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TITOLO TESI

Profiling the Innovation Management discipline: a comprehensive perspective focused on creativity-based vs. knowledge-based strategies

Settore Scientifico Disciplinare ING-IND/35 Ingegneria Economico-Gestionale

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A mio padre
vero gentiluomo
animo buono, integerrimo e colto
esempio di chi sa pensare senza bisogno di seguire altri
per i valori, per la sensibilità e per ciò che di buono ho fatto e farò

Grazie papà

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ABSTRACT (ITALIANO)

La tesi in oggetto tratta della gestione del processo di innovazione. Essa si basa su tre concetti fondamentali: (1) creatività, conoscenza e innovazione sono fortemente interrelati; (2) l'output del processo dipende dalle mutue interazioni tra i tre elementi sopra citati; (3) tale risultato consta di un valore incrementale fornito agli stakeholders del processo di innovazione. Tuttavia, è possibile rilevare in letteratura la presenza di contributi che analizzano tali interazioni su una base uno-a-uno e non considerano il sistema a tre variabili nel suo complesso. Al fine di superare tale limite la tesi approfondisce le interazioni tra Creatività, Conoscenza e Innovazione (CKI) e i loro effetti in termini di valore incrementale agli stakeholders sia dal punto di vista tangibile che intangibile. La tesi presenta, dunque, il modello CKI (o modello del triangolo CKI), il quale si propone come: (1) un framework che promuove un'analisi sistemica delle relazioni CKI; (2) un metodo per la misurazione delle performance di un sistema di interazione CKI; (3) un supporto per governi, manager e ricercatori che si occupano della progettazione e della valutazione di programmi di innovazione volti ad assicurare un valore incrementale agli stakeholders.

Dal momento che diverse tipologie di stakeholders sono interessate dagli effetti generati dal processo di innovazione, lo studio adotta una prospettiva più ampia rispetto a quella presente in letteratura. Tale prospettiva include quattro dimensioni: macroeconomica, istituzionale, socio-culturale e aziendalistica. In quest'ottica il lavoro svolto mira a contribuire ad estendere il nuovo profilo disciplinare dell'Innovation Management (IM).

Il modello CKI e gli studi concernenti l'Innovation Management sono stati realizzati grazie alla guida sapiente, alla collaborazione pluriennale e all'incitamento costante del Professor Roberto Palmieri.

Alla trattazione teorica è stato affiancato uno studio basato su case studies che hanno portato in evidenza dei risultati pienamente coerenti con quanto esplicitato nell'esposizione teorica. Tali casi hanno riguardato:

1) la progettazione e l'implementazione del modello dell'Enterprise 2.0 nel settore automotive e, più in particolare, all'interno di un contesto organizzativo proprio di una multinazionale. Il caso di studio copre principalmente gli aspetti relativi alla strategia knowledge-based e ai risultati in prospettiva macroeconomica, istituzionale e corporate. Anche per tale progetto è stata svolta un'attenta supervisione da parte del Professor Roberto Palmieri;

2) la progettazione e l'implementazione di una piattaforma di vehicle pooling che rientra nell'ambito delle iniziative di Social Innovation messe in atto in agglomerati macroeconomici caratterizzati da soggetti mediamente a basso reddito – e. g. Regioni Convergenza nell'Unione Europea (EU). Il caso di studio copre entrambe le strategie sopra citate e i risultati riguardano principalmente le prospettive istituzionale, socio-culturale e corporate;

3) la progettazione e l'implementazione di un innovativo attrezzo per l'aratura da parte di due gruppi di studenti universitari. Tali gruppi contengono al loro interno soggetti con background differenti, ma la loro composizione risulta essere omogenea e pienamente confrontabile. I gruppi di studenti hanno partecipato a una summer school di livello internazionale tenutasi a Copenhagen – i. e. "Innovation Inspired by Nature" (IIN). Essa è stata incentrata sulle dinamiche di creatività orientate all'innovazione e ispirate da processi biologici. Essa è stata organizzata dalla Copenhagen University (KU) e dalla Technical University of Denmark (DTU) in collaborazione con molte aziende danesi tra le quali Kongskilde Industries A/S, multinazionale danese con subsidiaries in tutto il mondo e production facilities in Danimarca, Germania, Svezia, Stati Uniti (U.S.A.) e Polonia. Si tratta di una "azienda operante a trecentosessanta gradi nel campo della preparazione del

terreno, di macchine per i campi, miscelatori a regime completo, attrezzature per la movimentazione del grano e trasporto via pneumatico nei settori della plastica, della carta e degli imballaggi"[1]. I dati sono stati raccolti con la metodologia della Participant Observation presentata inizialmente da Bronislaw Malinowski[2] e successivamente elaborati attraverso una versione modificata della metodologia inizialmente introdotta da Julie Ugleholdt Pedersen[3]. Tale caso di studio copre principalmente gli aspetti legati alla strategia creativity-based e ai suoi risultati in prospettiva istituzionale, socio-culturale e corporate. Il caso è stato realizzato grazie alla collaborazione di ricerca con i Professori Jason Li-Ying e Balder Onarheim afferenti al "Design and Innovation Group" (D&I) della "Technology and Innovation Management Division" (TIM) del "Department of Management Engineering" presso la Technical University of Denmark (DTU) e con la Dott.ssa Julie Ugleholdt Pedersen, ricercatrice del Copenhagen Institute of NeuroCreativity (CINC).

Keywords: innovation management; creativity; knowledge; CKI model; incremental value to stakeholders.

1 I prodotti Kongskilde sono commercializzati sotto i seguenti brand conosciuti a livello internazionale: Kongskilde, Howard, Nordsten, Becker, Överum e JF, oltre al brand locale Juko. Per maggiori dettagli: http://www.kongskilde.com/.

2 La metodologia della Participant Observation nelle sue fasi iniziali era legata anche a ricerche effettuate nel campo

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3 Tale metodologia è stata introdotta dallo studio di Julie Ugleholdt Pedersen (2013), *Creativity in Innovation Processes. A Study of the Influence of Creativity in the Context of 'Innovation Inspired by Nature'*. Copenhagen Business School.

ABSTRACT (ENGLISH)

This thesis deals with managing the innovation process. It is based on three fundamental concepts: (1) creativity, knowledge and innovation are strongly related with each other; (2) the output of the process depends on their mutual interactions; (3) such a result should consists of an incremental value to some stakeholders. Unfortunately, in this field most of contributions analyze those interactions on a one-to-one basis and a lack of investigation about these three-variable system currently emerges. In order to help filling this gap this work aims at deepening the Creativity-Knowledge-Innovation (CKI) interactions and their effects in terms of incremental value to stakeholders from both a tangible and intangible point of view. As a result of the related findings, this thesis proposes the CKI triangle model that is thought to be: (1) a framework fostering a systemic analysis of CKI relationships; (2) a method for measuring the performances of a CKI interaction system; (3) a support for governments, managers and researchers coping with the design and the assessment of innovation programs aimed at ensuring an incremental value to stakeholders.

Since different categories of stakeholders are concerned with the outcomes of the innovation process, this study adopts a broader perspective than the existing one in literature. It embraces four perspectives: macroeconomic, institutional, socio-cultural and corporate. Based on this slant, this work aims at contributing to the enrichment of the Innovation Management (IM) discipline.

The CKI model and the study about the Innovation Management discipline have been carried out thanks to the wise mentorship, the multi-year collaboration and the continuous stimulus of Professor Roberto Palmieri.

Finally, some practical results are discussed in order to complement these theoretical argumentations. The findings related to the case study approach proved to be coherently aligned with the theoretical results of the aforementioned model. Such case studies involve:

1) the design and implementation of the Enterprise 2.0 model in a multinational company operating in the automotive industry. The case study mainly covers the knowledge-based strategy and its outcomes affect the institutional, corporate and macroeconomic perspectives. Also this project was developed thanks to the supervision of Professor Roberto Palmieri;

2) the design and implementation of a vehicle pooling platform intended to be a Social Innovation initiative in low-income macroeconomic agglomerates – e. g. Convergence Regions in the European Union (EU). It mainly covers both the creativity-based and the knowledge-based strategies and the outcomes affect the institutional, corporate and socio-cultural perspectives;

3) the design and implementation of an innovative tine by two groups of students. There were different backgrounds within the teams, but a homogeneous composition between the teams. The groups of students attended an international summer school in Copenhagen – i. e. "Innovation Inspired by Nature" (IIN). It focused on innovation-oriented creativity dynamics inspired by biological processes. It was organized by the Copenhagen University (KU) and the Technical University of Denmark (DTU) in collaboration with several Danish companies among which Kongskilde Industries A/S, a Danish multinational with subsidiaries worldwide and production facilities in Denmark, Germany, Sweden, United States and Poland. It is "a full line company within soil preparation, grassland machinery, complete diet mixers, grain handling equipment and pneumatic conveying in the plastic, paper and packaging industries"[4]. The data were collected

4 Kongskilde's products are marketed under the global brands Kongskilde, Howard, Nordsten, Becker, Överum and JF and the regional brand Juko. For more info: http://www.kongskilde.com/.

through the Participant Observation methodology introduced first by Bronislaw Malinowski[5] and elaborated through some revisions to the Julie Ugleholdt Pedersen's original methodology[6]. This case study mainly covers the creativity-based strategy and its outcomes are related to the institutional, corporate and socio-cultural perspectives. This case study has been carried out thanks to a research collaboration with the "Design and Innovation Group" (D&I) of the "Technology and Innovation Management Division" (TIM) at the "Department of Management Engineering" of the Technical University of Denmark (DTU) and, in particular, with Professor Jason Li-Ying and Professor Balder Onarheim. It was also possible thanks to Julie Ugleholdt Pedersen, researcher at the Copenhagen Institute of NeuroCreativity (CINC).

Keywords: innovation management; creativity; knowledge; CKI model; incremental value to stakeholders.

5 The Participant Observation methodology in the early stage was concerned also the research related to the tilling field. It has been first described in: (a) Malinowski, Bronislaw. 1922. *Argonauts of the Western Pacific*. London: Routledge and Kegan Paul; (b) Malinowski, Bronislaw. 1935. *Coral Gardens and Their Magic: A Study of the Methods of Tilling the Soil and of Agricultural Rites in the Trobriand Islands*. 2 vols. London: Allen and Unwin; (c) Malinowski, Bronislaw. 1948. *Magic, Science, and Religion, and Other Essays*, ed. Robert Redfield. Boston: Beacon; (d) Malinowski, Bronislaw. 1967. *A Diary in the Strict Sense of the Term*. Trans. Norbert Guterman. London: Routledge and Kegan Paul.

6 Such a methodology was introduced in the work by Julie Ugleholdt Pedersen (2013), *Creativity in Innovation Processes. A Study of the Influence of Creativity in the Context of 'Innovation Inspired by Nature'*. Copenhagen Business School. She is a researcher at the Copenhagen Institute of NeuroCreativity (CINC).

INTRODUCTIVE SECTION

OBJECTIVES

«Every organization – not just business –
needs one core competence:
innovation»
(Peter F. Drucker)

The objective in the first stage is deepening the management of the innovation process by adopting a broader perspective than the existing one and focusing on creativity-based vs. knowledge-based strategies.
Afterwards, this work aims to analyze all the outcomes of the innovation process aimed at providing its stakeholders with an incremental value. Since such a value is concerned with different kinds of stakeholders, a framework is proposed. It is geared to provide a valuable tool for the design, monitoring and assessment of innovation programmes at the international, national, regional and corporate level. This tool includes a set of indicators grouped by perspective as it is detailed in the operating framework
The model as a whole proposes four dimensions of analysis – i. e. macroeconomic, institutional, socio-cultural and corporate – and aims at demonstrating the need for profiling the IM discipline with a broader perspective. This stage of the work aims at moving a step forward towards the elaboration of the disciplinary profile of the IM.
Finally, a case study approach is proposed in order to prove further the outcomes of this study with innovation projects covering the four perspectives of analysis and the creativity-based vs. knowledge-based strategies.

STRUCTURE

This work is composed of eight chapters grouped by five conceptual blocks or sections.

In the first section a literature review and a theoretical study about the CKI model (Chapter 1) are proposed. This section focuses on creativity-based vs. knowledge-based strategies involved in the management of innovation processes and proposes the four perspectives of analysis. The model was developed thanks to Professor Roberto Palmieri – University of Calabria – Department of Mechanical, Energy and Management Engineering (DIMEG).

In the second section there are two chapters. Chapters 2, 3 and 4 focus on the first case study dealing with the design and implementation of the Enterprise 2.0 model in a multinational company operating in the automotive industry realized under the supervision of Professor Roberto Palmieri – University of Calabria – Department of Mechanical, Energy and Management Engineering (DIMEG).

In the third section this thesis deals with a new vehicle pooling initiative aimed at realizing a Social Innovation project in low-income macroeconomic agglomerates. Chapters 5 and 6 focus on the second case study about the design and implementation of the vehicle pooling platform.

In the forth section this work aims at dealing with the observations for data collection about CKI interactions within groups of students involved in new product development projects. Chapter 7 aims at describing the context and the CKI interaction patterns observed in Copenhagen during the international summer school "Innovation Inspired by Nature" organized by the Copenhagen University and the Technical University of Denmark in collaboration with Kongskilde Industries A/S and other Danish companies. The third case study has been possible thanks to the research collaboration with Professor Jason Li-Ying and Professor Balder Onarheim – Technical University of Denmark – and Julie Ugleholdt Pedersen, researcher – Copenhagen Institute of NeuroCreativity (CINC).

Chapter 8 ends with theoretical and empirical conclusions about the CKI model and its application to the three case studies by adopting the CKI perspectives (i. e. macroeconomic, institutional, socio-cultural and corporate).

INNOVATIVE CONTRIBUTION OF THE THESIS

This work provides the following innovative contributions:

1) it contributes to shift forward the current state of the art (one-to-one analysis) about CKI interactions;

2) it helps filling the gap by adopting a more comprehensive framework and enlarging the traditional slant about the management of the innovation process;

3) it focuses on C-K-I and K-C-I approaches by analyzing the dynamics between creativity vs. knowledge resource policies and innovation goals;

4) it proposes a more advanced framework – i. e. the CKI triangle model – endowed with a set of indicators through which innovation outcomes are captured;

5) it proves helpful in supporting decision making and control tasks within operating contexts;

6) it is a valuable tool for the design, monitoring and assessment of innovation programmes at the government and the corporate level;

7) it allows academicians and researchers to conduct more comprehensive studies in this field;

8) it provides a significant contribution to the enrichment of the disciplinary profile of the IM;

9) it is endowed with a case study approach covering the above mentioned strategies and perspectives proposed in the CKI model;

10) it aims at demonstrating how the Innovation Management disciplinary profile should be more comprehensive and incorporate the four CKI perspectives.

SECTION I

CHAPTER 1

THE CREATIVITY-KNOWLEDGE-INNOVATION MODEL [47] [48] [49]

As an introductory step, let's briefly focus on the relationships among knowledge, creativity and innovation as they are mainly dealt with in current literature, that is, on a one-to-one basis.

1.1 From Creativity To Knowledge

Knowledge is relevantly powered by creativity, and we may even acknowledge creativity a shaping role while defining some important features of knowledge economy [12] [4] [32]. A revealing example is given by the curiosity-driven discovery of graphene for which Professors Geim and Novoselov were awarded with the 2010 Nobel Prize in Physics. Initially, there was no specific knowledge at all about graphene (a 2D material), simply because it did not exist. It was obtained from graphite (a 3D material) jus as the result of some creative experiments which consisted in applying the mechanical exfoliation method, through a Scotch tape, to a carbon block. The experiment revealed the extraordinary properties of the new material and its potential technological applications (i.e. solar cells, chips, magnetic devices, computers, sensors), thus favouring the definition of a new product knowledge domain.

1.2 From Knowledge To Creativity

In order to reveal its potential, creativity always requires at some extent a recombination of existing knowledge [12] [6]. The role of Amazon in the development of cloud computing proves very useful to support this point. In this case, existing knowledge about such technologies as grid computing, utility computing, cluster computing etc. was all specific to the aforementioned model. In fact, these different knowledge sources were only recombined – though in a creative way – just in the aim of developing the Cloud Computing model [31] [15]. Amazon, just due to its domain-specific knowledge about distributed information technology, while facing the modernization of its own data centres was able to implement a creative approach for transforming a weakness in an advantage. The internal management of these units did not prove efficient in delivering highly customized services to its millions of users. So Amazon firstly decided to reduce its complexity by providing external users with some storage space and other services to be managed on their own. Afterwards, it further exploited knowledge in a creative way by extending its advanced cloud computing services (i.e. Amazon Web Services) to a number of internationally renowned firms operating in many different sectors, thus shaping the future of the business service market [16]. On the other hand, existing knowledge can also have a negative impact on creative capabilities. Individuals and organizations are often too confident with their consolidate knowledge and tend to keep close with traditions and old practices. This phenomenon leads to a sort of psychological inertia and a disinclination toward original, "divergent" thinking [19] [41] McAdam and McClelland, 2002). Let's look for example to the recent, dramatic loss of market share by Nokia [17]. This company being the former market leader of mobile phones

focused too much on its consolidate knowledge, thus not sufficiently caring about new concepts developed by competitors (i.e. Samsung).

1.3 From Creativity To Innovation

Creativity promotes different and original perspectives in looking at things and solving problems [5] [37]. At Google for example innovations rise from the creative environment established in its headquarters. It is explicitly aimed to enhance overall creativity [38] [14]. This organizational strategy clearly shows how creativity engenders innovation and may finally lead to new business opportunities in a very broad perspective. In fact, Google's innovations are not exclusively related to the improvement of its own traditional business lines. Although Google is the world leader in the search engine sector, innovations given birth within its creative environments spread up to new business fields like for example the augmented reality Head-Mounted Display and the Driverless Car. So we can argue that creativity is not only concerned with innovating specific products or processes, but its effects may also extend up to reshaping an entire innovation strategy.

1.4 From Innovation To Creativity

The influence of innovation on creativity is also widely recognized in the literature [36] [29]. In particular it emerges that the larger the number of successful innovations cases, the stronger the inclination to divergent thinking and creativity-based activities workers are likely to develop [40]. An example is given by Ferrari. Since its foundation in 1929 this company continuously generated successful innovations in both products and processes within the sport car sector. Due to the continuous improvements of the innovation process overtime, workers progressively reduced their involvement in failures and got more and more confident about their own capabilities. In turn, this increased their self-motivation and boosted their creative endowments. In 1997, the company introduced its "Formula Uomo" program aimed at providing employees with the best possible breeding ground for creativity, and successively it was appointed "The European Workplace of the Year" [18]. On the other hand, according to the concept of "creative destruction" [39], innovation provides the innovating company with a temporary monopolistic position and, as a consequence, stimulates competitors' creative reaction. A suggestive example is given by Google's increasing innovation efforts in the smartphone and tablet sector, subsequent to the adoption of its new creative strategy (see above). Successively, Samsung decided to develop its own creativity management program [3]. The most recent and undeniable outcome of Samsung's creative strategy consists of Samsung Galaxy S3, the current world’s best-selling smartphone model [27]. But, for our purposes, what seems to be most interesting in this example is the prospective cause and effect relationship among Google's innovation strategy and Samsung's creative strategy. In fact, in the Schumpeterian perspective, it may be read like a Samsung's counter move due to its glimpsing the risk of being threatened by a new potential entrant like Google just in the market where it played as one of the main competitors. This interpretation suggests that an innovating firm (i.e. Google) stimulates creativity also outside its boundaries (i.e. Samsung's creativity program), thus influencing the entire market evolution.

