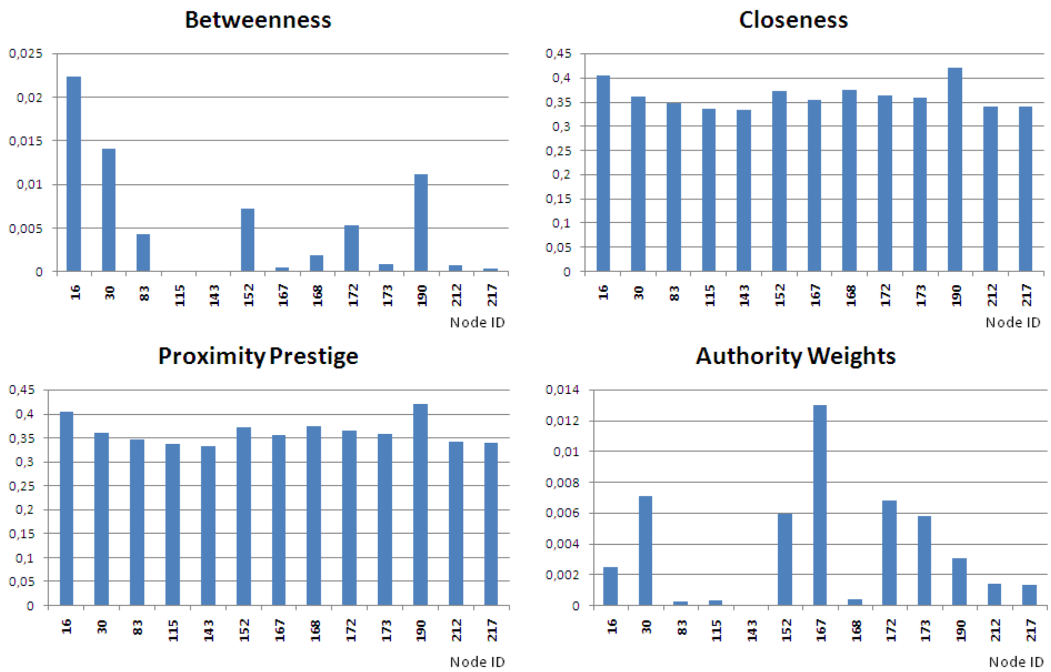


Figure 7.52 Case A - NO&S IPTV Team: Complementary SNA Metrics

To sum up, from *ID 16* analysis (which is one of many possible examples), we concluded that complementary SNA metrics are useful to better understand the role of network members regarding their connection to other organization groups. As described, these metrics do not necessarily express the activity level of a given network member, such as degree centralities used to fill NP network member properties. However, they enrich the individual's data, namely through other network roles. For this reason, concerning specific scenarios to be analyzed in the future, we have concluded that besides centrality degrees, metrics, such as *betweenness*, *closeness*, *proximity prestige*, and *authority*, may be also used as SNARE-RCO NP parameters.

7.4.5. The Challenge of Comparing Distinct Networks

After applying the SNARE-RCO model, another challenge emerges: *how to compare the RCV of distinct networks?* This is a problem because SNARE-RCO model parameters settings criteria changes according to specific organizational contexts. Thus, as the validation results showed, computed relational capital values may range significantly. E.g., the LOP Network RCV has a significant higher value when compared to Vodafone and the analyzed school. The reason for that difference is the human capital settings criteria used, namely the native LOP system credits that we used to fill HCP parameters.

When comparing the same network RCV evolution during time, parameter settings criteria are not a problem, however, when comparing distinct networks with different parameters settings criteria, the solution is to normalize the RCV computed data. Normalization ensures that a given dimension does not overlap with another. The ideal scenario is to adopt the same parameters criteria for distinct networks. However, when this procedure is not possible, normalization methods[44] are suitable for comparing distinct networks, even when SNARE-RCO settings criteria are different. For example, despite the homogeneous weighting system used, as above stated, validation cases A, B, and C have significant differences regarding human capital valuing, and relational capital computed values.

Figure 7.53 depicts normalized values for the global relational capital value of validation cases A, B, and C. As stated, the global RCV refers to different networks with significant differences regarding human capital valuing, and relational capital computed values[45]. Thus, when observing Figure7.53, two apparently similar questions emerged:

(1) *Is it possible to have Case C RCV as the highest relational capital value when compared with Cases A and B?*

(2) *Considering those scenarios, does the analyzed digital platform produce more relational capital than the analyzed telecommunications operator, or the school?*

[44] E.g. *the equalized Max-Min method:*$newx = \frac{x - \min(x)}{\max(x) - \min(x)}$

[45] Normalizing values with different original assumptions would imply parameters adjustments. Despite this and notwithstanding, the global RCV normalization helps compare distinct networks.

These questions hold a significant difference. In question (1), the answer is *yes*, because as Figure 7.53 shows, case C has effectively the higher RCV value. Thus, the RCV reflects reality, i.e. when abstracting the target organization type in order to evaluate a concrete network, the *Analyst* may be confronted with specific contexts that may imply also the use of local specific evaluation systems and metrics. Then, concerning SNARE-RCO model, since there are no standards to compute the RCV of an organizational network, such differences may occur. To minimize this fact, as referred, ideal scenarios occur when comparing identical organization kinds using the same evaluation criteria for *OVF, NVF, SEVF Sum*, and *RV Sum* top-level parameters.

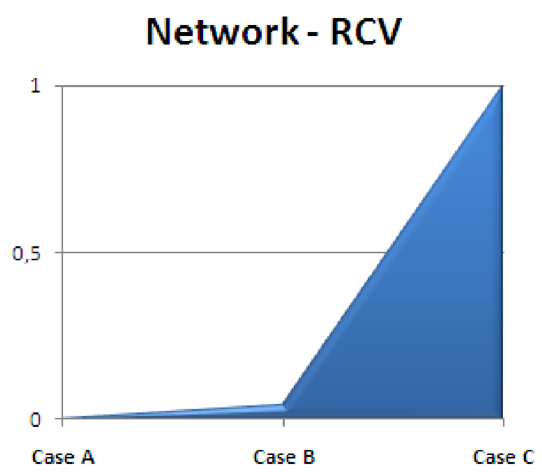


Figure 7.53 Normalized RCV (Cases A, B, and C)

Figure 7.54, depicts for each case, *normalized values* of *NVF*, *SEVF Sum*, and *RV Sum* top-level parameters. Values were normalized using the global network RCV of each case (Table E.13 in Appendix E shows the normalization of these top-level parameters). Thus, in question (2), the answer is *no*. As Figure 7.54 shows (more specifically *RV Sum*), the produced relational capital of the analyzed digital platform is the lowest when compared with Case A and B. Thus, the computed *RV Sum* reflects the realities analyzed. Moreover, *RV Sum* normalized values enable, as depicted, a comparative relational analysis, showing that Vodafone has produced the highest relational capital when compared with the school and digital platform cases. In fact, regarding real scenarios collected data, this interpretation is reality adherent. E.g., Vodafone *RV Sum* contributes more than 80% for the global network RCV. Thus, using this analysis, the *Analyst* has an effective way of understanding, comparing and monitoring the value of interpersonal dynamics of target networks.

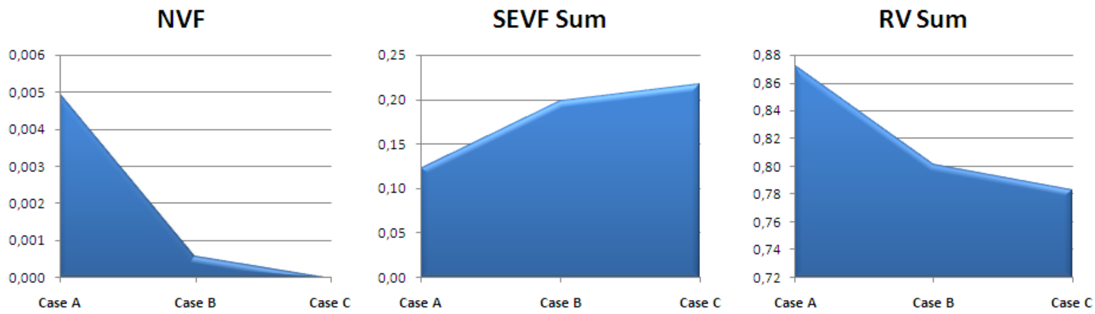


Figure 7.54 Normalization of Top-Level Parameters

Regarding *NVF* normalized analysis, Case A (Vodafone) has captured the highest RCV, next Case B (The School), and, finally, Case C (The LOP system) which has the lowest RCV. In fact, based on the number of network members and network density, which reflects the communication level of the organizational networks, results shows that Case A's *NVF* is significantly higher than Case B and Case C. Regarding collected data, this comparative analysis has confirmed reality.

SEVF Sum normalized analysis reflects the valuing criteria used for *NP* and *HCP* parameters, mainly the last one, because: (1) In Case A, *HCP* was considered neutral for all network members (e.g., a network member valued with *HCP*=1 *RCVs*); (2) In Case B, for all network members, *HCP* was computed with parameters prestige, competence, experience, friendship, and proximity (e.g., a network member valued with *HCP*=51 *RCVs*); and finally (3) In Case C, the *HCP* of all network members was computed using the amount of credits of each user (e.g., a network member with *HCP*=7000 *RCVs*). When comparing Case A and B, this valuing criteria induced a significant increase on Case C *SEVF Sum*. However, as previously depicted in Figure 7.53, these valuing criteria had also contributed for the expressive differences found, regarding the global network RCV of the analyzed cases.

As showed in Figure 7.54, through a normalized analysis of SNARE-RCO top-level parameters *OVF*[46], *NVF*, *SEVF Sum*, and *RV Sum*, it is possible to compare the value of networks with context-dependent evaluation parameters over time. Thus, from the validation experience we had, we can conclude that the network RCV is a reliable metric, because it allows us to measure the relational capital value of specific organizations and has enough flexibility to be configured regarding precise contexts.

[46] OVF was disclosed from the analysis as previously referred. However, when using this SNARE-RCO model parameter, the same normalization and analysis principles may be applied.

Chapter 8

Conclusion

It is your work in life that is the ultimate seduction.

Pablo Picasso

This research proposes a new approach to evaluate the relational capital of organizations based on social network modeling and analysis, as well as the identification of human and structural capital. In this chapter we summarize the main contributions, and, after a final discussion, we also introduce future work.

The author's fundamental research question was stated as: *What is the value of this social network?* The state of art analysis led us to conclude that any metric for assessing the relational capital of an organization should include aspects of human capital and structural capital. We found several evaluation approaches for studying aspects, such as economic impact or operational impact. However, there is a lack of methodologies for an organizational assessment that combines techniques derived from social network analysis with organizational aspects and also with intellectual capital. The above general question was further decomposed into the following research questions (taken from Section 1.3):

RQ1: Which model is needed to define organizational social network descriptions using a set of contextual views, during the evaluation process of the relational capital in organizations?

RQ2: Using a set of organizational parameters, how can we measure the relational capital of social networks and its organic units, content management systems and social media platforms?

RQ3: How to monitor the relational capital value of an organization?

RQ4: How to approach an organization with the aim of analyzing and evaluating its relational capital?

The thesis statement of this research was the following (taken from Section 1.3):

The relational capital value of a network can be defined by taking into account the effects of tangible and intangible organizational variables, analyzed and monitored through an engineering framework.

Next, main results are reviewed in Section 8.1, and an introductory description of future work is given in Section 8.2.

8.1. Main Results and Contributions

We propose the SNARE-Framework to monitor and understand an organizational social network. Based on a specific methodology, this framework includes: a language to describe social networks (RG1); a model to evaluate the relational capital value of organizations (RG2); a tool for computation, analysis and monitoring (RG3); and a methodology to help analysts perform a systematic evaluation approach in organizations (RG4).

As proposed and discussed through this dissertation, our work focuses on the value of a network and several formulas have been presented on measuring the value of a network. Our model integrates factors of human capital and structural capital in the computation of relational capital, using metrics from social network analysis as well, thus, in a sense, giving a new definition to the relational capital of organizations.

In addition, to achieve a meaningful interpretation of the data in what concerns the values formulas as well as to support and validate the thesis statement, several case studies were presented, which spread across different types of organizations. The case studies presented are relevant because they describe how the SNARE-Framework can be used and applied in distinct organizations.

The research goals that drove our research were defined as follows (From Section 1.4):

RG1. Define a language to represent social network structures focused on organizations, respective relations, entities, and roles (See Chapter 3);

RG2. Define a model to evaluate the relational capital of organizations but to be applied with KMSs, such as content management systems and social media platforms (See Chapter 4);

RG3. Design and implement a prototype system to support the experiences, cases studies performed, and better validate the thesis research (See Chapter 5);

RG4. Define a methodology to drive and help other researchers and analysts to monitor the relational capital value of organizations (See Chapter 6);

RG5. Validate the results through controlled case studies using the developed prototype tool and follow the proposed method (See Chapter 7).

RG1 – SNARE-Language. First, we started by analyzing the state of art of several knowledge areas. After analyzing the state of art of social network analysis, we identified several limitations and problems. We found three approaches for describing social networks, namely: (1) descriptive methods, also through graphical representations; (2) mathematical analysis procedures, often based on a decomposition of the adjacent matrix; and (3) statistical models based on probability distributions. We concluded that the approaches outlined above are essential to analyze existing social networks, but we argue that new visual models are needed to better represent new or established relations. This research proposes: the **SNARE-Language**. The SNARE-Language is defined as an UML profile and can be applied to several organizational domains. SNARE-Language includes an appropriate set of diagrammatic model elements, again based of UML stereotypes, and which are unambiguous and supported by UML tools. As an informal descriptive method, the SNARE-Language is the common ground of SNARE-Framework, and includes a collection of elements, such as *SocialEntity, Relation*, *Role*, *Action and Event,* which are able to capture and describe social networks. The SNARE-Language does not intent to replace existing languages for social network representation, such as XML-based languages. However, it does intend to improve the visualization of these social network designs by using UML-based CASE tools.

RG2 – SNARE-RCO. After analyzing relational capital evaluation approaches, we concluded that there is a lack of standard metric for identifying the relational capital of a social network. We found that there are no standard IC measures and organizations need a unique understanding of which intangible assets are really valuable for them. We proposed a model particularly oriented to combine aspects of human, structural and relational capital. Thus, we developed a new model that can be used to achieve a relational capital metric to evaluate and monitor the relational capital of the organizations: the **SNARE-RCO**. SNARE-RCO allows us to measure the relational capital of organizations (eventually from the knowledge kept on content management systems, or social media platforms). SNARE-RCO is based on three key-concepts to compute the RCV, namely: (1) the value of a social network represents a contribution to satisfy a given demand; (2) this demand is conducted by its social entities; and (3) the value of relations in a given context reflects offers and demands from social entities. Thus, to compute the RCV, the definition and classification of parameters may change depending on the type of analyzed organization, and SNARE-RCO is flexible, because it allows adapting those model parameters. Besides computing the overall RCV, SNARE-RCO model also allows us to identify and compute other network aspects, like the existing human capital value. This feature is important to perform human capital and relational capital comparative analysis. To use SNARE-RCO model in organizations, a set of guidelines to perform its instantiation in organizations was suggested. In addition, by using SNARE-RCO, the *Analyst* may develop specific criteria procedures to extract the RCV of organizational networks. However, because each organizational approach, for example, is a specific case, these guidelines provide specific insights to help analysts and suggests, for example, how to:

- Identify the value of organizational attributes to compute OVF;
- Identify the value of members within a network regarding SNA metrics to compute NP;
- Identify the value of network characteristics using SNA, so as to compute NVF;
- Identify and measure the human capital value within a network, to compute HCP;
- Analyze the value of human capital within a network regarding also its activity, centrality, and position using SEVF;
- Identify what relational flow types are to be valued and analyzed within a network, to define and set RTV;
- Identify interpersonal relation levels to value within a network, in order to define and set RLV;
- Measure and analyze the value of network flows within a network, using RV; and
- Identify the global relational capital value within a network, through RCV.

Using SNARE-RCO model, a monitoring system can help analysts to track relational capital and predict its variation using suitable metrics and correlations when observing aspects like: organizational seasonal phenomena; merging of organizational units; organizational downsizings; hiring employees; and identifying key individuals; or team's performance.

RG3 – SNARE-Explorer. We have analyzed existing social network analysis tools. However, in the scope of this specific research, we developed a new tool – the SNARE-Explorer - to specifically implement the SNARE-RCO model. This tool is able to compute and monitor networks' relational capital. Developed with Java technology, SNARE-Explorer is able to extract data and analyze social networks from information systems not originally designed with relational capital analysis features. SNARE-Explorer features help the *Analyst* edit and analyze several social networks, and the *Analyst* can use SNARE-Explorer to perform SNA operations, network statistics, and compute RCV. Despite the full implementation of the SNARE-RCO model, this tool includes additional algorithms to be used when analyzing the relational capital of organizational networks, such as the *Minimum Connection Strength* algorithm, which was introduced to predict RCV variations regarding adding hypothetical connections to specific network members. The monitoring feature allows us to trace in real-time a log and a linear chart of computed RCV values and the *Analyst* can dynamically change RCV parameter settings using SNARE-Explorer interface. This tool has been tested in several contexts and has proved that it is able to compute and monitor the relational capital of organizations.

RG4 – SNARE-Methodology. The SNARE-Methodology can be used for an organizational evaluation approach. This methodology considers several roles for participants, namely: *Analyst*, *Sponsor*, *Manager*, and *Team*. *SNARE-Methodology* makes use of SNARE-Explorer tool to produce the *Analysis Pack*, SNARE-Language to produce the *Organizational Structure* document, and SNARE-RCO model to classify relational input parameters, which are used to compute the relational capital value of the organization. Starting with organizational needs, SNARE-Methodology considers four main processes: *Diagnosing*; *Designing*; *Executing*; and *Reporting*. Based on our experience, this methodology helps promote a collaborative working environment. More specifically, during SNARE-Methodology processes, participants work together with the aim of finding ways to improve the relational capital value. SNARE-Methodology can help promote iterative ways for organizational change. I.e. change begins with *awareness* and the *Analyst* and *Sponsor* work together for that purpose: to evaluate the relational capital of the organization to find possible organizational changes as well as to improve the organizational knowledge. However, we found a constraint, when using SNARE-Methodology: the *Analyst*'s presence can probably affect the situation on the experiment field, because it allows direct intervention into organizational dynamics. Thus, this intervention must be carefully prepared and the team must be aware of the evaluation objectives. Despite this fact, improvements can be reflected in an increase of relational capital, which is an essential organizational knowledge.

RG5 – Validate the results. We validate the thesis and its research goals through the implementation of three case studies.

8.2. Discussion

In what concerns our central hypothesis (From Section 1.5), we have experimentally verified that a social network can be valued using an *offer-demand* logic. Thus, the value of its social network relations represents the level of satisfied demands, i.e. the value of network relations reflects the link between things (e.g., a good or service) and social entities that are connected in a given context. This framework has showed that it is possible to evaluate those *offers* made by network social entities with *producer* role and demands from social entities with *consumer* role. Moreover, we also showed that the relational capital value of a network should be valued using interdependent dimensions, namely: human, structural, and relational capital. Thus, it is possible to combine these dimensions to achieve a metric to value and monitor an organizational network. Also, we have extended a discussion by analyzing possible applications of SNARE-Framework in order to evaluate other systems, and, it is possible to apply our framework and, consequently, the SNARE-RCO model as well, to collaborative platforms.

When performing a relational capital analysis, SNARE-RCO parameters must be defined, and we have proposed a set of guidelines, which are suggestions to help analysts. The weighting system criteria depends on the organizational scenario, thus, a previously weight analysis must also be considered to apply SNARE-RCO model. The role of complementary SNA metrics to be used as SNARE-RCO NP parameters was also analyzed. Thus, despite *degree centrality* metrics, other SNA metrics can be used to value and characterize network members, such as *betweenness*, *closeness*, *proximity prestige*, and *authority*. They reveal network members' positions, recognition, and possible abilities to reach or influence other members in the organization. In this sense, we tested complementary SNA metrics, which are useful to better understand the role of network members regarding their connection to other organization groups. For this reason, concerning specific scenarios to be analyzed in the future, we have concluded that besides centrality degrees, metrics like *betweenness*, *closeness*, *proximity prestige*, and *authority*, may be also used as SNARE-RCO NP parameters.

After applying the SNARE-RCO model to distinct networks, another challenge emerged, namely: *how to compare the RCV of distinct networks?* As previously analyzed, this is a problem because SNARE-RCO model parameters settings criteria change regarding specific organizational contexts, and we have concluded that the solution is to normalize the RCV computed data. Moreover, through a normalized analysis of SNARE-RCO top-level parameters - *OVF*, *NVF*, *SEVF Sum*, and *RV Sum* –, it is possible to compare the value of networks with context-dependent evaluation parameters over time. Thus, from the validation experience we had, the network RCV is a reliable metric, because it measures the relational capital value of specific organizations with enough flexibility to be configured regarding precise contexts.

To sum up, from the starting research questions, we developed a strategy to answer the question, *"What is the value of this network?"*. Our first research question was to find a model to support organizational social network descriptions using a restricted set of contextual views to be used during the evaluation process. To answer this question we have defined the SNARE-Language, which gives social network structures' a new representation.

The second research question was "Using a set of organizational parameters, how to measure the relational capital of social networks and its organic units, and content management systems and social media platforms as well?". To answer this question, we have defined and developed a relational capital evaluation model: the **SNARE-RCO** model. Using this model, it is possible to define metrics to analyze the relational capital of a given organization (as well as a content management system, or social media platform).

The third research question was how to monitor the relational capital value of an organization. To answer this question, we developed the SNARE-Explorer prototype tool that shows how to compute and monitor the relational capital.

The fourth research question was how to approach an organization with the aim of analyzing and evaluating its relational capital. To answer this question, we have defined the SNARE-Methodology.

We validate the thesis and its research goals through the implementation of three case studies, namely in the context of: (1) A telecommunications company (Case A); (2) a school (Case B); and (3) a CMS-based application (Case C).

Finally, based on the work reported here, it is fair to say that the methodology proposed in this dissertation has successfully fulfilled the objectives set up in the early phases of the research and, as referred in the thesis statement, *the relational capital value of a network can be defined by taking into account the effects of tangible and intangible organizational variables, analyzed and monitored through an engineering framework.*

8.3. Future Work

After the period of investigation, which led us to the writing of this thesis, we consider that this work can be continued in multiple ways. Besides the use of SNARE-Framework in processes of organizational consulting, the following issues pose further research that could be pursued in line with this dissertation:

Comparing RCV from organizations of same kind. We would like to continue to evaluate the relational capital of organizations. An interesting study would be applying this model in the evaluation of several organizations of the same class, for example schools at a regional or national scale. Using the same parameters of analysis would be interesting to compare various schools RCVs. Other issues to explore include increasing the analysis period and continuing to research how to analyze the relational capital of organizations in real time.

Extending SNARE-Explorer with SNA tools integration features. Since there are popular tools for social network analysis (as discussed in Chapter 2), we consider that SNARE-Explorer may include new data integration features with those tools. E.g., importing and exporting compatible files with *Pajek* and *UCINET* tools. Thus, with these new features, in order to evaluate the relational capital of networks, the SNARE-Explorer might be used by the scientific community that already employs these tools.

Extending SNARE-Explorer with social platforms integration features. Using public APIs, we also would like to extend SNARE-Explorer data integration features in order to compute and monitor the relational capital of virtual organizations supported by popular platforms such as *Moodle*, *LinkedIn* or *Facebook*.

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Appendix

A. Research Methods

Research methods can be classified into several approaches such as: (1) Quantitative Research; (2) Qualitative Research; and (3) Mixed-Method Approach [ABSN 01]. Quantitative research refers to the systematic and empirical investigation of social phenomena via statistical, mathematical or computational techniques. Examples of quantitative methods include: surveys, laboratory experiments and numerical methods. Qualitative research refers to a better understanding of human behavior. It is an interpretative approach to investigate subjects in the field [Hun 04]. Examples of qualitative methods include interviews, questionnaires, and documents. The mixed-method approach seeks convergence across quantitative and qualitative approaches [ABSN 01].

There is a growing interest among information systems researchers in several qualitative research techniques, and the choice of research method should be made in relation to research objectives [Hun 04]. From several qualitative research methods, Hunter has selected five common qualitative research approaches [Hun 04]: (1) Action Research, to study the impact of change on an individual or group; (2) Case Study, to research a phenomenon in its environment; (3) Ethnography, to conduct primary observations over an extended period of time; (4) Grounded Theory, to approach a research question without adopting *a priori* a research framework; and (5) Narrative Inquiry, to number facts relating to a specific person. They all adopt a social perspective to the area of investigation.

A.1 Action Research

The *Action Research* methodology was proposed by Lewin [Lew46]. The Tavistock Clinic developed an operational research version of Action Research [Tri 76] and Lewin and Tavistock inspired a vast stream of work in this field. Toward the end of the 1990s, *Action Research* began growing in popularity for use in scholarly investigations of information systems [Bas 99]. The Action Research method produces highly relevant research results, because it is grounded on practical action [Bas 99].

Action Research refers to a class of research approaches, rather than a single, research method and the various forms of this approach share some common characteristics [Bas 99]: (1) an action and change orientation; (2) problem focus;

(3) a process involving systematic and iterative stages; and (4) collaboration participants. After the establishment of a client-system infrastructure or research environment details, there is a cyclical process with five phases [SE 78]. The figure bellow (adapted) illustrates this cyclical process.

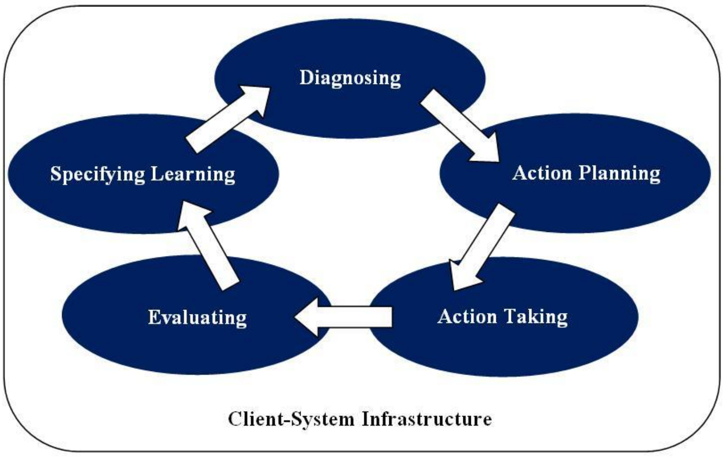


Figure A.1 The Action Research Cyclical Process
(Adapted from [SE 78])

The **client-system infrastructure** is the specification and agreement that constitutes the research environment, in which the five phases occurs. Baskerville summarizes these five phases [Bas 99]:

1) **Diagnosing** is the identification of the primary problems that can be causes of the organization's desire for a change. This phase involves self-interpretation of the complex organizational problem. Also, diagnosing will develop theoretical assumptions about the nature of the organization and its problem domain;

2) **Action Planning s**pecifies organizational actions that should relieve or improve primary problems. The discovery of the planned actions is conducted by a theoretical framework;

3) **Action Taking** implements the planned action. It is an intervention into the client organization, which can induce certain changes to be made;

4) **Evaluating** includes determining whether the theoretical effects of the action were conducted, and whether these effects (consequences of an action) help solve the problems; and

5) **Specifying Learning** is identifying general findings.

The *Action Research* cycle can continue, whether the action proved successful or not to develop further knowledge about the organization and the validity of relevant theoretical frameworks [Bas 99]. As a result of the studies, the organization thus learns more about its nature and environment, and theoretical elements of the scientific community continue to benefit and evolve [Bas 99].

In information systems, Action Research involves iterative and reflective processes and has four primary goals [BW 98]: (1) Organizational Development; (2) System Design; (3) Scientific Knowledge; and (4) Training.

In Action Research a researcher participates and acts in the area of study and simultaneously evaluates the results of this participation with two main objectives [Tol 98]: (1) The action researcher aims to improve the situation in the organization; and (2) The action researcher aims to contribute to scientific knowledge by creating generalizable concepts and theories of the problem setting and its behavior.

There is a close interaction between theory and practice in Action Research. In the research process, the roles of a research subject and a researcher can be reversed [Gal 92]. Action researchers must be aware that their presence will probably affect the situation on the experiment field, because this method allows the intervention of the researchers in the events, permits to plan interventions and to record them for evaluation purposes, which are essential forms of action research [Tol 98]. The action researcher intervention can vary from direct intervention as an equal coworker to indirect intervention through other role. E.g., a direct intervention could be participating in the method selection, and indirect intervention could be playing an expert role in a given tool adaptation [Tol 98].