1.5 From Knowledge To Innovation

Knowledge is a raw material of the innovation process (Yusuf, 2009). In fact, innovation depends on new knowledge creation and its application in new products or processes [1]. This is particularly clear when spatially-specific factors are considered, including knowledge sharing and accumulation of skills and know-how, since they shape technological specialization of regions and the innovation success rate of district firms [20]. For example, the area of Maranello (Italy), known as "Motor Valley", is the region where many renowned firms - Maserati, De Tomaso, Ferrari, Lamborghini, Ducati etc. - have operated since the 1910s. The strong innovation capabilities of this district are based on the knowledge background which rose from the presence of: (1) an important F.I.A.T. plant, (2) several innovative small and medium enterprises, (3) some "motor academies" (e.g. technical high schools, company academies etc.). Based on this existing knowledge, since the 1970s many other successful innovations have been developed by new local entrepreneurs as well. Among these latter, for example, LEM Motor has been established in 1973 and operates in a very innovative market niche - that of children motorcycles – by hiring several local specialists and leveraging existing knowledge background.

1.6 From Innovation To Knowledge

Innovation is in turn a relevant trigger for activating knowledge generation, update and diffusion at both the organizational and individual level [23] [30]. Such cause and effect relationships have also been empirically proved [22]. For example, during the last century, innovation aimed at realizing space missions leaded to significant knowledge improvements in many science, technology and commercial branches (e.g. health, physics; telecommunications, computers; air transportation, space tourism).

This short review of past literature helps appreciate how deeply creativity, knowledge and innovation are interrelated each other. At the same time, it shows that the impacts of such reciprocal interdependencies must be conceived in a very broad perspective (technological, organizational, strategic, etc.). On the other hand, all mentioned argumentations emphasize a widespread attitude of researchers to investigate these interactions - although deeply and properly – on a one-to-one dimension at most. Unfortunately, we are convinced, this way research in innovation management is losing a more comprehensive perspective embracing creativity, knowledge and innovation all together. This wider perspective is now going to be discussed in the rest of this work by deepening the creativity-knowledge-innovation framework which we will refer to as "CKI triangle". Chapter 2 is organized as follows:

- the second section contains a discussion of the background and basic concepts of the CKI triangle;
- the third section is focused on the results emerging from the adoption of a model based on the CKI triangle perspective (CKI triangle model);
- the last section ends with conclusions.

1.7 CKI triangle: background and basic concepts

Prior to formalizing the theoretical framework which supports the CKI triangle's framework, further observations and considerations have to be provided in order to complement the above remarks with other concepts we will refer to. For doing this, within the proposed CKI

triangle (Figure 1) we will now consider only those two basic approaches (or paths) through which it is possible to dynamically combine creativity and knowledge resources in the pursuit of innovation objectives, that is:

1) C-K-I path (creativity-based approach);
2) K-C-I path (knowledge-based approach).

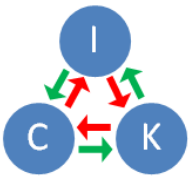

FIGURE 1. THE CKI TRIANGLE

The two approaches are not so trivial as they could appear at first sight since both of them imply:

• a prioritization of the resource (creativity or knowledge) to be predominantly leveraged at the beginning of the process, depending on the kind and ambition of its innovation objectives;
• depending on the above choice, a specific interaction pattern among creativity and knowledge;
• depending on both the above requirements, different expectations about possible outcomes of the innovation process.

These requirements highlight the complex and dynamic nature of the two approaches.
On the other hand, the CKI triangle "works" - that is, the CKI interactions converge to innovation goals - if at least one of those two approaches work. This means that: 1) an appropriate level of creative capabilities and a suitable knowledge base have to handily support the innovation process when needed; 2) each one-to-one relationship discussed in the first section has to meet favourable working conditions; 3) each approach has to be adopted and conducted by caring about an effective integration among the resources (C, K), the couples of relationships involved (C-K, K-I; K-C, C-I) and the objectives of the innovation process.

1.8 C-K-I path (Creativity-Based Approach)

As already noticed above, creative environment encourages generating, sharing and experiencing knowledge at innovation purposes which may vary from inventing or discovering new products or processes to defining new organizational paradigms and business strategies. On the one hand the above cited example of graphene shows how, within creativity-based innovation processes not explicitly finalized in advance to a specific objective, a suitable knowledge base that may possibly help is constituted by a variety of old and new knowledge sources to be extracted, generated and combined contingently according to the progress and the current requirements of the experimental context. On the other hand, the example of Google's new businesses Head-Mounted Display and Driverless Car helps

understand how creativity management may even favour the adoption of new business strategies. In both cases, we can notice that the expected result is not well stated at the very beginning of the process. So in a way, the outcome of a creativity-based innovation process is something we could address as a result we “stumble” in. On the other hand,
creativity assumed as a starting point is likely to lead to quite radical innovations, if any, since initially it is substantially unconstrained. By contrast, a surplus of creativity may also lead to diverge too much from realistic objectives, thus making more difficult or even inhibiting the accomplishment of any innovation purpose. So it turns out that adopting a creativity-based approach corresponds to accepting a priori a very high degree of uncertainty and failure risk in the innovation processes [21]. Thus, within the C-K-I path creativity emerges as the most important factor since:

1) It engenders knowledge circularization - Creativity is the engine for a cross-fertilization and a continuous development of knowledge bases; countries and organizations can generate new and valuable knowledge by enhancing and leveraging their own creative potential;
2) It fosters innovation processes and their contribution to competitiveness and economic growth - Creativity is a trigger for transforming knowledge into radical innovation and higher levels of market dynamics and corporate competitiveness; as a consequence, emerging of creative environments in companies, regions and cities favours global economic evolution by means of knowledge exploitation [13].

The key role played by creativity in the C-K-I approach is borne out also by the "3Ts" model [41], aimed to quantify creative potential in a given context by measuring its levels of “Talent", "Technology" and "Tolerance". In brief, according to this model, talent and technology levels are measured through innovation capability and knowledge-related sub-indicators. In turn, the level of Tolerance does not appear directly related to knowledge and innovation, but it looks like playing a key role in directly fostering creativity by means of talent attraction and retention [28] and divergent thinking style [44] [43]. As a general finding of our analysis of the “3Ts” model, knowledge and innovation capabilities within a specific socio-economic contexts are the consequence of its creative potential. This helps appreciating once more our recommendation about the crucial relevance of creativity while adopting a C-K-I approach.

1.9 K-C-I path (Knowledge-Based Approach)

"If we apply knowledge to tasks we already know how to do, we call it 'productivity'. If we apply knowledge to tasks that are new and different, we call it 'innovation'" [9]. It is like saying that knowledge applied creatively generates innovation, or better, the transformation of existing knowledge into innovation requires creativity in order to combine old ideas and concepts into new ones [37] [24]. Thus, within the K-C-I approach, setting creative environments is just to be finalized to achieve proper conditions for leveraging on knowledge in order to attain a higher innovation potential and hence, more competitive advantages [8] [6]. However, starting from consolidate knowledge generally may lead to develop less radical innovations than through the C-K-I approach. In fact, in this path, creativity starts having an effect only at the second step, thus operating with an initial anchorage to the existing knowledge. For example, in our interpretation of the above mentioned Nokia’s case, due to this kind of anchorage a sort of psychological inertia occurred that resulted in a negative

impact on its innovation capability. By contrast, such an anchorage facilitates minimizing uncertainty and risk since creativity impact is less unpredictable while operating on consolidate knowledge domains and more dependable objectives. For instance, Amazon developed its advanced cloud computing services thanks to a workable and reliable knowledge base specific to the information technology field. The end result of Amazon's knowledge-based approach was characterized by a lower degree of uncertainty compared, for instance, to Google's Head-Mounted Display and Driverless Car. Also in the case of the "Motor Valley", knowledge is highly specific. It leaded overtime to a series of incremental innovations in several fields of car and motorcycle mechanics (design, aerodynamics, body shell, engine, etc.), by creatively leveraging and enriching the knowledge background of that area (e.g. local specialists). Actually, the two above mentioned approaches (C-K-I and K-C-I) can be seen as two endless circles. Every variable (C, K, I) activates the next one and this circular process may continuously lead to new, potentially more advanced levels of creativity, knowledge and innovation at each step of the process. So, if no negative interaction or lack condition inhibits a specific process then it can be defined a "virtuous circle", otherwise it may result in a "vicious circle". Except for some further basic observations and considerations, this circular perspective is not exhaustively analyzed in this work, but we are convinced it is worth to be further deepened in future research efforts.

1.10 CKI triangle: a model oriented to provide Incremental Value to Stakeholders

After the introduction of the CKI triangle, it is now time to point out how beneficial it may result adopting a model based on its slant, which we refer to as "CKI triangle model" (Figure 2).

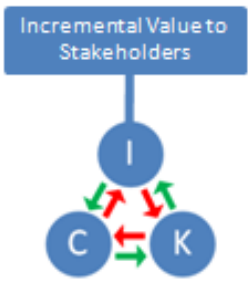

FIGURE 2. A GRAPHICAL REPRESENTATION OF THE CKI TRIANGLE MODEL

At this purpose, the CKI triangle model has to be intended as: 1) a framework where all components of the CKI triangle are explicitly related to one or more valuable outcomes; 2) a set of complementary indicators through which those outcomes can be assessed. A first kind of outcome is in terms of "incremental value to stakeholders" (IVS), that is, the tangible and/or intangible end result of the innovation process (i.e. a new product or process) to which individuals or groups of individuals may be concerned as an additional value to them compared with the value they already got in the past from previously owned products or processes. However, this value is not the only outcome that originates from the innovation process as it stands out by considering the following two points:

1) in addition to those two approaches (C-K-I and K-C-I) analyzed in the second section, four different paths could be considered such as C-I-K, K-I-C, I-K-C and I-C-K. We will not further deepen these approaches here, however as a general observation their expected end result is a higher value in terms of creativity or knowledge alternatively. In these cases innovation may be considered as a resource contributing in turn to raise creativity/knowledge value depending on the approach. So, a further finding follows: adopting a specific approach may have an influence not only on incremental value due to innovation, but also on the increase of creativity and/or knowledge values. As a consequence of these "secondary order" effects the decision about the approach to be adopted may even more take a long-term, strategic dimension;
2) according to the circular perspective defined in the second section, endless circles may bring to an increased value to some stakeholders, e.g. by means of an improvement of creativity and knowledge. So, in general, in a virtuous circle not only the incremental value is provided to stakeholders. In fact, in this case the additional value provided through creativity and/or knowledge is a sort of "byproduct value" of the innovation process (BV_C and BV_K respectively). Otherwise, in a vicious circle no incremental value is generated and the increased value of creativity and/or knowledge (DV_C and DV_K respectively) is the only outcome of the circularization process. We can refer to this last outcome as "default value". Byproduct and default values have a similar nature to the incremental value since at each step of the circular process they provide some stakeholders with an increased value compared to the one they already owned in the past. If we refer to a single cycle of an endless circle, these last theoretical argumentations may be expressed in mathematical terms through the Equation 1:

$$VIP = (IVS + BV_C + BV_K) * a + (DV_C + DV_K) * b \quad (1)$$

where VIP is the overall value generated in one cycle by the innovation process, IVS is the incremental value to stakeholders, BV_C and BV_K are the byproduct values of creativity and knowledge respectively, DV_C and DV_K are the default values of creativity and knowledge respectively and a is the ones' complement of b. So, a and b quantify to what degree each circle can be considered a virtuous or vicious circle, respectively. It goes without saying that by adding the VIPs of the runned cycles (i=1,...,n) within an endless circle, we can get the current cumulative overall value of the innovation process (CVIP):

$$CVIP = \sum (VIP_i) \quad i=1,...,n \quad (2)$$

Since societies, institutions, business organizations and even individuals may be concerned with such values, the need for adapting the model to different point of views emerges. In the following, four perspectives - i.e. macroeconomic, institutional, socio-cultural and corporate - are briefly considered in order to better delve into the possible outputs of the CKI triangle model. At this aim the literature [42] REPUTATION INSTITUTE, 2010; [33] [34] [2] [41] provides us with a wide set of indicators that capture altogether both tangible and intangible outcomes from CKI dynamics.

Some outputs of the CKI triangle model are now going to be discussed, grouped by perspective, by using for the sake of argument a limited subset of such indicators.

1.11 Macroeconomic Perspective

The macroeconomic perspective helps inquiring about the incremental value CKI relationships may bring to countries, regions and similar socio-economic aggregates in terms of wealth, technology, wellbeing of citizens, infrastructures, public and private services, etc. For example, leveraging effectively the CKI triangle model may lead an internationally open economy to growth, at the same time escaping the risk of being cut off from the global economy, thanks to its ability to trade innovative products abroad [45] [8] [10]. In this case the incremental value to companies, workers, citizens, etc. could be measured in terms of the contribution of innovative products to percent variation of Gross Domestic Product (G.D.P.), percent variation of Export and percent variation of balanced trade as a ratio of G.D.P.

1.12 Institutional Perspective

This perspective helps analyzing the overall coherence and the results at any level (e.g. international, national, regional, urban) of investment policies in creativity, knowledge and innovation. For instance, globalization paradoxically fosters the relevance of national and regional dimensions of economic systems and their local diversity. Coherently, cultural diversity should be encouraged by governments as a fundamental basis for socio-economic development and growth [7] [6]. As a consequence, while taking decisions about local infrastructures and governmental policies, institutions should shape the innovation capacity of those areas characterized by a common cultural background and a geographical proximity [25] [11] [20]. In this case, the incremental value to transnational, national or regional economic systems (and indirectly to companies and citizens) could for instance be measured in terms of general expenditure (G.E.R.D.) and business expenditure (B.E.R.D.) in R&D in those areas.

1.13 Socio-Cultural Perspective

Innovation process may provide individuals or groups of individuals with an incremental value in terms of a higher satisfaction rising from wealth redistribution, environmental sustainability, digital divide reduction, job enrichment etc. [46] [26]. For instance, from a cultural point of view, citizens' satisfaction may depend on the influence of creativity and knowledge resources localized in their own region/country (William and McGuire, 2010). In fact, being aware of the importance of learning and being absorbed with a culture of talent promotion people tend to be more creative and avid in pursuing knowledge by having a better schooling and developing more competitive skills to be spent in the labour market [46]. In this case, the graduates/labour force ratio and the percent variation of unemployment rate, by indicating how many and how competitive are the skills gained by people, may for instance provide some information about citizen's satisfaction especially if confronted with the variation of the "Creative Class Index" which measures new creative and knowledge-based tasks required by innovation processes thus giving an idea of job satisfaction opportunities [41].

1.14 Corporate Perspective

When we refer to business companies, their own incremental value can be expressed in terms of profits, market share, capacity to further invest in innovation etc. By the way, in a corporate perspective, performances should be taken into account also in terms of incremental value to workers, suppliers, customers, shareholders, potential investors, competitors, institutions, etc. From this point of view, the percent variation of innovation turnover may help to quantify the improved capacity of the company to pursuit a non-ephemeral competitive advantage. Innovation may also impact positively the power of the company in terms of percent variation of market share. Finally, since innovation may have a socio-cultural effect the innovating company could have a positive fallout by increasing its public perception which can be measured by the Corporate Social Responsibility Index [35].

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SECTION II

CHAPTER 2

KNOWLEDGE-BASED INNOVATION STRATEGIES IN THE AUTOMOTIVE INDUSTRY: SOCIAL RATING AND REPUTATION MANAGEMENT SYSTEMS FOR A MULTINATIONAL COMPANY [97] [98] [99]

2.1 Introduction

This chapter is the result of the analysis of methods and techniques of Social Rating and Reputation Management as part of the design of an Enterprise 2.0 solution for a multinational company operating in the automotive industry.
It aims at providing a thorough analysis of the following areas:

• analysis of the state of the art in terms of methodologies and tools of Social Rating and Reputation Management, with particular reference to rating approaches, Reputation Management models, classes of Reputation Computation Engines and Trust & Reputation Systems;
• mechanisms of Social Rating and Reputation Management in the Web 2.0 context, also by deepening the principles behind them;
• analysis of the impact of the implementation of such methods and techniques within the specific business context;
• analysis of statistical techniques and social issues related to systems based on the principles of the Bayesian inference and the Eigen Trust Algorithm;

In particular, this chapter aims at carrying out some research results related to the accurate definition of the state-of-the-art tools and models of Social Rating and Reputation Management related to the contexts of Enterprise 2.0 and Enhanced Enterprise 2.0.
In addition, it is based on the deepening of:

• the impacts on technology, culture and organization concerning with the introduction of mechanisms mentioned above, so that they are able to provide a stimulus for the Knowledge Sharing and support the creation of innovative systems of recognition and reward in business contexts;
• the structuring process of an advanced system geared to manage corporate knowledge as a whole;
• the assessment of the contributions generated by individual users and the company's total knowledge assets;
• the design and operations of an innovative reward system;
• the matchmaking for a dynamic human resource allocation on projects/processes, the reduction of time and costs of registration and/or training of resources and an increased ability to attract and retain talent within the company;
• statistical techniques and social issues related to systems based on Bayesian inference and Eigen Trust Algorithm, its mathematical models, potential benefits and possible problems;
• the contextualization of these methodologies and techniques in the automotive industry.

In order to achieve such results, the following activities have been carried out:

• analysis of issues related to methods and tools of Social Rating and Reputation Management;
• study of mathematical and statistical theories underlying mechanisms of social rating and reputation management;
• deepening of the backgrounds and the different approaches behind Social Rating models Reputation Management criteria, classes of Reputation Computation Engines and Trust & Reputation Systems;
• analysis of the impacts from the technological, organizational and cultural mechanisms related to the introduction of the above points within a multinational company in the automotive industry;
• study of the technical and social statistics, especially those related to the principles of the Eigen Trust Algorithm and the Bayesian inference;
• overall analysis of the mechanisms of Social Rating and Reputation Management in the automotive domain.

2.2 Objectives

The objectives of this work are geared to examine some of the emerging patterns in the economics of social networks, in particular the issues of Reputation Management and Social Rating.
In particular, we want to define and illustrate some of the methods and techniques most commonly used for the rating of contributions and the reputation management in today's business environments with the aim to provide a stimulus for the Knowledge Sharing and support the creation of innovative recognition and reward in business.
These elements are related to:

• the achievement of the objectives of the project. The areas related to the satisfaction of the predetermined purposes are: the structuring of a system for the management of knowledge; incentives to Knowledge Sharing; assessment of the contributions made by individual users, and knowledge of the company's overall wealth of knowledge; the support to the design and operations of an innovative and rewarding matchmaking for dynamic resource allocation on projects/processes; the reduction of time and costs of registration and/or training resources; the increase in the ability to attract and retain talent, and social and environmental sustainability;
• the design and implementation of such a platform to overcome the different and multiple barriers (technological, organizational, cultural, etc.) present both at the corporate and the individual level.