Action research processes and organizational consulting processes contain similarities, but differ in five key ways [Bas 99]: (1) Motivation, Action Research is motivated by its scientific prospects and consulting is motivated by commercial benefits, including profits and additional stocks of proprietary knowledge about solutions to organizational problems; (2) Commitment, Action Research makes a commitment to the research community for the production of scientific knowledge, as well as to the client, and, in a consulting process, the commitment is to the client alone; (3) Approach, collaboration is essential in action research because of its idiographic assumptions, and consulting values its unbiased viewpoint; (4) Foundation for recommendations, action research is a theoretical framework, and in consulting processes, consultants are expected to suggest solutions that, in their experience, proved successful in similar situations; and (5) Essence of the organizational understanding, in action research, organizational understanding is founded on practical success from iterative experimental changes in the organization, and in consultation teams, the development of organizational understanding is made through their independent critical analysis of the problem situation.

Action Research is suitable for organizational environments because it holds the possibility to test and refine principles, tools, and techniques [VB 90], and can be considered as a variant of a case study and field experiment. Action Research uses evaluations of particular subjects (case study), such as an organization or group of people, in a given moment, and attempts to capture reality in detail (field experiment). *Action Research* is about investigating change and the technology associated with information systems facilitates change [Hun 04]. Action Research is an appropriate method when conducting investigations with information systems [Hun 04].

A.2 Case Study

The case study research method is an empirical inquiry that investigates a contemporary phenomenon within its real-life context when the boundaries between phenomenon and context are not clearly evident and in which multiple sources of evidence are used [Yin 84]. A case study allows the researcher to concentrate on specific instances, and attempts to identify the interacting perceptions, issues, and processes at work [Dal 04]. Focusing on relationships and processes facilitates a holistic perspective, revealing underlying patterns and possibly some emergent properties [Dal 04].

In case study research, there are six steps that should be used [Soy 97]:

1) Determine and define the research questions;
2) Select the cases and determine data gathering and analysis techniques;
3) Prepare to collect the data;
4) Collect data in the field;
5) Evaluate and analyze the data; and
6) Prepare the report;

The unit of measurement in a case study is associated with the concept of entity, such as an individual, a group or an organization [Hun 04]. A research project employing the case study method may employ a single case or multiple cases, and conclusions could be determined based upon similarities and differences among the cases involved in the study [Hun 04].

A.3 Ethnography

Ethnography involves exploring the nature of phenomena, working with unstructured data, and analyzing data through the interpretation of the meanings attributed by research participants [AH 94]. Ethnography involves detailed investigation of an entity within its specific context [Hun 04]. This type of research is particularly appropriate for investigating the phenomena of social systems and is employed to study the social aspects of work practices [Hun 04]. In an ethnographic study, two of the most common methods for collecting data are direct observation of daily participation and interviewing.

A.4 Grounded Theory

Glaser and Strauss suggest the discovery of theory from data is systematically obtained from social research [GS 67]. It is a systematic methodology involving the creation of theory from data and the researcher approaches a research question without adopting *a priori* a research framework or theoretical context [Hun 04]. Rather than beginning with a hypothesis, the first step is data collection, which contradicts the traditional model of research, where the researcher chooses a theoretical framework, and then applies models to the studied phenomenon.

A.5 Narrative Inquiry

The narrative inquiry method allows research participants to tell their own story, and this method entails the documentation and analysis of individuals' stories of a specific domain of discourse [Hun 04]. It is an approach to understanding/researching the way people make meaning of their lives as narratives, and knowledge can be held in stories that can be relayed, stored, and retrieved.

B. Social Network Analysis Concepts

(Alphabetically Ordered)

Actor

In a given network an actor is
"a node, *vertice* or *point* denoted by n" [FF 94], *where*
$\mathcal{N} = \{n_1, n_2, \ldots, n_g\}$ is a set of nodes where g is the number of nodes in $\mathcal{N}$".

Affiliation Networks

"Affiliation networks are two-mode networks, consisting of a set of actors and a set of events. An affiliation network can be represented by a bipartite graph in which the nodes can be partitioned into two subsets, and all lines are between pairs of nodes belonging to different subsets. The lines in the bipartite graph represent the relation "is affiliated with" (from the perspective of actors) or "has a member" (from the perspective of events).
Since actors are affiliated with events, and events have actors as members, all lines in the bipartite graph are between nodes representing actors and nodes representing events" [FF 94].

Betweenness Centrality (Actor)

"Interactions between two nonadjacent actors might depend on the other actors in the set of actors, especially the actors who lie on the paths between the two.

Let $g_{jk}(n_i)$ be the number of geodesics linking the two actors j , k, that contain actor i.

The actor's betweenness index for n_i is the sum of estimated probabilities over all pairs of actors not including the ith actor [Fre 77]:

$$C_B(n_i) = \sum_{j<k} g_{jk}(n_i)/g_{jk}$$

For i is distinct from j and k. The index counts how between each of actors is as a sum of probabilities.

It has a minimum of zero, attained when n_i falls on no geodesics.

Its maximum is $(g-1)(g-2)/2$, which is the number of pairs of actors not including n_i.

Since the index's values depend on g a standardization can be made:

$$C'_B(n_i) = C_B(n_i)/[(g-1)(g-2)/2].$$

Standardized takes values between 0 and 1 and can be compared to the other actor indices." [FF 94]

Betweenness Centralization (Group)

Freeman's group betweenness centralization index is [Fre 79]:

$$C_B = \frac{\sum_{i=1}^{g}[C'_B(n^*) - C'_B(n_i)]}{(g-1)}$$

"The index reaches its maximum value for the star graph, and its minimum value zero occurs when all actors have exactly the same actor betweenness index, i.e. in a network in which all actors are equal in betweenness" [FF 94].

Bridge

"An edge is a bridge if removing it would cause its endpoints to lie in different components of a graph." [FF 94]

Centrality (Actor)

For nondirectional relations, "A central actor is one involved in many ties, no matter if is a receiver or a transmitter. Let A be a generic measure, then the centrality of an actor may be denoted as $C_A(n_i)$. The index i will range from 1 to g." [FF 94]

Clique

"A clique in a graph is a maximal complete subgraph of three or more nodes. It consists of a subset of nodes, all of which are adjacent to each other that are also adjacent to all of the members of the clique [LP 49][HNC 65]" [FF 94].

Closeness Centrality (Actor)

"The closeness measure focuses on how close an actor is to all the other actors in the set of actors.

Let $d(n_i, n_j)$ be the number of lines in the geodesic linking actors $i$and j.

$d(\cdot,\cdot)$is a distance function.

The total distance that i is from all other actors is

$\sum_{j=1}^{g} d(n_i, n_j)$where the sum is taken over all $j \neq i$.

The index of actor closeness is

$$C_C(n_i) = \left[\sum_{j=1}^{g} d(n_i, n_j)\right]^{-1}$$

The subscript C is for closeness, the index is the inverse of the sum of the distances from actor i to all the other actors. At a maximum, the index equals $(g-1)^{-1}$, which arises when the actor is adjacent to all other actors. At a minimum, the index attains the value of 0 in its limit.

Beauchamp [Bea 65] suggested standardizing the indices so that maximum value equals unity multiplying $C_C(n_i)$ by $g-1$:

$$C'_C(n_i) = \frac{g-1}{\left[\sum_{j=1}^{g} d(n_i, n_j)\right]}$$

$= (g-1)C_C(n_i)$." [FF 94]

Closeness Centralization (Group)

"Freeman's [Fre 79] general group closeness index is based on the actor closeness centralities standardization:

$\sum_{i=1}^{g}[C'_C(n^*) - C'_C(n_i)]$,

where $C'_C(n^*)$ is the largest standardized actor closeness in the set of actors.

The maximum possible value for the numerator is

$[(g-2)(g-1)]/(2g-3)$,

thus the index group closeness is

$$C_C = \frac{\sum_{i=1}^{g}[C'_C(n^*) - C'_C(n_i)]}{[(g-2)(g-1)]/(2g-3)}$$

The index reaches its maximum value of unity when one actor chooses all other $g-1$ actors.

There are other group-level closeness indices. E.g., calculating the variance of the standardized actor closeness indices,

$$S_C^2 = \frac{\left[\sum_{i=1}^{g}(C'_C(n_i) - \bar{C}_C)^2\right]}{g}$$

which summarizes the heterogeneity among the $\{C'_C(n_i)\}$.

The average normed closeness, $\bar{C}_C = \sum C'_C(n_i)/g$, is the mean of the actor-level closeness centralities.

The variance attains its minimum value of 0 in a network with equal actor indices, i.e. equal distances between all nodes." [FF 94]

Clustering Coefficient

"The clustering coefficient expresses how well connected the neighborhood of a given node is. If the neighborhood is fully connected, the coefficient is 1 and a value close to 0 means that there are hardly any connections in the neighborhood" [Wat 99].

It is computed as the ratio of actual links to all possible links ina node's neighborhood. More specifically, "it is the number of edges connecting a vertex's neighbors divided by the total number of possible edges between the vertex's neighbors" [HSS 10].

Cohesive Subgroups

"Cohesive subgroups are subsets of actors among whom there are relatively strong, direct, intense, frequent, or positive ties. The notion of subgroup is formalized by the general property of cohesion among subgroup members based on specified properties of the ties among the members. There are four general properties of cohesive subgroups that have influenced social network formalizations: the mutuality of ties; the closeness or reachability of subgroup members; the frequency of ties among members; and the relative frequency of ties among subgroup members compared to non-members" [FF 94].
See also *Subgroup.*

Connected Graph

"A graph is connected if there is a path between every pair of nodes in the graph, i.e. all pair of nodes are reachable" [FF 94].

Density of a Directed Graph

"The density of a directed graph is calculated with the number of arcs, L, divided by the possible number of arcs. Since an arc is an ordered pair of nodes, there are $g(g-1)$ possible arcs.

The density, Δ, is:

$\Delta = \frac{L}{g(g-1)}$. " [FF 94]

Density of Graphs

"The proportion of possible lines (ties) that are actually present in the graph, i.e. the ratio of the lines present, L, to the maximum possible.

Density of a graph:

$$\Delta = \frac{L}{g(g-1)/2} = \frac{2L}{g(g-1)} = \frac{\bar{d}}{(g-1)}$$

The density of a graph goes from 0, if there are no lines present ($L = 0$), to 1, if all possible lines are present ($L = g(g-1)/2$). If all lines are present, then all nodes are adjacent, and the graph is said to be *complete*. It is standard to denote a complete graph with g nodes as K_g.

A *complete* graph contains:

- All g(g-1) possible lines;
- Δ=1; and

All nodal degrees are equal to g-1" [FF 94].

Density of Subgraphs

"The density of a subgraph expresses the proportion of ties that are present among a subset of the actors in a network.

The density of subgraph $\mathcal{G}_S$ is defined as the number of lines present in the subgraph.

Nodes in subgraph $\mathcal{G}_S$ are denoted as g_S, and the lines in the subgraph $\mathcal{G}_S$ as L_S.

Density of a subgraph:

$$\Delta_S = \frac{2L_S}{g_S(g_S-1)}$$

The possible number of lines in a subgraph is equal to $g_S(g_S-1)$"[FF 94].

Diameter of a Graph	"The diameter of a connected graph is the length of the largest geodesic between any pair of nodes. Formally, the diameter of a connected graph is equal to $max_i max_j d(i, j)$. The diameter of a graph can range from a minimum of 1 (if the graph is complete) to a maximum of $g - 1$. If a graph is not connected, its diameter is infinite (or undefined) since the geodesic distance between one or more pairs of nodes in a disconnected graph is infinite" [FF 94].
Directed Graph	A graph in which a direction is shown for every arc. Also known as digraph.
Dyad	"A pair of actors and the possible tie between them. A subgraph consisting of a pair of nodes and the possible line between the nodes. An unordered pair of nodes can be in only one of two dyadic states: either two nodes are adjacent or they are not adjacent. Dyads are node-generated subgraphs, since they are defined as a subset of nodes and all lines between pairs of nodes in the subset" [FF 94].
Eigenvector Centrality	A measure of the importance of a node in a network. It is based on the principle that connections with high scores contribute more to the score of a given node, relative scores are assigned to all network nodes.
Geodesic Distances in Graphs	"A shortest path between two nodes is referred to as geodesic. If there is more than one shortest path between a pair of nodes, then there are two (or more) geodesics between the pair. If there is no path between two nodes, then the distance between them is infinite or undefined. In a graph, a geodesic between n_i and n_j is also a geodesic between n_j and n_i, thus the distance between n_i and n_j is equal to n_j and n_i; $d(i, j) = d(j, i)$ " [FF 94].
Isolate Node	*See Nodal Degree.*
Mean Indegree and Mean Outdegree (Directed Graphs)	"The mean indegree and the mean outdegree are equal since the indegrees count arcs incident from the nodes, and the outdegree count arcs incident to the nodes. $\bar{d}_I = \frac{\sum_{i=1}^{g} d_I(n_i)}{g}$ $\bar{d}_O = \frac{\sum_{i=1}^{g} d_O(n_i)}{g}$ since: $\sum_{i=1}^{g} d_I(n_i) = \sum_{i=1}^{g} d_O(n_i) = L$, thus: $\bar{d}_I = \bar{d}_O = \frac{L}{g}$. " [FF 94]

Mean Nodal Degree	"Informative to summarize the degrees of all actors in the network. It is the average degree of nodes in the graph. $\bar{d} = \frac{\sum_{i=1}^{g} d(n_i)}{g} = \frac{2L}{g}$ If all degrees of all of the nodes are equal, the graph is said to be *d-regular* (a measure of uniformity), where d is the constant value for all the degrees ($d(n_i) = d$, for all i and some value d" [FF 94].
Multimodal Network	"A network which includes different types of vertices. A common type of multimodal network is a bimodal network with exactly two types of vertices. Data for these networks often include individuals and some event, activity, or content with which they are affiliated creating an affiliation network"[HSS 10].
Nodal Degree	A measure of the "activity" of the actor it represents. "The degree of a node $d(i)$, is the number of lines that are incident with it. Equivalently, the degree of a node is the number of nodes adjacent to it. $0 \leq d(i) \leq g - 1$ A node with degree equal to 0 is called an *isolate*"[FF 94].
Nodal Indegree and Outdegree (Directed Graphs)	"In social networks, the indegrees are measures of receptivity, or popularity, and the outdegrees are measures of expansiveness. The indegree of a node $d_I(n_i)$ is the number of nodes that are adjacent to n_i. The indegree of node n_i is equal to the number of arcs of the form $l_k = < n_j , n_i >$ for all $l_k \in \mathcal{L}$, and all $n_j \in \mathcal{N}$. Indegree is thus the number of arcs terminating at n_i. The outdegree of a node $d_O(n_i)$ is the number of nodes that are adjacent from n_i. The outdegree of node n_i is equal to the number of arcs of the form $l_k = < n_i , n_j >$for all $l_k \in \mathcal{L}$, and all $n_j \in \mathcal{N}$. Outdegree is thus the number of arcs originating with node n_i" [FF 94].
Prestige (Actor)	"A prestigious actor is defined as one who is the object of extensive ties, focusing the actor as a receiver. Thus, the prestige of an actor increases as the actor becomes the object of more ties but not necessarily when the actor itself initiates the ties" [FF 94].
Prominence (Actor)	"A social network actor is prominent if the ties of the actor make the actor particularly visible to the other actors in the network. Knoke and Burt [Kno 83] distinguish two classes of prominence: centrality and prestige." [FF 94]

Proximity Prestige

"A proximity prestige standardization suggested by Lin [Lin 76] reflects how proximate an actor is from the set of all actors:

$$P_P(n_i) = \frac{I_i/(g-1)}{\sum d(n_j, n_i)/I_i}$$

This index is the ratio between the proportion of actors in the influence domain to the average distance of these actors to actor i.

If actor i is unreachable,

$P_P = 0$; if all actors are directly tied to actor i, $P_P = 1$

($I_i$is the number of actors who can reach actor i)." [FF 94]

Social Network (Graph perspective)

"The nodes represent actors, and the lines represent the ties that exist between pairs of actors on the relation.

A simple graph $\mathcal{G}$ consists of two sets of information: A set of nodes $\mathcal{N}$ and a set of lines $\mathcal{L}$, $\mathcal{G}(\mathcal{N}, \mathcal{L}\,)$, or simply $\mathcal{G}$ if there is no ambiguity about the node set and the line set.

With an undirected dichotomous relation:

- lines are unordered pairs of nodes, $l_k = (n_i, n_j) = (n_j, n_i)$; and
- the graph has no loops and includes no more than one line between a pair of nodes.

A graph that contains only one node is *trivial*.

A graph that contains g nodes and no lines ($L = 0$) is *empty*"[FF 94].

Structural Cohesion

"The minimum number of members who, if removed from a group, would disconnect the group" [MW 03]

Structural Equivalence

Refers to nodes which have a common set of linkages to other nodes in the network. These nodes may not be connected to each other to be structurally equivalent.

"Structural equivalence [LW 71] is a mathematical property of subsets of actors in a network. Two actors are structurally equivalent if they have identical ties to and from all other actors in the network" [FF 94].

Subgroup	"A subset of actors of the network. A graph $\mathcal{G}_S$ is a subgraph of $\mathcal{G}$ if the set of nodes of $\mathcal{G}_S$ is a subset of the nodes of $\mathcal{G}$, and the set of lines in $\mathcal{G}_S$, is a subset of the lines in the graph $\mathcal{G}$. • $\mathcal{N}_S$, are nodes in $\mathcal{G}_S$ • $\mathcal{L}_S$, are lines in $\mathcal{G}_S$ $\mathcal{G}_S$ is a subgraph of $\mathcal{G}$ if $\mathcal{N}_S \subseteq \mathcal{N}_S$and $\mathcal{L}_S \subseteq \mathcal{L}$. A *node-generated* subgraph (widely used in the analysis of cohesive subgroups in networks) is generated with a subset of nodes considering all lines that are between the nodes in the subset. A *line-generated* subgraph is generated with a subset of lines considering all nodes that are incident with the lines in the subset. Analyses of the network might have to be restricted to the subset of actors for whom data are available for all time points. The study of cohesive subgroups in networks focus on subsets of actors among whom ties are relatively strong, numerous, or close" [FF 94].
Tie	"A connection present between two actors in the network" [FF 94].
Triad	"A subgroup of three actors and the possible ties between them" [FF 94].
Undirected Graph	A graph whose edges do not have assigned directions.
Unimodal Network	A network that connects the same type of entity.
Variance of Indegrees and Outdegrees **(Directed Graphs)**	"The variance of the indegrees denoted by $\mathcal{S}^2_{D_I}$, is: $\mathcal{S}^2_{D_I} = \frac{\sum_{i=1}^{g}(d_I(n_i) - \bar{d}_I)^2}{g}$ The variance of the outdegrees denoted by $\mathcal{S}^2_{D_O}$, is: $\mathcal{S}^2_{D_O} = \frac{\sum_{i=1}^{g}(d_O(n_i) - \bar{d}_O)^2}{g}$. " [FF 94]

Variance of the Degrees	"Variability in nodal degrees means that the actors represented by the nodes differ in activity, as measured by the number of ties they have to others. The variance of the degrees: $S_D^2 = \frac{\sum_{i=1}^{g}(d(n_i) - \bar{d}\,)^2}{g}$ A graph that is *d-regular* has $S_D^2 = 0$" [FF 94].
Weighted Network	A weighted network is a network where the ties among nodes have weights assigned to them.

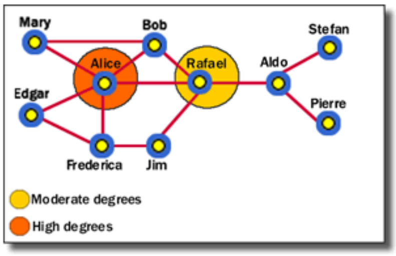
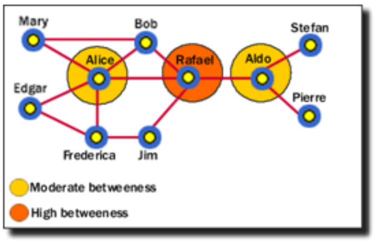
C. Uncovering Network Relationships and Individual Roles

Table C.1 Questions to Uncover Important Network Relationships

Relationships that reveal collaboration in a network	
Communication	"How often do you talk with the following people regarding a topic?"
Information	"How frequently have you acquired information necessary to do your work from this person in the past three months?"
	"From whom do you typically seek work-related information?"
	"To whom do you typically give work-related information?"
Problem solving	"Who do you typically turn to for help in thinking through a new challenging problem at work?"
Innovation	"Whom are you likely to turn to in order to discuss a new or innovative idea?"
Relationships that reveal the information-sharing potential of a network	
Access	"When I need information or advice, this person is generally accessible to me within a sufficient amount of time to help me solve my problem."
Engagement	"If I ask this person for help, I can feel confident that he or she will actively engage in problem solving with me"
Relationships that reveal rigidity in a network	
Decision making	"Please indicate whom you turn to for input prior to making an important decision."
Communicate more	"I would be more effective in my work if I were able to communicate more with this person."
Task flow	"Please indicate the extent to which people listed below provide you with the inputs necessary to do your job."
	"Please indicate the extent to which you distribute outputs from your work to the people listed below."
Power or influence	"Please indicate the extent to which you consider each person listed below to be influential."

Relationships that reveal well-being and supportiveness in a network	
Liking	"Please indicate how much you like each person."
Friendship	"Please indicate the people you consider to be personal friend, that is, those people you see most frequently for informal activities such as going out to lunch, dinner, drinks, visiting one another's homes, and so on."
Career support	"Please indicate who has contributed to your professional growth and development. Include people who have taken an active interest in and helped you advance in your career."
Personal support	"Please indicate people you turn to for personal support when your work is going poorly, a project is failing, or you are frustrated with certain decisions."
Energy	"When you interact with this person, how does it affect your energy level?"
Trust	"Please indicate the people in this group you would trust to keep your best interests in mind."

Table C.2 SNA Metrics to Detect Individual Roles

SNA Metrics[47]
Degree centrality is the number of direct relationships that a network member has. An entity with high degree centrality: • Is typically an active member in the organization. • Is often a connector or hub in the network. • Is not necessarily the most connected member in the network • May be in an advantaged position in the network. • May have alternative ways to satisfy organizational needs, and consequently may be less dependent on other individuals. • Can often be identified as third parties or deal makers. **Example:**  **Interpretation:** *"Alice has the highest degree centrality, which means that she is quite active in the organization. However, she is not necessarily the most powerful person because she is only directly connected within one degree to people in her clique—she has to go through Rafael to get to other cliques."*
Betweenness centrality identifies an entity's position within a network in terms of its ability to make connections to other pairs or groups in the organization. A network member with a high betweenness centrality generally: • Holds a favored or powerful position in the network. • Represents a single point of failure—take the single betweenness spanner out of a network and you sever ties between cliques. • Has a greater amount of influence over what happens in the organization. **Example:**  **Interpretation:** *"Rafael has the highest betweenness because he is between Alice and Aldo, who are between other entities. Alice and Aldo have a slightly lower betweenness because they are essentially only between their own cliques. Therefore, although Alice has a higher degree centrality, Rafael has more importance in the network in certain respects."*

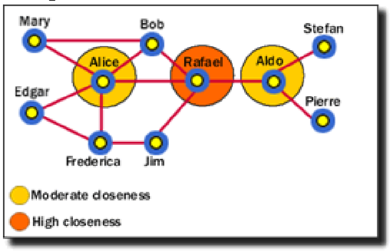
[47]SNA examples extracted from FMS Advanced Systems Group [FMS 12] – Under Permission.

SNA Metrics[47]

Closeness centrality measures how quickly a network member can access more members in the organizational network. A member with a high closeness centrality typically:

- Has quick access to other members in the network.
- Is close and has a short path to other members.
- Has high visibility as to what is happening in the organizational network.

Example:

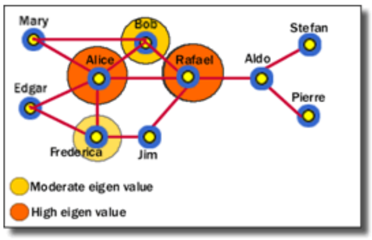


Interpretation:
"Rafael has the highest closeness centrality because he can reach more entities through shorter paths. As such, Rafael's placement allows him to connect to entities in his own clique, and to entities that span cliques."

Eigenvalue measures how close an entity is to other highly close entities within a network.

I.e. Eigenvalue identifies the most central entities in terms of the global or overall makeup of the network. A high eigenvalue generally:

- Indicates an organizational member that is more central to the main pattern of distances among all members.
- Is a reasonable measure of one aspect of centrality in terms of positional advantage.



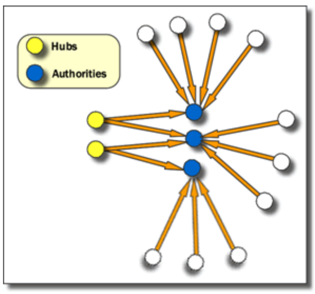
Interpretation:
"Alice and Rafael are closer to other highly close entities in the network. Bob and Frederica are also highly close, but to a lesser value."

Entities that many other entities point to are called **Authorities**.
Hubs are entities that point to a relatively large number of authorities.

If an entity has a high number of relationships pointing to it, it has a high authority value, and generally:

- Is a knowledge or organizational authority within a domain.
- Acts as definitive source of information.

Example:



Interpretation:
"Authorities point to high hubs. Hubs point to high authorities."

D. SNARE Project Charter Template

SNARE PROJECT CHARTER	
General Information	
Project Name	*[Name to identify the project]*
Organization	*[Name of the analyzed organization/system]*
Project Sponsor	*[Sponsor name]*
Project Analyst	*[Analyst name]*
Overview	
Identification *[Project description brief]*	
Project Objectives *[Overall objectives for the project]*	
Business Need *[Overall expectations]*	
Sponsorship & Ownership *[Project sponsorship and final analysis ownership. This should include a listing of sponsoring stakeholders]*	
Project Approach	
Project Deliverables and Quality Objectives *[List of key deliverables that will be generated during and on completion of the project. Identify key milestones. For each deliverable, provide a description of its quality objectives in terms of output quality and approval requirements]*	
Responsibilities *[Assign roles and responsibilities to individuals]*	
Dependencies *[Describe any dependencies outside of the analyst direct control, or outside of the scope of the project which may influence the project's success]*	
Project Facilities and Resources *[Requirements for project facilities and resources]*	

SNARE PROJECT CHARTER
Risk Management *[Risks associated with the project and the actions that can be taken during the project to minimize the risks]*
Project Stages *[Brief description of the project life cycle]*
Project Control *[Explains the methods to help the analyst in identifying project progress and communicating that progress project spons manager and team]*
Project Schedule *[High-level schedule for the project]*
Project Cost Estimate *[Estimated project cost]*
Project Approval
Project Approval [Sponsor and Analyst signatures]

E. Cases Studies - Supplementary Materials

Additional information from cases studies is provided in this appendix.

E.1 Organizational Context

Each GSS team has a Manager. ID 162 is manager of GSS IN Corp and NO&S IN; ID 240 is manager of NO&S Messaging; and ID 215 is Manager of NO&S Service Platforms. NO&S IN is split into 2 teams, one focusing on Support (Incident and Problem Processes) and the other focusing on configuration, ID 132 manages the first and ID 187 the second. ID 13, ID 49 and ID 12 constitute the configuration Team, the remaining belongs to the support team. VOC Service Desk and NO&S IPTV are Managed Services and have a special Governance Module where ID 190 and ID 199 are Team Leaders, ID 83 is a Service Manager (according to ITIL) and ID 16 is a Vodafone Manager. ID 168 is a Vodafone Incident Manager for TV Services.

Table E.1 provides a full list of Vodafone Units and Teams under analysis.

Table E.1 Case A - Vodafone Units and Teams

Unit	Unit Teams
Network Products & Services	3GLab-NS
Network Products & Services	DSI IN-Prepaid
Network Products & Services	ZON IN –Prepaid
Network Products & Services	Np&s - Messaging & Service Enablers
Network Products & Services	Np&s - Online Charging Systems
Desenho de Rede	DRD-Edge
Desenho de Rede	TCI-CI
Desenho de Rede	Cte - Multimédia Core & Edge
Desenho de Rede	Cte - NsuIp& Transport
Desenho de Rede	Cte - Transmission
DSCE	DSCE-Backoffice
DSCE	DSCE-GEO WOF
DSE	DSE-Delivery
DSE	DSE-GP
DSE	DSE-Service Desk
DSE	DSE-STI
DSE	DSE-Suporte
DSPL	DSPL-I&R
DSPL	DSPL-SMC

Unit	Unit Teams
DSPL	DSPL-SVC
DSPL	DSPL-SFD
DSPL	No&s - 1ls - Nmc Network Mgmt. Center
DSPL	No&s - 1ls - Smc Network Mgmt. Center
DSPL	No&s - 1st Line Support
DSPL	No&s - 1ls - International & Roaming
DTSI	DTSI-AM-RD
DTSI	DTSI-DM-NS
DTSI	DTSI-SAOPER
DTSI	DTSI-TS-DBA
DTSI	DTSI-HDAPLC
DTSI	DTSI-HDCONT
DTSI	DTSI-HDPL
DTSI	DTSI-HDSL-PO
DTSI	DTSI-SEGCORP
DTSI	DTSI-SI-CTX
DTSI	DTSI-SWM
DTSI	IT-UAM
DTSI	I&st - ao - Crm/billing & Delivery
DTSI	I&st - Commissions
OSS	OSS-WOW
OSS	OSS-AS
OSS	OSS-Cramer
OSS	OSS-SG
OSS	OSS-WOW
OSS	BPMOSS
UOP	UOP-GI
UOP	UOP-SAC-RH+
UOP	MVNOSuporte
UOP	OL-mCare
UOP	DSL UOP
UOP	PA-Service Desk
UOP	Co - 1st Line Consumer (lisboa)
UOP	Co - 1st Line Consumer (porto)
UOP	Co - Business Inbound - 16914
UOP	Co - Castelo Branco (1291 e Pa)
UOP	Co - Complaints Manag. Reporting
UOP	Co - GaqLisboa
UOP	Co - Gaq Porto
UOP	Co - Inbound (Porto)
UOP	Co - Inbound Business
UOP	Co - Tec Support Sme/soho
UOP	Co - Technical Call Center
UOP	Co - Technical Projects
UOP	Co - User Support
DOS (n GSS) Network Operations & Support	NSU-IP-Operations-PT

Unit	Unit Teams
DOS (n GSS) Network Operations & Support	Suporte CSS
DOS (n GSS) Network Operations & Support	DRC-Core
DOS (n GSS) Network Operations & Support	No&s - Fixed Access & Internal Netw
DOS (n GSS) Network Operations & Support	No&s - Fixed Access Op. Adsl
DOS (n GSS) Network Operations & Support	No&s– North
DOS (n GSS) Network Operations & Support	No&s - NsuIp Operations
DOS (n GSS) Network Operations & Support	No&s - Operations
DOS (n GSS) Network Operations & Support	No&s - South
DOS (n GSS) Network Operations & Support	No&s - Support
DOS (n GSS) Network Operations & Support	No&s–Bss
DOS (n GSS) Network Operations & Support	No&s– Centre
Negócio	UNP-MARKT-YORN
Negócio	DPGI
Negócio	DSCE-Backoffice
Negócio	GrandesContas Centro
Negócio	Ebu - Enterprise Solut.-implementation
Negócio	Ebu/mkt - M2m & Partnerships
Negócio	Ane - Center&madeira
Negócio	Ane - Design&optimization
Negócio	Ane - Mobile Testing
Negócio	Ane– North
Negócio	Ane - South&azores
Negócio	Cbu - Portimão Shop
Negócio	Cbu - South & Islands Region Sales
Parceiros e Fornecedores	WIT
Parceiros e Fornecedores	Celfocus - OneNet UK
Fraude Auditoria e Revenueassurance	DAI
Fraude Auditoria e Revenueassurance	Fr&sm - Fraud
Fraude Auditoria e Revenueassurance	Fr&sm - Revenue Assurance
Fraude Auditoria e Revenueassurance	Fr&sm - Security Enablers
Fraude Auditoria e Revenueassurance	I&st - ao - Crm/billing & Delivery
Fraude Auditoria e Revenueassurance	I&st - Commissions
DRRO	DRRO-Roaming
GSS	No&s– Services
GSS	No&s – Messaging (Focused Unit)
GSS	No&s - Service Platforms (Focused Unit)
GSS	No&s – Iptv (Focused Unit)
GSS	No&s – In (Focused Unit)
GSS	GSS IN Corp (Focused Unit)
GSS	VOC Service Desk (Focused Unit)

E.2 Data Gathering Processes

We include in this section the starting Managers' interview. For confidentiality reasons, each name was replaced by an ID.

Manager Interview:

"The six groups under study have very different profiles and challenges and there are expected to have different resiliencies.

Groups have different Maturity. GSS group adopts ITIL best practices and maturity levels are related with ITIL maturity.

GSS teams are responsible for Operation, Maintenance and administration of several Vodafone services (i.e. SMS, MMS, Content services, One Net Mobile, TV Solutions, Voice Mail, Pre-Paid and others).

Each team is responsible for a set of services clustered with a team taking into account its technology.

GSS Messaging is the most mature group; it has a consistent team, supportive of others. Its members normally have high evaluations, are the most dynamic and have a consistent and homogeneous team. In terms of workload, on average they have less workload than others, which helps groups sharing dynamics, creating the time for it.

GSS SAS is a technological disperse group, supporting several small and very distinct services, highly dynamical. This team tends to have less homogeneous knowledge sharing and is frequently dependent on specific members for specific issues. They have been making an effort for information sharing. ID 215 is a very critical element and the team is affected if ID 215 is missing. The team has an intense workload and is affected if one of its members is not present.

GSS IN is less homogeneous and very dependent on key members (ID 162; ID 187; ID 132). This team has made an effort on information sharing and some elements are aggregators of that dynamic (ID 58; and ID 90). Group resilience should be low.

GSS Corp is a new group, and therefore information is mostly on every one's heads. The team has been growing in consistency but is dependent on ID 60 and ID 1.

VOC is a manage services group and acts based on procedures. It should be very resilient and only dependent on its team leader ID 199.

IPTV 2nd Line is a manage services group and has specific areas of knowledge for which there are dependencies. Head-end is dependent on ID 172 and ID 190 has an important role. ID 168 and ID 16 (mostly this last one) connects the group to Vodafone teams and both are critical in guaranteeing and managing contacts and relations outside the IPTV 2nd Line and VOC."

E.3 Network Analysis

Table E.2 provides a full description of analyzed GSS Members Centrality Rank.

Table E.2 Case A - NP GSS Rank (With Neutral Weights)

ID	Unit Team	IN	OUT	TYPE	NP
236	No&s - Messaging	254	116	Ordinary	370
32	No&s - Service Platforms	195	155	Ordinary	350
240	No&s - Messaging	140	194	Ordinary	334
189	No&s - Messaging	83	238	Ordinary	321
215	No&s - Service Platforms	112	178	Ordinary	290
201	No&s - Service Platforms	49	231	Ordinary	280
90	No&s - In	40	231	Ordinary	271
25	No&s - Messaging	77	168	Ordinary	245
190	No&s - Iptv	82	158	Ordinary	240
30	No&s - Iptv	71	151	Ordinary	222
222	No&s - Service Platforms	108	109	Ordinary	217
179	No&s - Messaging	74	132	Ordinary	206
148	GSS IN Corp	113	77	Ordinary	190
199	VOC Service Desk	152	36	Ordinary	188
198	VOC Service Desk	89	79	Ordinary	168
22	No&s - Service Platforms	81	76	Ordinary	157
152	No&s - Iptv	71	75	Ordinary	146
58	No&s - In	50	92	Ordinary	142
172	No&s - Iptv	43	91	Ordinary	134
173	No&s - Iptv	76	56	Ordinary	132
103	No&s - In	70	61	Ordinary	131
217	No&s - Iptv	17	97	Ordinary	114
88	VOC Service Desk	91	15	Ordinary	106
16	No&s - Iptv	32	69	Ordinary	101
71	VOC Service Desk	92	9	Ordinary	101
115	No&s - Iptv	10	89	Ordinary	99
147	VOC Service Desk	82	14	Ordinary	96
132	No&s - In	47	47	Ordinary	94
111	No&s - Service Platforms	70	19	Ordinary	89
13	No&s - In	49	37	Ordinary	86
212	No&s - Iptv	25	54	Ordinary	79
167	No&s - Iptv	61	9	Ordinary	70
1	No&s - In	24	45	Ordinary	69
60	No&s - In	32	34	Ordinary	66
49	No&s - In	41	20	Ordinary	61
143	No&s - Iptv	3	53	Ordinary	56
12	No&s - In	47	7	Ordinary	54
125	No&s - In	43	5	Ordinary	48

ID	Unit Team	IN	OUT	TYPE	NP
243	VOC Service Desk	35	13	Ordinary	48
168	No&s – Iptv	8	39	Ordinary	47
52	No&s - Services	14	28	Ordinary	42
83	No&s – Iptv	11	29	Ordinary	40
187	No&s – In	14	18	Ordinary	32
365	GSS IN Corp	30	0	Receiver	30
26	VOC Service Desk	29	0	Receiver	29
153	No&s – In	3	26	Ordinary	29
319	GSS IN Corp	22	6	Ordinary	28
162	No&s – In	11	16	Ordinary	27
346	GSS IN Corp	17	6	Ordinary	23
197	VOC Service Desk	18	3	Ordinary	21
146	GSS IN Corp	16	2	Ordinary	18
300	No&s – In	17	1	Ordinary	18
324	GSS IN Corp	12	5	Ordinary	17
281	No&s - Iptv	6	0	Receiver	6
196	GSS IN Corp	0	5	Transmitter	5
160	GSS IN Corp	3	1	Ordinary	4
74	No&s - In	0	3	Transmitter	3
123	GSS IN Corp	1	1	Carrier	2
216	GSS IN Corp	1	0	Receiver	1
316	No&s - Service Platforms	0	1	Transmitter	1
329	No&s - Iptv	0	1	Transmitter	1
339	VOC Service Desk	0	1	Transmitter	1
370	No&s - In	1	0	Receiver	1
372	No&s - Messaging	1	0	Receiver	1
384	GSS IN Corp	1	0	Receiver	1
39	GSS IN Corp	0	0	Isolate	0

Table E.3 Case A - NP GSS Rank (wg_in=1, wg_out=0)

ID	Unit Team	IN	wg_in	OUT	wg_out	NP
236	No&s - Messaging	254	1	116	0	254
32	No&s - Service Platforms	195	1	155	0	195
199	VOC Service Desk	152	1	36	0	152
240	No&s - Messaging	140	1	194	0	140
148	GSS IN Corp	113	1	77	0	113
215	No&s - Service Platforms	112	1	178	0	112
222	No&s - Service Platforms	108	1	109	0	108
71	VOC Service Desk	92	1	9	0	92
88	VOC Service Desk	91	1	15	0	91
198	VOC Service Desk	89	1	79	0	89

ID	Unit Team	IN	wg_in	OUT	wg_out	NP
189	No&s - Messaging	83	1	238	0	83
190	No&s - Iptv	82	1	158	0	82
147	VOC Service Desk	82	1	14	0	82
22	No&s - Service Platforms	81	1	76	0	81
25	No&s - Messaging	77	1	168	0	77
173	No&s - Iptv	76	1	56	0	76
179	No&s - Messaging	74	1	132	0	74
30	No&s - Iptv	71	1	151	0	71
152	No&s - Iptv	71	1	75	0	71
103	No&s - In	70	1	61	0	70
111	No&s - Service Platforms	70	1	19	0	70
167	No&s - Iptv	61	1	9	0	61
58	No&s - In	50	1	92	0	50
201	No&s - Service Platforms	49	1	231	0	49
13	No&s - In	49	1	37	0	49
132	No&s - In	47	1	47	0	47
12	No&s - In	47	1	7	0	47
172	No&s - Iptv	43	1	91	0	43
125	No&s - In	43	1	5	0	43
49	No&s - In	41	1	20	0	41
90	No&s - In	40	1	231	0	40
243	VOC Service Desk	35	1	13	0	35
16	No&s - Iptv	32	1	69	0	32
60	No&s - In	32	1	34	0	32
365	GSS IN Corp	30	1	0	0	30
26	VOC Service Desk	29	1	0	0	29
212	No&s - Iptv	25	1	54	0	25
1	No&s - In	24	1	45	0	24
319	GSS IN Corp	22	1	6	0	22
197	VOC Service Desk	18	1	3	0	18
217	No&s - Iptv	17	1	97	0	17

ID	Unit Team	IN	wg_in	OUT	wg_out	NP
346	GSS IN Corp	17	1	6	0	17
300	No&s - In	17	1	1	0	17
146	GSS IN Corp	16	1	2	0	16
52	No&s - Services	14	1	28	0	14
187	No&s - In	14	1	18	0	14
324	GSS IN Corp	12	1	5	0	12
83	No&s - Iptv	11	1	29	0	11
162	No&s - In	11	1	16	0	11
115	No&s - Iptv	10	1	89	0	10
168	No&s - Iptv	8	1	39	0	8
281	No&s - Iptv	6	1	0	0	6
143	No&s - Iptv	3	1	53	0	3
153	No&s - In	3	1	26	0	3
160	GSS IN Corp	3	1	1	0	3
123	GSS IN Corp	1	1	1	0	1
216	GSS IN Corp	1	1	0	0	1
370	No&s - In	1	1	0	0	1
372	No&s - Messaging	1	1	0	0	1
384	GSS IN Corp	1	1	0	0	1
196	GSS IN Corp	0	1	5	0	0
74	No&s - In	0	1	3	0	0
316	No&s - Service Platforms	0	1	1	0	0
329	No&s - Iptv	0	1	1	0	0
339	VOC Service Desk	0	1	1	0	0
39	GSS IN Corp	0	1	0	0	0

Table E.4 Case A - NP GSS Rank (wg_in=0, wg_out=1)

ID	Unit Team	IN	wg_in	OUT	wg_out	NP
189	No&s - Messaging	83	0	238	1	238
201	No&s - Service Platforms	49	0	231	1	231
90	No&s - In	40	0	231	1	231

ID	Unit Team	IN	wg_in	OUT	wg_out	NP
240	No&s - Messaging	140	0	194	1	194
215	No&s - Service Platforms	112	0	178	1	178
25	No&s - Messaging	77	0	168	1	168
190	No&s - Iptv	82	0	158	1	158
32	No&s - Service Platforms	195	0	155	1	155
30	No&s - Iptv	71	0	151	1	151
179	No&s - Messaging	74	0	132	1	132
236	No&s - Messaging	254	0	116	1	116
222	No&s - Service Platforms	108	0	109	1	109
217	No&s - Iptv	17	0	97	1	97
58	No&s - In	50	0	92	1	92
172	No&s - Iptv	43	0	91	1	91
115	No&s - Iptv	10	0	89	1	89
198	VOC Service Desk	89	0	79	1	79
148	GSS IN Corp	113	0	77	1	77
22	No&s - Service Platforms	81	0	76	1	76
152	No&s - Iptv	71	0	75	1	75
16	No&s - Iptv	32	0	69	1	69
103	No&s - In	70	0	61	1	61
173	No&s - Iptv	76	0	56	1	56
212	No&s - Iptv	25	0	54	1	54
143	No&s - Iptv	3	0	53	1	53
132	No&s - In	47	0	47	1	47
1	No&s - In	24	0	45	1	45
168	No&s - Iptv	8	0	39	1	39
13	No&s - In	49	0	37	1	37
199	VOC Service Desk	152	0	36	1	36
60	No&s - In	32	0	34	1	34
83	No&s - Iptv	11	0	29	1	29

ID	Unit Team	IN	wg_in	OUT	wg_out	NP
52	No&s - Services	14	0	28	1	28
153	No&s - In	3	0	26	1	26
49	No&s - In	41	0	20	1	20
111	No&s - Service Platforms	70	0	19	1	19
187	No&s - In	14	0	18	1	18
162	No&s - In	11	0	16	1	16
88	VOC Service Desk	91	0	15	1	15
147	VOC Service Desk	82	0	14	1	14
243	VOC Service Desk	35	0	13	1	13
71	VOC Service Desk	92	0	9	1	9
167	No&s - Iptv	61	0	9	1	9
12	No&s - In	47	0	7	1	7
319	GSS IN Corp	22	0	6	1	6
346	GSS IN Corp	17	0	6	1	6
125	No&s - In	43	0	5	1	5
324	GSS IN Corp	12	0	5	1	5
196	GSS IN Corp	0	0	5	1	5
197	VOC Service Desk	18	0	3	1	3
74	No&s - In	0	0	3	1	3
146	GSS IN Corp	16	0	2	1	2
300	No&s - In	17	0	1	1	1
160	GSS IN Corp	3	0	1	1	1
123	GSS IN Corp	1	0	1	1	1
316	No&s - Service Platforms	0	0	1	1	1
329	No&s - Iptv	0	0	1	1	1
339	VOC Service Desk	0	0	1	1	1
365	GSS IN Corp	30	0	0	1	0
26	VOC Service Desk	29	0	0	1	0
281	No&s - Iptv	6	0	0	1	0

ID	Unit Team	IN	wg_in	OUT	wg_out	NP
216	GSS IN Corp	1	0	0	1	0
370	No&s - In	1	0	0	1	0
372	No&s - Messaging	1	0	0	1	0
384	GSS IN Corp	1	0	0	1	0
39	GSS IN Corp	0	0	0	1	0

Table E.5 Case A - NP GSS Rank (wg_in=0,5, wg_out=0,5)

ID	Unit Team	IN	wg_in	OUT	wg_out	NP
236	No&s - Messaging	254	0,5	116	0,5	185
32	No&s - Service Platforms	195	0,5	155	0,5	175
240	No&s - Messaging	140	0,5	194	0,5	167
189	No&s - Messaging	83	0,5	238	0,5	160,5
215	No&s - Service Platforms	112	0,5	178	0,5	145
201	No&s - Service Platforms	49	0,5	231	0,5	140
90	No&s - In	40	0,5	231	0,5	135,5
25	No&s - Messaging	77	0,5	168	0,5	122,5
190	No&s - Iptv	82	0,5	158	0,5	120
30	No&s - Iptv	71	0,5	151	0,5	111
222	No&s - Service Platforms	108	0,5	109	0,5	108,5
179	No&s - Messaging	74	0,5	132	0,5	103
148	GSS IN Corp	113	0,5	77	0,5	95
199	VOC Service Desk	152	0,5	36	0,5	94
198	VOC Service Desk	89	0,5	79	0,5	84
22	No&s - Service Platforms	81	0,5	76	0,5	78,5
152	No&s - Iptv	71	0,5	75	0,5	73
58	No&s - In	50	0,5	92	0,5	71
172	No&s - Iptv	43	0,5	91	0,5	67
173	No&s - Iptv	76	0,5	56	0,5	66
103	No&s - In	70	0,5	61	0,5	65,5

ID	Unit Team	IN	wg_in	OUT	wg_out	NP
217	No&s - Iptv	17	0,5	97	0,5	57
88	VOC Service Desk	91	0,5	15	0,5	53
16	No&s - Iptv	32	0,5	69	0,5	50,5
71	VOC Service Desk	92	0,5	9	0,5	50,5
115	No&s - Iptv	10	0,5	89	0,5	49,5
147	VOC Service Desk	82	0,5	14	0,5	48
132	No&s - In	47	0,5	47	0,5	47
111	No&s - Service Platforms	70	0,5	19	0,5	44,5
13	No&s - In	49	0,5	37	0,5	43
212	No&s - Iptv	25	0,5	54	0,5	39,5
167	No&s - Iptv	61	0,5	9	0,5	35
1	No&s - In	24	0,5	45	0,5	34,5
60	No&s - In	32	0,5	34	0,5	33
49	No&s - In	41	0,5	20	0,5	30,5
143	No&s - Iptv	3	0,5	53	0,5	28
12	No&s - In	47	0,5	7	0,5	27
125	No&s - In	43	0,5	5	0,5	24
243	VOC Service Desk	35	0,5	13	0,5	24
168	No&s - Iptv	8	0,5	39	0,5	23,5
52	No&s - Services	14	0,5	28	0,5	21
83	No&s - Iptv	11	0,5	29	0,5	20
187	No&s - In	14	0,5	18	0,5	16
365	GSS IN Corp	30	0,5	0	0,5	15
26	VOC Service Desk	29	0,5	0	0,5	14,5
153	No&s - In	3	0,5	26	0,5	14,5
319	GSS IN Corp	22	0,5	6	0,5	14
162	No&s - In	11	0,5	16	0,5	13,5
346	GSS IN Corp	17	0,5	6	0,5	11,5
197	VOC Service Desk	18	0,5	3	0,5	10,5

ID	Unit Team	IN	wg_in	OUT	wg_out	NP
146	GSS IN Corp	16	0,5	2	0,5	9
300	No&s - In	17	0,5	1	0,5	9
324	GSS IN Corp	12	0,5	5	0,5	8,5
281	No&s - Iptv	6	0,5	0	0,5	3
196	GSS IN Corp	0	0,5	5	0,5	2,5
160	GSS IN Corp	3	0,5	1	0,5	2
74	No&s - In	0	0,5	3	0,5	1,5
123	GSS IN Corp	1	0,5	1	0,5	1
216	GSS IN Corp	1	0,5	0	0,5	0,5
316	No&s - Service Platforms	0	0,5	1	0,5	0,5
329	No&s - Iptv	0	0,5	1	0,5	0,5
339	VOC Service Desk	0	0,5	1	0,5	0,5
370	No&s - In	1	0,5	0	0,5	0,5
372	No&s - Messaging	1	0,5	0	0,5	0,5
384	GSS IN Corp	1	0,5	0	0,5	0,5
39	GSS IN Corp	0	0,5	0	0,5	0

Table E.6 Case A - SNA, Members Network Metrics (Normalized)

ID	NP	Betweenness	Closeness	Proximity Prestige	Authority Weights
1	0,186486	0,019881	0,446367	0,446346	0,003275
2	0,021622	0,000019	0,305837	0,305823	0,000065
3	0,008108	0	0,344674	0,344657	0,003269
4	0,464865	0,019048	0,470849	0,470826	0,205595
5	0,002703	0	0,266724	0,266711	0,000002
6	0,002703	0	0,266724	0,266711	0,000002
7	0,154054	0,000047	0,374767	0,374749	0,007529
8	0,002703	0	0,302331	0,302316	0,000133
9	0,002703	0	0,332264	0,332248	0,000351
10	0,002703	0	0,332264	0,332248	0,000351
11	0,010811	0,000477	0,294845	0,294831	0
12	0,145946	0,00236	0,317681	0,317666	0,002773
13	0,232432	0,017067	0,37978	0,379761	0,00408
14	0,027027	0	0,331966	0,33195	0,003156
15	0,002703	0	0,332264	0,332248	0,000351
16	0,272973	0,022319	0,404765	0,404746	0,002533

ID	NP	Betweenness	Closeness	Proximity Prestige	Authority Weights
17	0,135135	0,028017	0,388984	0,388965	0,001625
18	0,132432	0,006063	0,304325	0,30431	0,000086
19	0,002703	0	0,24528	0,245268	0,000001
20	0,051351	0,00145	0,345642	0,345625	0,001058
21	0,005405	0	0,332264	0,332248	0,000702
22	0,424324	0,007436	0,435827	0,435806	0,077082
23	0,005405	0	0,332264	0,332248	0,000702
24	0,002703	0	0,332264	0,332248	0,000351
25	0,662162	0,015356	0,37553	0,375512	0,145365
26	0,078378	0	0,323245	0,323229	0,001292
27	0,010811	0	0,337428	0,337411	0,001067
28	0,010811	0	0,332264	0,332248	0,001405
29	0,132432	0,001964	0,380563	0,380544	0,004389
30	0,6	0,014077	0,360846	0,360829	0,007108
31	0,024324	0	0,296265	0,29625	0,000011
32	0,945946	0,021041	0,456864	0,456842	0,24027
33	0,002703	0	0,302331	0,302316	0,000133
34	0,002703	0	0,332264	0,332248	0,000351
35	0,008108	0,000127	0,284177	0,284163	0,005133
36	0,002703	0	0,256351	0,256339	0,000007
37	0,002703	0	0,303574	0,303559	0,000419
38	0,008108	0	0,332264	0,332248	0,001054
39	0	0	0	0	0
40	0,5	0,011324	0,45294	0,452918	0,22989
41	0,016216	0,000108	0,300119	0,300104	0,000013
42	0,064865	0,003607	0,368777	0,368759	0,000625
43	0,002703	0	0,31605	0,316034	0,001431
44	0,07027	0,000009	0,362975	0,362958	0,004027
45	0,008108	0	0,270041	0,270028	0,000003
46	0,002703	0	0,31605	0,316034	0
47	0,021622	0	0,323528	0,323513	0,002235
48	0,051351	0,001772	0,348251	0,348234	0,00071
49	0,164865	0,003159	0,411534	0,411514	0,013162
50	0,016216	0	0,29842	0,298406	0,016362
51	0,002703	0	0,255818	0,255806	0
52	0,113514	0,036839	0,436343	0,436321	0,013028
53	0,013514	0	0,342754	0,342737	0,000702
54	0,010811	0	0,266724	0,266711	0,000009
55	0,064865	0,001825	0,358394	0,358377	0,00015
56	0,227027	0,006138	0,45743	0,457408	0,073698
57	0,002703	0	0,332264	0,332248	0,000351
58	0,383784	0,029131	0,467865	0,467843	0,016024
59	0,016216	0	0,331966	0,33195	0,00152
60	0,178378	0,025479	0,391044	0,391025	0,002386

ID	NP	Betweenness	Closeness	Proximity Prestige	Authority Weights
61	0,054054	0,000256	0,345642	0,345625	0,000359
62	0,037838	0	0,342118	0,342102	0,004421
63	0,018919	0	0,340227	0,34021	0,002115
64	0,018919	0,000608	0,378611	0,378593	0,001259
65	0,313514	0,01874	0,394387	0,394367	0,008452
66	0,005405	0	0,332264	0,332248	0,000702
67	0,037838	0,00182	0,341802	0,341785	0,001061
68	0,002703	0	0,266724	0,266711	0,000002
69	0,002703	0	0,303574	0,303559	0,000419
70	0,283784	0,002898	0,359441	0,359424	0,001673
71	0,272973	0,000086	0,335587	0,335571	0,004869
72	0,002703	0	0,256351	0,256339	0,000007
73	0,037838	0	0,37553	0,375512	0,006387
74	0,008108	0	0,329594	0,329579	0
75	0,002703	0	0,266724	0,266711	0,000002
76	0,035135	0	0,335587	0,335571	0,004311
77	0,008108	0	0,332264	0,332248	0,001054
78	0,018919	0,001423	0,285938	0,285924	0,000027
79	0,002703	0	0,332264	0,332248	0,000351
80	0,051351	0,017067	0,351233	0,351216	0
81	0,008108	0	0,29842	0,298406	0,008463
82	0,005405	0,000027	0,324667	0,324651	0,000059
83	0,108108	0,004257	0,346616	0,346599	0,000317
84	0,013514	0	0,342754	0,342737	0,001054
85	0,002703	0	0,332264	0,332248	0,000351
86	0,510811	0,060528	0,456864	0,456842	0,04294
87	0,002703	0	0,332264	0,332248	0,000351
88	0,286486	0,00006	0,339601	0,339584	0,005796
89	0,005405	0	0,347268	0,347251	0,000351
90	0,732432	0,01977	0,438937	0,438916	0,007059
91	0,008108	0	0,355975	0,355958	0,000906
92	0,002703	0	0,332264	0,332248	0,000351
93	0,037838	0	0,382139	0,38212	0,005563
94	0,043243	0	0,373629	0,373611	0,005664
95	0,002703	0	0,332264	0,332248	0,000351
96	0,051351	0	0,352912	0,352895	0,007807
97	0	0	0	0	0
98	0	0	0	0	0
99	0,043243	0	0,335587	0,335571	0,004603
100	0,002703	0	0,259414	0,259401	0
101	0,018919	0	0,338977	0,33896	0,00202
102	0,008108	0,000187	0,282654	0,28264	0,000016
103	0,354054	0,031196	0,387351	0,387333	0,006835
104	0,043243	0	0,374008	0,37399	0,0024

ID	NP	Betweenness	Closeness	Proximity Prestige	Authority Weights
105	0,005405	0	0,332264	0,332248	0,000702
106	0,251351	0,019216	0,408347	0,408327	0,002097
107	0,010811	0	0,341802	0,341785	0,001054
108	0,054054	0	0,326678	0,326662	0
109	0,445946	0,008712	0,45294	0,452918	0,210398
110	0,002703	0	0,332264	0,332248	0,000351
111	0,240541	0,003057	0,423332	0,423312	0,088305
112	0,021622	0	0,349901	0,349884	0,001058
113	0,032432	0	0,361199	0,361182	0,002597
114	0,008108	0	0,263112	0,263099	0
115	0,267568	0,000018	0,336198	0,336182	0,000361
116	0,005405	0	0,328422	0,328406	0,000438
117	0,002703	0	0,332264	0,332248	0,000351
118	0,013514	0	0,351903	0,351886	0,000356
119	0,059459	0,000112	0,36369	0,363673	0,001611
120	0,037838	0	0,401245	0,401226	0,004867
121	0,010811	0	0,350566	0,350549	0,00089
122	0,432432	0,018103	0,451279	0,451257	0,21476
123	0,005405	0,000164	0,309946	0,309931	0,00011
124	0,005405	0	0,299875	0,29986	0,00235
125	0,12973	0,000351	0,404765	0,404746	0,013854
126	0,013514	0,000019	0,361553	0,361536	0,000897
127	0,002703	0	0,266724	0,266711	0,000002
128	0,537838	0,012665	0,469054	0,469032	0,253949
129	0,002703	0	0,247749	0,247737	0
130	0,002703	0	0,332264	0,332248	0,000351
131	0,002703	0	0,266724	0,266711	0,000002
132	0,254054	0,014841	0,419961	0,419941	0,009711
133	0,02973	0	0,283305	0,283291	0,000022
134	0,008108	0	0,335892	0,335876	0,000702
135	0,081081	0,000244	0,373252	0,373234	0,00198
136	0,013514	0	0,283305	0,283291	0,00001
137	0,010811	0	0,364769	0,364751	0,000832
138	0,018919	0	0,342754	0,342737	0,001054
139	0,010811	0	0,350566	0,350549	0,000633
140	0,002703	0	0,332264	0,332248	0,000351
141	0,002703	0	0,258868	0,258855	0,000013
142	0,835135	0	0,501557	0,501533	0
143	0,151351	0,000004	0,333164	0,333148	0,000104
144	0,021622	0,000086	0,362263	0,362245	0,001506
145	0,002703	0	0,332264	0,332248	0,000351
146	0,048649	0,000154	0,359791	0,359774	0,024389
147	0,259459	0,004047	0,355975	0,355958	0,003717
148	0,513514	0,028247	0,388575	0,388556	0,016052