2.3 Business impacts of Social Rating and Reputation Management

The focus on this type of topics is motivated by the fact that reputation management systems are playing an increasing role in business contexts by impacting even in the economic and financial fields [13]. In particular, the salient aspects concern with:

• the definition, procurement, storage, explicitation, management and exploitation of knowledge within the company, to be intended as a set of activities aimed at increasing productivity and/or the generation of innovations;
• the campaign to support the activities of sharing and dissemination of knowledge [17] in the organizational realities, in order to eliminate waste of resources of various kinds, avoid the generation of repeated and independent expertise, best practices, etc. in different areas within the company or the individual function/division;
• the systematization of the assessment process of cognitive contributions made by the individual to the organization and, as a consequence, the assessment of the knowledge accumulated over time by the company or that one generated in the current financial year. This process must necessarily possess a strong collaborative, user-driven and bottom-up connotation;
• the definition of a reward system based on social methodologies and techniques that complement, integrate and, if necessary, correct the traditional mechanisms already existing within companies and organizations [22]. About it, there is also the opportunity to customize recognition and reward systems based on the information of user profiles obtained from the methods and techniques adopted;
• the definition and use of innovative matchmaking for allocation of human resources on projects/processes within the company;
• the time and cost reduction inherent to the process of integration of new human resources, as well as the facilities in terms of meeting the aspirations of growth [21; 16], which characterize the typical profile of the "knowledge worker" (increasing, in addition, the effectiveness of policies for talent retention);
• the increase in terms of competitiveness and the need for continuous professional development of human resources (e. g. taking some aspects of the Lifelong Learning model);
• the need to associate the significant resources invested in enterprise technologies with an intangible semantic value, which promotes the spread of a new organizational philosophy and provides a telling example where the single "knowledge worker" is fully involved;
• the objectivity, measurability and transparency of reputation management and social rating mechanisms, in order to promote gender equality, environmental sustainability [37; 15] and the lifestyle of the average "knowledge worker" [11; 12].

Ultimately, such a strong interest in Reputation Management and Social Rating is also related to the increasing portion of the organizational realities that use or are approaching the use of the basic concepts of the so-called "Web 2.0" (e. g. Amazon.com and Digg.com).

2.4 Basic concepts and criticisms

Ratings and reputation are two complementary aspects that are implicated mainly to realize an assessment of corporate reputation, credit risk or content authors/providers.
One of the salient aspects of the concept of Social Rating is given by the characteristic of being an open and very adequate system for the purposes of the typical collective assessment. While this feature leads to better adherence to the policy of the model of Security 2.0, it also raises the need to overcome some limitations [8], such as:

• the increased influence by users who publish content in greater quantities, regardless of the actual quality of the latter;
• the penalization of content published recently if compared to the older one, always regardless of the actual quality of the latter.

These objectives can be achieved solely by integrating and possibly correcting the traditional systems of social rating and reputation management of users through the use of hybrid models that combine purely statistical and social aspects.
Such a set of methods and techniques is ultimately a real multi-objective and multi-criteria subsystem. The combination of these different elements is resolved, ultimately, in a wide range of solutions, which tend to be diverse and often complementary. For instance, we can analyze solutions based on different systems such as:

• thumbs up/down: the rating is dichotomous (positive in case of thumbs-up, negative for thumbs down);
• star rating: systems in which the satisfaction level is expressed by values typically, but not necessarily, placed on a scale, and defined on a narrow range of integers associated with scale symbols (e. g. stars). The scales generally cover the following intervals: [1,3], [1,5], [1,7] and [1,10];
• feedbacks, reviews, discussion: forum in text format by which you can provide, receive, share and interact on specific content with other users.

In particular, Social Rating provides the tools to measure and assessing the reputation of human resources where the content comes from. Based on these assessments made by users the rankings of relevant information can be realized and grouped by set of resources based on different criteria specified by users [8] as it is shown in Figure 4.

FIGURE 4: EXAMPLES OF OUTPUT FROM SOCIAL RATING & RANKING SYSTEMS [8].

In detail, the linchpin any system of Reputation Management and Social Rating is based on is the fact that the higher the level of reputation of a resource, the more reliable the set of information and knowledge that can be drawn from this.
However, the partial failure of many of the current rating systems is intimately tied to the scarcity or absence of elements such as [22]:

• customization: the rating and reputation management system must have the ability to aggregate and summarize the feedback of individuals with a high degree of similarity to the user who creates or provides the content (or to the user making a search for objects that interest him according to specific criteria defined by this ranking);
• context: as part of the systems of Reputation Management, reputation of a user is strongly influenced by the specific area of interest referred to by the content (or ranking) currently assessed (or involved in the process of aggregation and synthesis of the evaluations made by similar users as it is described in the paragraph immediately above).

The implementation of these features allows you to meet the growing need of users to have access to information and knowledge that are not just relevant, but above all, reliable, overcoming the system of so-called "global reputation measures", i. e. those metrics used to estimate the level of user reputation not giving due consideration to the above mentioned problems of contextualization and personalization. In particular, this demand can be met through those systems which incorporate the concept of Collaborative Filtering [14] and implement it in a large organization, whose performance in the context of the emerging techniques for social reputation management are validated by large numbers of users [22].

2.5 Rating approaches and reputation models

Rating and reputation, as already mentioned in the previous section, are two important elements for the proper performance of the activities of identification of content authors/providers, and are not used, therefore, solely to resolve issues related to the quantification of credit risk or the assessment of corporate reputation.
To further emphasize the importance of these issues is sufficient to refer to the increasing speed with which scholars make space to them, in the social field as well as in purely corporate social networks. In fact, the methods and techniques of social rating refer to a system having a certain degree of openness and lending itself to the emergence of the assessments made by the community as a whole, in full compliance with fundamental aspects of the Enterprise 2.0 model.
Systems of Social Rating and Reputation Management, if contextualized to a particular business reality, and eventually to a network of its stakeholders, primarily seek to reward authors with the best reputation and to provide a model of functional ranking in search of the best content available. However, the fact that the above mentioned systems are strongly related to the specific field of application implies the existence of a significant variety of models whose characteristics largely depend on the context and the target of the particular requirements relating to it.
By analyzing the different rating systems, it is possible to classify them according to two approaches [61]:

• binary or single criterion rating systems: users express a synthetic evaluation and, thereby, only an overall assessment with respect to a particular event or content or to another user. This makes the evaluation less accurate and reliable than in other systems;
• multi-criteria rating systems: users express evaluations of various aspects increasing the overall accuracy and reliability of the information.

The rating given by users of a system is the basis of the calculation of the reputation of an object under evaluation. First, it is necessary to distinguish between simple and complex (or combined) models of reputation [62]:

• simple: they are focused on key elements such as counters, accumulators and "likes". The simplicity of such models sometimes involves a high degree of inaccuracy of reputation. However, their adoption in certain contexts can be particularly useful: many online systems, in fact, adopt this kind of models in the early stages since they are adequate for the basic needs emerging during the launch of the business. This shows, among other things, a high degree of dependence on the application context (context dependency);
• combined: many advanced systems have the need of using particularly sophisticated models of reputation. Therefore, it is increasingly common that within a given system is introduced an aggregate model that contains two or more simple models to cover different aspects and provide, therefore, a more accurate assessment.

Ultimately, the choice of the class of models of reputation to be taken must be related to contingent and contextual characteristics such as, for example, business goals and/or values, and the parameters of the target communities.
The following provides an overview of simple models widely used in various real-world settings [62]:

- Rating-based models provide a synthetic assessment explicitly expressed by a user with respect to a particular attribute (quantitative or qualitative) of the interaction or the interaction itself as a whole. The set of rating on a specific target is typically aggregated to obtain the average value provided by the community. The possible scales used in this context include:

    • star rating: assignment of stars on a default scale (usually 1 to 5 stars);
    • bar rating: assignment of a value represented on bars;
    • "HotOrNot": one of the pioneers among rating systems. It allows you to cast a vote on the photos of other users.
    • 1-10 scales: scale from 1 to 10 to be assigned to the target;
    • Likert scales: a psychometric scale initially used only in research, particularly in questionnaires. It is based on the adoption of predefined levels of response on the basis of n, where n is an integer;

- Points: it is a model suitable for systems that require a very thorough analysis of users and their activities and characterized by multiple levels of granularity. These activities are logged, they are associated with a weight and then scores are assigned. We consider the views, the average time spent, the number and type of pages viewed per visit, returns to the page and/or on the website (rebounds), bounces, etc.. This kind of reputation models is affected by two alternative problems that often occur:

• excessive closure about the underlying mechanisms of the Reputation System: an approach of utmost closure would be likely to reduce the level of the overall trust of the community because of the low level of communication and transparency that is perceived by users;
• excessive openness in disclosing the underlying mechanisms of the Reputation System: a detailed breakdown overly favors bad users making it easier to analyze and eventually dismantle the entire system. Furthermore, instead of improving the experiential factor for users, this will influence/direct users towards decisions made (totally or partially) as a function of the weights and the scores disclosed. Ultimately, this leads once again to forge the reputation scores obtained and reduce the confidence of the entire community;

- This or That Voting: in this model, the voting system is based on the comparison of user-driven target entities, which can make a judgment on the attributes of accuracy, usefulness and attractiveness. One of the main features of the voting system is the fact that the user can only express an opinion with respect to a limited set of target entities to assess. This shows a completely different perspective than that of the rating systems described above, since in those cases the default set limits the scale of the vote, and not the set of objects evaluated. The limitation in the number and variety of possible comparisons makes the system easy to use, but also useful in combination with other reputation models ensuring more accurate information for each attribute;

- Reviews: in contrast to systems like This or That Voting, it enables the user to perform a specific assessment for each target element using both quantitative rating and opinions rendered in text form. This feature allows users to capture multiple shades for each attribute of the entity target, while making more complex the reputation model. This complexity is then reduced by means of a synthetic judgment drawn up on the basis of judgments relating to the various attributes;

- Favorite and Flag: this class of models provides the opportunity to exploit a strong control of the community towards extraordinary assessments. These evaluations can be identified thanks to the determination of specific thresholds (upper and lower bounds), defining a range within which it is permissible to consider as normal the reputation scores obtained. The anomalies that fall outside of this range may be due, alternatively, to scores that go beyond the upper bound or remain below the lower bound. In addition, a model constructed in this way also facilitates the emergence of target entities particularly relevant for their quality as well as those characterized by a low value provided to the user, respectively. From the operational point of view, the model considered can include both explicit votes and implicit actions such as, for example, sharing or marking as a favorite a target content. These elements form a control system which is beneficial to the entire community of users and can also use a simple counter to aggregate the recorded actions and determine a synthetic judgment. However, there are three possible variants by which it is possible to differentiate the standard model:

• Favorite: in this case a counter quantifies the number of times the content is marked as preferred by the community. This mechanism is based on the assumption that an action of bookmarking facilitates and promotes the recovery and reuse of the content and, therefore, helps to increase the value of the network of users as a whole;
• Vote to promote: the user promotes a specific content within a set submitted to the judgment of the entire community of users. Like the bookmark in the case of the favorite, a promotion is calculated as a vote in favor of the content to which it is attached. This leads to a greater visibility of the target entity characterized by a higher quality in the opinion of the community. It also provides an added value to users by classifying their content through an open model of ideas development (crowdsourcing). However, this open approach in the voting system is proposed also in the varying set of contents to be rated. This last feature is an important element distinguishing this model from This or That Voting;
• report abuse: unlike all those presented above, it is a rating system whose purpose is to identify the negative elements of a specific content. In particular, this model aims to identify and report to the community contents with mistakes. From the point of view of the mechanism underlying the model, a counter sums all abuse reports from users related to each content. This mechanism is very similar to the two previous variants of the favorite and flag class: the main difference lies in its "negative" approach directed to identify target items with incorrect contents, and not to reward the high quality ones. Some more advanced systems integrate this variant with the thresholds, related to the individual user or to the type of content, above which the level of abuse is no longer considered acceptable by the system. At this point can be taken three actions:

a) complete removal of the reported content;
b) classification and insertion in a particular category of content (for example the one for adults);
c) placement in a specific queue of all the content that should be further analyzed by the experts.

However, such reports of abuse only take into account the evaluations of the contents, but does not address another relevant problem, that is the reputation of reporting users;

- Karma is a simple model typically integrated into systems that make use of other types of reputation models. In fact, it aims to encourage, develop and record user activities within the community. In addition to the evaluation of all actions the reputation of the user depends on, it is used also for other purposes such as, for example, the calculation of the reputation to determine the ranking in search engines or to highlight the best content. As in the case of the favorites and flags model, there are some differences in the general model, including:

• karma based on quality: the basic mechanism focuses on the assessment of the level of quality associated with the content. The quality grade is determined by aggregating the assessments made by the community;
• karma based on participation: as in the case of the models favorites and flags, the participation Karma uses a counter that quantifies the number of actions taken. Each action has a specific score that is in turn combined to obtain the total value;
• negative karma: the model is also known as "strikes" and is based on the same principle of participation karma, but its approach is "negative", as in the case of the variant report abuse of the favorites and flags. In fact, it penalizes bad actions of users;
• robust karma: this variation is the result of a combination of karma based on participation with the one based on the quality of the content. In this way it is possible to overcome some problems due to the excessively narrow perspective of the two models mentioned above. The participation karma tends to reward only those very active users, but does not consider what is their actual contribution in terms of added value to the entire community. The simple activities covered by this mechanism does not fully grasp the concept of reputation, or rather reduce it to mere quantitative aspects. Similarly, the quality score karma tends to highlight only those who fear ruining their reputations or their rankings and, for this reason, it is limited to provide only contributions of a certain quality and/or intervene on issues that provide increased security. By extending the time horizon, such a behavior takes the user with a high reputation to interact less and less and to reduce the added value for the community. The solution proposed in the robust karma is to integrate both the models mentioned above to determine the total value of users contributions, deriving their reputation and resolving critical issues. The weights of the factors of participation and quality are typically assigned based upon the specific application context. Ultimately, it is a built-in incentive mechanism so that users publish high-quality content and do so more often. Another option to consider for the more advanced systems is to provide a higher level of service to users better positioned in the ranking. It is also important to note that the eventual adoption of the model within the robust strike karma would also identify and report to the community the agents who commit acts of abuse and reduce the value of the network and its contents, discouraging this behavior .

2.6 Classes of Reputation Computation Engines

In this paragraph a review of the state-of-the-art models in literature is provided. They cover the different approaches and techniques in terms of mechanisms of Social Rating and Reputation Management.
However, in order to make the discussion more exhaustive, these models are first classified according to the type of Reputation Computation Engine they are associated to [61]:

1) Deterministic models (FIRE, PeerTrust) [63; 64; 65] are based on a composite metric that includes multiple parameters and then aggregates them and gets the trust value (e. g. credibility of witnesses, reputation information, youth of judgments, transitivity

rate, context similarity rate, criteria similarity rate, etc.). This approach also provides the possibility of a dynamic update of the level of credibility of witnesses also through the use of an error threshold. In detail, this threshold is compared to the difference between the performance of the most recent interaction and the degree of reputation information previously achieved. Whether such a threshold was achieved or not in the last update, the content provider loses or gains credibility. In order to give a generally valid formalization, we adopt the following mathematical expression of trust referring to the user w (T (w)):

$$T(w) = k * \sum_{i=1}^{I(w)} A(w,i) * FT\big(o(w,i)\big) * TC(w,i) + z * C(w)$$

where:

- w is the generic user for which the calculation of the metric is performed;
- I (w) is the total number of transactions carried out by the user w with other users in a given time interval;
- o (w, i) are all other users in the i-th user transaction of w;
- A (w, i) is the normalized overall level of satisfaction that the user w receives from o (w, i) in the i-th transaction;
- FT indicates the level of credibility associated with the feedback that w receives from other users;
- TC (w, i) represents the factor of contextualization relating to the transaction (adaptive transaction context factor) for the i-th user transaction of w. This factor takes into account the importance (or weight) of the transaction which varies, for example in the case of contexts oriented to online services and e-commerce, depending on the amount of money in the transaction, the given time or the functionality;
- C (w) is the factor related to the community (adaptive community factor), which considers information of a "community-specific" such as, for example, the willingness to provide feedback for the growth of the entire community;
- k and z are some weights.

2) Belief models (Yu & Singh's model) [66; 67; 68; 69; 70; 71]: based on evidence theory of Dempster and Shafer. It is a generalization that extends the Bayesian theory of subjective probability and is used especially as a method of approximation of the reasoning in the presence of a significant level of uncertainty. In particular, any matter of interest is associated with a certain degree of confidence (or opinion), said "degree of belief", that does not necessarily equate to a level of probability. In fact, the underlying theory includes a kind of "third degree of truth" that makes it impossible to find automatically a mathematical relationship between the probability relative to a given hypothesis and that associated to its negation. Therefore, the sum of the degrees of confidence, in general, will not be equal to one and, therefore, this model also

considers a certain range of values associated with uncertainty. Further contextualizing this approach to the case of open environments, a content provider characterized by uncertain reputation is not treated as one with a low level of reputation, as it would occur by adopting many of the traditional approaches related to probability theory. Below we recall the formal definitions of the theory in question.
We consider:

- Ω as a finite non-empty set of events mutually exclusive and exhaustive;
- 2^{Ω} as the power set of Ω that includes all its subsets, $A \in 2^{\Omega}$, including the empty set and also Ω.

The function

$$m: 2^{\Omega} \mapsto [0; 1]$$

is defined as the basic probability assignment (bpa) if the following conditions are met:

$$m(\emptyset) = 0 \quad ; \quad \sum_{A \in 2^{\Omega}} m(A) = 1$$

The bpa associates to each subset A a degree of trust equal to m (A). Furthermore, the subsets A of 2^{Ω} is such that the corresponding m (A) are strictly positive and are called "focal elements".
They define as function of confidence (belief function) of the function Ω

$$\text{Bel}: 2^{\Omega} \mapsto [0; 1]$$

such that

$$\text{Bel(A)} = \sum_{B \subseteq A} m(B)$$

In conclusion, while m (A) calculates the exact degree of trust related to the subset A, Bel (A) provides an assessment of its overall strength in terms of belief.
Furthermore, it is important to emphasize once again how this model is not strictly tied to concepts of probability theory. In fact, said x the degree of belief concerning a generic implementation, it does not automatically lead to quantify in 1-x the degree of belief of the negation of that particular realization. Being a belief not assigned (uncommitted belief), the one's complement of x, in general, is allocated to the set of possible events (frame of assignment).

3) Fuzzy models (REGRET) [61]: in this case the parameters considered are typically characterized by adopting fuzzy set based on scales of values associated with linguistic

expressions (e. g. bad, average, good in the case of the evaluation of opinions or information; short, average, long in the case of the recency of information), which are, among other things, affected by considerable problems of ambiguity of meaning. This approach is in contrast with the binary logic and allows to consider the many different aspects that it can not grasp. The fuzzy logic is based on the so-called "Membership Function" for which, considered a subset of elements of S, the value zero indicates a complete non-membership, the membership value of one represents a complete membership and the intermediate values a level of partial membership. Applied to the case of the Online Collaborative Systems, the use of fuzzy rules to represent the relationships between members of a community allows also to determine the degree of reliability. In order to define in mathematical terms the logic mentioned above, we can consider the following:

- the set I is defined as a fuzzy set of a non-fuzzy domain X if I is composed of pairs of elements. In particular, each pair contains a generic element x of X and a value contained in the interval [0,1] that indicates the degree of membership of x to I, with exactly one pair that contains each element of X. The zero value associated with the generic element x indicates its total non-membership in I, while the value of one indicates the opposite condition. It is intended that each intermediate value between the two extremes of the interval represents the membership degree (degree of membership);
- the membership function (membership function) of the fuzzy set I, M (I), is an extension of the crisp set in which the concept of membership is applied in a dichotomic way. Mathematically:

$$M_{(I)}: X \mapsto [0,1]$$

The function M (I) above, therefore, overcomes this dichotomy by assigning values t hat fall within the range [0,1]: the higher the value associated with the element x, the higher the level of membership to the fuzzy set I.