ID	NP	Betweenness	Closeness	Proximity Prestige	Authority Weights
149	0,005405	0	0,270635	0,270622	0,000004
150	0,048649	0	0,360846	0,360829	0,006778
151	0,056757	0	0,376679	0,376661	0,006352
152	0,394595	0,0072	0,372123	0,372105	0,00593
153	0,078378	0,001567	0,379	0,378981	0,003326
154	0,002703	0	0,283958	0,283945	0,000063
155	0,078378	0,008815	0,351903	0,351886	0,000468
156	0,002703	0	0,308135	0,30812	0,00075
157	0,010811	0	0,24528	0,245268	0,000005
158	0,005405	0	0,266724	0,266711	0,000005
159	0,027027	0	0,373629	0,373611	0,00341
160	0,010811	0	0,28616	0,286146	0,000266
161	0,008108	0	0,283305	0,283291	0,000002
162	0,072973	0,003163	0,358046	0,358029	0,001626
163	0,018919	0	0,343711	0,343695	0,001054
164	0,010811	0	0,336812	0,336796	0,000354
165	0,024324	0	0,335587	0,335571	0,00285
166	0,013514	0	0,331072	0,331056	0,00146
167	0,189189	0,00053	0,354607	0,35459	0,012965
168	0,127027	0,001911	0,374387	0,374369	0,000436
169	0,102703	0,008921	0,352238	0,352221	0,001078
170	0,002703	0	0,266724	0,266711	0,000002
171	0,013514	0	0,354607	0,35459	0,001127
172	0,362162	0,005352	0,364049	0,364031	0,006808
173	0,356757	0,000886	0,358742	0,358725	0,005827
174	0,002703	0	0,24528	0,245268	0,000001
175	0,051351	0	0,408347	0,408327	0,010558
176	0,002703	0	0,266724	0,266711	0,000002
177	0,181081	0,005409	0,376295	0,376277	0,006529
178	0,278378	0,00353	0,456299	0,456277	0,124782
179	0,556757	0,009167	0,384127	0,384108	0,1231
180	0,002703	0	0,266724	0,266711	0,000002
181	0,035135	0,002697	0,390218	0,390199	0,004901
182	0	0	0	0	0
183	0,054054	0,000011	0,365491	0,365473	0,001878
184	0,027027	0	0,373252	0,373234	0,002781
185	0,002703	0	0,266724	0,266711	0,000002
186	0,002703	0	0,266724	0,266711	0,000002
187	0,086486	0,006079	0,375912	0,375894	0,002267
188	0,005405	0	0,332264	0,332248	0,000702
189	0,867568	0,002667	0,368409	0,368391	0,137063
190	0,648649	0,011151	0,419484	0,419464	0,003065
191	0,016216	0	0,331966	0,33195	0,00191
192	0,027027	0,000002	0,34054	0,340524	0,00106

ID	NP	Betweenness	Closeness	Proximity Prestige	Authority Weights
193	0,018919	0,000754	0,354948	0,354931	0,001084
194	0,002703	0	0,332264	0,332248	0,000351
195	0	0	0	0	0
196	0,013514	0	0,351233	0,351216	0
197	0,056757	0	0,314167	0,314151	0,00069
198	0,454054	0,006223	0,360142	0,360125	0,008876
199	0,508108	0,013613	0,377836	0,377818	0,009255
200	0,040541	0	0,37553	0,375512	0,004779
201	0,756757	0,014561	0,450728	0,450706	0,025308
202	0,07027	0,000628	0,362263	0,362245	0,001102
203	0,002703	0	0,332264	0,332248	0,000351
204	0,024324	0,000185	0,3066	0,306585	0,000101
205	0,035135	0,000104	0,36369	0,363673	0,005174
206	0,027027	0	0,335587	0,335571	0,002837
207	0,002703	0	0,266724	0,266711	0,000002
208	0,002703	0	0,266724	0,266711	0,000002
209	0,17027	0,007488	0,393127	0,393107	0,00775
210	0,308108	0,007675	0,399077	0,399057	0,008545
211	0,002703	0	0,332264	0,332248	0,000351
212	0,213514	0,00079	0,341486	0,341469	0,00142
213	0,072973	0	0,396931	0,396912	0,00888
214	0,040541	0	0,365853	0,365835	0,004773
215	0,783784	0,041474	0,465505	0,465483	0,079277
216	0,002703	0	0,277971	0,277958	0,000195
217	0,308108	0,000411	0,339601	0,339584	0,001399
218	0,008108	0	0,24528	0,245268	0,000003
219	0,172973	0,046293	0,365853	0,365835	0,000139
220	0,002703	0	0,332264	0,332248	0,000351
221	0,154054	0,000001	0,391459	0,39144	0,086658
222	0,586486	0,02861	0,448537	0,448515	0,097717
223	0,291892	0,003074	0,450728	0,450706	0,130623
224	0,002703	0	0,332264	0,332248	0,000351
225	0	0	0	0	0
226	0,013514	0	0,292973	0,292959	0,000132
227	0,002703	0	0,266724	0,266711	0,000002
228	0,018919	0,000324	0,344352	0,344336	0,000353
229	0,062162	0,013989	0,358742	0,358725	0,000714
230	0,016216	0	0,324952	0,324937	0,000222
231	0,027027	0	0,339913	0,339897	0,000359
232	0,024324	0	0,298179	0,298165	0,000054
233	0,002703	0	0,266724	0,266711	0,000002
234	0,024324	0,015092	0,339601	0,339584	0,000338
235	0,016216	0	0,334674	0,334658	0,001435
236	1	0,036614	0,431245	0,431224	0,672451

ID	NP	Betweenness	Closeness	Proximity Prestige	Authority Weights
237	0,008108	0	0,329594	0,329579	0,001042
238	0,008108	0,000002	0,348909	0,348892	0,000702
239	0,002703	0	0,266724	0,266711	0,000002
240	0,902703	0,018477	0,418533	0,418512	0,31988
241	0,083784	0,010709	0,364769	0,364751	0,002563
242	0,005405	0	0,238775	0,238763	0
243	0,12973	0,000096	0,322398	0,322382	0,001244
244	0,027027	0	0,323812	0,323796	0
245	0,024324	0	0,306854	0,30684	0
246	0,016216	0	0,317408	0,317393	0
247	0,016216	0	0,323812	0,323796	0
248	0,005405	0	0,279868	0,279854	0
249	0,056757	0	0,344352	0,344336	0
250	0,005405	0	0,271831	0,271817	0
251	0,002703	0	0,279868	0,279854	0
252	0,002703	0	0,278601	0,278587	0
253	0,016216	0	0,333164	0,333148	0
254	0,002703	0	0,278601	0,278587	0
255	0,027027	0,000019	0,321276	0,32126	0,000077
256	0,005405	0	0,291124	0,29111	0
257	0,148649	0	0,337736	0,33772	0
258	0,008108	0,000018	0,324667	0,324651	0,000204
259	0,002703	0	0,279868	0,279854	0
260	0,002703	0	0,278601	0,278587	0
261	0,013514	0	0,308393	0,308378	0
262	0,018919	0	0,326101	0,326085	0
263	0,045946	0,00041	0,28616	0,286146	0,000105
264	0,002703	0	0,279868	0,279854	0
265	0,078378	0	0,318504	0,318488	0
266	0,018919	0,000009	0,305332	0,305317	0,000101
267	0,010811	0	0,291124	0,29111	0
268	0,024324	0	0,343711	0,343695	0
269	0,021622	0,000011	0,337736	0,33772	0,000414
270	0,002703	0	0,293672	0,293658	0
271	0,002703	0	0,312042	0,312027	0
272	0,072973	0	0,335892	0,335876	0
273	0,016216	0	0,304576	0,304561	0,000101
274	0,002703	0	0,278601	0,278587	0
275	0,002703	0	0,278601	0,278587	0
276	0,005405	0	0,28616	0,286146	0
277	0,010811	0	0,284615	0,284601	0
278	0,005405	0	0,291124	0,29111	0
279	0,008108	0,000021	0,338977	0,33896	0,000195
280	0,008108	0,000019	0,295081	0,295066	0,000044

ID	NP	Betweenness	Closeness	Proximity Prestige	Authority Weights
281	0,016216	0	0,299146	0,299131	0,000167
282	0,005405	0	0,326101	0,326085	0
283	0,002703	0	0,278601	0,278587	0
284	0,143243	0	0,331072	0,331056	0
285	0,002703	0	0,277971	0,277958	0
286	0,008108	0,000002	0,323245	0,323229	0,001431
287	0,016216	0	0,338666	0,338649	0
288	0,008108	0	0,278601	0,278587	0
289	0,002703	0	0,278601	0,278587	0
290	0,086486	0,000004	0,347595	0,347578	0,001207
291	0,027027	0,000867	0,308909	0,308894	0,000306
292	0,008108	0	0,277971	0,277958	0,000195
293	0,002703	0	0,277971	0,277958	0
294	0,008108	0	0,29579	0,295776	0
295	0,008108	0	0,276307	0,276293	0
296	0,005405	0	0,27405	0,274037	0
297	0,002703	0	0,271831	0,271817	0
298	0,002703	0	0,30711	0,307095	0
299	0,067568	0,000714	0,34858	0,348563	0,01215
300	0,048649	0,000029	0,270635	0,270622	0,000501
301	0,013514	0	0,323528	0,323513	0,011016
302	0,002703	0	0,277971	0,277958	0,000195
303	0,005405	0	0,279868	0,279854	0,000044
304	0,005405	0	0,326678	0,326662	0,000794
305	0,005405	0	0,279868	0,279854	0,000089
306	0,018919	0	0,351233	0,351216	0,011082
307	0,018919	0	0,326101	0,326085	0,009339
308	0,005405	0	0,323245	0,323229	0,004118
309	0,005405	0	0,32268	0,322664	0,004521
310	0,005405	0	0,324952	0,324937	0,003572
311	0,002703	0	0,31605	0,316034	0,001431
312	0,005405	0	0,31605	0,316034	0,002863
313	0,002703	0	0,30711	0,307095	0,00011
314	0,005405	0	0,333465	0,333449	0
315	0,005405	0	0,294375	0,29436	0
316	0,002703	0	0,257604	0,257591	0
317	0,002703	0	0,31605	0,316034	0
318	0,002703	0	0,31605	0,316034	0
319	0,075676	0,000031	0,295081	0,295066	0,002155
320	0,005405	0	0,32268	0,322664	0
321	0,002703	0	0,299875	0,29986	0
322	0,016216	0	0,326101	0,326085	0
323	0,032432	0	0,312042	0,312027	0
324	0,045946	0,000412	0,334069	0,334052	0,001048

ID	NP	Betweenness	Closeness	Proximity Prestige	Authority Weights
325	0,002703	0	0,264053	0,26404	0
326	0,005405	0	0,304576	0,304561	0
327	0,008108	0	0,331072	0,331056	0,002141
328	0,002703	0	0,31605	0,316034	0
329	0,002703	0	0,264053	0,26404	0
330	0,027027	0	0,351903	0,351886	0
331	0,002703	0	0,312042	0,312027	0
332	0,002703	0	0,286827	0,286813	0
333	0,018919	0	0,330776	0,33076	0,00075
334	0,035135	0	0,305837	0,305823	0
335	0,021622	0	0,362975	0,362958	0
336	0	0	0	0	0
337	0,005405	0	0,312042	0,312027	0
338	0,002703	0	0,271831	0,271817	0
339	0,002703	0	0,261435	0,261422	0
340	0,002703	0	0,312042	0,312027	0
341	0,013514	0	0,328422	0,328406	0,004294
342	0,002703	0	0,30711	0,307095	0
343	0,002703	0	0,299875	0,29986	0
344	0,005405	0	0,317136	0,31712	0
345	0,035135	0	0,359791	0,359774	0
346	0,062162	0,000005	0,320717	0,320702	0,001955
347	0,013514	0	0,348909	0,348892	0,004425
348	0,016216	0	0,355632	0,355615	0,00587
349	0,010811	0	0,327547	0,327531	0,01103
350	0,013514	0	0,360846	0,360829	0,005378
351	0,005405	0	0,320717	0,320702	0,002986
352	0,008108	0	0,327547	0,327531	0,005457
353	0,008108	0	0,276307	0,276293	0,0077
354	0,002703	0	0,276307	0,276293	0,002567
355	0,008108	0	0,3293	0,329285	0,000505
356	0,002703	0	0,303574	0,303559	0,000419
357	0,013514	0	0,35529	0,355272	0,003899
358	0,002703	0	0,286827	0,286813	0,001077
359	0,002703	0	0,286827	0,286813	0,001077
360	0,002703	0	0,286827	0,286813	0,001077
361	0,008108	0	0,338355	0,338339	0,004276
362	0,002703	0	0,296027	0,296013	0,000185
363	0,005405	0	0,275688	0,275674	0,002687
364	0,008108	0	0,324096	0,324081	0,00087
365	0,081081	0	0,278601	0,278587	0,001071
366	0,002703	0	0,278601	0,278587	0,000036
367	0,002703	0	0,270041	0,270028	0,000027
368	0,008108	0	0,304576	0,304561	0,005439

ID	NP	Betweenness	Closeness	Proximity Prestige	Authority Weights
369	0,002703	0	0,299875	0,29986	0,001175
370	0,002703	0	0,272031	0,272018	0,000008
371	0,002703	0	0,272031	0,272018	0,000008
372	0,002703	0	0,312306	0,312291	0,000123
373	0,002703	0	0,308135	0,30812	0,00075
374	0,008108	0	0,318229	0,318214	0,004186
375	0,002703	0	0,308135	0,30812	0,00075
376	0,002703	0	0,308135	0,30812	0,00075
377	0,008108	0	0,323245	0,323229	0,006805
378	0,008108	0	0,323245	0,323229	0,00555
379	0,002703	0	0,293672	0,293658	0,003089
380	0,002703	0	0,294375	0,29436	0,000101
381	0,002703	0	0,309167	0,309152	0,002141
382	0,002703	0	0,309167	0,309152	0,002141
383	0,005405	0	0,287721	0,287707	0,000124
384	0,002703	0	0,30711	0,307095	0,00011

E.4 Social Entity Analysis

Table E.7 provides the network SEVF of each Vodafone Unit and Table E.8 provides a detailed computed SEVF values list of GSS Teams.

Table E.7 Case A - Network SEVF (Organizational Units)

Unit	SEVF
Network Products & Services	295
Desenho de Rede	44
DSCE	10
DSE	10
DSPL	1462
DTSI	147
OSS	22
UOP	255
DOS (n GSS) Network Operations & Support	1570
Negócio	416
Parceiros e Fornecedores	25
Fraude Auditoria e Revenue assurance	18
DRRO	53
GSS	**6599**
Total	**10926**

Table E.8 Case A - Network SEVF (GSS Teams)

GSS Teams	SEVF
GSS IN Corp	319
No&s - In	1132
No&s - Iptv	1487
No&s - Messaging	1477
No&s - Service Platforms	1384
No&s - Services	42
VOC Service Desk	758
Total	**6599**

Table E.9 provides a detailed description of network node types of each Vodafone Unit and Table E.10 describes network node types of each GSS Team.

Table E.9 Case A - Node Types of Each Unit

Unit	Isolate	Transmitter	Receiver	Carrier	Ordinary
Network Products & Services	0	12	2	1	10
Desenho de Rede	0	0	8	1	1
DSCE	0	3	0	0	2
DSE	0	7	0	1	0
DSPL	3	1	19	0	17
DTSI	0	12	26	0	5
OSS	0	1	10	0	0
UOP	2	12	30	0	2
DOS (n GSS) Network Operations & Support	0	3	31	0	41
Negócio	1	16	27	0	1
Parceiros e Fornecedores	0	0	0	0	1
Fraude Auditoria e Revenue assurance	0	3	4	0	1
DRRO	0	1	0	0	0
GSS	1	5	7	1	52
Total	7	76	164	4	133

Table E.10 Case A - Node Types of Each GSS Team

Teams	Isolate	Transmitter	Receiver	Carrier	Ordinary
GSS IN Corp	1	1	3	1	6
No&s - In	0	1	1	0	14
No&s - Iptv	0	1	1	0	13
No&s - Messaging	0	0	1	0	5
No&s - Service Platforms	0	1	0	0	6
No&s - Services	0	0	0	0	1
VOC Service Desk	0	1	1	0	7
Total	1	5	7	1	52

E.5 Relational Analysis

This section provides a detailed description of RV computed values. Table E.11 shows the computed RV Sum for each relational action: *Change, Incident, Problem,* and *Information Share*. Table E.12 provides a full description of RV computed values for each GSS Unit. In the referred table it is also possible to analyze RV individual contribution.

Table E.11 Case A - RV Sum per Relational Action

	CHANGE	INCIDENT	PROBLEM	INFORMATION SHAR	TOTAL (RCV units)
RV Sum	8147,5	7371	956,8	61169,9	77645,2

Table E.12 Case A - GSS Teams RV & Members Contribution

ID	Unit	Unit Name	Team RV Contribuition (RCV units)	%
148	151	GSS IN Corp	2147	89,9
365	151	GSS IN Corp	90	3,8
319	151	GSS IN Corp	61,6	2,6
346	151	GSS IN Corp	39,1	1,6
146	151	GSS IN Corp	28,8	1,2
324	151	GSS IN Corp	20,4	0,9
160	151	GSS IN Corp	1,2	0,1
123	151	GSS IN Corp	0,2	0,0
216	151	GSS IN Corp	0,1	0,0
384	151	GSS IN Corp	0,1	0,0
196	151	GSS IN Corp	0	0,0
39	151	GSS IN Corp	0	0,0
		Subtotal	2388,5	
90	152	No&s - In	1084	22,7
103	152	No&s - In	917	19,2
58	152	No&s - In	710	14,9
132	152	No&s - In	441,8	9,3
13	152	No&s - In	421,4	8,8
12	152	No&s - In	253,8	5,3
49	152	No&s - In	250,1	5,2
60	152	No&s - In	211,2	4,4
125	152	No&s - In	206,4	4,3
1	152	No&s - In	165,6	3,5
187	152	No&s - In	44,8	0,9
300	152	No&s - In	30,6	0,6
162	152	No&s - In	29,7	0,6
153	152	No&s - In	8,7	0,2
370	152	No&s - In	0,1	0,0
74	152	No&s - In	0	0,0

ID	Unit	Unit Name	Team RV Contribuition (RCV units)	%
		Subtotal	4775,2	
190	153	No&s - Iptv	1968	26,2
30	153	No&s - Iptv	1576,2	21,0
152	153	No&s - Iptv	1036,6	13,8
173	153	No&s - Iptv	1003,2	13,4
172	153	No&s - Iptv	576,2	7,7
167	153	No&s - Iptv	427	5,7
16	153	No&s - Iptv	323,2	4,3
212	153	No&s - Iptv	197,5	2,6
217	153	No&s - Iptv	193,8	2,6
115	153	No&s - Iptv	99	1,3
83	153	No&s - Iptv	44	0,6
168	153	No&s - Iptv	37,6	0,5
143	153	No&s - Iptv	16,8	0,2
281	153	No&s - Iptv	3,6	0,0
329	153	No&s - Iptv	0	0,0
		Subtotal	7502,7	
236	154	No&s - Messaging	9398	46,6
240	154	No&s - Messaging	4676	23,2
189	154	No&s - Messaging	2664,3	13,2
25	154	No&s - Messaging	1886,5	9,4
179	154	No&s - Messaging	1524,4	7,6
372	154	No&s - Messaging	0,1	0,0
		Subtotal	20149,3	
32	155	No&s - Service Platforms	6825	43,5
215	155	No&s - Service Platforms	3248	20,7
222	155	No&s - Service Platforms	2343,6	14,9
201	155	No&s - Service Platforms	1372	8,7
22	155	No&s - Service Platforms	1271,7	8,1
111	155	No&s - Service Platforms	623	4,0
316	155	No&s - Service Platforms	0	0,0
		Subtotal	15683,3	
199	157	VOC Service Desk	2857,6	39,0
198	157	VOC Service Desk	1495,2	20,4
88	157	VOC Service Desk	964,6	13,2
71	157	VOC Service Desk	929,2	12,7
147	157	VOC Service Desk	787,2	10,7
243	157	VOC Service Desk	168	2,3
26	157	VOC Service Desk	84,1	1,1
197	157	VOC Service Desk	37,8	0,5
339	157	VOC Service Desk	0	0,0
		Subtotal	7323,7	

Individual NP results were compared with the Managers' perspective, and with members RV contribution in respective teams: GSS IN Corp; NO&s IN; NO&S IPTV; NO&S – Messaging; NO&S - Service Platforms; and VOC Service Desk.

GSS IN Corp Manager's Perspective:*"GSS Corp is a new group, and therefore information is mostly on every one's heads. The team has been growing in consistency but it is dependent on ID 60 and ID 1."* Figure E.1 depicts GSS In Corp RCV per Process. GSS IN Corp has distinct clusters of members, the first four elements with NP Greater than average (39) and the remaining elements, which are not presently part of the team. They helped the team during a temporary period. Their contribution to the team was far from average. This is an important insight for future cooperation.ID 148 was mainly responsible for incident and information sharing (90% Team RCV) and clearly stands out from the group, contrasting with ID 60 (4,4% Team RCV),ID 103 (19% Team RCV), and ID 1 (3,5 Team RCV). A detailed analysis is required to observe the nature of such difference, because this evidence is opposite to the manager's perception. The team seems dependent on ID 148 and it is advisable to understand why. Team resilience is low.

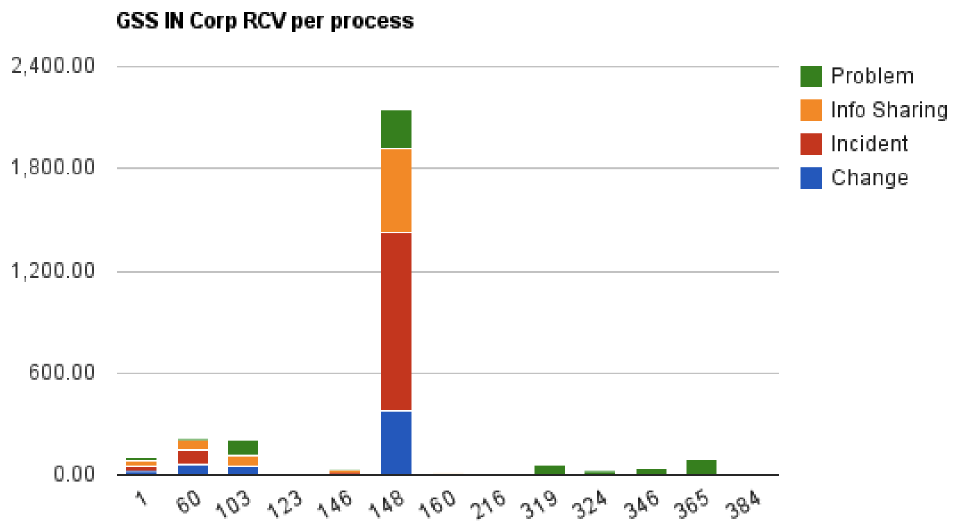


Figure E.1 Case A - GSS IN Corp RCV per Process

NO&s IN Manager perspective:*"NO&s IN is less homogeneous and very dependent on key members (ID 162; ID 187; and ID 132). An effort on information sharing was made and some elements are aggregators of that dynamic (ID 58; and ID 90). Group resilience should be low."*Figure E.2 depicts NO&s IN RCV per process. In fact, the group seems reasonably disperse in what concerns NP[48]. The team divides the work in the following way: elements ID 58, ID 125, and ID 153 are focused on *Incident* and *Problem* processes, while ID 13, ID 12, and ID 49 are focused on *Change* Process. In particular ID 13 has a special role, because it assumes support activities during one week per month. Both ID 90, ID 49, and ID 125 are contractors. Element ID 103 has a significant contribution to the group (19,2% Team RCV) while elements 370 do not (0%). If the team is analyzed taking into account this division, the "Change Team" seems almost a balanced part from ID 187, who is a team leader, is left with the more complex changes and supports the group on its execution (0,9% Team RCV). Also ID 49 is a new element in the team, justifying its lower NP value (5,8% Team RCV). As partof the "Incident and Problem" team, ID 90 is presently executing an improvement program, demanding a big more effort in Information Sharing (22,7% Team RCV). Element ID 153 is under performance (0,2% Team RCV) and already has an improvement program established. This is enforced by the present study as this element is far from team average. ID 162 is the team Manager, which justifies its deviation (0,6% Team RCV).As a general conclusion, team resilience (and performance) could be improved and this analysis gives important diagnosis information.

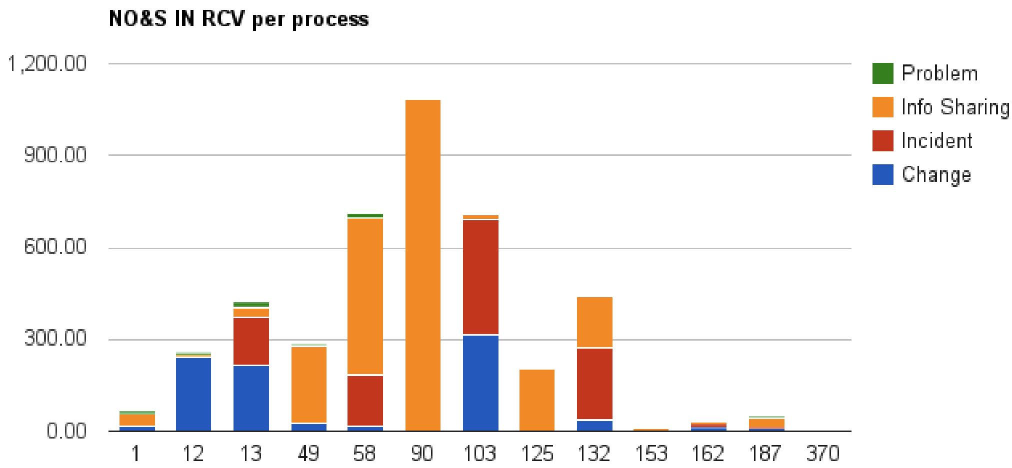


Figure E.2 Case A - NO&s IN RCV per Process

NO&s IPTV Manager perspective:*"IPTV 2nd Line is a manage services group and has specific areas of knowledge for which there are dependencies Team is dependent on ID 172 and ID 190. ID 168 and ID 16 (mostly this last one) connects the group to Vodafone teams and are critical in guaranteeing and managing contacts and relations*

[48] Note: Elements 1, 103, 60, 74 and 370 are no longer part of the group and were discarded from this detailed analysis. ID 300 and 49 are the same and were analyzed as such.

outside the IPTV 2nd Line and VOC." Figure E.3 depicts NO&s IPTV RCV per process. ID 190 (26,2% Team RCV) along with ID 30 (21% Team RCV) NP are high above the average. This indicates a degree of dependency that needs to be detailed and explored. ID 190 enforces the Manager's intuition.ID 83 is a team manager and its deviation is justified by the low level of day-to-day involvement in the business processes (0,6% Team RCV). ID 329 represents one of the vendors and was excluded from the analysis. ID 16 (4,3% Team RCV) and ID 168 (0,5% RCV) roles are not formalized through the process workflow, and therefore it is not well captured. In a general way, the team is not balanced. There are already on-going initiatives to balance the team workload, namely sharing the *problem* process effort that was normally executed by ID 190. Team resilience is low.

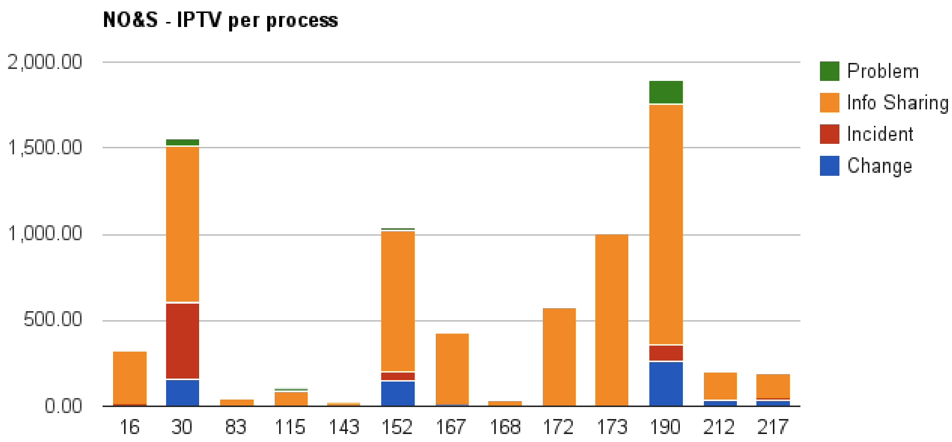


Figure E.3 Case A - NO&S IPTV RCV per Process

GSS Messaging Manager perspective:*"GSS Messaging is the most mature group; it has a consistent team, supportive of others. Its members have normally high evaluations, are the most dynamic and have a consistent and homogeneous team. In terms of workload, on average they have less workload than others, which helps group sharing dynamics, creating the time for it."* Figure E.4 *depicts GSS Messaging RCV per Process*. GSS Messaging team is reasonably homogeneous in what regards NP distribution. ID 236 (46,6% Team RCV) is an outsourcer, but it reveals a high NP due to *information sharing*. ID 179 (7,6% Team RCV) and ID 25 (9,4% Team RCV) seem to be lower than average, the reasons for this deviation should be evaluated in detail but does not seem to be critical. Team resilience is high.

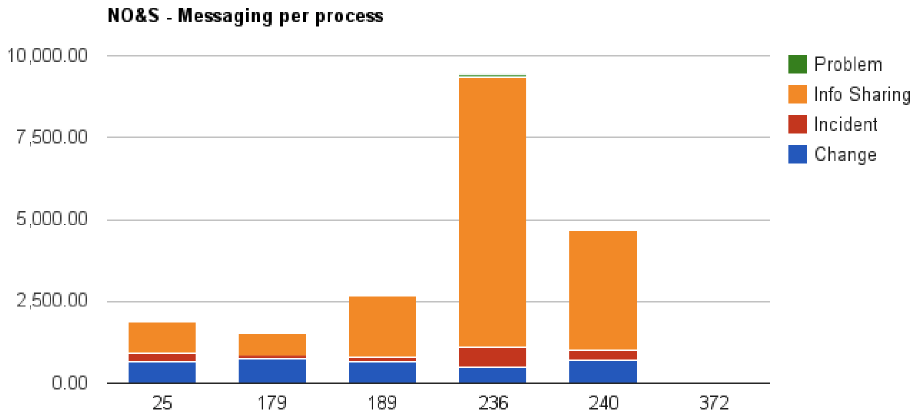


Figure E.4 Case A - NO&S - Messaging RCV Per Process

GSS SAS Manager perspective:*"GSS SAS is a technological disperse group, supporting several small and very distinct services, highly dynamic. Team tends to have less homogeneous knowledge sharing being frequently dependent on specific members for specific issues. They have been making an effort for information sharing. ID 215 is a very critical element and team gets affected if is missing. Team has an intense work load and is affected if one of its members is not present."* Figure E.5 depicts GSS SAS RCV per process. ID 32 has a very important role in *sharing knowledge*, providing extra input into the manager's analysis (43,5% Team RCV). ID 215 ensures a significant part of *Change* effort (20,7% Team RCV). Elements ID 22 (8,1% Team RCV) and 111 (4% Team RCV) are outsourcers, and their involvement with the team must be improved. Team resilience: medium.

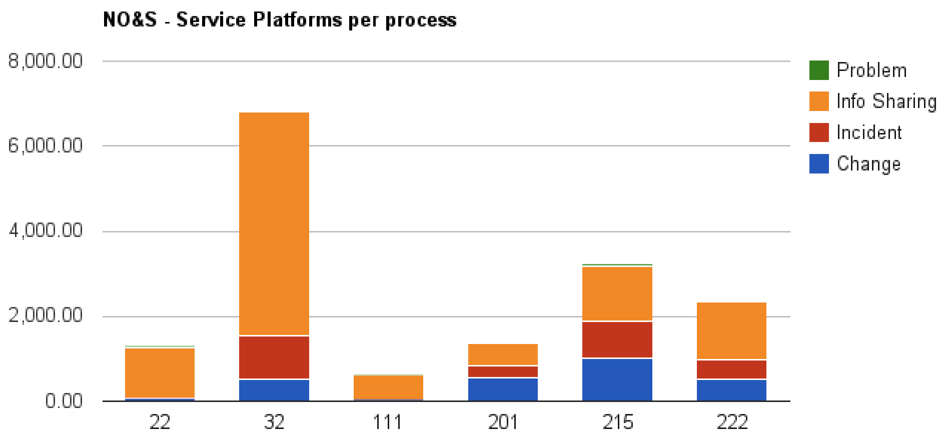


Figure E.5 Case A - NO&S SAS RCV Per Process

VOC Service Desk Manager Perspective:*"VOC is a managed services group and acts based on procedures. It should be very resilient and only dependent on its team leader ID 199."* Figure E.6 depicts VOC Service Desk RCV per Process. The VOC NP distribution confirms the Manager's insight. ID 199 has a high NP. Elements ID 26 (1,1% Team RCV) and ID 197 (0,5% Team RCV) are new in the team, this justifies the low NP. Member ID 243 (2,3% Team RCV) has a deviation to the average that should be investigated in detail. Team resilience: medium.

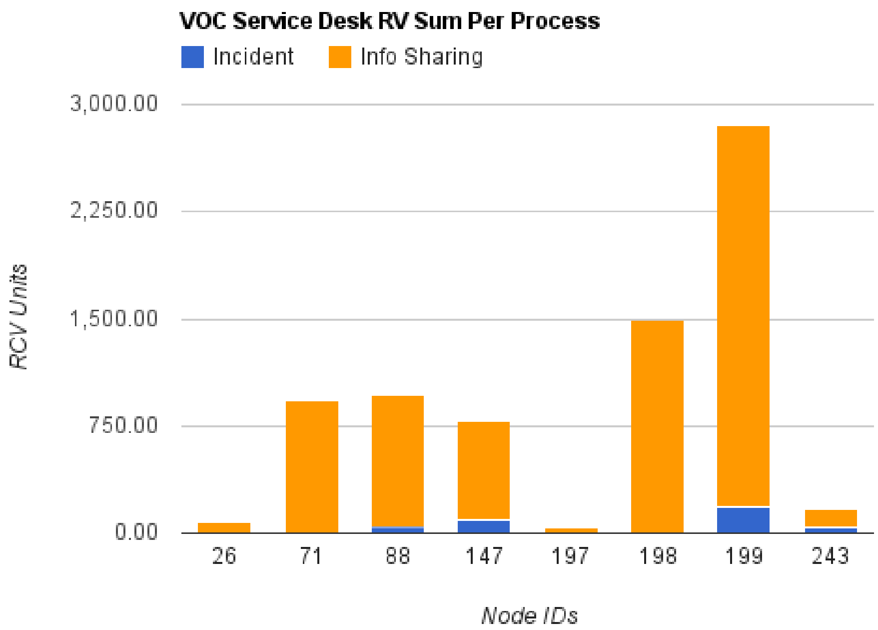


Figure E.6 Case A - VOC Service Desk RCV Per Process

Table E.13 Normalization of Top-Level Parameters

Case	NVF	SEVF Sum	RV Sum	RCV Maximum Reference Values
A	0,00499512	0,12274081	0,87225286	89016,848
B	0,00059983	0,19798293	0,80141588	733012,680
C	0,00000307	0,21687260	0,78312427	15261835,769

E.6 Questionnaire

Observatório da Qualidade

Questionário: Mecanismos de Comunicação e Informação

Objectivo: Saber se a nossa Escola está optimizada para produzir e transmitir conhecimento (análise de rede).

Compromisso de confidencialidade

Na divulgação pública deste estudo será omitida a identificação dos participantes, i.e. o respectivo número e nome.

Este estudo é um instrumento de suporte à decisão e os resultados preliminares serão monitorizados pelo Observarório de Qualidade da Escola.

A sua participação é fundamental. Todos trabalhamos em prol dos alunos. Melhorar os mecanismos de comunicação e informação internos contribui para melhorar o serviço que prestamos aos nossos alunos.

O Observatório da Qualidade da Escola

Número ______ Nome ______

Lista de pessoal com identificação numérica para utilizar nas respostas do questionário Pág. 1/7

Artes visuais
1–8 [redacted]

Biologia e Geologia
9–20 [redacted]

Economia e Contabilidade
21–41 [redacted]

Educação Física
42–55 [redacted]

Educação Especial 1
56 [redacted]

Educação Tecnológica
57–58 [redacted]

Filosofia
59–73 [redacted]

Física e Química
74–80 [redacted]

Física e Química (cont.)
81–86 [redacted]

Geografia
87–97 [redacted]

História
98–104 [redacted]

Informática
105–115 [redacted]

Inglês
116–119 [redacted]

Inglês (cont.)
120–132 [redacted]

Latim e Grego
133 Liliana Medalha

Matemática
134–154 [redacted]

Português
155–159 [redacted]

Lista de pessoal com identificação numérica para utilizar nas respostas do questionário (continuação) Pág. 2/7

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Comunicação presencial

Por favor, observe os nomes da lista de colegas.

Questão 1

Consegue associar o nome à pessoa reconhecendo visualmente o(a) colega?

Nos casos afirmativos assinale um X à frente de cada nome

Pág. 3/7

Revelar relações de colaboração na rede

Por favor, para identificar colegas utilize os números fornecidos na lista das páginas 1 e 2.

Questão 2 - a) Difusão de informação

Quem é que lhe transmite informação importante para o exercício das suas funções?

Por favor identifique pelo menos um(a) colega utilizando a numeração sugerida na lista, assim como pelo menos um factor facilitador da interacção com a pessoa em causa utilizando um X.
Entende-se por *factor facilitador de interacção* uma característica que contribua mais para a sua aproximação profissional ao(à) colega em causa.
O caso particular *proximidade* refere-se a um contexto físico (e.g. comunicar com o(a) colega frequentemente em virtude de partilhar o mesmo horário/turno e/ou instalações físicas.

Factores facilitadores da interacção com o(a) colega
Assinale com um X

Número do(a) colega	Prestígio	Competência	Experiência	Amizade	Proximidade	Número do(a) colega	Prestígio	Competência	Experiência	Amizade	Proximidade	Número do(a) colega	Prestígio	Competência	Experiência	Amizade	Proximidade	Número do(a) colega	Prestígio	Competência	Experiência	Amizade	Proximidade
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Pág. 4/7

Revelar relações de colaboração na rede

Por favor, para identificar colegas utilize os números fornecidos na lista das páginas 1 e 2.

Questão 2 - b) Resolução de problemas

A quem pede ajuda quando tem que resolver um novo problema?

Por favor identifique pelo menos um(a) colega utilizando a numeração sugerida na lista, assim como pelo menos um factor facilitador da interacção com a pessoa em causa utilizando um X.

Factores facilitadores da interacção com o(a) colega
Assinale com um X

Número do(a) colega	Prestígio	Competência	Experiência	Amizade	Proximidade	**Número do(a) colega**	Prestígio	Competência	Experiência	Amizade	Proximidade	**Número do(a) colega**	Prestígio	Competência	Experiência	Amizade	Proximidade	**Número do(a) colega**	Prestígio	Competência	Experiência	Amizade	Proximidade
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Pág. 5/7

Revelar potencial para partilha de informação na rede

Por favor, para identificar colegas utilize os números fornecidos na lista das páginas 1 e 2.

Questão 3 - a) Consciência (Re)conhecimento

Quem reconhece particularmente pelo seu profissionalismo, conhecimento e/ou domínio científico?

Factores facilitadores da interacção com o(a) colega
Assinale com um X

Número do(a) colega	Prestígio	Competência	Experiência	Amizade	Proximidade	**Número do(a) colega**	Prestígio	Competência	Experiência	Amizade	Proximidade	**Número do(a) colega**	Prestígio	Competência	Experiência	Amizade	Proximidade	**Número do(a) colega**	Prestígio	Competência	Experiência	Amizade	Proximidade
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Pág. 6/7

Revelar potencial para partilha de informação na rede

Por favor, para identificar colegas utilize os números fornecidos na lista das páginas 1 e 2.

Questão 3 - b) Comunicação com recurso a tecnologias (e.g. mail, chat)

Com quem mais comunica para tratar de assuntos profissionais recorrendo a tecnologias de informação?

Por favor identifique pelo menos um(a) colega utilizando a numeração sugerida na lista, assim como pelo menos um factor facilitador da interacção com a pessoa em causa utilizando um X.

Factores facilitadores da interacção com o(a) colega
Assinale com um X

Número do(a) colega	Prestígio	Competência	Experiência	Amizade	Proximidade	Número do(a) colega	Prestígio	Competência	Experiência	Amizade	Proximidade	Número do(a) colega	Prestígio	Competência	Experiência	Amizade	Proximidade	Número do(a) colega	Prestígio	Competência	Experiência	Amizade	Proximidade
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Resposta aberta

Questão 4

a) Relativamente à circulação da informação na escola, se desejar, identifique pontos fracos, pontos fortes, ameças, oportunidades.

b) Relativamente ao relacionamento/articulação entre as estruturas de orientação educativa/órgãos da escola, se desejar, identifique pontos fracos, pontos fortes, ameças,

Fim do questionário. Obrigado pela sua participação.

F. SNARE-Explorer Features

In this Appendix, SNARE-Explorer's main features are presented. As stated in Chapter 5, SNARE-Explorer is developed with Java technology and provides a multiple document interface system, which allows editing and analyzing multiple social networks. This tool is able to compute and monitor the relational capital of social networks.

An overview of SNARE-Explorer features is given in Section F.1. Section F.2 describes selectors to draw nodes (social entities) and edges (relations). Section F.3 describes available drawing operations, such as adjusting the network layout, assigning labels to identify nodes, viewing several networks, adjusting graph layouts automatically, and moving and rotating network graphs. Section F.4 presents edit and find tools for nodes, edges, and clusters. With these tools, it is possible to view and/or edit human capital NP and HCP properties. SNARE-Explorer analysis operations are described in Section F.5. Analysis operations include: performing social network analysis, starting the relational capital monitor system (to compute the network RCV) as well as defining necessary analysis settings, such as: nodes and edges structural properties, and OVF, NVF, RTV, and RLV definitions. Finally, Section F.6 describes SNARE-Explorer I-O operations. These operations include importing SNARE-Web network databases, updating SNARE-Web databases, importing networks from CSV files, and exporting network layouts to JPEG files.

F.1 SNARE-Explorer Features Overview

SNARE-Explorer allows us to edit and analyze multiple social networks. For each opened network the *Analyst* can use a toolbox for analysis operations. See Figure F.1 for a summary of SNARE-Explorer toolbox available features based on the following issues: *Drawing Selectors*; *Drawing Operations*; *Edit/Find Tools*; *I-O Operations*; and *Analysis Operations*.

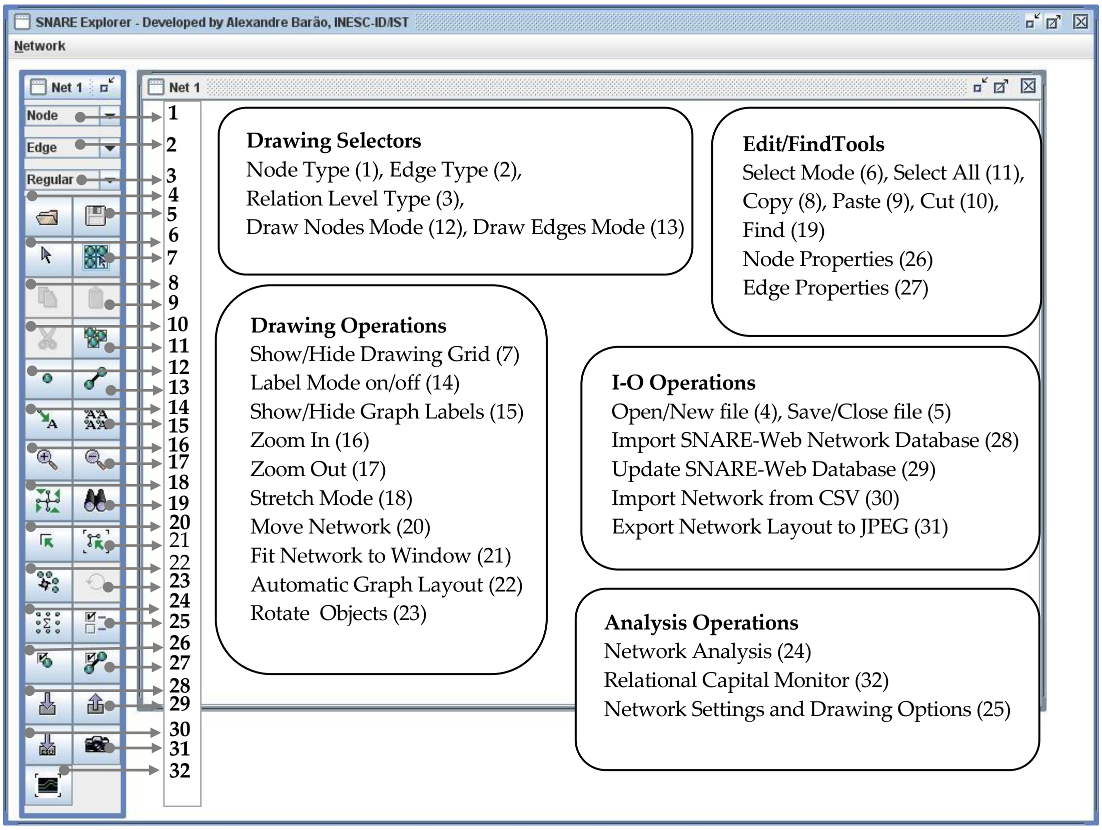


Figure F.1 SNARE-Explorer Toolbox Buttons

F.2 Drawing Selectors

SNARE-Explorer allows the design of social networks. It provides several drawing selectors, such as: *node type*, *edge type* and *relation level type*. Also, it provides the *draw nodes mode* selector and the *draw edges mode* selector.

- **Drawing Nodes and Edges**

The *Analyst* can choose the type of node to be drawn (social entity), the type of edge (relation) and the level of the connection (relation level type). When a new network is created, the tool sets by default the node type as "node", the edge type as "edge", and the relation level type as "regular". Thus, it is possible to start designing a social network without any prior configuration.

With the *draw nodes mode* button selected, the user can immediately start drawing a new network (Figure F.2).

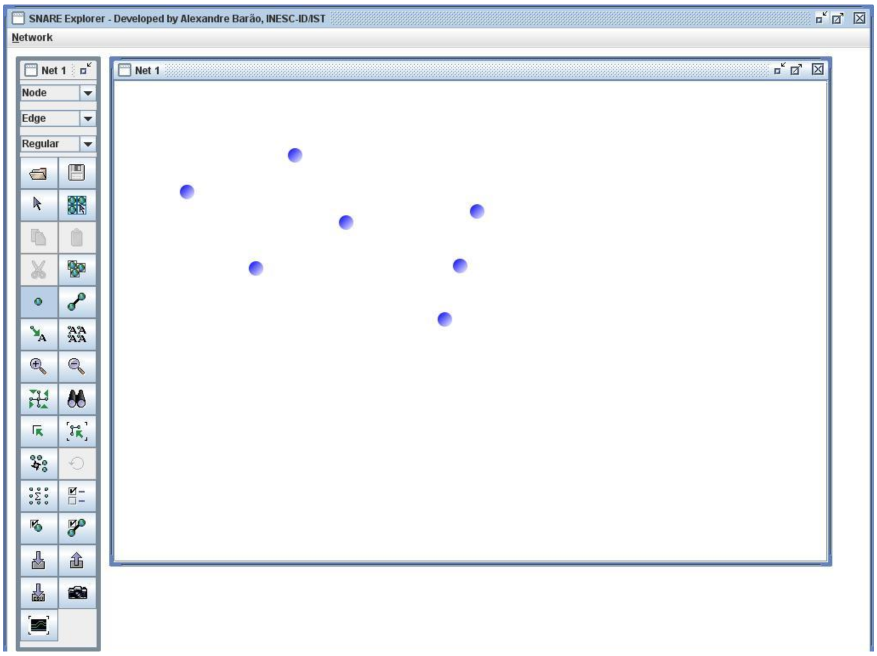


Figure F.2 SNARE-Explorer Creating Nodes

With the draw edges mode button selected, the user can establish connections between designed nodes (Figure F.3). Nodes and edges can be customized in *network settings* button.

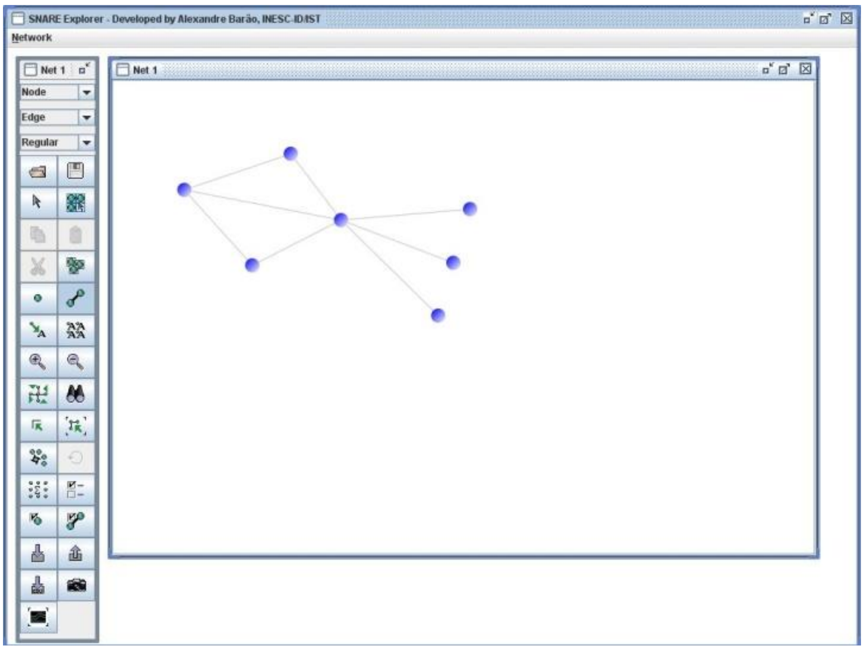


Figure F.3 SNARE-Explorer Creating Edges

F.3 Drawing Operations

SNARE-Explorer is a vectorial system and provides drawing operations to help the *Analyst* adjust the network layout. This can be done manually or automatically.

- **Adjusting the Layout**

The grid mechanism helps the *Analyst* to visually adjust the position of network nodes, i.e. a fit to grid system (See Figure F.4). This is a tool to visually align nodes of a given network.

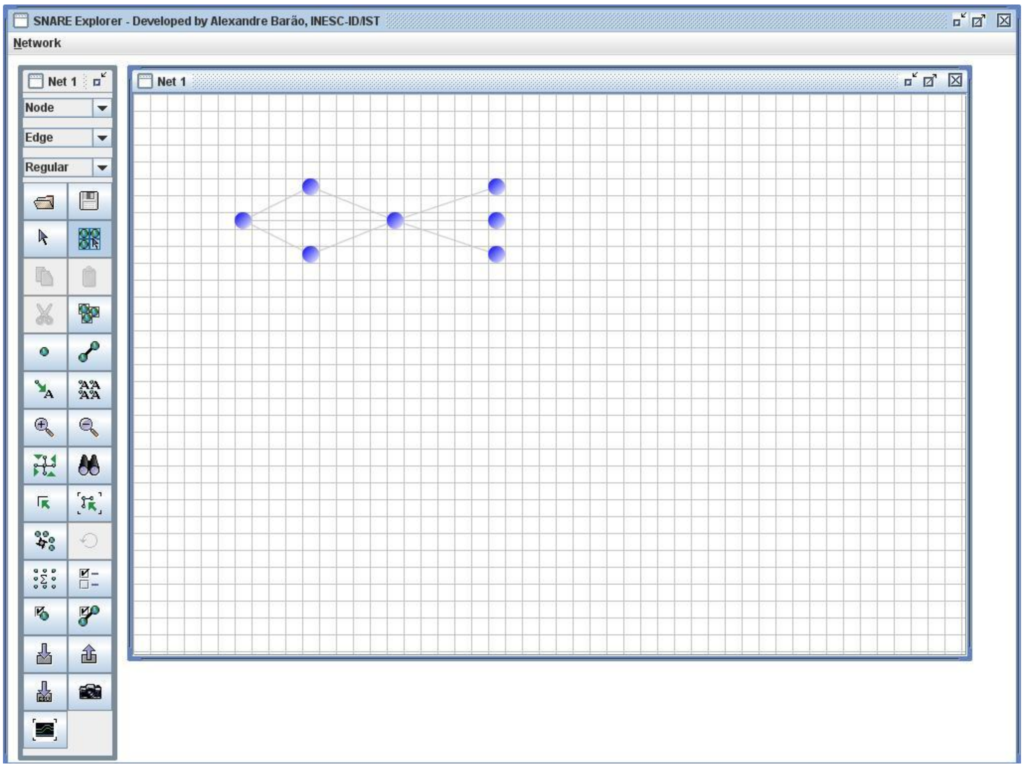


Figure F.4 SNARE-Explorer Fit to Grid

- **Identifying Nodes**

When designing a new network, the *Analyst* can use the *label on mode* button. This procedure allows us to show node labels during the network design process. Also, SNARE-Explorer is able to hide or show graph labels. A node label can be an identification number or a name. Figure F.5 and Figure F.6 shows node labels as numbers.

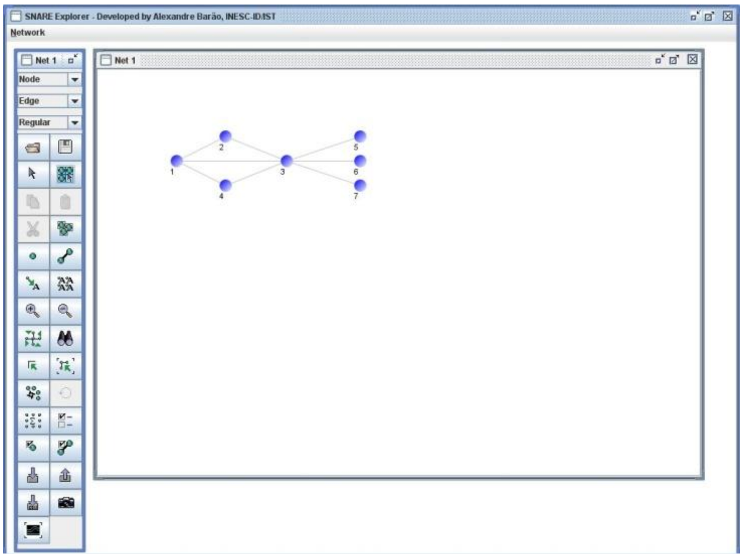


Figure F.5 SNARE-Explorer Node Label Visualization

- **Viewing Networks**

As a vectorial system, SNARE-Explorer provides mechanisms to stretch the graph layout, automatic network translation to upper left corner of a window, fit network to window size and zoom in/out operations. Figure F.6 shows a zoom-in operation (in window *net1*) and a fit to window size procedure (in window *net2*).