4) Bayesian models (TRAVOS, BRS) [66; 72; 73; 74]: being founded on probability theory, this category of statistical models is focused on the adoption of the probability density (Probability Density Function, PDF) of the beta function, completely defined by the pair of parameters (a, b). The latter representing, by the modeling point of view, the historical values of the positive and negative ratings, respectively. In this case, the reputation is calculated based on the expected value of a random variable having a beta density with parameters a and b. In addition, the PDF function allows a dynamic update of the rating level by aggregating the time series of scores and new assessments. The concepts expressed above can be formalized in mathematical notation as it follows:

$$f(x \mid a, b) = k * x^{(a-1)} * (1-x)^{(b-1)}$$

$$= \frac{x^{(a-1)} * (1-x)^{(b-1)}}{\int_0^1 u^{(a-1)} * (1-u)^{(b-1)}\, du}$$

$$= \frac{\Gamma(a+b) * x^{(a-1)} * (1-x)^{(b-1)}}{\Gamma(a) * \Gamma(b)}$$

$$= \frac{x^{(a-1)} * (1-x)^{(b-1)}}{B(a,b)}$$

with $0 \leq x \leq 1$, a, b> 0, where:

- Γ is the Gamma function, meromorphic and continue on all positive real numbers and such that $\forall n \mid n \in \mathbb{N}_0: \Gamma(n+1) = n!$;
- B is the probability density function of the beta function characterized by the parameters (a, b); that is $B(a,b) = \int_0^1 u^{(a-1)} * (1-u)^{(b-1)} du$;
- x is the realization of the random variable X.

2.7 Trust&Reputation Systems

After introducing the main categories of models that underpin the Reputation Computation Engines and providing for each a mathematical formalization of the basic concepts, here are analyzed in detail some of the main relevant and most frequently adopted models in the literature, which are used in many different contexts [61]:

1) PeerTrust model [75; 76; 64; 77]. It is a system of the deterministic multi-criteria category used mainly for peer-to-peer community in e-commerce contexts. It is essentially based on five elements:

    - feedback in terms of amount of satisfaction: judgment on a user provided by other users based on completed transactions between the parties. The value of the trust of a user with respect to this dimension of analysis is the sum of all feedback received by that user based on such transactions;
    - feedback brooms: total number of transactions the user is involved in. An even more advanced metric is the ratio between the total satisfaction and the number of made by that user;
    - credibility factor: level of honesty of the sources of feedback. In particular, the feedback provided by very credible users assumes a much greater weight than the feedback related to other members of the community;
    - transaction context factor: factor of contextualization related to each user's transaction. It is based primarily on the fact that the transactions differ from each other. In particular, estimates the weight of the transaction according to certain pre-established criteria (time, economic importance, functionality, etc.);
    - community context factor: "community-specific" factor about the problem of incentives for users to provide feedback geared to encourage the growth of the entire community. In addition, it can also play an important role in making the system more robust against possible fraudulent behaviors.

A first distinctive feature of PeerTrust is linked to the introduction of the transaction context factor that poses serious limitations to any bad intentions of some users and, in doing so, helps to increase the overall level of trust in the system. Ultimately, it is a valid mechanism for risk management in contexts such as, for example, those of the online community. It should be noted, in fact, that this factor gives rise to a valid mechanism for discouraging and control possible fraudulent activities implemented by users. In detail, these actions are typically hidden from the fraudsters users thanks to the increase in the volume of transactions. However, by combining the factor related to the importance of the transactions with the values of the feedback and the number of transactions made by the user in question, it is possible to intercept many fraud attempts and, therefore, to reduce the vulnerability of the system and increase the attractiveness for users.
In addition, the model also includes the measure of the credibility of the sources of information by comparing the rate of similarity of feedback (feedback similarity rate) of the evaluator user and that of other witnesses who express their ratings about the same object element of their previous transactions.
However, it should be specified that these systems can not guarantee the performance if they are characterized by a high level of participation of users in terms of rating provided. One possible solution to this problem is given with the use of the community context factor that has a function of reward (reward function) and aims to increase the propensity of users to evaluate the other members of the community.

2) FIRE model [63; 78; 79; 80]. This second system adopts a deterministic and multi-criteria approach based on the use of the following four components:

   - trust based on the interaction or experience: the level of trust that measures the direct experience of a user with other users;
   - testified reputation: reputation related to the direct observation of user operated by external parties;
   - certified reputation: it is the reputation associated with a user obtained from certified sources of evaluation;
   - trust based on the role: it focuses on the role played by each user in each specific relationship and also allows you to make predictions about the degree of reliability of future interactions.

   With regard to the credibility of the assessments, the system integrate the metric on witnessed and certified reputation with the tolerance threshold of the accuracy. If this threshold is exceeded, it is possible to identify and penalize proportionally users-witnesses or dishonest certifiers.
   It is also important to specify that the system uses a weight to each factor mentioned above in the composite metric and provides the possibility of a dynamic update function of the mutations occurred from time to time in the application context.

Furthermore, there is also a specific metric to evaluate the confidence level of a user about the expectations placed in another user. This metric considers two aspects:

- reliability rating: calculated by considering the number of available ratings that exceed a minimum threshold and are related to the object of evaluation;
- reliability of the deviation: in this case we evaluate the overall inconstancy of a user in completing a generic transaction by comparing the aggregate of the ratings obtained with the expected value.

In both cases the results impact negatively or positively on the overall assessment of the level of reliability considered user.
All these elements provide a continuous update of the FIRE model parameters, as well as a high degree of scalability and high dynamicity in order to cope with continuous changes in some contexts and, above all, the behavior of some members of the community. Consequently, it can be easily adopted in many contexts, also considering that, leaning on a wide range of information sources, it ensures an adequate level of reliability of ratings and credibility given by the sources themselves.
Despite these advantages, the model fails to provide an effective solution to the problem of discriminating behavior or preferential treatment that occurs when a user provides a rating totally different from the transaction actually occurred. The threshold of accuracy is not able to discern between an evaluation actually dishonest and inaccurate and another simply incorrect, since all ratings exceeding this threshold are automatically classified by the system as dishonest.

3) Yu & Singh's model [81; 67; 69; 70; 82; 83]. It belongs to the class of multi-criteria Belief Models and is one of the most innovative model that underlies different network systems where trust (Trust Networks) is calculated. It refers to contexts such as those based on Multi-Agent Systems. In particular, it takes into account two main aspects:

   - Local opinion: the overall degree of belief of an agent of the system is seen as a function of the interaction with other members. Ultimately, it indicates the ability to act in order to inspire confidence to other users (expertise);
   - opinion based on evidence: the global belief is calculated based on the assessments made by third parties. Concerns the ability of the agent of socialization (sociability).

   The two levels of belief are then aggregated into a composite metric with the use of appropriate weights for the two components.
   The model predicts the existence of a set of acquaintances (acquaintances) within the Trust Network surrounding a given agent. A particular subset of these acquaintances is that of its neighbors.

Operationally, the system allows an agent wishing to know the degree of confidence to put in another member of the community to specifically request the degree of belief in each of its neighbors. The latter can provide feedback as members who have interacted in the past with the agent to be evaluated or as witnesses of transactions that occurred in the past. In the case where they play the role of witnesses, the credibility of the evaluation and its source, and the efficiency in research references are guaranteed by two parameters:

- depthLimit: factor determining a threshold in terms of exploration in the vertical dimension (depth) of the network of neighbors to whom evaluations are requested;
- branching factor: parameter that establishes a threshold in terms of horizontal exploration (branch) of the network of neighbors to whom evaluations are requested.

In any case, the search process ends at the achievement of a significant quantity of references or if the maximum threshold for the two parameters specified above is reached.
In the case of the new users (newcomers) there is a known issue that is the "bootstrapping", i. e. the initial uncertainty about the determination of the degree of newcomers reliability: the solution provided by the model is to exploit the underlying logic to credibility theory to discriminate agents with a bad reputation from the new entries, whose reputation is not defined a priori.
In addition, the system also provides the ability to capture and penalize three distinct types of deceptions perpetrated by agents to damage the entire system. They are classified according to the patterns of behavior of evaluators (rater):

- complementary: "complementary reception" indicates the behavior of a rater providing consciously highly questionable evaluations;
- exaggeratedly positive: it is a behavioral model based on falsehood, since the rating provided significantly exceeds the level of satisfaction of real-raters. Typically, these actions are positively influenced by a commission otherwise undue;
- exaggeratedly negative: it is the opposite situation to the one immediately above, where the commission can be seen, for example, as the advantage taken by the harm done to others by assigning an unjust negative evaluation.

4) REGRET [84; 80; 79; 85; 63; 81]. This system is an instantiation of Reputation Computation Engines based on fuzzy logic. It provides the ability to manage the rating and reputation systems in particularly complex contexts within e-commerce businesses through the use of models that consider the social relations in terms of transactions, cooperation and competition, called "sociograms". This system, like its

predecessors, is based on a multi-criteria approach to rating activities and considers the following three aspects:

- subjective or individual reputation: primarily based on direct experiences reported by users for a given object under evaluation;
- social reputation: estimating the degree of confidence in the system if it is not provided a sufficient basis for ratings referred to the agent to be evaluated or when the latter came just to be part of the community. In detail, there are three different sub-categories of information sources such as:

  - ✓ reputation of the witnesses: the witnessed reputation taken into account is provided by the nodes of the sociogram adjacent to the agent to be evaluated;
  - ✓ reputation of neighbors: the reputation level of neighbors is used as an indirect indicator of the reliability of the agent considered;
  - ✓ reputation of the system: it takes into account the overall reliability at the system level.

    The three sub-categories provide some criteria complementary to subjective rating and increase the accuracy and credibility of the assessment as a whole with extended benefits to the entire community of users. Moreover, the identification of witnesses is done by special fuzzy rules that associate to each witness a precise degree of honesty and credibility.

- reputation-based ontological dimension: it consists of the combination of multiple elements in a single aggregate metric underlying the calculation of the reputation. In fact, the two previous factors (individual and social reputation) pertain to specific issues and, if used separately, can not give indications of the overall rating.

Like the FIRE system, this model also provides a metric to calculate the confidence level of reputation through the aggregation of the total number of expressed ratings and their variability.

5) BRS [72; 86; 87; 88; 89; 90]. The Bayesian Reputation System (BRS) enables alternately both rating approaches (single criteria vs. multi-criteria), providing, therefore, a flexible solution applicable to different contexts also based on the desired level of accuracy.
   The multi-criteria variant sets the stage on the probability density function of Dirichlet (Dirichlet Probability Density Function, DPDF): scores are calculated based on the reputation obtained through a set of rating levels predefined by the system. The Reputation Computation Engine uses, therefore, the classical theory of the Bayesian

inference and the rules of combination of multiple observations. The DPDF is defined mathematically as:

$$f(x_1, \dots, x_{n-1}; k_1, \dots, k_n) = \frac{\Gamma(\mathrm{K})}{\Gamma(\mathrm{k}_1) * \dots * \Gamma(\mathrm{k}_n)} * x_1^{(k_1-1)} * \dots * x_n^{(k_n-1)}$$

where:

- K and X are two vectors of parameters whose values are strictly positive real numbers (k1, ..., kn> 0 and x1, ..., xn-1> 0) such that n ≥ 2 and that x1 + ... + xn = 1, or xn = 1 - (xn-1 + ... + x1);
- B (K) is the beta density function introduced earlier that, in this case, is parameterized on K.

Dirichlet's function indicates the degree of belief that the probabilities of n alternative events between them are equal to x_j with each event observed K_1-1 times.
It can be observed that the DPDF represents the multi-dimensional version of the beta density function. This difference implies an inability to grasp more accurate assessments, unlike in the multi-criteria case, where specific ratings can be provided and are associate with each of the considered aspects. Such considerations will, consequently, lead to a high degree of uncertainty and unreliability of the scores associated with the reputation, also due to inability to distinguish between polarized ratings and ratings converging towards a mean value.
In addition, the Bayesian model can overcome the problem generated by the presence of endogenous agents, intended as external agents that are outside the control of the system, but they can influence the level of reputation. To ensure the dynamic of updating of the sensitivity of the system in response to these changes, two thresholds are used (upper and lower bound). This makes it possible to identify and exclude raters whose probability distribution of ratings is characterized by a significant deviation compared to total assessments received by the agent in question.
An additional factor provided by the system is the longevity factor (longevity factor) that assigns a weight to each rating in proportion to his youth and, beyond a certain threshold, it ceases to be considered as a computational process of the reputation level. This aspect makes the BRS system easily upgradeable and highly dynamic if compared to many other models currently existing.

6) TRAVOS [73; 66; 90; 74]. As in the case of the BRS, it is focused on the approach of the typical computational Bayesian systems. It also uses a rating system to single policy. The main application context is that of virtual organizations with very large user community in which it is necessary to ensure a high quality of relationships. Two factors are considered:

    - direct interaction: the element of greater weight in determining the level of trust as it is considered more reliable. In this regard a special metric is adopted to assess the level of confidence with which it is possible to determine whether

the direct interactions alone guarantee a reliable overall assessment or if it is necessary to resort to alternative information sources;

- demonstrated experience: the alternative source to which the model gives the highest level of credibility after that related to the direct interaction. This factor intervenes if and only if the confidence level reveals that a base of ratings pertaining to direct interactions is not sufficient to ensure the reliability of the assessment.

From the point of view of the accuracy of reputation, the system is equipped with a system that bases the assessment of the reliability of a given rating issued by a user on the analysis of the overall credibility of its assessments made in the past. Unlike most systems considered, it avoids, therefore, to use as a discriminating factor the deviation from the aggregate result of the ratings given by other users. Operationally, it is rebuilt the time series of ratings expressed by a specific user. Next, you build the beta distribution of the user's current rating, and calculate the corresponding expected value:

$$f(x) = \frac{x^{(a-1)} * (1-x)^{(b-1)}}{B(a,b)}$$

where:

- x is a generic realization or observed value of the stochastic process X;
- a, b ∈ [0,1];
- B (a, b) is the probability density function of beta, already introduced in the context of Bayesian models, which is parameterized on a and b.

2.8 Multi-criteria social-statistical rating techniques

Collaboration and knowledge sharing in business contexts are some of the key elements of the new competitive paradigms, as well as an emerging and more and more relevant trend in society.

In this perspective, the set of methods, techniques and tools used in the field of Enterprise 2.0 covers a wide range of potential scenarios. However, in order to provide appropriate techniques to the specific design scenarios, it is necessary to take into account the methodologies covering both social and purely statistical aspects with reference to the mechanisms of Social Rating and Reputation Management.

To this end two models are shown below and analyzed in detail. The basic principles and problems are also discussed, as well as the benefits associated with them:

• a model based on Bayesian inference, proposed by Mui, Mohtashemi, Ang, Szolovits and Halberstadt and developed in the Laboratory for Computer Science at the Massachusetts Institute of Technology (MIT) in the United States [22];

• the Eigen Trust Algorithm, introduced by a research group from the Stanford University [60].

2.9 A model based on Bayesian inference

The model proposed in Mui, Mohtashemi, Ang, Szolovits and Halberstadt [22] can be easily transposed (with minor changes) in the systems of Reputation Management and Social Rating & Ranking within the automotive company.
In particular, A and O are two sets: the first one contains all the users of a Social Rating system and the second one includes all objects (items) to be evaluated (also users are considered as items, i. e. $A \subset O$):

• set of users: $A = \{a_1, ..., a_{|A|}\}$;
• set of items: $O = \{o_1, ..., o_{|O|}\}$.

The rating ρ_s expressed by any user, i = 1, ..., | A |, for the object o_k, k = 1, ..., | M |, is modeled quantitatively using a "probability-like" scale defined in [0,1], which is a subset of $\mathbb{R}$:

• Rating: $\rho_s: A \times O \rightarrow [0,1]$.

However, a user is able to express an evaluation on a certain item in O only when a trigger event occurs, i. e. the matching between the request for rating by user i-th and the actual reception of a response by user j-th:

• Trigger event: $d \in D = A^2 \times O \times [0,1] \cup \{\perp\}$

where $\{\perp\}$ is the set of triggers that do not occurr.
At this point the concepts of "contextualization" and "customization" come into play, in order to enable the innovative systems of Ratings&Reputation Management to overcome several limitations such as: the limited/absent use of customization and contextualization techniques; the criminalization of the latest contents; the greater weight exerted by the influencer.
In particular, the subscript s of each rating ρ_s must be replaced by a set of three subscripts (i, k, j), where i and j represent the users' subscripts i and j, respectively, and k is the subscript related to the specific item to be evaluated. Ultimately, we have the following representation:

• Rating: ρ_{ikj}.

From the operational point of view, before expressing an opinion about an item and interacting with user i, which is requesting a rating, user j aims at knowing the ratings given by other users on that specific item. If the sum of the ratings at the end of that investigation is above a certain threshold, user j expresses his/her own judgment. The reputation of the requesting user i is intended as a sort of indication about the probability that in a trigger event

in the future his/her own assessment is approved by the evaluator user j within the specific context of reference s-th. (uniquely identified by the triple subscript i, k, j).
In addition, each context is characterized by certain attributes:

• attribute: $b \in B$ and $b: O \rightarrow \{0,1\}$.

The set of these attributes is defined as:

• set of attributes $B = \{b_1, ..., b_{|B|}\}$

A particular context is represented by the power set of B, being therefore defined as:

• context: $c \in C$ and $C = 2^B$.

where 2^B is the power set of B.
Therefore, the reputation is defined as:

• Reputation: $R: A \times A \times C \rightarrow [0,1]$.

Then, in this model reputation is (possibly) modified only by means of interactions with the object placed under evaluation or interactions with other users of the system.

2.10 The Eigen Trust Algorithm

The Eigen Trust Algorithm is an algorithm designed to address a number of issues that arise in networks devoted to information distribution and sharing. In particular, it was originally designed for file sharing in peer-to-peer contexts. The main features of such systems are: scalability, robustness and variety of available data, the anonymity and the open nature of the network. The last two items involve a complete lack of accountability for the contents that a user spreads through the network and, therefore, provide an ideal environment for self-replication of files that are not authentic [60]. A practical example is given by the uncontrolled spread of certain viruses that self-replicate in users' client devices or damages caused by malicious peers' files based on the use of inauthentic "bait" [58].
In this context, it is essential to minimize the number of untrustworthy file downloads. To this end, the algorithm calculates users reputation based on the history of files they uploaded. This makes it possible to identify users guilty of misbehavior (hereinafter malicious users or malicious peers) in the network.
Even in the worst case in which more malicious users agree to overthrow the system (i. e. malicious collective), this algorithm provides a valuable tool to identify the entire group and minimize the damage.
Since the development of these networks is highly dependent on the availability of new methods for users geared to obtain reliable information about the quality and authenticity of resources [45], an attempt to identify directly the malicious peers rewards much more than capturing untrusted files. In fact, the malicious users can easily generate an unlimited number

of files aimed at damaging the global trust of the network [60]. Thus, the goal is to minimize the likelihood that users remain active in the network and continue to reap the benefits. This can be done by assigning each user a unique global trust value reflecting the experiences he had with all other network users: in this way it is relatively easy to detect and isolate malicious users from other users showing a standard behavior.
In summary, there are five key issues that must be addressed with regard to Reputation Systems associated with this type of networks [60]:

- self-policing. The ethics shared by all users must be defined by the users themselves and not imposed by the central authority;
- anonymity. Users must have a reputation attached to a so-called "opaque identifier" (e. g. username), rather than to the real identity of the user;
- no profit to newcomers. A good reputation can and should be obtained only through actually positive and worthwhile behaviors within the network. Therefore, malicious users with low reputation should not be able to benefit even by changing their "opaque identifier" and to obtain any advantages due to the status of newcomers;
- minimal overhead. Commitments in terms of storage, computation, infrastructures and the complexity of the messages must be minimized;
- robust to malicious collectives. The system must be able to deal with this problem if there are groups of people who know each other and act to subvert the system.