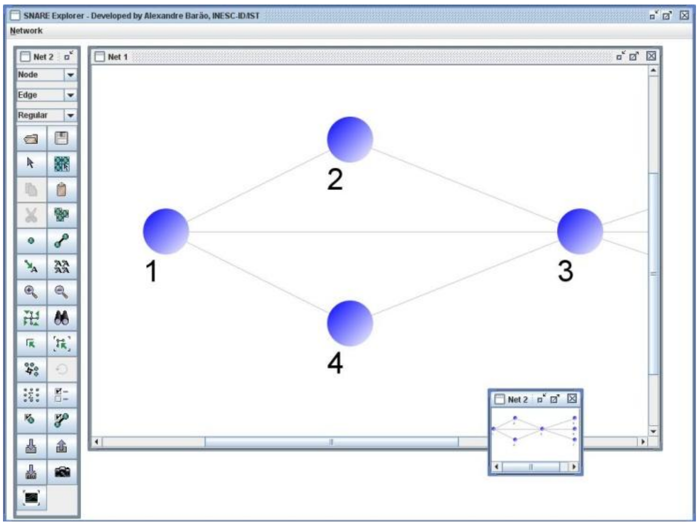
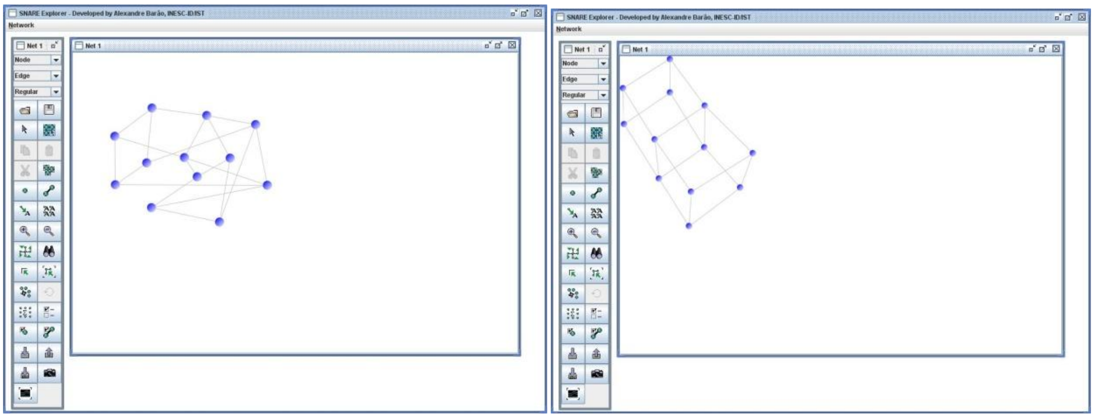


Figure F.6 SNARE-Explorer Zoom-In and Fit to Window Size

- **Automatic Graph Layout**

When reading a network from a database with, for example, hundreds of nodes, it is necessary to draw a graph automatically. The graph must meet aesthetic standards, minimizing crossing lines and representing nodes according to its centrality in the network. To achieve this, as referred in Chapter 5, Fruchterman-Reingold algorithm was used [FR 91]. SNARE-Explorer uses a specific and modified version of Fruchterman-Reingold algorithm. Using principles of physics (attraction/repulsion), several heuristics where modified to, for example, represent clusters. The Fruchterman-Reingold algorithm is a force-directed layout algorithm. This kind of algorithm considers the force between any two nodes. The attractive force is analogous to the spring force and the repulsive force is analogous to the electrical force. "The algorithm minimizes the energy of the system by moving the nodes and changing the forces between them until achieves an equilibrium state" [FR 91]. The main purpose is to position the nodes in space with as few crossing edges as possible.



a) b)

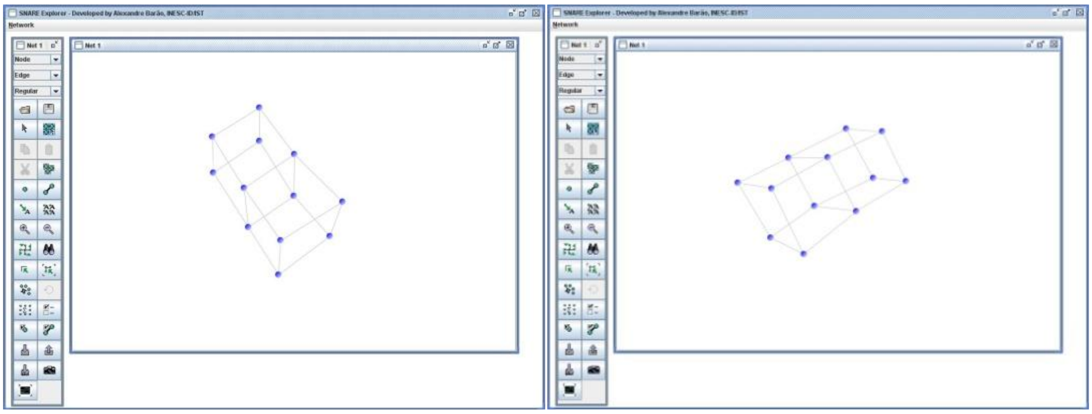
Figure F.7 SNARE-Explorer Twin-Cube Automatic Layout in 3D Space

The above Figure F.7 a) shows an unordered graph network. In Figure F.7 b) it is possible to see the resulting automatic layout. In this case: twin-cubes in 3D space. The mechanism *automatic network translation* to upper-left corner was also used in this example.

- **Graph Moving and Rotation**

Sometimes it is necessary to move an entire network in 2D space. SNARE-Explorer provides ways to manually execute graph movings and rotations. Also, it is possible to execute partial moving or rotation of a given network.

Figure F.8 a)shows moving the graph operation from position depicted in Figure F.7 b), and the resulting 2D rotation is depicted in Figure F.8 b). The moving process is visual.



a) b)

Figure F.8 SNARE-Explorer Twin-Cube Moving and Rotation

F.4 Edit/Find Tools

When performing social network analysis, viewing and editing properties from nodes and edges are important features. SNARE-Explorer provides mechanisms to select and edit nodes and edges as well as to find, copy, paste and cut nodes or edges from a network.

- **Editing Nodes**

After selecting the desired node, e.g. via cursor mode or find mechanism, the *Analyst* is able to view node properties. SNARE-Explorer provides three kinds of node properties: global; network; and human capital. All properties are dynamic and can be customized. When nodes represent people, global properties may consist of personal data such as address, contacts, or other kinds of personal data. Global properties can be defined for all nodes, e.g. in node type settings, or they can be specific for a given node instance. Network properties are filled by SNARE-Explorer social network analysis mechanisms, e.g. centrality measures in a given network relation. Human capital properties are also dynamic and may be customized by the *Analyst*, e.g. organizational performance evaluation data. It is important to refer that network properties and human capital properties are used by the relational capital monitor in order to compute the relational capital value of the network. When viewing nodes properties, SNARE-Explorer enables the change property mechanism and the *Analyst* can freely change any kind of property value. Figure F.9 shows the view/edit node properties system for a given network node. Node names are omitted for confidentially reasons. In this example, network properties (NP) were computed by SNARE-Explorer social network analysis algorithms, and human capital properties (HCP) were imported from CSV files.

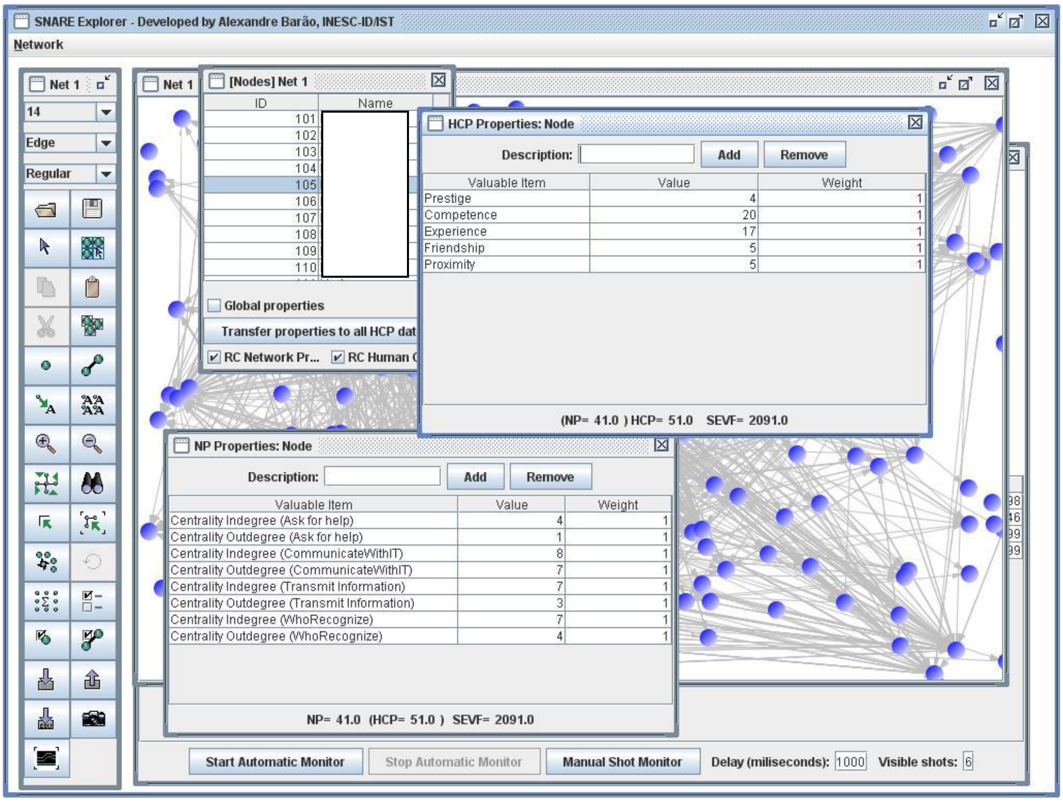


Figure F.9 SNARE-Explorer Node Properties

- **Editing Edges**

SNARE-Explorer provides mechanisms to view and edit edges properties. An edge is a connection between two nodes. In this sense, in directed relations, there is a *sender* node (origin) and a *receiver* node (destination). SNARE-Explorer supports directed and undirected relations in the same network. When the relation is undirected, edge arrows are not represented. Using the edit edges dialog window, the *Analyst* can change edge properties. Edge properties can be customized in edge type settings, which are applied to all edges of a given type. When viewing a specific edge, the *Analyst* can edit its specific properties as well. Figure F.10 shows a selected edge from a network. Names and values are partially omitted for confidentially reasons.

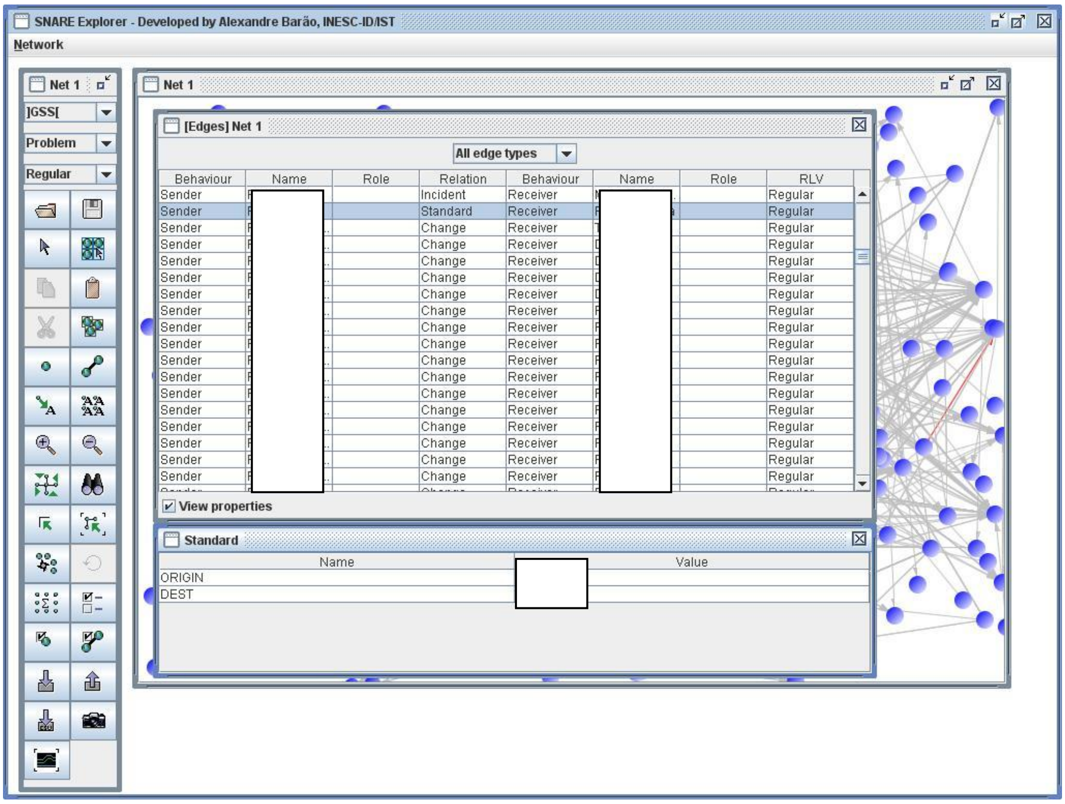


Figure F.10 SNARE-Explorer Edge Properties

- **Finding Nodes or Edges**

The find tool is a mechanism to search and filter nodes and edges. The *Analyst* can select the *find nodes mode* or the *find edges mode*. In nodes search mode, if the target nodes are human type, the *Analyst* can select several node attributes to find, such as: *node ID, name, node type, url, mail, gender, birth date, address, postcode, country, telephone* or *fax*. In edges search mode, the *Analyst* can choose the following attributes: *edge ID, edge type, directional kind, relation ID* or *relation name*. Another feature: it is possible to find nodes or edges with user-defined properties as well.

Searches can be done using logical operations (Figure F.11). During the find process, for both nodes and edges, six logical operators are provided by SNARE-Explorer: "Equal to"; "Not equal to"; "Greater than"; "Greater than or equal to"; "Less than"; and "Less than or equal to". Also, the string operator

"Contains" is provided. These operators can be used with customized properties also. Search results can be copied to other windows (Figure F.12).

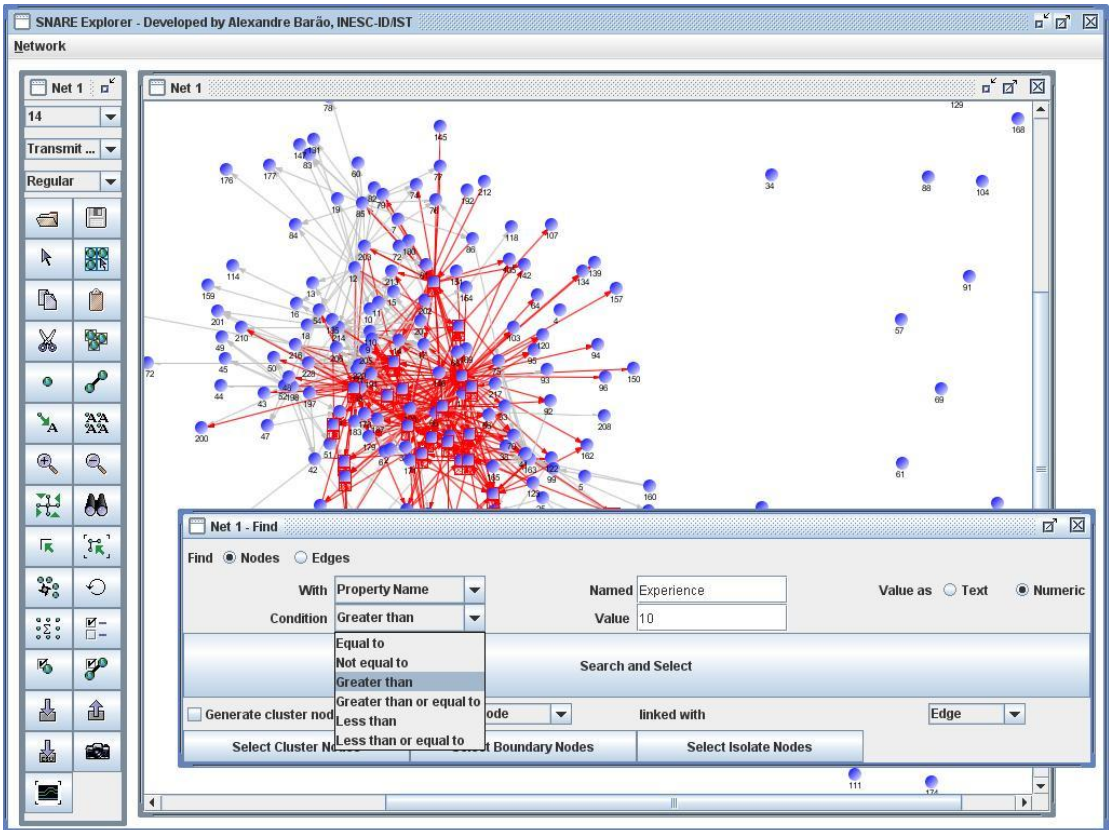


Figure F.11 SNARE-Explorer Find Tool

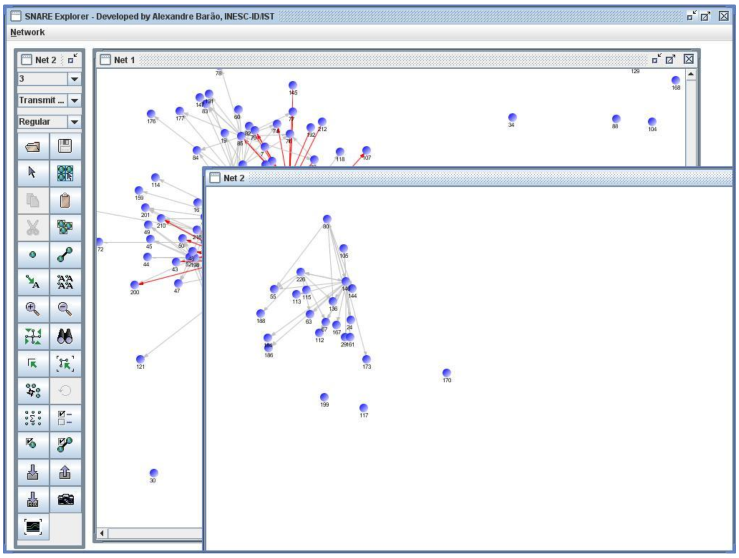


Figure F.12 SNARE-Explorer Partial Network Copy-Paste

- **Finding Homomorphic Clusters**

SNARE-Explorer can generate new clusters through the find tool. Figure F.13 depicts this concept. After the search criteria are specified, the *Analyst* can select the option "Generate cluster node as new node". This way, it is possible to define cluster nodes and choose a specific kind of edge to be used in this cluster process. This feature is used to group nodes from a network in 2D space, regarding to homomorphic characteristics. In the referred example, five clusters were defined: *Experience*; *Competence*; *Proximity*; *Friendship*; and *Prestige*. The nodes position holds semantic, i.e. it is possible to observe nodes with related proximity threshold value to defined clusters. This SNARE-Explore feature treats cluster nodes as special node *attractors*.

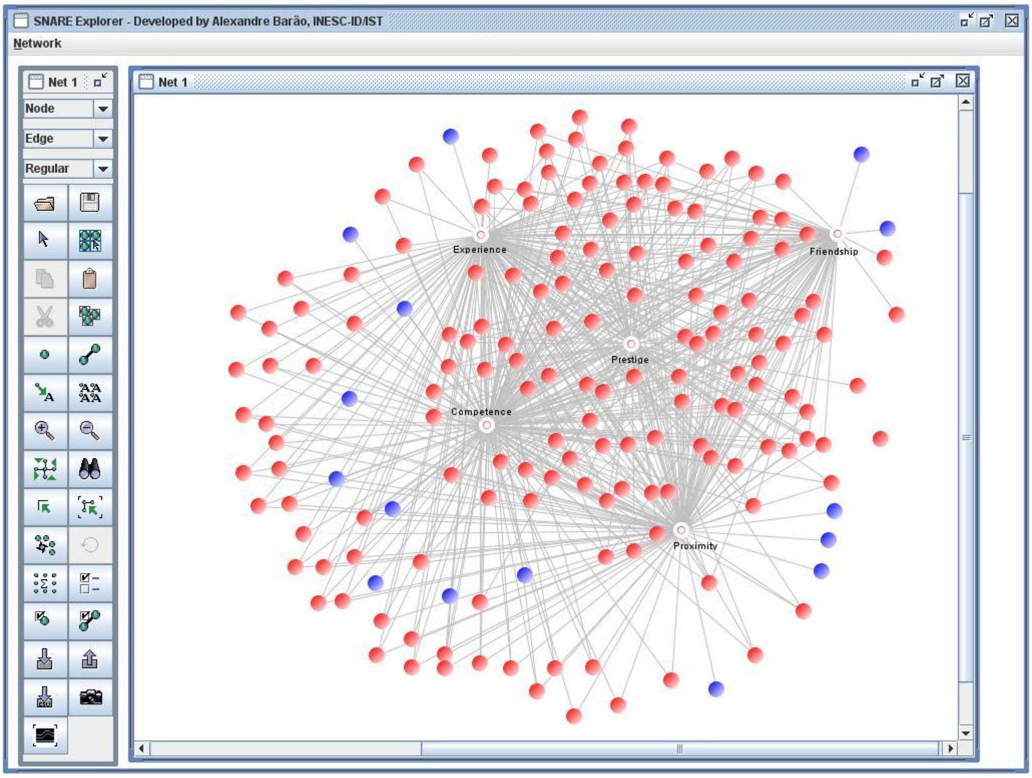


Figure F.13 SNARE-Explorer Five Generated Clusters

As an engineering tool, SNARE-Explorer is able to simulate scenarios. As an example, Figure F.14 depicts a simulated scenario with 5000 nodes (they are all isolated nodes, i.e. they are not connected to each other) and Figure F.15 shows the automatic layout produced with SNARE-Explorer after a specific clustering process. Each node represents a person of a given multinational organization and the clustering was made based on *induced attractors*. The *induced attractor* of this example is the *work location city* property of each person. Blue nodes in Figure F.15 represent people with only one work location city, and red nodes represent people working on more than one city. SNARE-Explorer is able to produce attractors (which are new nodes) on a new network and generate homomorphic clusters. Thus, SNARE-Explorer is able to produce new networks from nodes attributes. This is a complementary feature, and it can be used to depict new views of the organizational network, e.g. in team matching processes to discover people with similar skills.

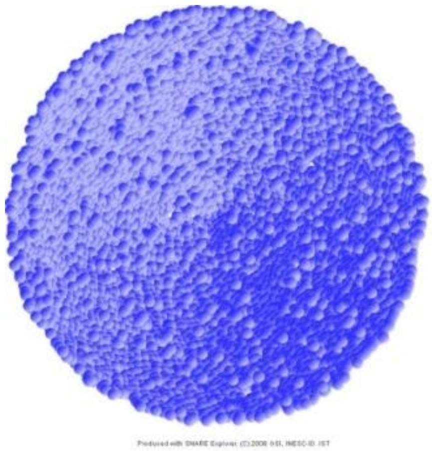


Figure F.14 SNARE-Explorer Simulated Scenario

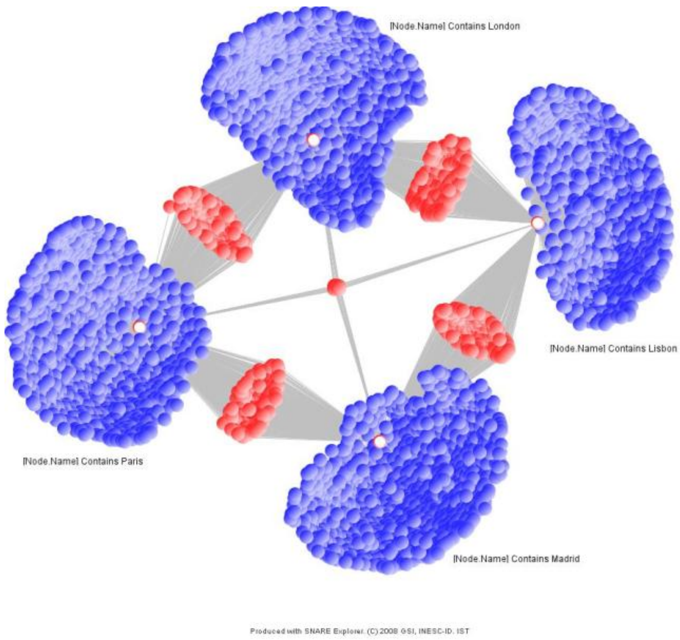


Figure F.15 SNARE-Explorer Homomorphic Clustering

F.5 Analysis Operations

SNARE-Explorer supports social network analysis operations, like network density, nodal *indegree*/outdegree, means and related variances. Thus, SNARE-Explorer produces several statistics, e.g. node type and relation type network statistics. Moreover, as stated, SNARE-Explorer fully implements SNARE-RCO model to compute the relational capital value of a given network.

- **Performing Social Network Analysis**

To perform social network analysis of a given network, SNARE-Explorer provides the relation selector dialog (Figure F.16). This dialog is a filter to all relations present in the network. The *Analyst* can choose the relation type (directed or undirected), and after that, SNARE-Explorer produces a list of possible relations to analyze. SNARE-Explorer can perform analysis algorithms in single or all relations from the network. This is feature can be used in situations where the *Analyst* only wants to analyze one type of relation, e.g. the network density of a given relation. Also, the *Analyst* can exclude isolate nodes from the desired analysis.

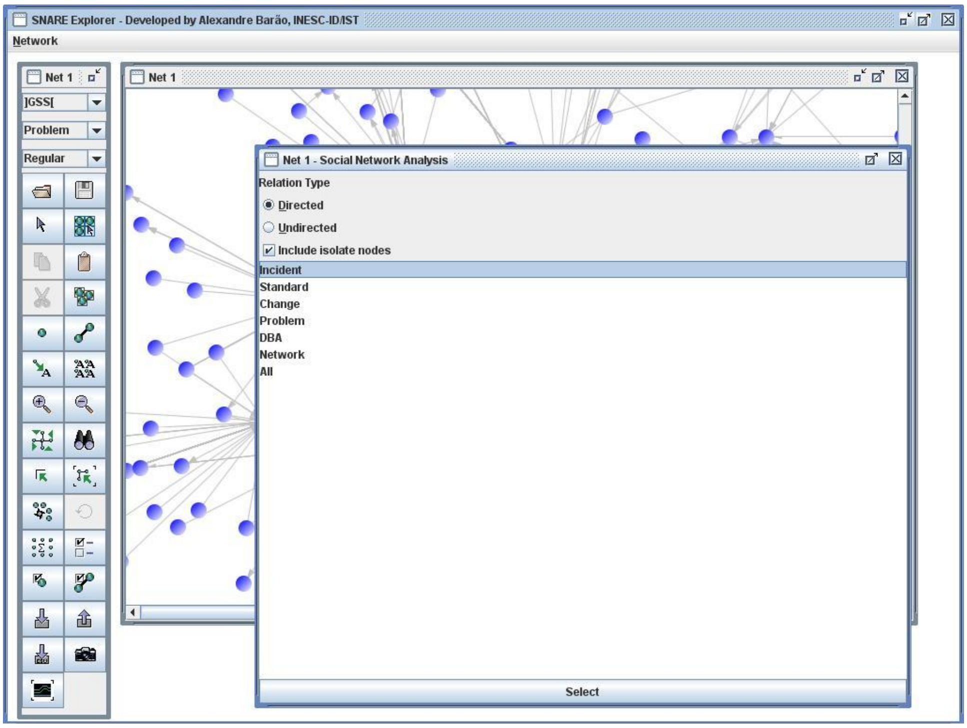


Figure F.16 SNARE-Explorer SNA Relation Selector Dialog

After choosing the relation(s) to be analyzed, the *Analyst* can select the algorithm to be performed using the *SNA algorithm selector* dialog (Figure F.17).

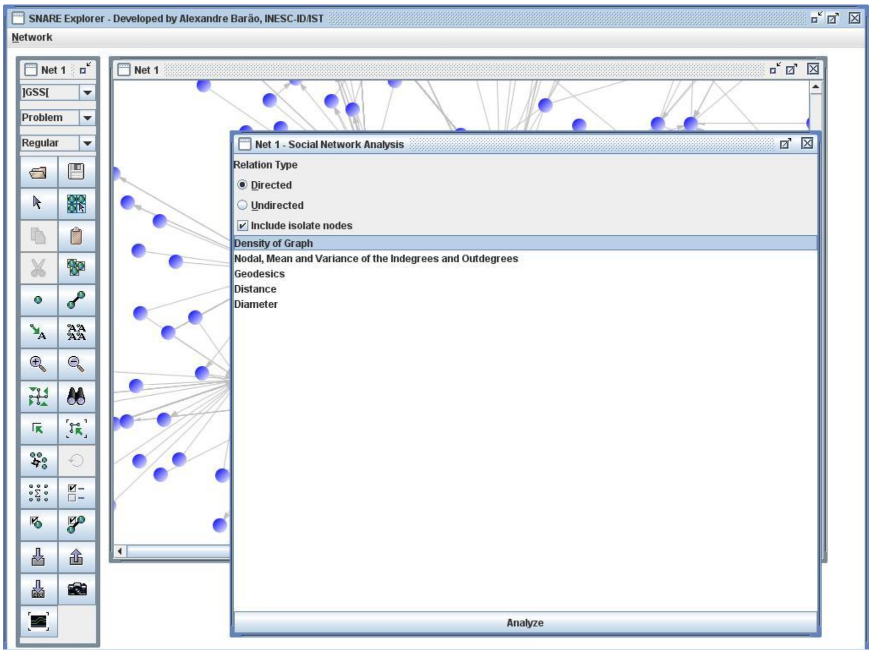


Figure F.17 SNARE-Explorer SNA Algorithm Selector Dialog

In this case, SNARE-Explorer has produced a graph-density matrix and a network statistics analysis frame (Figure F.18). Results can also be copied to other software applications, e.g. spreadsheets.