2.11 Basics components of the Eigen Trust Algorithm

In a generic reputation system, each user has the opportunity to express a rating on all others with which it has carried out a transaction. The sum of these ratings is the overall reputation of each user [48].
Whenever the i-th user enjoys a content uploaded in the network by the j-th user, user i has to provide an assessment of the transaction, indicated by tr (i, j).
In particular, tr (i, j) is a variable that can assume the values 1 or -1:

- tr (i, j) = 1 indicates a positive rating given by user i about user j;
- tr (i, j) = -1 indicates a negative rating given by user i about user j, due to an unreliable or damaged file or to an interruption of the download.

According to the various rating expressed by peers in the network, it is possible to get a local trust value s (i, j) [40, 45] calculated as the sum of the ratings of the user i about his/her transactions with user j:

$$s(i,j) = \sum tr(i,j)$$

Similarly, the i-th user can store the information regarding the number of satisfactory and unsatisfactory transactions held with the j-th customer, indicated as sat (i, j) and unsat (i, j), respectively. Thus, the local trust value can be also defined as [60]:

$$s(i,j) = \sum tr(i,j)$$

$$= sat(i,j) - unsat(i,j)$$

In a distributed environment, there is a further complication for the determination of the overall trust value compared to the case of centralized systems, namely the one linked to the modes of aggregation of the various local trust values s (i, j) defined above.
Accordingly, systems of this type leads invariably to two possible, alternative drawbacks:

- aggregation of ratings of a few users without having a broad view of the reputation of a user;
- aggregation of ratings of all users congesting the network in terms of computational costs.

The Eigen Trust Algorithm requires the adoption of a Reputation System that aggregates the amount of local trusts s (i, j) according to the principle of transitivity of trust [60]. More specifically, according to this principle, if the user is confident about people he/she completed transactions with and, in turn, they acquired a high level of trust about other peers that do not know directly, then the user will be also confident of the latter. The idea behind this assumption is that users proving to be honest while sharing content tend to be honest also while reporting the local trust values expressed towards other users.
A Reputation System built on this basis involves a set of global trust values expressed as the left principal eigenvector of a matrix of normalized local trust values. It can be calculated with a limited effort in terms of computation. The results show that the algorithm is very effective and reduces significantly the number of unsatisfactory downloads even when one faces a malicious collective including up to 70% of the users of the entire network [60].
From the operational point of view, the global reputation of each user is calculated by considering the local trust values associated with it and weighing them appropriately with the values of global reputation of users who expressed the underlying ratings.
However, before proceeding to the calculation of global reputation, some problems have to be solved about the normalization of the local trust values. In fact, malicious users can assign arbitrarily high levels of local trust value to other malicious peers, creating the typical effect of malicious collectives. They can also assign arbitrarily bad ratings to very poor people who actually have honest behavior. The normalization process aims at solving or at least mitigating these issues. In particular:

$$c(i,j) = \frac{\max(s(i,j), 0)}{\sum_j \max(s(i,j), 0)}$$

where c (i, j) represents the normalized local trust value, which is a variable defined in the interval [0,1].
This standardization involves two fundamental issues:

- the normalized value obtained does not distinguish between users the i-th peer never interacted with and users he had little interaction with;
- moreover, c (i, j) expresses relative values. For instance, if c (i, j) = c (i, k), then we can argue that j and k have the same reputation according to the i-th user, but we can not say anything whether that reputation is high or low.

However, this standardization also has some advantages, among which the fact that it allows to perform the calculation of the reputation without having to resort again to the normalization in order to determine the value of the global reputation, thus reducing the computational costs.
The process of aggregation of normalized values requires that each user request his/her neighbors in the network to express their opinion about other peers. In this way, the values of normalized trust c (i, j) is expressed by such peers weighed for the confidence that the requesting user puts in them.
In formulas:

$$t(i,k) = \sum_{j} c(i,j) * c(i,k)$$

where t (i, k) represents the level of trust that user i puts in user k based on evaluation requests made to his/her own friends in the network.
In matrix notation:

$$\underset{t_i}{\rightarrow} = C^T * \underset{c_i}{\rightarrow}$$

where:

- C is the matrix containing elements [cij] with all the normalized values of trust;
- the normalized values of trust referred to the pairs (j, k) are represented by the vector $\underset{c_i}{\rightarrow}$;
- the level of trust that the i-th user puts in user k based on the evaluation requests made to his/her own friends in the network is represented by the vector $\underset{t_i}{\rightarrow}$. In addition, the vector is such that:

$$\sum_{j} t(i,j) = 1$$

The aggregation of values of local trust is necessary in order to provide an overall view of the network to each user. However, the global trust values obtained provide the i-th user's vision, complemented by that of his/her own neighbors.
A wider perspective is given by adding to the information provided also the vision of neighbors' friends.

In formulas:

$$\underset{t_i}{\rightarrow} = (C^T)^2 * \underset{c_i}{\rightarrow}$$

By extending up to the n-th power this procedure:

$$\underset{t_i}{\rightarrow} = (C^T)^n * \underset{c_i}{\rightarrow}$$

In this way, we can get a complete view of the entire network by iterating n times the calculation of the global reputation of users. These conclusions are valid under the assumption that C is a matrix irreducible and aperiodic.
Moreover, if n is a sufficiently large number, then the vector obtained converges towards a single valid vector for each user, which is namely the left eigenvector of the matrix C. Therefore, the vector thus defined is called "global trust vector". Its j-th element, t_j, indicates how much trust the system as a whole puts in the j-th user.

2.12 The probabilistic interpretation of Eigen Trust Algorithm and its variants

Some studies show that there is a unique and unambiguous interpretation of the algorithm introduced above, very similar to that associated with the Random Surfer model [51].
Assuming that an agent is looking for trusted users and, therefore, with a positive reputation, it must be able to surf the net. Starting from the node that represents the i-th user, he will get to the j-th user node with probability c (i, j). After a certain period of time, user i will reach likely another user with a significantly positive reputation.
However, depending on the application context, there are several versions dell'Eigen Trust Algorithm. We analyze the main variants below [60]:

- Basic Eigen Trust Algorithm. First, we must specify that this version ignores completely the features of distributed networks and, hence, their specific issues. Furthermore, we assume that central servers contain the values c (i, j) of the whole network.
  Given a sufficiently large number n of iterations we can calculated:

$$\underset{t}{\rightarrow} = (C^T)^n * \underset{e}{\rightarrow}$$

  where:

  - the vector $\underset{e}{\rightarrow}$ of size m contains the uniform probability distribution with elements e_i equal to 1/m for all the m users;
  - C is the matrix with elements $[c_{ij}]$ containing all the normalized values of the trust;

- the level of trust that the i-th user puts in the k-th user based on the evaluation requests made to his friends in the network is represented by the vector $\underset{t}{\rightarrow}$. Even this vector, such as that described in the general case, has the following property:

$$\sum_{j} t(i,j) = 1$$

It is important to point out how the use of the vector $\underset{e}{\rightarrow}$ in place of the vector $\underset{c_i}{\rightarrow}$ is justified by the fact that both vectors converge towards the left eigenvector of the matrix C.
The Eigen Trust algorithm is shown below in its basic version adapted to the case of a distributed system and using the notation introduced above [60]:

$\vec{t}^{(0)} = \vec{e}$;
repeat
  $\vec{t}^{(k+1)} = C^T \vec{t}^{(k)}$;
  $\delta = ||t^{(k+1)} - t^k||$;
until $\delta < \epsilon$;

This variant is characterized by three fundamental problems:

- Users with a priori trust. In a network of trusted users, there are a priori (pre-trusted peers) [41]. They can be easily identified as they are those users entering the first part of the network and are often the designers or the first users interested in receiving the benefits (early users). They are the hard core and the starting point for the calculation of the level of overall trust of the community of users. In practice, they form what is known as the "seed of the trusted accounts". Having said this, it is easy to notice that they have little or no motivation to ruin what they have built [72].
  In operational terms, if P is the set of pre-trusted users, we can define a distribution $\underset{p}{\rightarrow}$ with elements $p_i = 1/|P|$, if $i \in P$, $p_i = 0$, otherwise.
  The use of this approach is of considerable help in the event that there are malicious peers in the network.
  In this case, by replacing the term generally used in the basic version:

$$\underset{t}{\rightarrow} = (C^T)^n * \underset{e}{\rightarrow}$$

with the following:

$$\underset{t}{\rightarrow} = (C^T)^n * \underset{p}{\rightarrow}$$

the resulting vector will converge more quickly by adopting $\underset{p}{\rightarrow}$ as a starting vector;

- Inactive users. If a user never interacted with the rest of the network, or in the case he interacted without giving a rating different from zero to other peers, the following equation:

$$c(i,j) = \frac{\max\left(s(i,j),0\right)}{\sum_j \max\left(s(i,j),0\right)}$$

results undefined.
To overcome this problem, we do the following assignment:

$$c\ (i,\ j) = p_j$$

In light of this change we obtain:

$$c(i,j) = \begin{cases} \frac{\max(s(i,j),0)}{\sum_j \max(s(i,j))} \; se \sum_j \max(s(i,j),0) \neq 0; \\ p_j \; altrimenti \end{cases}$$

In this way, if the user does not know any member of the network (i. e., no ratings are assigned), or does not trust anyone (i. e., only null ratings are assigned), he/she can still choose to have faith in the default pre-trusted peers. In addition, it is good to notice that this procedure is not a stretch, since the act of voluntary registration to a network logically entails assigning a high level of confidence, at least initially, to the first users of the network and its designers;

- Malicious peers. As it was already mentioned in the previous paragraphs, the formation of a group of malicious users is a serious threat to honest users and to the entire network [57].
Within a group of such users each individual knows each other and tends to assign high values to the rest of the group. Such a user also tends to provide a negative feedback about other users in the network.
Their ultimate goal is to damage honest users and, especially, the network in its entirety, in order to subvert it.
The solution to this problem is given by the introduction of some weights which, starting from the standard equation, take into account the set of pre-trusted peers.
In matrix notation:

$$\underset{t^{(k+1)}}{\longrightarrow} = (1-a) \; * \; C^T * \underset{t^{(k)}}{\longrightarrow} + a \; * \underset{p}{\rightarrow}$$

where:

- C is the matrix with elements $[c_{ij}]$, which contains all the normalized values of trust;
- the trust level at time k and time k + 1 the i-th user puts in the j-th user based on the evaluations made by his/her friends is represented by the vector $\underset{t}{\rightarrow}$. It has the following property:

$$\sum_{j} t(i,j) = 1$$

- P is the set of pre-trusted users. The distribution $\underset{p}{\rightarrow}$ is used. Its elements are $p_i = 1/|P|$, if $i \in P$, $p_i = 0$, otherwise;
- a is a constant lesser than 1.

Ultimately, this solution is equivalent to impose the original vector containing the normalized values of local trust equal to:

$$\underset{c_i}{\rightarrow} = (1-a) * \underset{c_i}{\rightarrow} + a * \underset{p}{\rightarrow}$$

In fact, this will break the chain of mutual benefits between malicious users because it forces each member of the malicious collective to put some level of trust even in the pre-trusted peers that are among the safest and most reliable members of the entire network.
So, even a generic user searching for peers with high reputation increases his chances to avoid running into a malicious collective.
Obviously, the assumption of reliability of the members of the set P also implies that pre-trusted peers are not members of a malicious collective as this will void, at least in part, the findings and considerations about the algorithm.
A system to reduce the possibility that this may occur is that of lowering the cardinality of P, i. e. the number of pre-trusted peers initially recognized.
The Eigen Trust Algorithm is shown below, modified in accordance with the above considerations about users with trust in advance, inactive users and malicious users [60]:

$\vec{t}^{(0)} = \vec{p}$;
repeat
  $\vec{t}^{(k+1)} = C^T \vec{t}^{(k)}$;
  $\vec{t}^{(k+1)} = (1-a)\vec{t}^{(k+1)} + a\vec{p}$;
  $\delta = ||t^{(k+1)} - t^{(k)}||$;
until $\delta < \epsilon$;

- Distributed Eigen Trust Algorithm. By adopting a distributed perspective, the system leads to a reduction in terms of individual efforts supported by users and related to storage, computation and messaging.
  In particular, in a distributed context, the problem is how to store the values of C and $\vec{t}$. The solution suggested by the algorithm is to ensure that each user arranges a solution for the storage of his/her own values, assuming, at the moment, that there are no safety issues with regard to this aspect.
  In addition, we must specify how each user can compute its global trust value according to the following formula:

$$t_i^{(k+1)} = (1-a) * \left(c_{1i} * t_1^{(k)} + \cdots + c_{ni} * t_n^{(k)}\right) + a * p_i$$

  where all the elements of the mathematical expression have the corresponding meaning already introduced above.
  In matrix form we obtain the expression:

$$\overrightarrow{t^{(k+1)}} = (1-a) * C^T * \overrightarrow{t^{(k)}} + a * \vec{p}$$

  Since, in general, the i-th user had fews and limited interactions with respect to the potential of the network, many components in the expression will be equal to zero.
  In addition, in this view only users from the P set will have to know the value of p_i and possibly will remain anonymous because no one needs to know that they are pre-trusted.
  The low level of interaction between users in a network has two additional effects:

  - because of the scarcity or lack of interaction, the computational burden is never so intense as to require too much effort to the system and/or to individual users;
  - the number of messages exchanged in the system is low.

  In case many users are particularly active in the network, it is possible to reduce the number of local trust values c (i, j) that a user can express.
  The Eigen Trust Algorithm is shown below in the version adapted to the distributed case [60]:

Definitions:

- A_i: set of peers which have downloaded files from peer i
- B_i: set of peers from which peer i has downloaded files

Algorithm:
Each peer i do {
Query all peers $j \in A_i$ for $t_j^{(0)} = p_j$;
repeat
Compute $t_i^{(k+1)} = (1-a)(c_{1i}t_1^{(k)} + c_{2i}t_2^{(k)} + \ldots + c_{ni}t_n^{(k)}) + ap_i$;
Send $c_{ij}t_i^{(k+1)}$ to all peers $j \in B_i$;
Compute $\delta = |t_i^{(k+1)} - t_i^{(k)}|$;
Wait for all peers $j \in A_i$ to return $c_{ji}t_j^{(k+1)}$;
until $\delta < \epsilon$.;
}

Again, with reference to the computational aspects of the algorithm, it can be stated, on the basis of two simple considerations, that the computational cost is minimized because:

- the Eigen Trust Algorithm converges quickly, so that the value of global trust does not change significantly after a low number of iterations (Figure 5) which is estimated in less than 10 exchanges of updated values of trust between users [49];
- it is possible to reduce significantly the number of normalized local trust values c (i, j) that each user is able to express, setting an upper bound according to appropriate criteria.

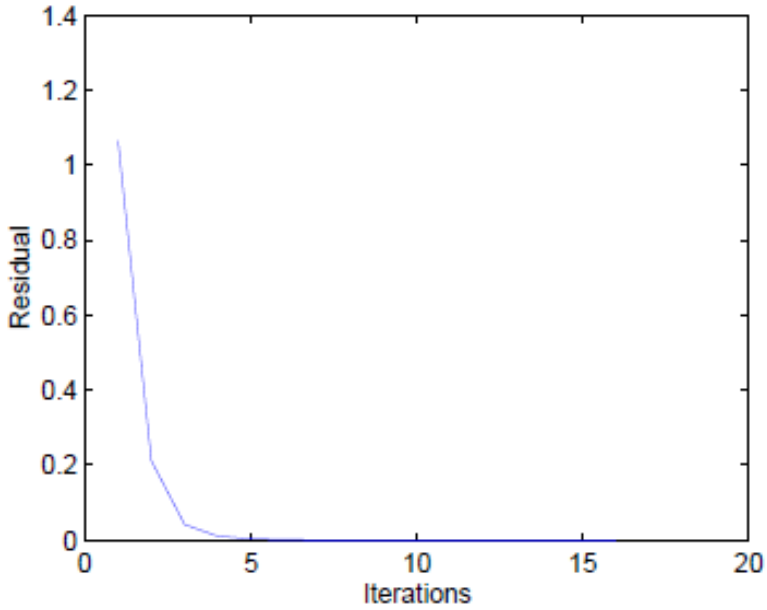

FIGURE 5: CONVERGENCE OF THE EIGEN TRUST ALGORITHM [60].

2.13 The Security Eigen Trust Algorithm

As described above, the algorithm requires that each member is able to take care of his/her own storage values of C and $\underset{t}{\rightarrow}$.

However, it should address the problem of security because malicious users may invalidate trust values and try to subvert the system, especially if they are organized in groups (malicious collectives).

There are two possible solutions that can be implemented and which are not alternative among them [60]:

- the values of trust must not be calculated and must not reside in the user node they relate to. In fact, they can be changed very easily. The suggested solution is to calculate the trust value associated with a peer starting from a third party user that is not in connection with it;
- returning false statements is an activity usually done by malicious users. So, calculating trust values from third party users does not solve the whole problem of security and reliability of data. A further solution is to assign the task of computation of these values to more than one third party user.

Therefore, in order to calculate trust values of the i-th user, M third party users are selected (i. e. score managers of user i).

Operationally, when a user needs to know the level of trust of the i-th user, some information can be requested to the M score managers, considering the high reliability provided by the majority of them.

In this context, another topic of discussion is the selection and allocation of score managers to different users. The solution generally adopted by the

algorithm is to use the tool called “distributed hash table” (DHT) such as, for example, CAN [42] or Chord [47]. In this way, through a hash function files names are identified deterministically and, subsequently, they are associated with the spatial coordinates.

The space is dynamically partitioned between the score managers so that all users cover all regions of the space itself. When a score manager leaves the network, its task is passed to neighboring peers. In addition, all data is replicated to reduce the risk of losing valuable information for individual users and for the entire network.

On the basis of these considerations, it is possible to define an algorithm for calculating the global trust value with a high level of security. In particular, each peer has a number of score managers equal to M, identified and located through DHT coordinates attributed to them by a set of hash fuctions h_0, ..., h_{M-1}. To the score managers is also linked a set of indices D_i, which refers to peers that will be evaluated by such score managers. Therefore, they store the c_{id} vector containing the scores stored in the peer node i and referred to users in D_i.

In addition, the i-th user can also keep track of A_{id}, that is the set of users who interacted with the user $d \in D_i$ by exploiting his/her own contents. The score manager can store the evaluation made by these users about the peer d.

Similarly, the i-th user will be able to track even with the B_{id}, which is the set of users from which the user $d \in D_i$ downloaded some contents. At this point, the score manager will receive the feedback by the user d and store it within the system.

Based on considerations, the Eigen Trust Algorithm provided below includes modifications related to the new variant, i. e. the Secure Eigen Trust Algorithm:

foreach *peer* i **do**
Submit local trust values $\vec{c_i}$ to all score managers at positions $h_m(pos_i), m = 1 \ldots M-1$;
Collect local trust values $\vec{c_d}$ and sets of acquaintances B_d^i of daughter peers $d \in D_i$;
Submit daughter d's local trust values c_{dj} to score managers $h_m(pos_d), m = 1 \ldots M-1, \forall j \in B_d^i$;
Collect acquaintances A_d^i of daughter peers;
foreach *daughter peer* $d \in D_i$ **do**
Query all peers $j \in A_d^i$ for $c_{jd}p_j$;
repeat
Compute $t_d^{(k+1)} = (1-a)(c_{1d}t_1^{(k)} + c_{2d}t_2^{(k)} + \ldots + c_{nd}t_n^{(k)}) + ap_d$;
Send $c_{dj}t_d^{(k+1)}$ to all peers $j \in B_d^i$;
Wait for all peers $j \in A_i^d$ to return $c_{jd}t_j^{(k+1)}$;
until $|t_d^{(k+1)} - t_d^{(k)}| < \epsilon$.;
end
end

In summary, the strengths of the secure version of the algorithm are the following:

- Anonymity. A user who is also a score manager calculating the trust value of a user can not know the identity of the latter. Therefore, the groups of malicious peers can not increase the reputation of other members of the team simply because they can not recognize the network;
- Randomization. Users - once they are part of the network – can not decide autonomously which are the coordinates assigned to them by the hashing functions. In fact, thanks to the properties of the DHT-based systems, they can not know in any way their hash value and, therefore, can not go back to their coordinates to calculate the trust value;
- Redundancy. Many score managers compute the trust value for a given user. The procedure for assigning scores managers to peers to be evaluated is performed through multidimensional hash functions. In particular, such functions delimit some regions and, subsequently, users - simple score managers or peers -, are assigned to these areas.