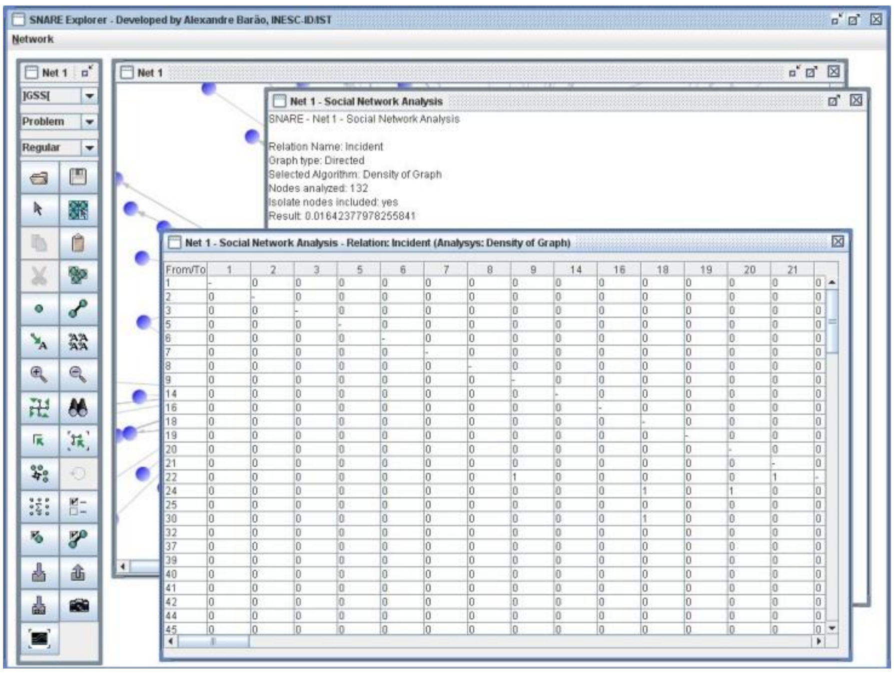


Figure F.18 SNARE-Explorer Graph-Density Matrix

Nodal analysis is a way to understand nodes roles of a given network. Figure F.19 shows the *nodal analysis table* of a given relation (“Incident”). In this table, for each node, it is possible to view the analyzed *node ID*, *nodal indegree*, *nodal outdegree*, *node type behavior*, *NP value*, *HCP value*, and *SEVF value*. In this analysis, nodes are categorized according Table F.1 (*Node Type Behavior* definitions from [FF 94]).

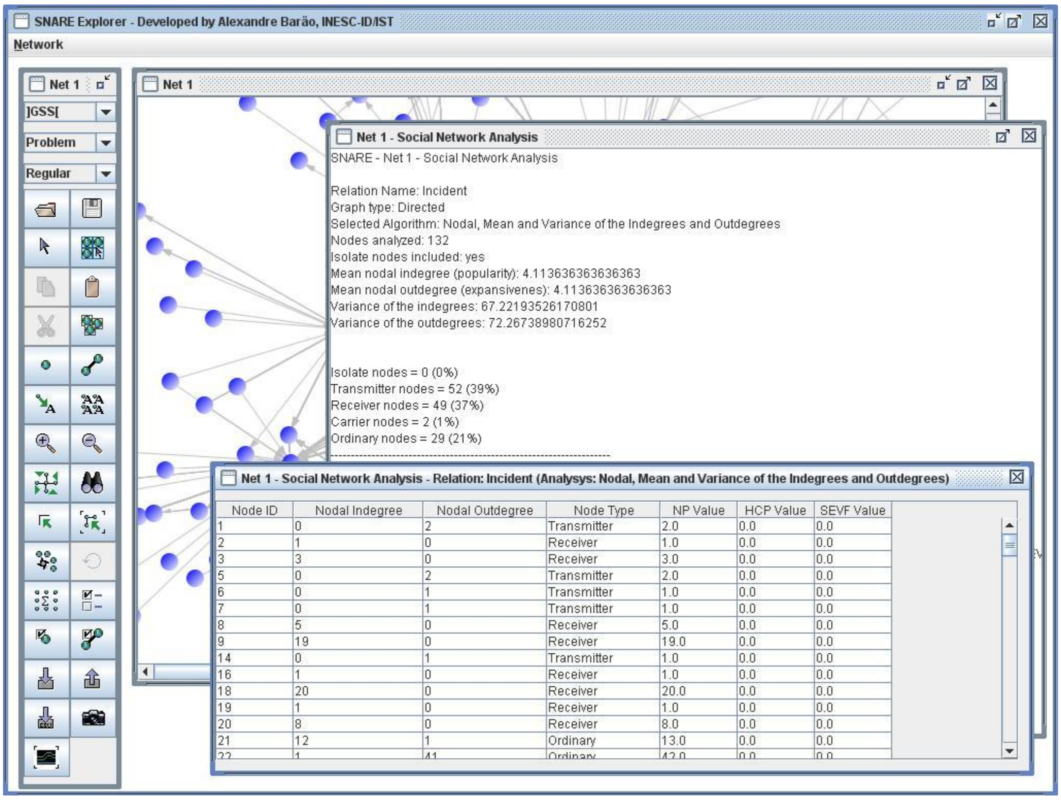


Figure F.19 SNARE-Explorer Nodal Analysis Table

Note: NP, HCP and SEVF value are parameters of the relational capital value. In the example, NP metrics were added to nodes properties. The assignment of NP metrics to nodes can be programmatically customized.

Table F.1 SNARE-Explorer Node Type Behavior (Directed Graphs)

Node type	*Indegree*	*Outdegree*
Isolate	0	0
Transmitter	0	> 0
Receiver	> 0	0
Carrier	> 0 With (*indegree* = 1 and *outdegree* = 1)	> 0
Ordinary	> 0 With (*indegree*> 1 or *outdegree*> 1)	> 0

- **Starting the Relational Capital Monitor**

The relational capital monitor is based on SNARE-RCO model. To activate the relational capital monitor, the *Analyst* can choose the "Start Automatic Monitor" button or the "Manual Shot Monitor" one. In automatic mode, the delay of relational capital analysis system can be customized by the *Analyst* (in milliseconds). Also, visible timelines can be defined by the *Analyst* (visible shots).

The monitoring system traces a log of computed relational capital data (Figure F.20). This log has the following information: *Date; Time; RCV value; OVF value; NVF value; SEVF Sum; RV Sum;* and *Ratio (RV/SEVF)*. To graphically represent OVF, NVF, SEVF, RV and RCV value, the monitor draws a color line for each analyzed instant. Also, the monitor keeps information of maximum values reached for each referred value.

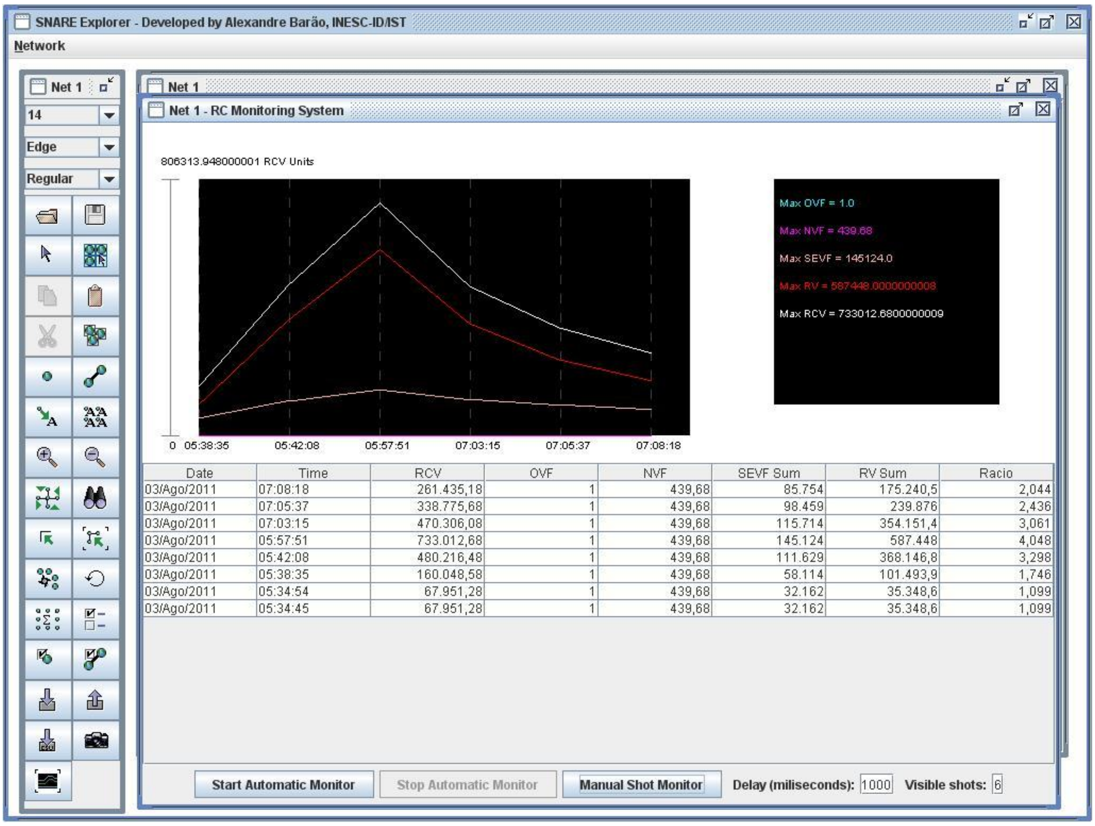


Figure F.20 SNARE-Explorer Relational Capital Monitor

Note: when using the automatic monitor mode, any change in the network relational capital is depicted by the system in real-time.

Defining Settings and Options

SNARE-Explorer settings and options definitions are presented next.

- **Network Authoring Data**

Authoring data can be stored in author and version data fields. Also, in this dialog it is possible to rename the network file name (Figure F.21).

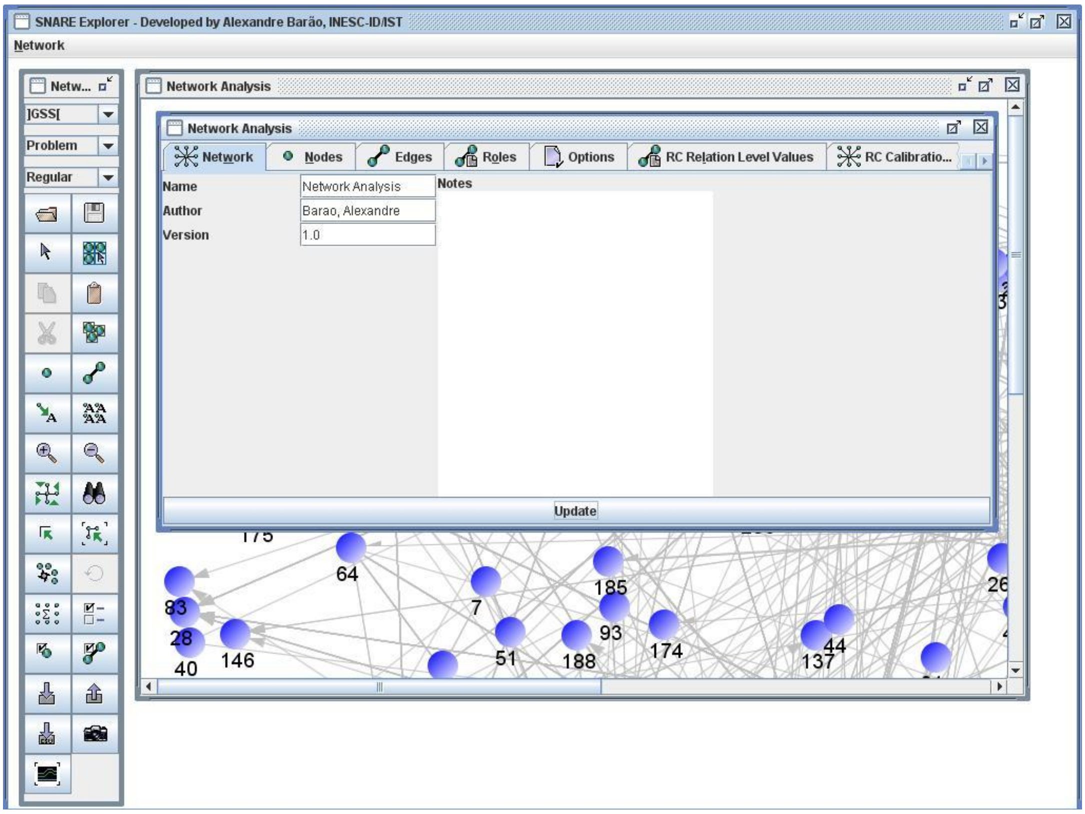


Figure F.21 SNARE-Explorer Authoring Data Dialog

- **Node Type Settings**

Nodes from a network can be categorized using node type settings dialog. Each node type has an *identifier*, a *node type name*, a *color* to be represented and a *shape*. The *Analyst* can customize nodes types using specific colors and a set of eight kinds of shapes. The attribute *cluster node* (yes/no) is used by SNARE-Explorer force-directed drawing algorithms. I.e. when drawing the network graph, the attractor/repulsive force of this kind of nodes is quite different from non-cluster nodes, producing spaced layouts.

If the *Analyst* defines a set of node type properties, all node instances of this kind will inherit them. Figure F.22 shows SNARE-Explorer node type settings dialog. As a result of different node type configuration, it is possible to see two distinct node shapes in the network.

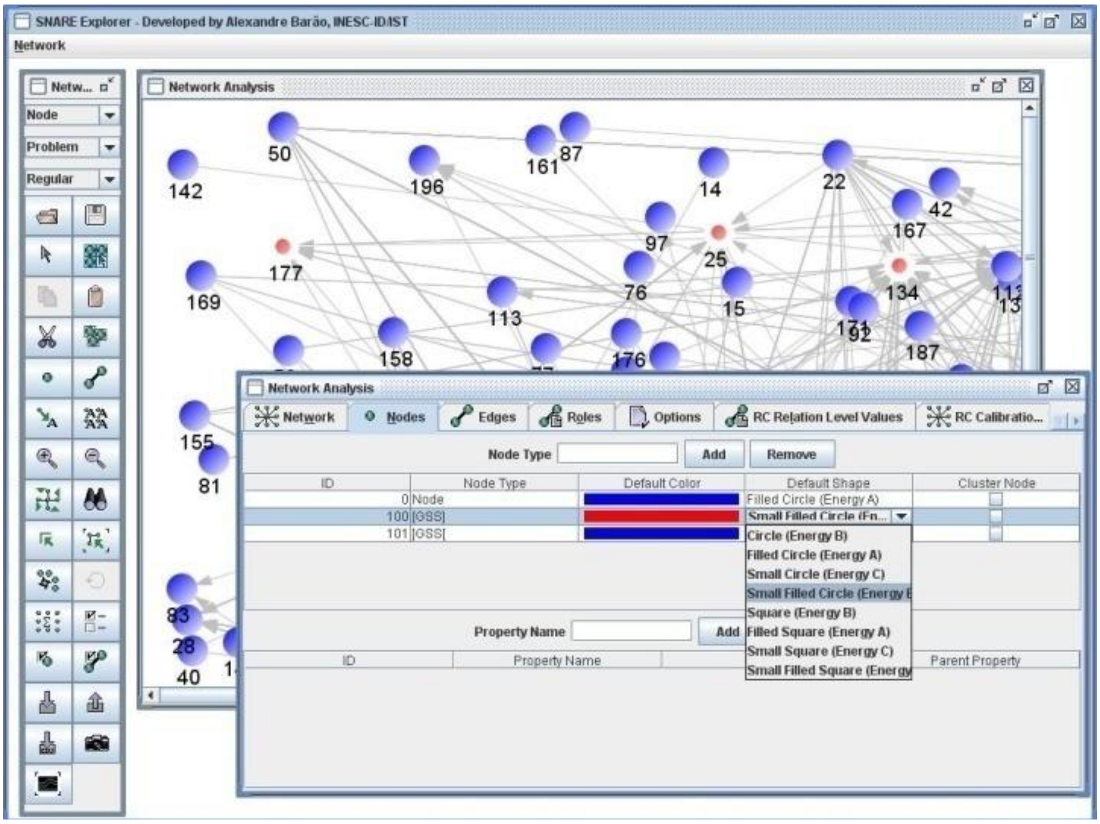


Figure F.22 SNARE-Explorer Node Type Settings Dialog

- **Edge Type Settings**

A network can have several types of relations. For each kind of relation, it is possible to define an edge type (See Figure F.23). Each edge type has main attributes: identifier; name; color; and directional (yes/no). Also, it is possible to define custom roles of social entities to edge types. E.g. considering an edge type *Teaches* (directional), the *sender* role could be *Teacher* and the *receiver* role *Student* (Figure F.24). For each edge type, the relational type value (RTV) from SNARE-RCO model is defined in edge type settings dialog.

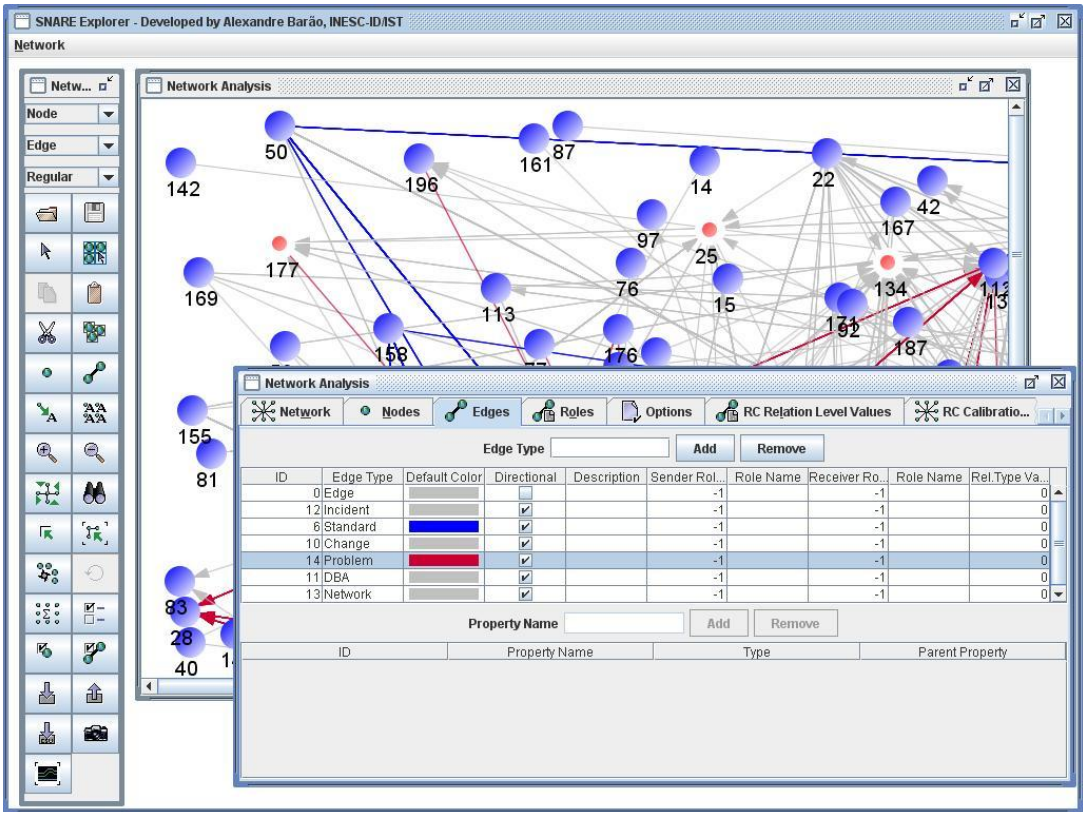


Figure F.23 SNARE-Explorer Edge Type Settings Dialog - Relations

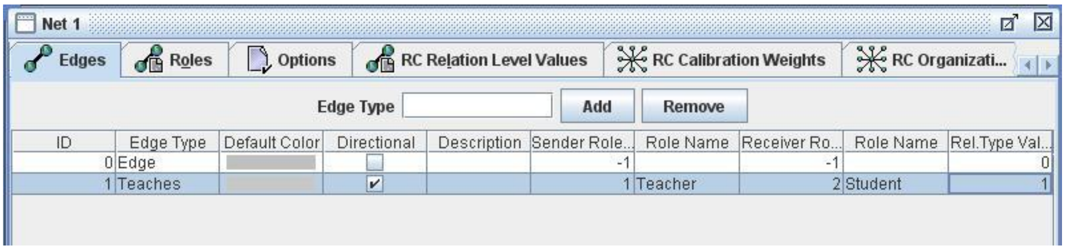


Figure F.24 SNARE-Explorer Edge Type Settings Dialog - Roles

- **Role Type Definition**

Roles from network participants can be associated to edge types. In the role type definition dialog, the *Analyst* can define roles and descriptions (Figure F.25).

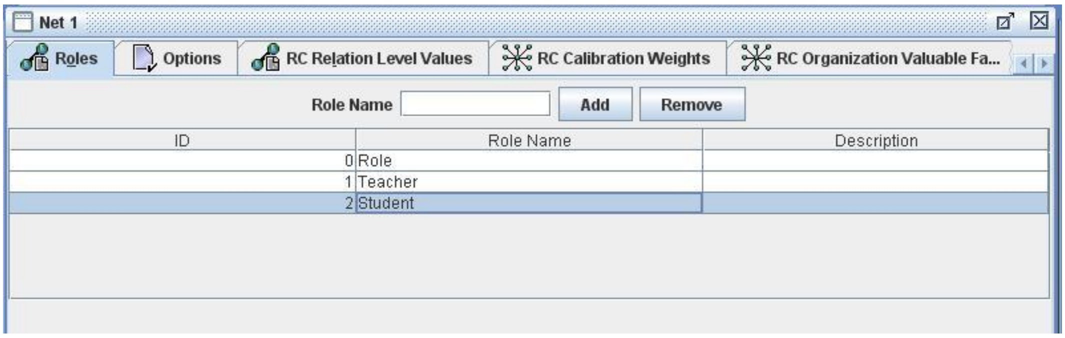


Figure F.25 SNARE-Explorer Role Type Definition Dialog

- **Drawing Options**

SNARE-Explorer drawing options are customizable (Figure F.26). As a vectorial system, the tool allows the *Analyst* to define the scale of each grid unit (in pixels), the zoom factor for each zoom-in/zoom-out, and the node default size (in pixels).

When SNARE-Explorer produces automatic graph layouts, the *Analyst* can see iterations in animation mode. With large amounts of data this feature can be turned off, increasing the speed of the final resulting layout. Distance factors can be customized as well as the maximum iterations number of the used force-directed drawing algorithm, and the number of visible frames per second when using animation mode. If "Final Auto Fit" is selected, the entire graph is reduced (only if necessary) to fit the visible area of network window.

Other options are available such as: apply a specific color to boundary nodes (used in clustering processes) and select node labels as *names* or *IDs*.

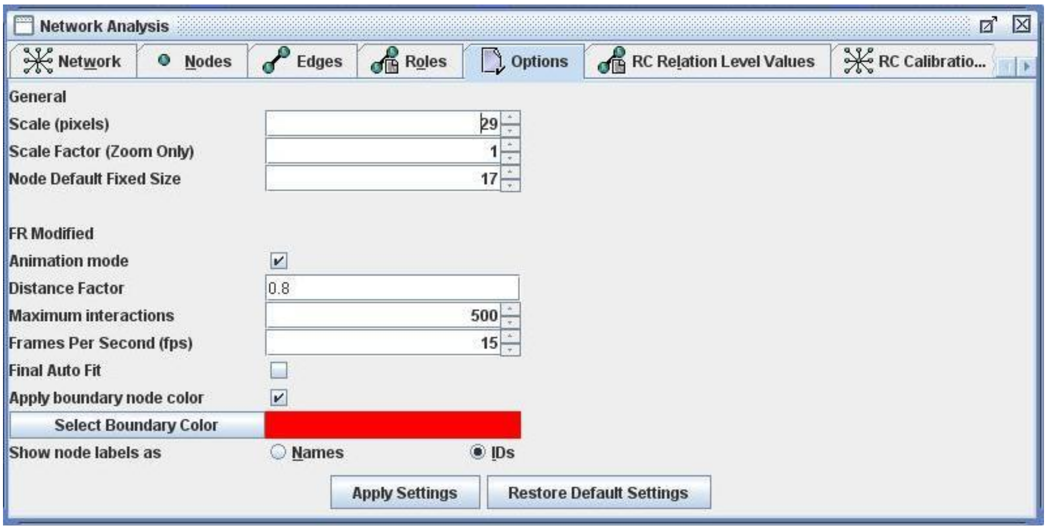


Figure F.26 SNARE-Explorer Drawing Options Dialog

- **SNARE-RCO Settings**

As detailed in SNARE-RCO model, the *Analyst* can define relation level values (RLV), calibration weights (CW), organization valuable factors (OVF), and network valuable factors (NVF).Figure F.27, Figure F.28, Figure F.29, and Figure F.30 depicts the related settings dialogs.

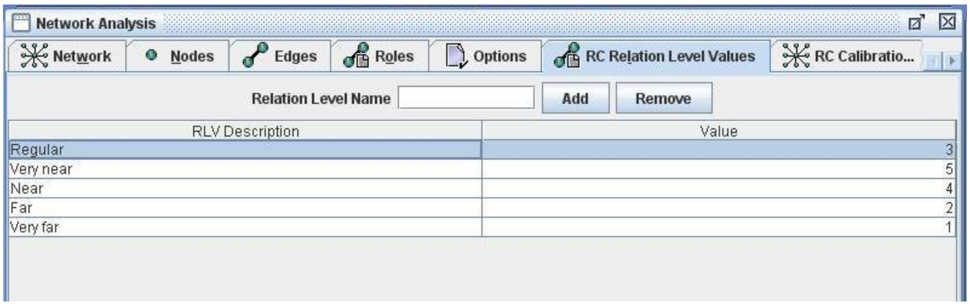


Figure F.27 SNARE-Explorer RLV Definition Dialog

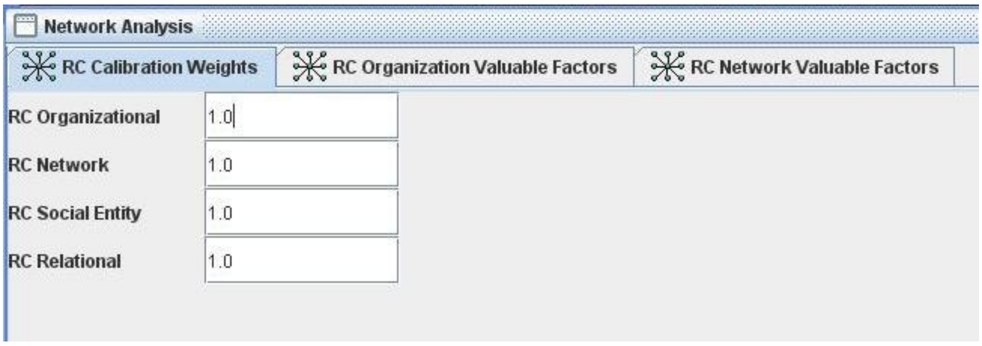


Figure F.28 SNARE-Explorer Calibration Weights Definition Dialog

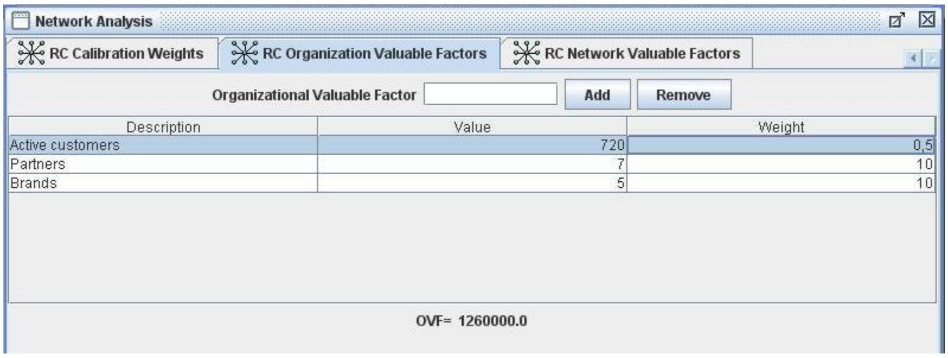


Figure F.29 SNARE-Explorer OVF Definition Dialog

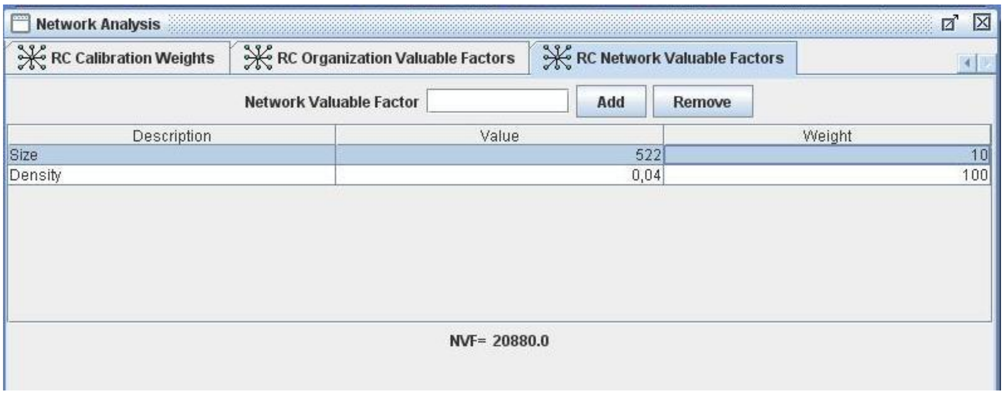


Figure F.30 SNARE-Explorer NVF Definition Dialog

F.6 Input-Output Operations

This section presents SNARE-Explorer I-O special features. *Input* corresponds to *data import* operations, and *output* corresponds to *data export* operations.