After introducing the Secure Eigen Trust Algorithm, it is good to emphasize that the issue of security is central not only in the context of reputation management, but also for various other contexts, such as, for example, those relating to incentive schemes in firms and micro payment systems (where they exist) [59].
In addition, the security paradigm is proposed about the mitigation of the risk that an individual user or a group of users can manipulate the values of trust and subvert the system as a whole. For this reason it is possible to say that it does not ensure a high level of safety in the traditional sense, but describes a procedure for a very secure a network that can be also particularly extended [59].

2.14 The use of global trust values and the workload distribution in a trust-based network

The global trust value can be used to achieve two main objectives, namely [60]:

1) isolating malicious peers. It is the ability to exploit the information contained in the global trust values in order to encourage the download of contents from peers with a high reputation. This will automatically block malicious users with a bad reputation.
The first strategy would be to use the values of global trust t_j to draw up a list of trusted and untrusted users, starting from those with a higher reputation. However, the choice of selecting more peers in a high ranking position would result in an overhead for the peers themselves. In addition, this practice would lead to build a reputation for newcomers, as they would never be selected for downloading content since they do not have a reputation.
The second strategy would be to choose the peers to download contents from through a probability-based criteria. Operationally, we select a specific user. To every other user in the network is assigned a level of probability proportional to t_j. According to such a probability level, the given user can download content. This policy involves a series of considerable advantages compared to the previous one, since:

- it significantly reduces the total number of unsatisfactory transactions that are carried out in the network;
- it balances the workload distribution in the network depending on a probabilistic approach;
- it provides the possibility to all newcomers to interact in the network and, therefore, to build their own reputation.

Users can ultimately base their decisions on information obtained from $\overrightarrow{t_{personal}} = d * \vec{t} + (1 - d) * \vec{c}$ or by a convex combination of global trust values and local trust assessments provided by other users.
In formulas:

$$\overrightarrow{t_{personal}} = d * \vec{t} + (1 - d) * \vec{c}$$

where:
- d is a constant defined in the interval [0, 1];
- all other quantities/features are similar to those already defined.

Thus, a generic user can avoid to download content from users having a high reputation and he/she had not good experiences personally. The use of this tool further increases the advantages linked to the adoption of the second strategy described above.
Here are some results of studies conducted on the effectiveness of the use of global trust values to counter the spread of inauthentic files coming from malicious peers, as individuals or groups (Figure 6, Figure 7, Figure 8 and Figure 9).

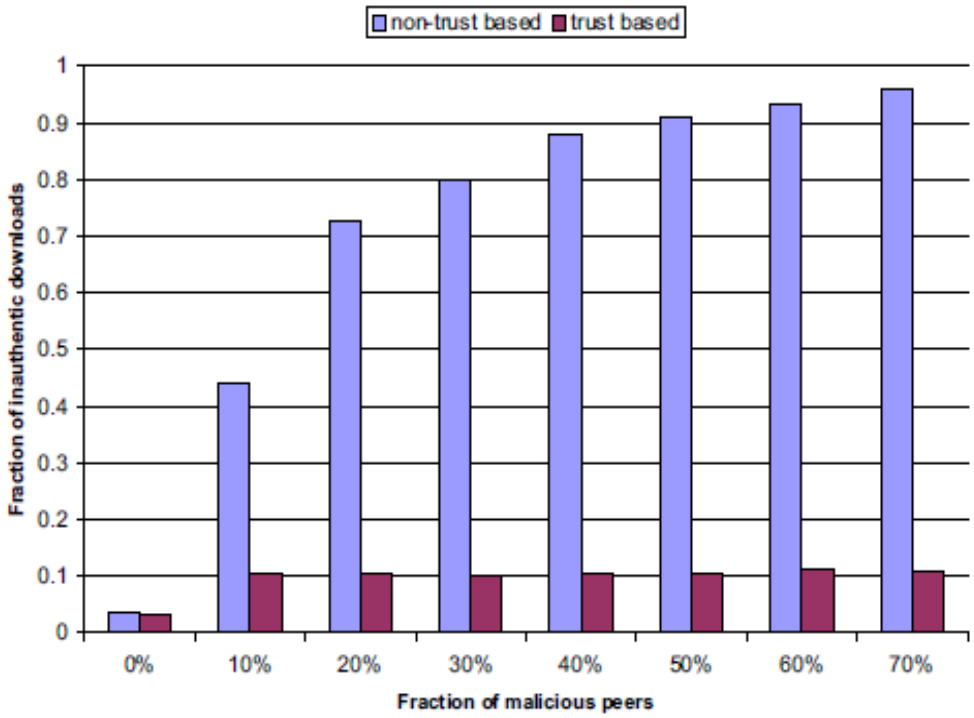

FIGURE 6: REDUCTION OF INAUTHENTIC FILES THROUGH GLOBAL TRUST VALUES IN THE PRESENCE OF MALICIOUS PEERS [60].

In this case (Figure 6), it is possible to note that the reputation management approach adopted allows to reduce to approximately 10% the number of not authentic files in the network.
In addition, the malicious peers in the network are virtually excluded from uploading not authentic files.

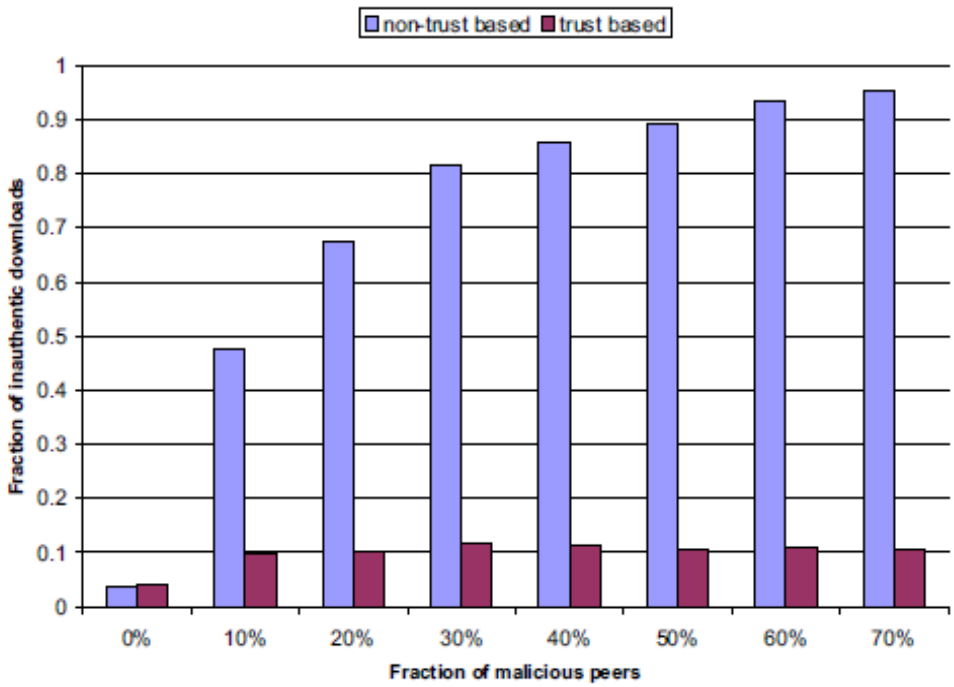

FIGURE 7: REDUCTION OF INAUTHENTIC FILES THROUGH GLOBAL TRUST VALUES IN THE PRESENCE OF MALICIOUS COLLECTIVES [60].

Similarly to the case immediately above (Figure 6), in which collectives are replaced by independent malicious users, also in this case (Figure 7) it is possible to note that the reputation management approach adopted allows to obtain a significant reduction in the number of inauthentic files on the network.
The formation of a group of malicious peers is not sufficient to substantially reinforce the trust values of the individual users it is composed of.
Even in this scenario, the members of the malicious collective in the network are virtually excluded from uploading inauthentic files.

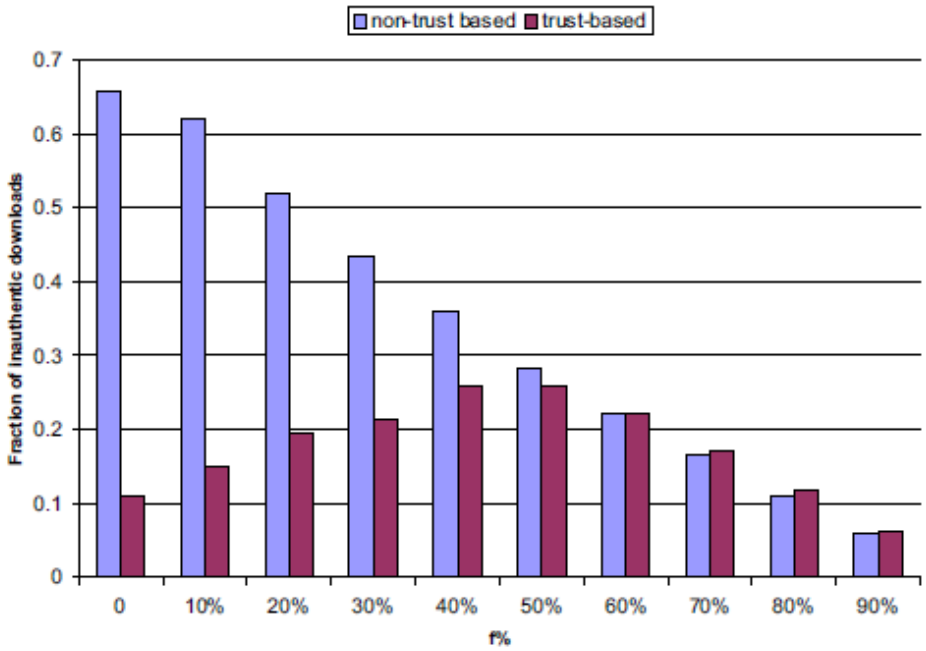

FIGURE 8: REDUCTION OF INAUTHENTIC FILES THROUGH GLOBAL TRUST VALUES IN THE PRESENCE OF MALICIOUS COLLECTIVES WITH TRUSTED CONTENT WITH A CERTAIN DEGREE OF PROBABILITY [60].

In the presence of a group of malicious peers that sometimes provide authentic files, there are some local trust values favorable to the members of the such a collective (Figure 8). This consideration shows how it is possible, therefore, that they could be selected as sources for downloads. In turn, this selection favors, for these users, an increase of probability of uploading unreliable contents.

However, the upload of trusted contents often brings some negative effects for malicious users.

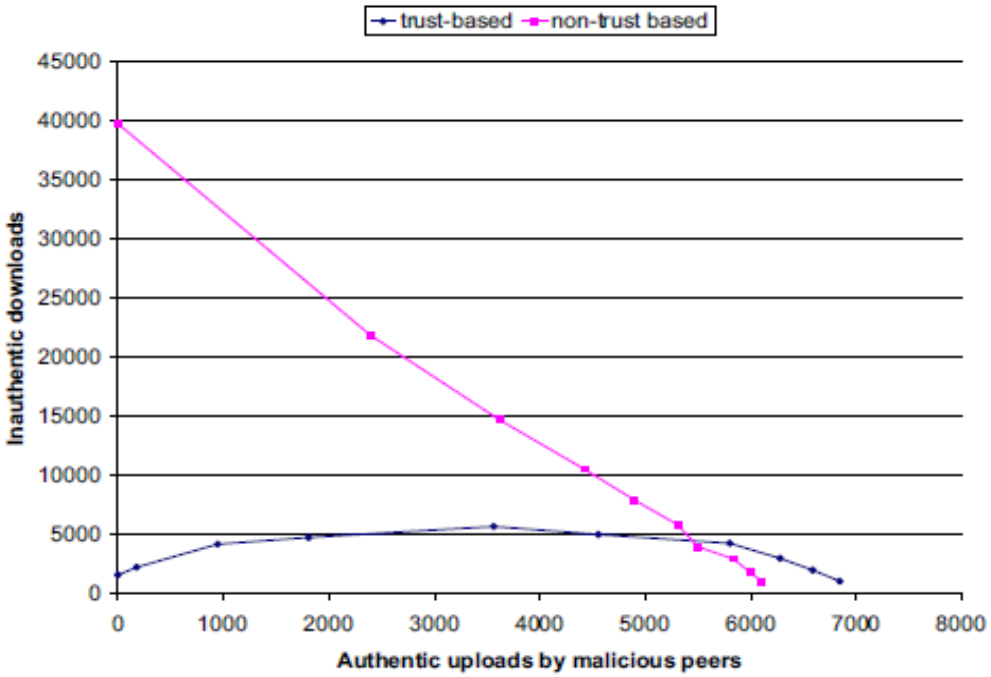

FIGURE 9: THE NUMBER OF AUTHENTIC UPLOADS MADE BY MALICIOUS USERS COMPARED WITH THE NUMBER OF NON-AUTHENTIC DOWNLOADS IN TWO DIFFERENT SCENARIOS: TRUST-BASED AND NON-TRUST BASED [60].

In the case the malicious users provide authentic files in a proportion exceeding 20% of the their total upload (Figure 9), the increase of authentic files by such users exceeds the increase in the download of non-authentic files. In this context, it can be stated that such a behavior can sometimes lead to a higher cost than any expected benefits for malicious users.

2) Encouraging freeriders to share contents. The achievement of this objective is related to a positive approach that contrasts strongly with the isolation of malicious peers detailed above. In fact, the system allows to identify and reward users with a high degree of trust.

In particular, the reward system may provide these users with an increase of connectivity to other sufficiently reliable peers or a greater bandwidth.

The effects of this policy can be briefly summarized in two points set out below:

- since it presupposes a high reputation and can only be achieved through the interaction activities in the network, such a reward system encourages content sharing within the community of users. Ultimately, this results into a significant reduction in the number of freeriders [50]. This issue is very relevant in different networks. In some real case studies [45], about 25% of the members of the network do not share any content, while only 7% of users accounts for more than a half of the files that are actually exchanged;

- the reward system also drives many non-malicious peers to delete completely inauthentic files, accidentally and mistakenly downloaded within the network. Ultimately, it strongly favors the creation of a much safer community and tends to reduce significantly the number of inauthentic files that could subsequently replicate and spread in the network.

Finally, the value of global trust can also be used to distribute the workload among all users within the network.
In fact, such a distribution is established taking into account contents (quality and quantity), bandwidth and level of reputation of the user. Users better positioned according to these criteria are those more likely to receive download requests and, therefore, to have higher interaction levels within the network and build a better reputation.
On the other hand, by operating in this way, the system runs the risk of creating a vicious cycle of accumulation of reputation levels. In fact, the greater likelihood of response to the needs of content sharing results in an increase of probability of improving one's reputation and, therefore, to be selected for further downloads and accumulate, in turn, even higher levels of reputation. This aspect is more noticeable than the networks not based on trust in which a user is randomly chosen: this selection criterion contributes to the good balance of the overall load on the network.
There are two specific algorithms for the selection of download sources, one deterministic and another probabilistic, for which we consider the set of trust values $\{t_0, ..., t_{R-1}\}$ [60]:

1) Deterministic algorithm. It chooses the peer with the maximum value t_{max} of trust between all those who respond to a very specific request for download;
2) Probabilistic algorithm. It chooses the peer i, among all those who respond to a definite download request, characterized by the probability

$$\frac{t_i}{\sum_{j=0}^{R} t_j}$$

With a probability of 10%, it chooses a peer j with the value of the trust equal to 0 ($t_j = 0$) or a newcomer.
If, at the end of the algorithm, a non-authentic file is obtained, the user who supplying it should be deleted and the algorithm should proceed to the new iteration of the algorithm from the initial step.
In the algorithm with probabilistic approach the newcomers are facilitated in the construction of reputation within the network through the use of the 10% threshold.
Here are some data from specific experimental studies. They compare the different workload distributions obtained by using different approaches in

relation to the behavior of non-trust-based networks. Such results show what has been discussed above (Figure 10 and Figure 11).

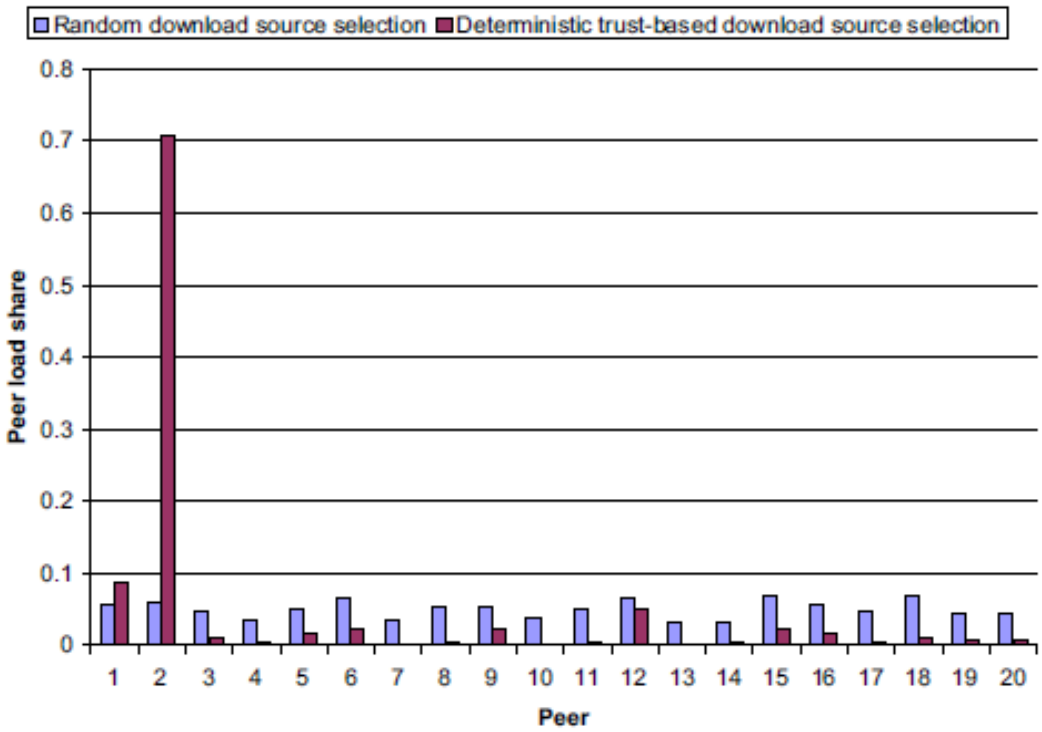

FIGURE 10: WORKLOAD DISTRIBUTION WITH THE DETERMINISTIC ALGORITHM FOR THE SELECTION OF DOWNLOAD SOURCES COMPARED TO A GENERIC TRUST-BASED NETWORK [60].

Peer 2 has an overwhelming probability of accumulating a growing reputation.

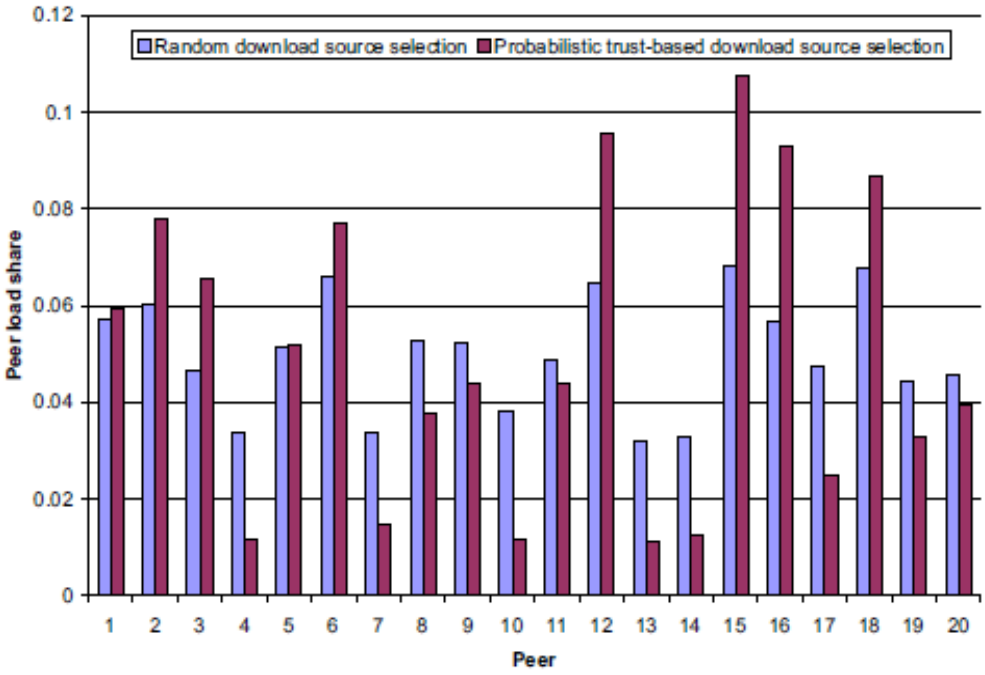

FIGURE 10: WORKLOAD DISTRIBUTION WITH THE PROBABILISTIC ALGORITHM FOR THE SELECTION OF DOWNLOAD SOURCES COMPARED TO A GENERIC TRUST-BASED NETWORK [60].

In this case, the workload distribution does not differ significantly from the one obtained with a non-trust-based random selection procedure.

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CHAPTER 3

KNOWLEDGE-BASED INNOVATION STRATEGIES IN THE AUTOMOTIVE INDUSTRY: REWARDING SYSTEMS IN A MULTINATIONAL COMPANY [72] [73] [74]

3.1 Introduction

An effective reward system, addressed both to individuals and working groups, must have as its primary purpose the incentive to collaboration and knowledge sharing, by means of taking advantage of the collaborative features arising from the paradigm of Enterprise 2.0.
For the achievement of such results the following activities have been carried out:

- analysis of traditional reward policies;
- identification of the best workers by means of SNA methods;
- analysis of Work Life Balance and Total Reward System methodology;
- application of SNA techniques to the automotive industry.

3.2 Objectives

The objective of this deliverable is to define rewarding methodologies and techniques to be implemented within the automotive industry in order to improve the performance of workers and the quality and efficiency of business processes.
In particular, we can adopt methods based on Social Network Analysis (SNA) to analyze social networks, and identify and reward users with a central position in them.

3.3 The evolution from contractual treatment to recognition of extra-working needs of employees

In order to investigate in detail the key elements of the rewarding systems in literature, it is useful to start from the basic concepts of the remuneration policy.
First, the goals shared by the majority of rewarding systems can be summarized as it follows [56]:

1) encouraging and motivating people;
2) retaining/attracting human resources helpful for the achievement of corporate objectives;
3) differentiating appropriately and consistently the different jobs (jobs) within the organization;
4) contributing to pay individuals working for the achievement of organizational goals.

These issues have several implications in terms of:

1) attractiveness/external competitiveness. Companies try to avoid the turnover towards their competitors and want to attract the best skills and experience available in the labour market;

2) internal fairness. Organizations want to differentiate the various job positions on the basis of fairness and transparency;
3) stimulus and recognition of contributions of individuals. In this way it is possible to obtain a greater motivation and appreciation, increasing the level of identification with values and culture of the company;
4) legitimacy. It consists in the full respect of the national collective bargaining agreement of the company, which can be integrated with other local and national norms in order to comply with the regulations of the labour market.

A thorough analysis of the basic principles of the Italian remuneration system is provided in Appendix A.

3.4 Organizational time and life time models

With reference to management systems and approaches, the last decades have been characterized first by questioning and later by overcoming the traditional rewarding paradigm.

In fact, it is possible to link such changes to various phenomena, which are very often interrelated with each other, such as:

- the continuous and rapid growth led to competition in many markets and sectors in hyper-competitive contexts;
- the increase in the technological innovation rate and the impact it generates in terms of organizational, cultural and technological development;
- the change (not without disruptive effects) in the level of concentration in certain industries;
- the removal of geographical and cultural barriers;
- the changing needs and, more generally, profiles of the average consumer;
- the rise of the service sector and the steady advance of the phenomenon of servitization of many products;
- the reduction in the use of hierarchy as the only solution for the management of organizations and the consequent flattening of corporate structures, as well as many other changes still in place in different production contexts [12].

Among all these factors also the decentralization should be mentioned. This new approach has been applied in various ways according to the specific context of application of each company. In particular, we have adopted mechanisms, tools, methods and structures to support the implementation of several initiatives: decentralize decision-making, self-control, knowledge sharing, privacy of human resources by means of a strong willingness to meet the need of personal and family flexibility coherently with company business goals.

This approach lays the foundations for the achievement of what is generally considered to be a major competitive advantage for organizations, namely the enhancement of diversity within the team and, more generally, the entire organization (in terms of age, ethnicity, sexual orientation, culture and education, geographic location, religion, etc.). In accordance to this philosophy, which fully complies with the principles of diversity management [6], the person can be expressed in its fullness and introduce valuable skills and experience, which, in the

traditional view, clashed with the concept of productivity of human resources and, then, with the criteria rewarding systems were based on [12].
To address this issue it is necessary a general introduction related to the organizations operating in the business context: time is an absolutely irreplaceable resource [7]. In fact, it is impossible to think and make so that it is replaced by resources of different nature. More precisely, one can think of replacing the time only with "other" time. In particular, one can think of replacing it with:

- his/her future time;
- time of other individuals.

These properties make time a precious resource that must be optimized to enable organizations to achieve its objectives (linked to the concept of effectiveness) and to minimize the consumption of resources (related to the concept of efficiency).
The set consisting of these elements is used to measure the productivity influenced by several factors related to the organization, the commitment and mood of human resources, as well as the time.
One element that suffered most of the changes over the past decades was that of the organizational time models.
They have been strongly shaped by the increasingly important concept of spatial-temporal flexibility within companies. The latter brings a great contribution on the discussion about the dichotomy that exists between the U.S.A. and the temporal model proposed by the European culture [8].
About the U.S.A. context, we should specify how it is strongly linked to the pre-crisis labor market in the Northern American area, where the ease of firing workers is balanced with the possibility of a quick reintegration into the labor market thanks to its high flexibility [12].
In this context, there is a vision strongly tied to the commercial model of the U.S.A. labour market where the only criteria is given by costs/benefits analysis expected from a specific employee, without taking into account the particular constraints due to the regulations.
A less flexible and autonomous slant is the one that concerns the European organizations as the latter and their employees must meet some basic requirements imposed by the regulations issued by the central government. In this context, we see that the autonomy of the parties involved appears to be more limited than in the case of Northern American regulations. The worker has not to negotiate any contract terms, while the company is deprived of the opportunity to cut jobs without a valid reason according to the regulatory standards [9].
A first result that comes from the comparative analysis of such systems is related to the consideration that flexibility depends very much on the regulations of the specific labor market [12].
In regard to this, it can be said that the adoption of standard time saw an attempt to flatten the commitment in terms of time spent working by almost all workers.
This approach has been a real social glue influencing the lifestyles of the people, then evening out them permanently.
This result is linked inextricably to the high level of formalization and standardization of organizational time models [10].

However, changes characterizing the environment organizations operate in, led to subvert the trend (Figure 12).
In particular, it was possible to detect significant changes with regard to some of the background elements of time models in organizations:

- differentiation of working hours by eliminating any standards previously adopted;
- clear separation between the time interval in which business systems work and the fraction of such an interval in which people are engaged in job tasks.

As a result, in the short term there is an influence on the lifestyles of people who are increasingly different with each other in terms of personal and family needs.
However, there is also a result related to the potential benefits for companies. More precisely, they may benefit from a de-structuring process of standard working hours, for example, in terms of higher levels of creativity [12] as already experienced in Google. In Figure 12 a comparison made by the Italian multinational company operating in the automotive industry is showed.

MODERN	PERIOD	POSTMODERN
Scientific Management	**STYLE**	Humanistic Management
Static, simple, structured	**EXTERNAL CONTEXT**	Dynamic, complex, de-structured
Serialization, standardization, labour/task specialization	**PRODUCTION**	Creativity
Best practice, one best way	**COGNITIVE MODEL**	New sharing and collaboration techniques
Totalitarian	**ORGANIZATIONAL MODEL**	Participatory
Formal, standard	**WORKING TIME**	Flexible and variable

FIGURE 12: DOWNTURN IN ORGANIZATIONAL TIME MODELS [12]

In addition, the "destandardization" of working hours does not only provides increased flexibility as it is described above, but greatly favors also the satisfaction of the people by allowing them to perform at the same time the role of irreplaceable corporate resources and members of the family and friends community they live in.
The paradigmatic shift of time models, which has been one of the cornerstones of the progress of the last few decades in business, considers no longer people merely like costs, but as a valuable resource for the organization. It led to the vision of a new architecture of working hours no longer intended as a simple contractual obligation, but as a true condition enabling the achievement of the company's innovation goals and, therefore, the achievement of its competitive advantages.
The change in working hours induces also changes at the structural, productive, personal and social level. As a result, an adaptation process is undertaken in terms of organizational subsystems that have to be based on the specific needs of individuals [13].

3.5 Rewarding approaches in Enterprise 2.0 contexts

The technological evolution that supported the adoption of the Web 2.0 paradigm in business contexts created in many organizations the conditions necessary for the definition of a "social system" aimed at enabling interaction and cooperation mechanisms between the users of a network.

Within this context, rewarding techniques and methodologies play a crucial role in contributing to the sustainability of such mechanisms, both in the short and medium/long term. In fact, they are increasingly being implemented in organizations and are intended essentially to create from scratch or strengthen the collaborative involvement of members in a given community.

In addition to the achievement of the objectives of collaboration and knowledge sharing within the community and the organization, the use of these techniques and methods is geared to the creation of a social environment based on the most advanced incentives, not only according to an economic point of view (e. g. Total Reward System, Work-Life Balance, etc.). It also ensures the participation in business activities and the increase of frequency of highly qualitative and fully consistent contributions in relation to the acquired expertise and experience in a specific field.

In addition, a rewarding system is structured to create a greater involvement of users with respect to the achievement of the objectives mentioned above. In this way users end up feeling more responsible for the participation in the activities of the corporate social network and, above all, about the quality of their contributions shared on the platform.

These are the basic elements of a system of Rewarding 2.0 and, together, constitute an essential pre-condition for a successful mechanism as much as the capacity to develop within the network some relevant social relations and reach the critical mass level of the platform.

On the basis of these observations it can be noticed how the influence exerted by certain users (influencers) on others (followers) as part of the decision-making process depends on the location of users in the network, their importance and the type of relationship between them, , both in real life and in virtual social networks [1].

For this purpose, it proves to be absolutely necessary to consider the influence of each user on the other members of the community. In particular, we can notice that also an evaluation of such an influence in both relative and absolute terms has to be performed. With regard to these considerations, we can take into account some of the fundamental properties of social networks which allow people to:

- identify critical users within the network based on pre-defined criteria;
- cluster groups of users according to particular, characterizing features.

A useful support in order to conduct this kind of study in a rigorous way is provided by the tools and techniques of SNA, thoroughly discussed in the following paragraph.

3.6 Rewarding methodologies: the Work Life Balance

The Work Life Balance is "a line of research that studies, reports and proposes solutions and tools for organizations in order to promote the well-being of individuals working within them" [47].

In the light of the paragraphs above, some peculiar features affecting life time models of people are increasingly involved in some discussions about how to make them compatible with organizational time models. In this way, such a process tends to align organizational and individual objectives and eliminate or minimize possible conflicts.
In fact, from a purely operational point of view, job tasks, personal and family needs (spouse, children, parents, etc.), property management (houses, other buildings with different destinations), interests and leisure activities constitute a set of elements in contrast with each other.
The most relevant result is that a good working environment is not simply characterized by a good salary and company benefits, but requires a global action affecting a broader part of individuals' life [12].
This approach requires a special attention focused on the definition and implementation of a range of strategies, programs and plans in order to support an adequate level of quality of life for employees, also based on context-specific requirements, as well as the more advanced strategies to attract and retain talents within the organization.
This approach is linked to the so-called Work Life Balance [12]. It assumes that organizations promote the integration of individual needs with the best conditions for the achievement of organizational goals. In this context, the set of services and solutions designed to increase the flexibility of the organization takes on an increasingly important role emphasizing the integration with the aforementioned extra-working perspective.
This approach provides a valuable way to stimulate employees, thus ensuring an optimal alignment of their goals with those of their company.

3.7 Backgrounds and basic concepts of the Work Life Balance

At the base of the Work Life Balance is, therefore, an issue strongly linked to the emergence of the dichotomous choice imposed in the past by many companies between work and private life, especially in hyper-competitive contexts. After the emergence of this issue in several companies, many centers belonging to large enterprises were provided with a range of services to help workers manage their lives outside the workplace. This set of services includes the "company perks" (nursery, gym, laundry, etc) and other counseling services [12].
It should be noticed that a new market for companies was born: it provides packages with different services to companies focusing on the implementation of the Work Life Balance paradigm for its employees. In particular, there are two areas of business:

1) work-life services for family needs;
2) employee assistance programs for a broad spectrum of consultancy services.

By assuming a much broader perspective than the one adopted so far, we can say that this approach is part of a growing emphasis on corporate social responsibility, currently considerably spread in Europe. Indeed, in addition to the areas of activity mentioned above, companies are increasingly interested and active in terms of well-being, child care, car sharing/pooling, conciergerie, etc..

Therefore, the next step was related to the realization of a coaching system as the one represented by the "Lifestyle Management" [12] which pays an extreme attention to all the practices of everyday life of the worker.
Briefly, the goals to achieve by means of the Work Life Balance are related to [47]:

- increase in the employee satisfaction while holding down costs;
- reduce turnover and encourage the retention of the best talents;
- reduce absenteeism;
- enhance the image of qualified employer outwards;
- encourage the recruitment of unique experts in key positions and of the best graduates.

All must be, however, consistent with a basic principle according to which the objectives must be defined, the so-called SMART (Specific, Measurable, Attachable / Reachable, Realistic, Timely).
Of course, none of these objectives can be easily reached in the absence of adequate sponsorship by management (in particular the one of the highest levels, to designate, where appropriate, a project champion), the establishment of an organizational climate optimum and the efforts of those who are responsible for designing, implementing and managing the system of Work Life Balance in the company.

3.8 Tools of the Work Life Balance methodology

From an operational point of view, the typical instruments of Work Life Balance can be grouped by [12]:

1) temporal articulations;
2) spatial articulations;
3) services.

The temporal articulations essentially concern with the aspects related to the management of working hours.
In this regard, it should be noticed, first, as the new market and the resulting business opportunities based on them have profoundly changed the requirements of time covering each organizational context, both in terms of quality and in quantity. In fact, the change implied by the intervention of various innovative solutions in some areas led some companies to extend the requirement of temporal coverage and others to reduce it. Also, the traditional model of the working time-slot has been substitued overtime by a more flexible approach.
In the following different kinds of temporal articulations are detailed [12]:

1) yearly time management of time. In this context, the working hours will be managed over a very large period and it is possible to opt for a medium level of flexibility. In fact, you can charge more hours in some weeks and make it less burdensome the rest of the year. This approach is particularly suited to cases where there is a significant

feature of the seasonality. In addition, this tool allows an optimal planning and a prudential management of leaves, vacations and overtimes;

2) bank of hours. This mechanism provides the ability to credit the hours worked by each individual on a specific account. In this way, the employee may choose to use the bonus time gained also by exploiting it in order to obtain leaves and solve the private problems;
3) part-time . First of all, it is good to notice that the part-time job has the same dignity as the full-time job. In particular, the part-time worker has the right to equal treatment with respect to other types of employment. Typically, the reduction of working day is not defined a priori, but ranges between 20% and 70% of full-time workers.
4) job sharing: it is a sort of shared part-time or a way of working that implies the sharing of the total responsibility associated with a certain job position. The distribution of the workload between the concerned parties is not defined a priori. In particular, they alternate half a day at work with half a day off, or work half a week for each, or even alternate weeks or months;
5) elasticity of the daily schedule: According to this mechanism, the employee has the right to decide about his/her own working hours and breaks granted by contract. It is a particularly flexible management of working time which is increasingly adopted for those positions not related to customer relationships.

The spatial articulations are related to the shift about the physical working location (i. e. workplace). It is, ultimately, a continuous process of separation (both physical and relational) of the worker from the traditional "locus" of the corporate headquarter. The procedures adopted for the realization of this separation are supported by various tools and mechanisms.
Telework is one of the most popular tools in regard to this. The employee works from home, is totally free, and is able to connect him/herself to the network with the most advanced technological systems. Obviously, as in the case of the elasticity of the daily schedule, there are real limits about the applicability of this model. In particular, telecommuting is unfeasible if there is the need for physical interaction and relationship with other members of the organization, partners, suppliers, customers, etc.. Some positions, however, appear to be partially related to the need for the physical presence, while in some periods (day, week, or month) employees can connect from home or some other places other than the place of business.
The services of companies linked to the Work Life Balance methodology aim at satisfying explicit needs of their human resources.
First, it is good to separate these services into two categories:

1) family services;
2) services to the employee.

In the area of family services are company crèches and spaces for children to play, play centers and nursery areas.
In addition, there are also care services dedicated to elderly family members (also through agreements with nursing homes, etc.), as well as facilities for the execution of shopping

activities that increase time savings (for instance, workers can order online their favourite products and receive them at the office).
Another element made available to employees and entered fully into the category of the Work Life Balance services is completion of paperwork issues (e. g. mailing and banking services and facilities within the company, often integrated with highly specialized experts).
Sometimes, especially in Northern America and Northern Europe, there are also some services covering the need for flexible and shared mobility among the many facilities offered by companies to their employees. This area grew up so much to require a new job position covered by a specific professional that is the mobility manager. An expected outcome – i. e. the reduction of transportation impacts of employees – is associated with this organizational role.
Another service that can be embodied in the Work Life Balance is traditionally linked to wellness and can be declined in the availability of a gym and/or swimming pool inside the corporate walls (as in many headquarters of Google scattered around the world) and/or in the signing of agreements with sports facilities and the like, etc..
There are also some very special initiatives due to the precise target they are devoted to. In fact, into this category fall some projects geared to promote equal opportunities for working mothers and, more generally, for workers recently cheered by the birth of a child. These employees are supported by gradual return programs in the workplace, taking into account the specific needs of each individual. In particular, such programs may involve communication services while employees are on maternity leave, or telework tools facilitating the integration of work and private life [14].
In conclusion, the benefits that can be obtained in terms of purely economic and financial performance by the company are [47]:

1) talent retention in the knowledge era (focusing more on time and less short-term monetary issues);
2) motivation and, therefore, a greater productivity (employed treated like human resources and not like machines);
3) a greater organizational capacity of employees;
4) improvement of corporate image and, therefore, a greater talent attraction;
5) no stress company and, thus, a higher quality of both the outputs and the organizational climate as a whole.