- **Importing SNARE-Web Network Database**

SNARE-Explorer supports different integration approaches and it is able to manage and automatically collect social networks data from other information systems, through *transparent* or *intrusive* approaches (See Chapter 5). Using web-services technology to provide database connection for information retrieval, Figure F.31 depicts a real network scenario captured with SNARE-Explorer. More specifically, a set of POSI [POSI 10] Alumni student relations in a given time shot. The POSI case study was developed in order to evaluate SNARE-Web capability to support and develop social network communities [Fre 08].

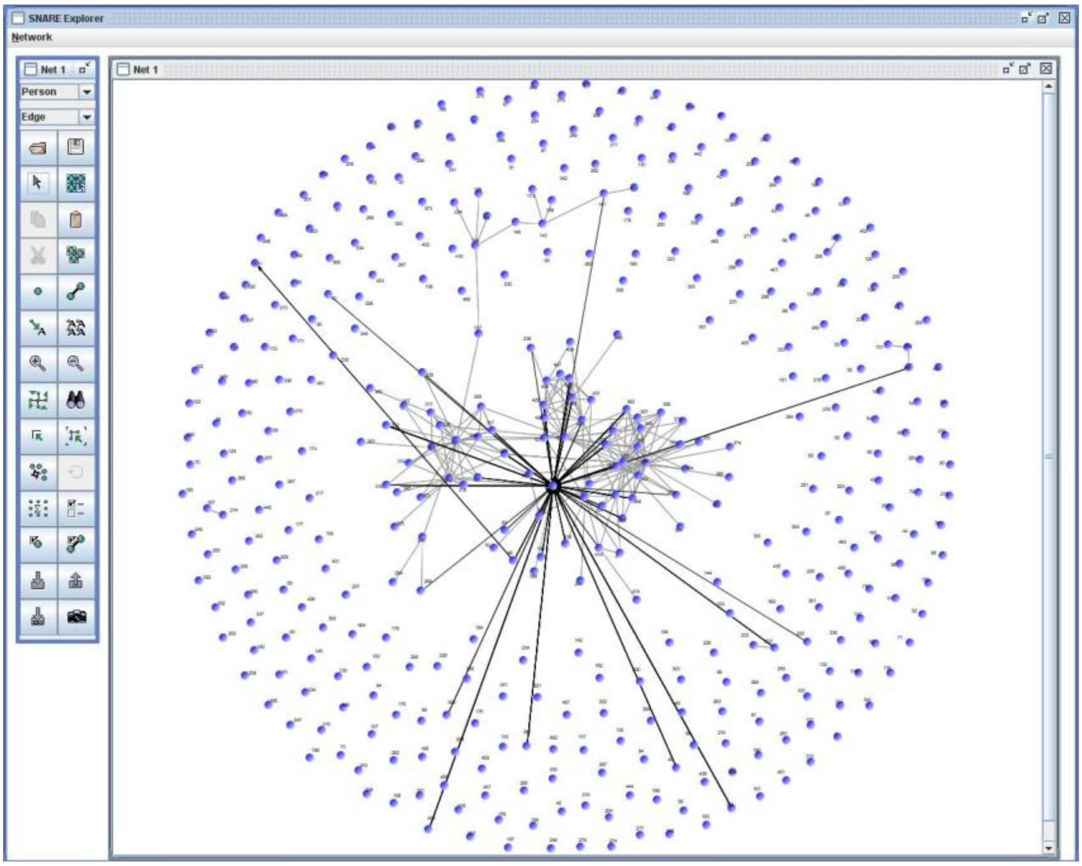


Figure F.31 SNARE-Explorer Importing a Network from a Database

- **Updating an SNARE-Web Database**

As mentioned, SNARE-Explorer allows editing nodes and edges information. After capturing a network from an external database, it may be necessary to update data (e.g., when node properties are edited by the *Analyst* with SNARE-Explorer). This feature was developed to update data from nodes and edges in SNARE-Web database [Fre 08].

- **Importing Networks from CSV files**

Comma-separated values (CSV) files are used to store plain-text data. Typically, lines in a CSV file represent rows in a table, and commas separate the columns. CSV is a simple file format that is widely supported by software applications to move data between programs that operate with proprietary data formats. CSV files can be used to transfer information from databases to spreadsheets.

SNARE-Explorer provides CSV files data import. This mechanism was designed to retrieve data from any information system that supports "Export to CSV" feature. SNARE-Explorer *import CSV* process is visual.

- **Importing Nodes from a CSV file**

First, the *Analyst* selects the CSV file to be opened. Second, if present, SNARE-Explorer detects CSV column information and prompts a column header conversion (Figure F.32).

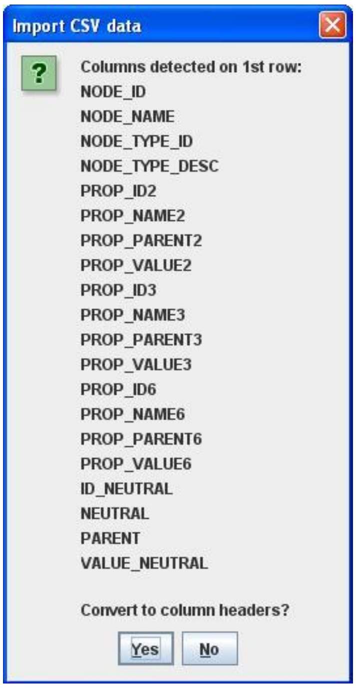


Figure F.32 SNARE-Explorer CSV Data Conversion (Nodes)

Third, SNARE-Explorer shows imported CSV data in a table. The *Analyst* can edit table cells, and add or remove rows and confirm import data process (Figure F.33).

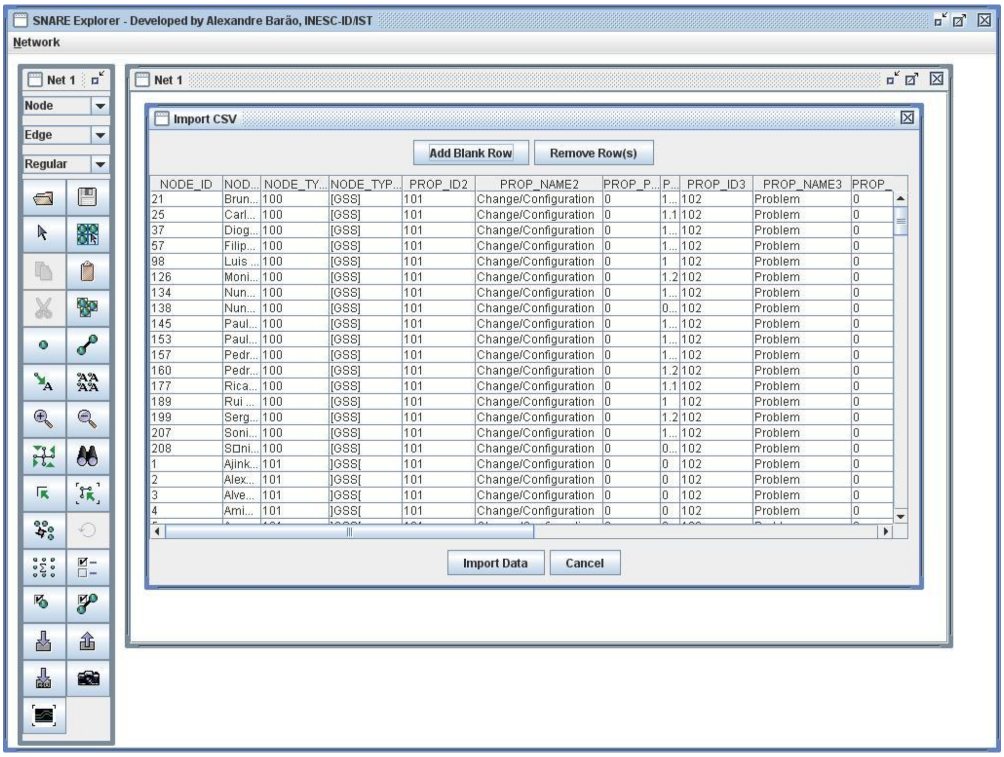


Figure F.33 SNARE-Explorer Imported CSV Data Table (Nodes)

Fourth, the *Analyst* chooses "Node Data Import" button (Figure F.34).

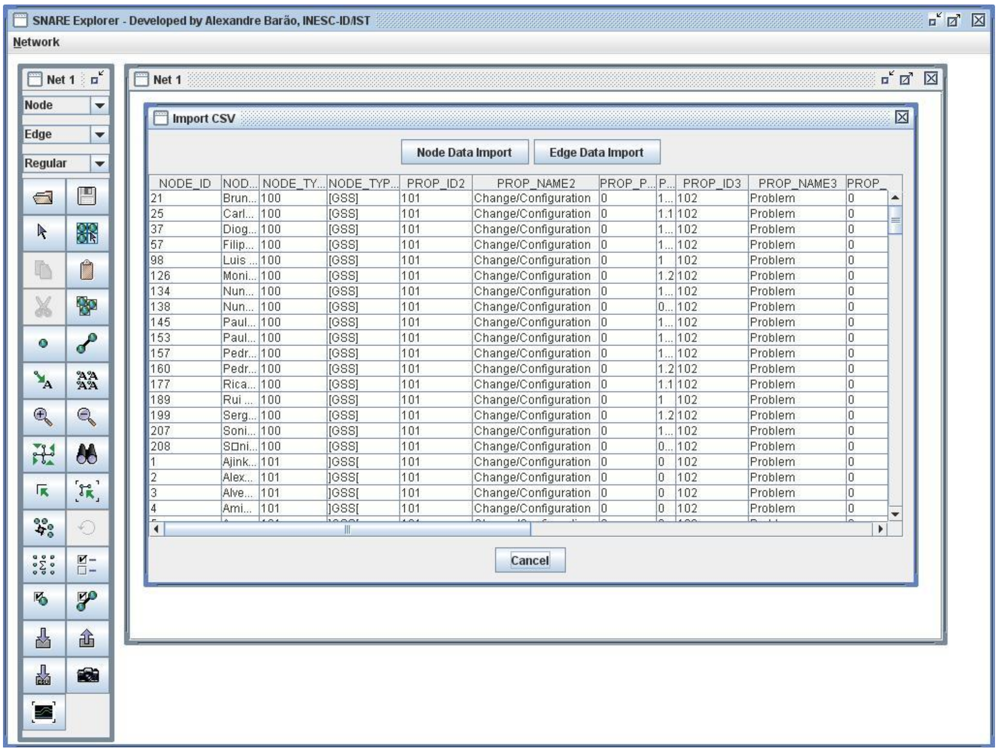


Figure F.34 SNARE-Explorer CSV Node Data Import Action

Fifth, the tool shows a window with the CSV nodes data on the left side and SNARE-Explorer node attributes (Figure F.35). With a few clicks, the *Analyst* can map CSV attributes to SNARE-Explorer attributes. In this example, CSV attributes *NODE_ID, NODE_NAME, NODE_TYPE_ID* and *NODE_TYPE_DESC* are respectively mapped to SNARE-Explorer *Node.ID, [Node.Name], Node Type ID,* and *Node.Type* description. All square brackets attributes are optional to SNARE-Explorer. The tool can import a customized number of node properties. For each property to be imported, the *Analyst* only has to choose the "Append Property" button and map its attributes. If necessary, for some particular reason, the *Analyst* can remove any property.

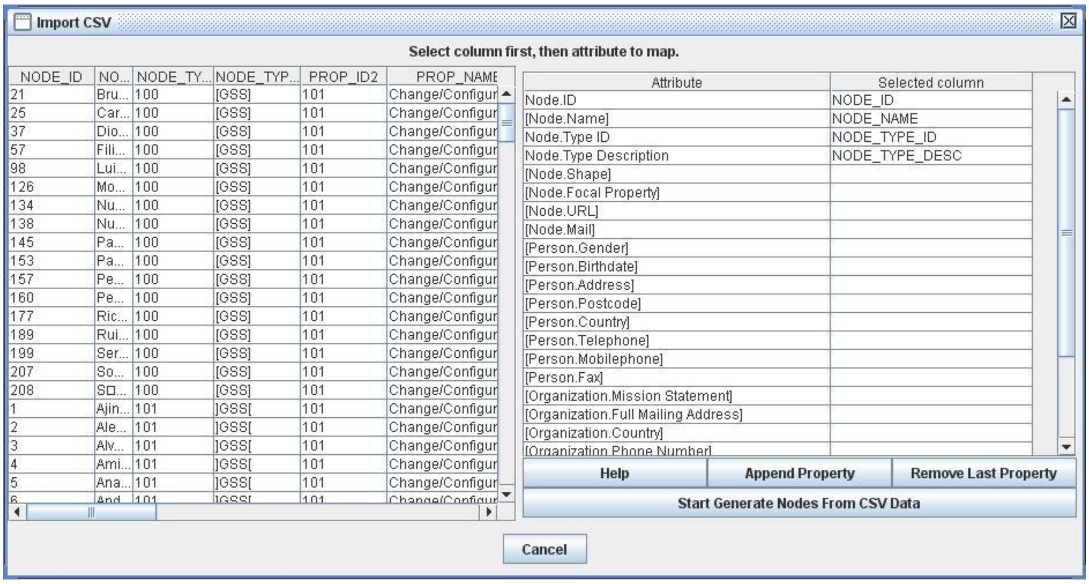


Figure F.35 SNARE-Explorer Mapping CSV Node Attributes

Finally, the *Analyst* must select the "Start Generate Nodes From CSV Data" button and SNARE-Explorer shows a message box with the number of imported nodes (See Figure F.36). Imported nodes can be pasted to SNARE-Explorer network window and the import process is finished (Figure F.37).

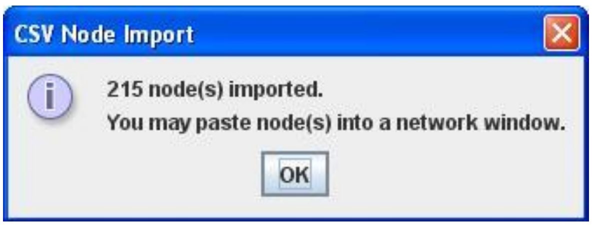


Figure F.36 SNARE-Explorer CSV Imported Nodes Message Box

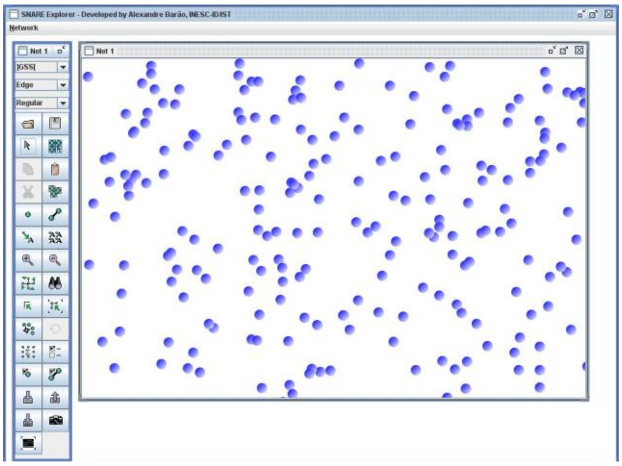


Figure F.37 SNARE-Explorer CSV Nodes Import Result

- **Importing Edges from a CSV file**

First, the *Analyst* selects the CSV file to be opened. Second, if present, SNARE-Explorer detects CSV column information and prompts a column header conversion (Figure F.38).

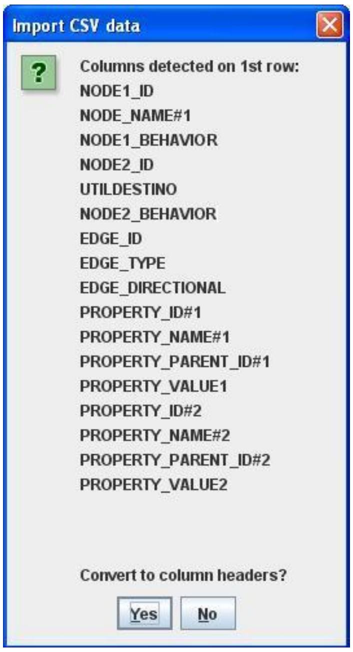


Figure F.38 SNARE-Explorer CSV Data Conversion (Edges)

Third, SNARE-Explorer shows imported CSV data in a table. The *Analyst* can edit table cells, add or remove rows, and confirm import data process (Figure F.39).

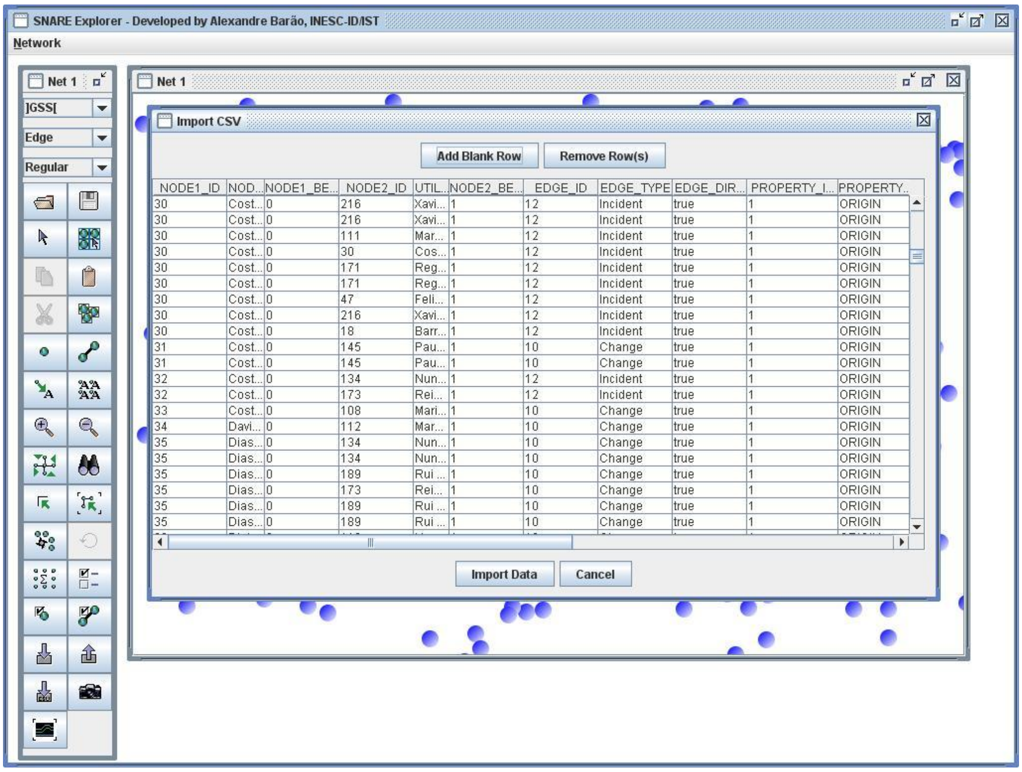


Figure F.39 SNARE-Explorer Imported CSV Data Table (Edges)

Fourth, the Analyst chooses "Edge Data Import" button (Figure F.40).

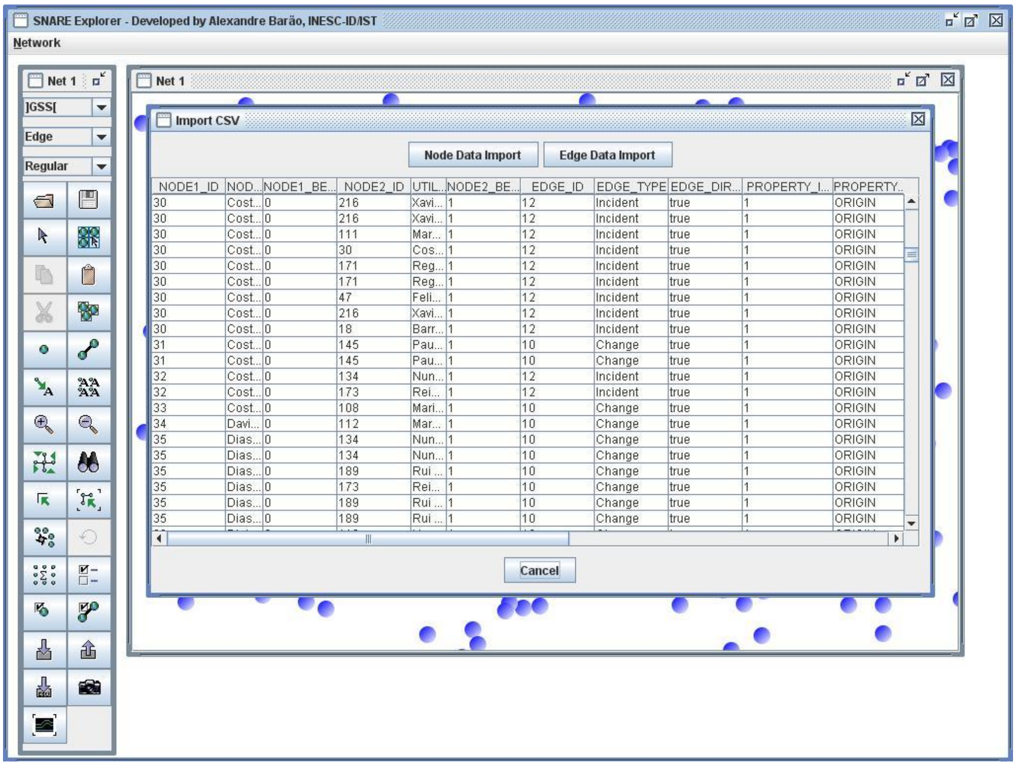


Figure F.40 SNARE-Explorer CSV Edge Data Import Action

Fifth, the tool shows a window with the CSV edges data on the left side and SNARE-Explorer edge attributes (Figure F.41). The *Analyst* can map CSV attributes to SNARE-Explorer attributes. In this example, CSV attributes *NODE1_ID, NODE1_BEHAVIOR, NODE2_ID, NODE2_BEHAVIOR, EDGE_ID, EDGE_TYPE, and EDGE_DIRECTIONAL* are respectively mapped to SNARE-Explorer *Node1.ID, Node1.Behavior, Node2.ID, Node2.Behavior, Edge.ID, Edge.Type*, and *Edge.Directional* respectively. All square brackets attributes are optional to SNARE-Explorer. The tool can import a customized number of edge properties. For each property to be imported, the *Analyst* only has to choose the "Append Property" button and map its attributes. If necessary, for some particular reason, the *Analyst* can remove any property.

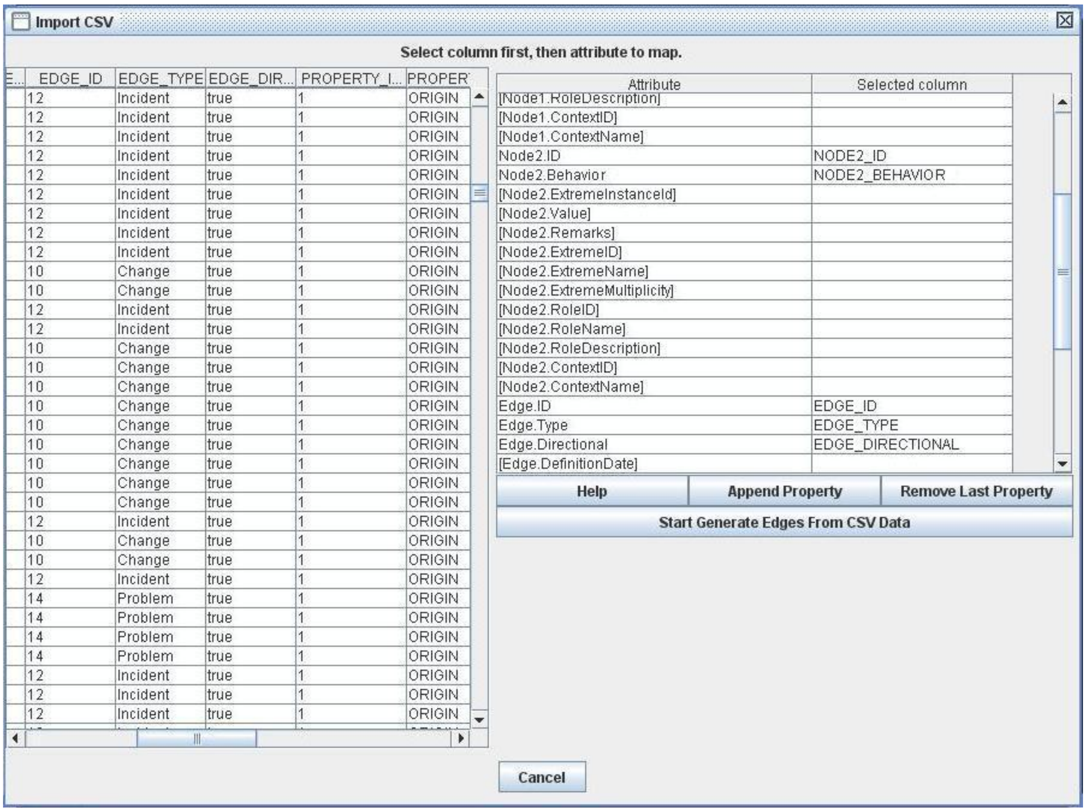


Figure F.41 SNARE-Explorer Mapping CSV Edge Attributes

Finally, the *Analyst* must select the "Start Generate Edges From CSV Data" button and SNARE-Explorer shows a message box with the number of imported edges (Figure F.42). Imported edges can be pasted to SNARE-Explorer network window and the import process is finished (Figure F.43). After this, the *Analyst* can generate an automatic graph layout using SNARE-Explorer drawing algorithms.

Figure F.42 SNARE-Explorer CSV Imported Edges Message Box

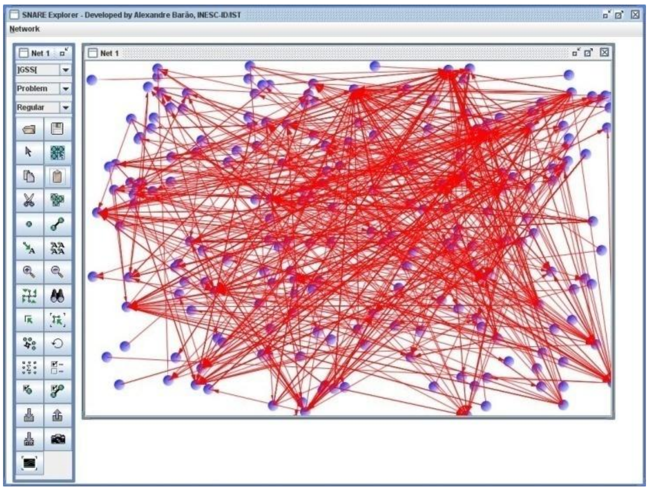
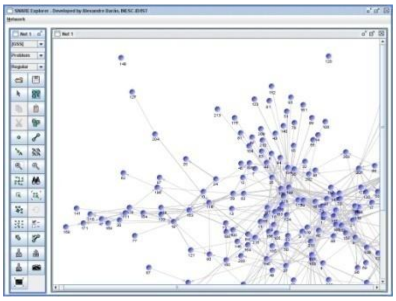


Figure F.43 SNARE-Explorer CSV Edges Import Result

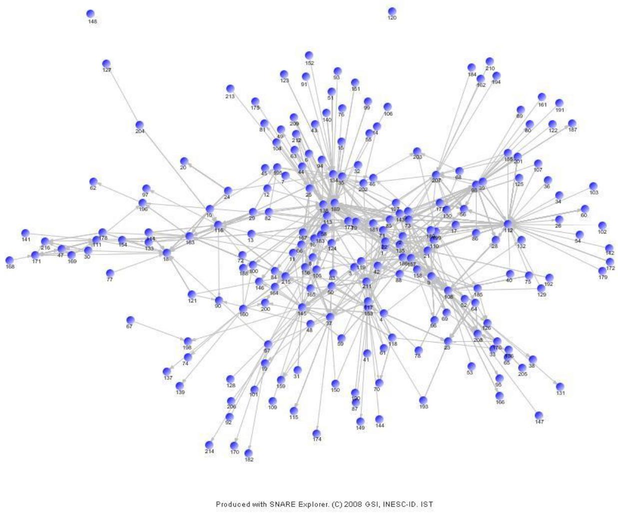
- **Exporting Network Layouts to JPEG files**

SNARE-Explorer is able to export network layouts to JPEG[49] files. When using this feature, the entire network is exported to an image. Figure F.44 a) shows the desktop window with the visible area of a given network, and Figure F.44 b) shows the network layout JPEG image produced with SNARE-Explorer.

[49] JPEG is an acronym for the Joint Photographic Experts Group that created this image file format



a)



b)

Figure F.44 SNARE-Explorer Exporting JPG Network Layouts