However, the theme of Work Life Balance can not be addressed separately from the Total Reward System, addressing the specific issues of compensation and company benefits. In this thesis a new model is proposed. It integrates the two perspectives highlighting areas for future improvements and potential benefits [12], as it is shown in Figure 13.

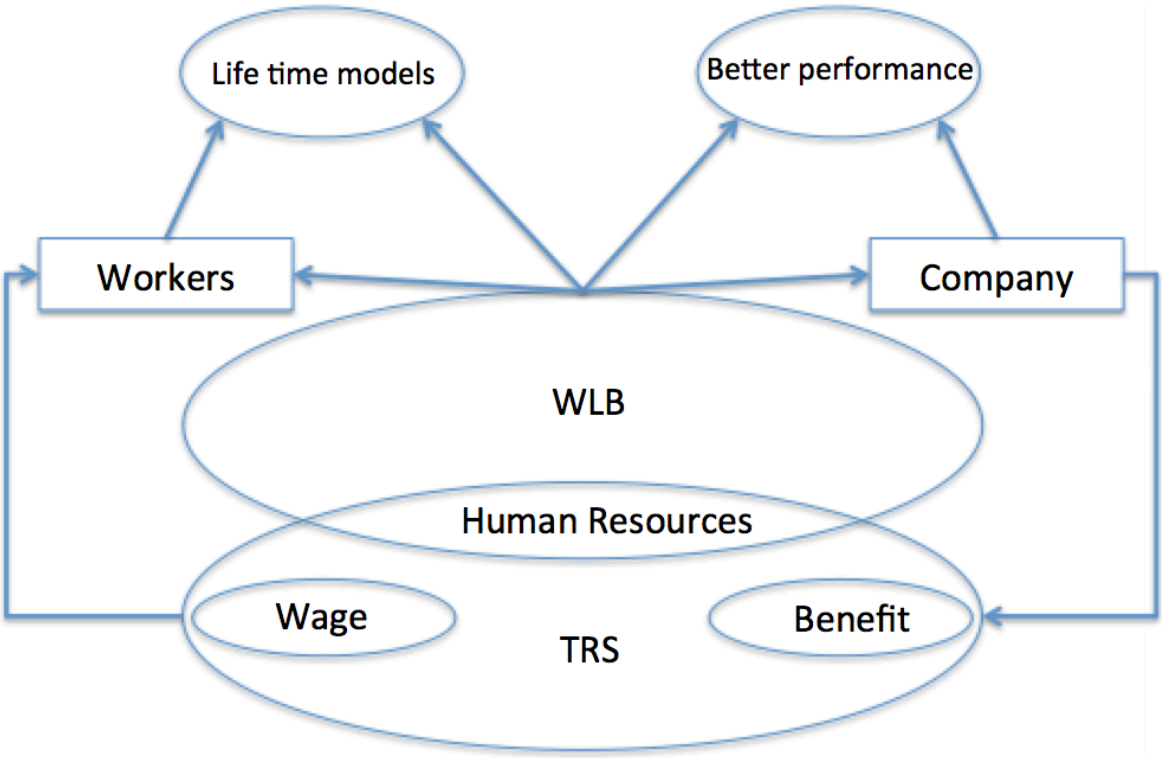

FIGURE 13:. AGGREGATE MODEL INTEGRATING WORK LIFE BALANCE (WLB) AND TOTAL REWARD SYSTEM (TRS) [12]

It is worth noticing that the Total Reward System is considered as a "new way of thinking about the payroll system that integrate the corporate intangible components to the traditional ones in order to attract and motivate people not only for the wage component. The Work Life Balance is part of it" [47].

In Figure 13 the integration between TRS and WLB is the most important feature of the model because it impacts both life time of people and corporate performance, intended to be as an economic and financial result, but also a result of a social nature.

In particular, life time is the result of the combination working time, time for personal care and time to conduct one's own private life. According to the model, the Work Life Balance, if properly implemented, has a positive effect on the business climate, on the attraction and retention strategy of human resources within the company, on staff motivation and organizational productivity as a whole. The integrated model also provides a global view of the advantageous effects that may result from such a system and, therefore, contributes to overcome the attention paid by many managers to short-term results by replacing it with a long-term approach.

At the same time, organizations strongly intertwined to their human resources play a very important role and affect (positively or negatively) the conditions of well-being or stress in the work environment, depending on the quality of the workplace they are realized in.

In conclusion, the following pre-conditions are fundamental in order to obtain the desired results [12]:

1) the Work Life Balance reveals the effects of a greater significance in the medium/long term. In particular, it generates very positive consequences, but only when such programs are supported by a prior process of planning and management;
2) the Work Life Balance is a strategy for attracting and retaining talents within the company, but in the light of the unawareness about the benefits it brings, often it proves to be a managerial fad that tends to die soon without making any the expected benefits;
3) the provision of a process of Work Life Balance programs monitoring and the need for a design approach constitute the basis for receiving feedback from internal customers (from both the employee and the company as a whole) and make it possible to implement the necessary corrections.

Therefore, the integrated system described above associated the traditional payroll system with a reward system based on complementary company benefits and a program facilitating the matching between working issues and family and private needs.

3.9 Rewarding methodologies: the Total Reward System

The Total Reward System is the set of tools available to the employer to attract, motivate and retain human resources within the company. It includes everything that is perceived as something valuable to the employee [48].

The basis of the system of Total Rewards is the change that has occurred at the organizational and individual level, also based on the changes that took place with regard to time models overtime. It also led to an increase in the level of uncertainty for both parties involved, especially since the advent of flexible manufacturing systems which influenced the evolution of the core features of the employment relationship.

The variety of models generated in this way implied a strong differentiation in relation to remuneration systems. The duty to fulfilling the salary led companies to change their perspective towards a strategy aimed at optimizing the human resources management while ensuring a high degree of flexibility and supporting high levels of productivity and quality [49].

In particular, by considering the growing importance of talent in the current competitive environment, companies are inclined to recognize and care more and more about people as they represent the sole basis for achieving a sustainable competitive advantage in most business contexts [50]. In particular, tools for the attraction and retention leverage also the quality of the business climate, innovation and professional growth.

The result is often a change of the previous relationship existing between fixed pay, variable pay and corporate benefits.

It is good to clarify that benefits are intended to be the different kinds of compensation granted as a surplus compared to what was agreed with the contract. They shall be adopted by companies as they provide a high degree of flexibility and adaptability of the overall

compensation solutions, including the fact that they are independent with respect to the collective bargaining.
In this way, companies can achieve the underlying objective of attracting, retaining and motivating the best talents useful to the company. Consequently, by obtaining these results, it is possible to create a positive impact of belonging and identification with the company's values [51].
The main element of leveraging in the employee's view became the wealth of skills they own, acquired and continuously updated thanks to systems based on lifelong learning [12].
This concept can be summarized without loss of generality by adopting the term "employability", that is a worker aiming at being "employable throughout his/her whole life".
This argumentation is supported also by the current crisis of the retirement systems in many countries, especially in the "Western Block", which is coupled with the disappearance of the open-ended contract.
For these reasons, it is increasingly important and urgent to establish a special compensation system in each company in order to address organizations to change (possibly) the combination of fixed pay, variable pay and benefits (Figure 14) [12].

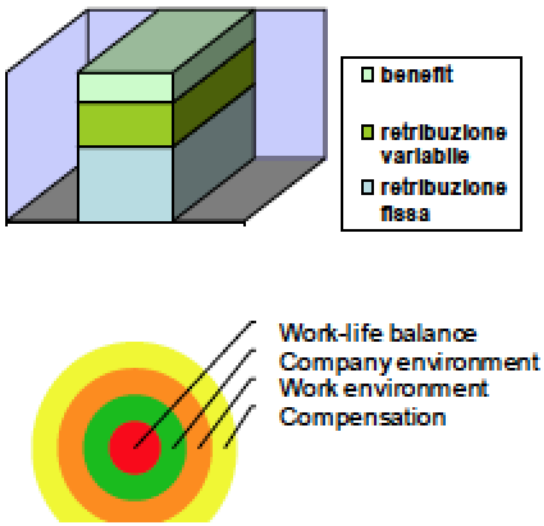

FIGURE 14: EVOLUTION OF THE COMPENSATION SYSTEMS [12]

In Figure 14 the whole block represents the traditional compensation system established in the organizational context. The lower layer is the fix pay, the intermediate one is the variable pay and upper one is the benefit component. The circular shape indicates the new system based on the aforementioned models including both WLB and TRS.
The paradigmatic shift took place recently concerning with the structure of compensation systems and is shown briefly in Figure 14.
The traditional system of compensation required that the company could determine a static relationship between the three components of the compensation system, generally preferring the fixed component, then the variable and finally the benefit ones.
In detail, work environment means the workplace and its own climate aimed at motivating people and being very comfortable. Company environment means the positioning of the

company from the economic and financial point of view and also in terms of ethics and social positioning. Finally, the Work Life Balance is placed as the core of the entire system as it focuses on factors relating to the private lives of workers and, more generally, to their quality of life [12].

Another existing model in the literature [45] to represent clearly the Total Reward System is that showed in Figure 15.

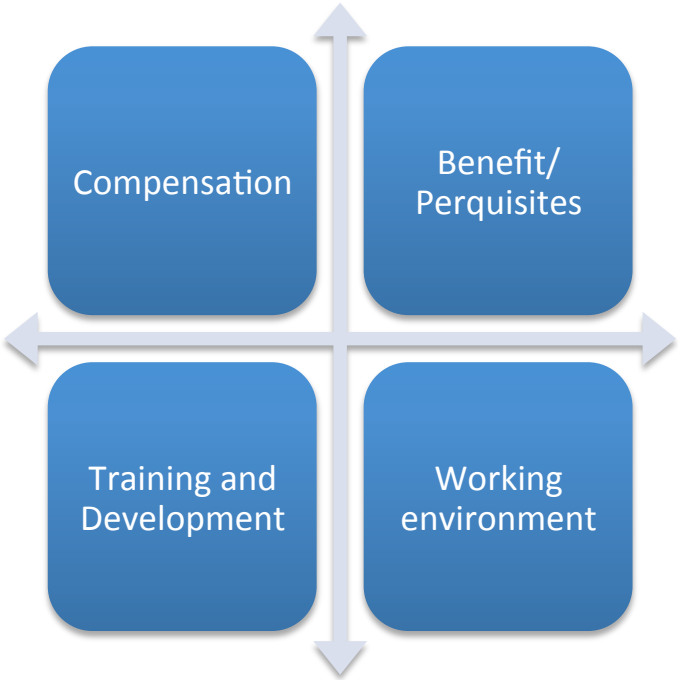

FIGURE 15: ALTERNATIVE APPROACH TO THE TRS [45]

At this point, it is necessary to deepen each component of the system separately:

1) Compensation**.** The component of compensation includes fixed and variable pay, divided into short and long term, and corporate awards.

   To understand the importance of this element it is useful to view the corresponding data (Figure 16 and Figure 17) provided by a recent study of OD&M Consulting [52]. While employees and managers' (i. e. "impiegati" and "managers") compensations grew up with Italian inflation rates, working class (i. e. "operai" and "dirigenti") and executives' growth rates remained flat.

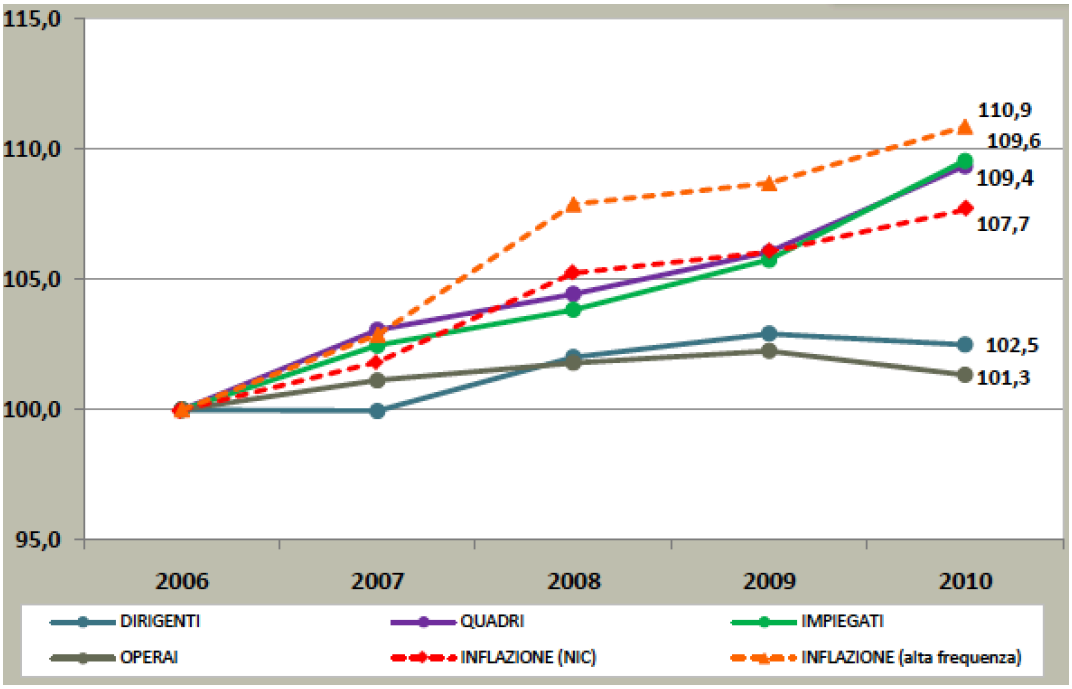

FIGURE 16: TRENDS OF NATIONAL COMPENSATION 2006-2010 [52]

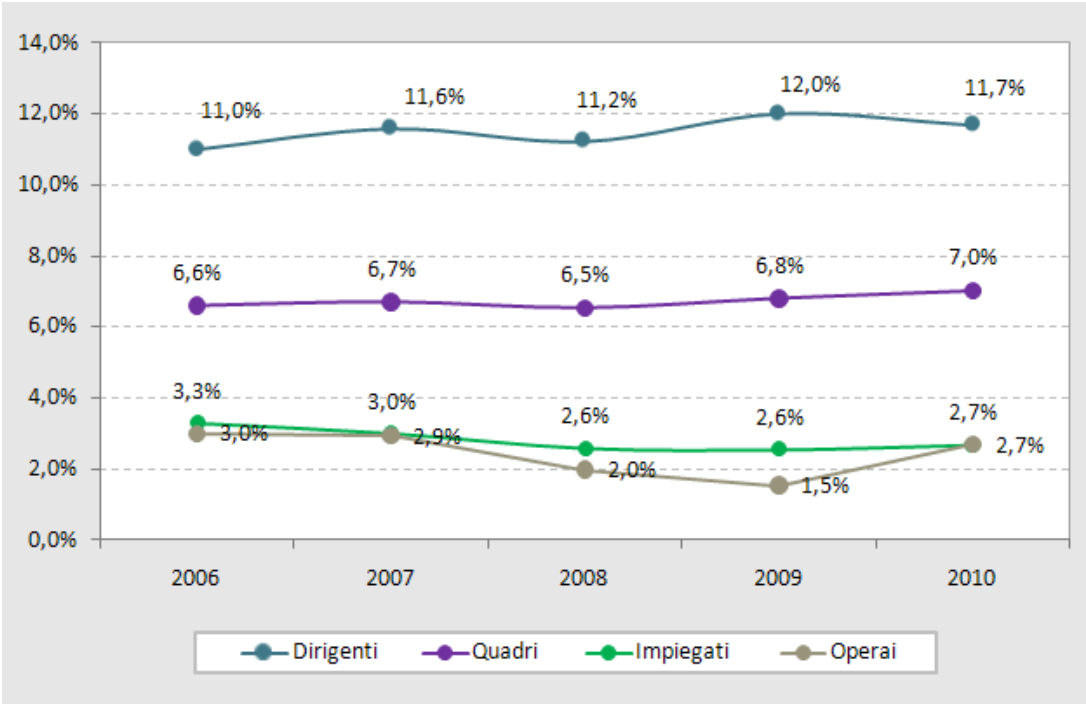

FIGURE 17: IMPACT OF THE VARIABLE PAY COMPONENT ON THE FIXED COMPONENT OF COMPENSATION 2006-2010 [52]

2) Benefits/perquisites. Benefits are intended to be "tools having essentially a social security and welfare goal aimed at protecting the future standard of living or the family heritage" [45]. They may be used for the entire workforce or framed on well identified clusters of employees. Within this sub-system it is still possible to vary the level of flexibility, starting from a base of predefined benefits to reach the far more innovative

Total Reward Optimization, also known as TRO (Figure 18). Flexibility, complexity and value grow up towards the TRO.

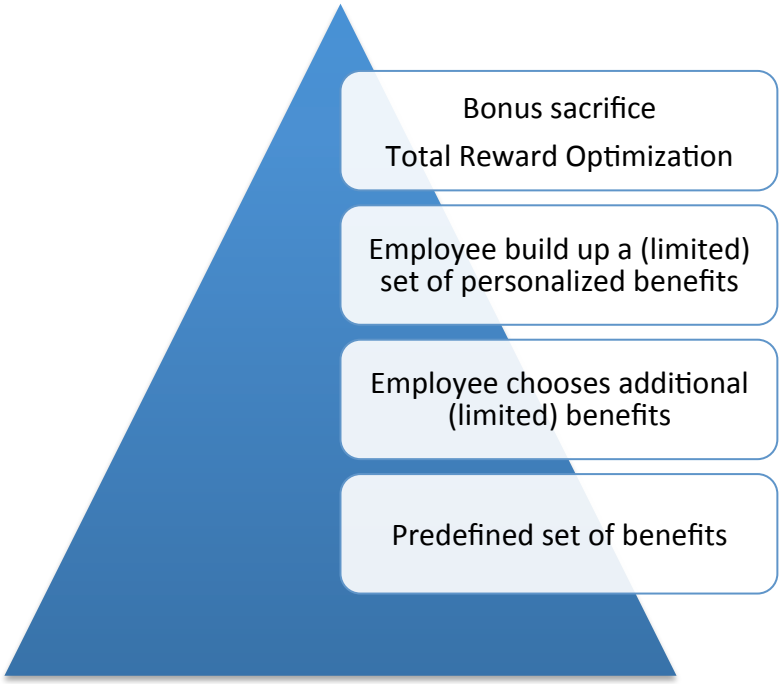

FIGURE 18: USE OF BENEFITS: FLEXIBILITY, ADMINISTRATIVE COMPLEXITY AND PERCEIVED VALUE [45]

On the contrary, perquisites means "the goods and/or services the employee may use immediately as working or extra-working tools" [45].
In the list of the benefits are included:

- pension plan;
- medical expenses;
- accidents;
- death and disability;
- health insurance.

There are also the following goods/services:

- company car;
- mobile phone/smartphone;
- PC;
- food stamps;
- discounts and special offers;
- gym;
- kindergarten;
- laundry/ironing;

- pediatric care for children.

3) Training and development. The third block of the model includes career development, learning opportunities, performance management and replacement plans.
   According to a research carried out by OD&M Consulting [53], it is clear that companies are focusing heavily on the sustainability of the professional development of senior - i. e. "dirigenti" - and middle management - (i. e. "quadri") (Figure 19).

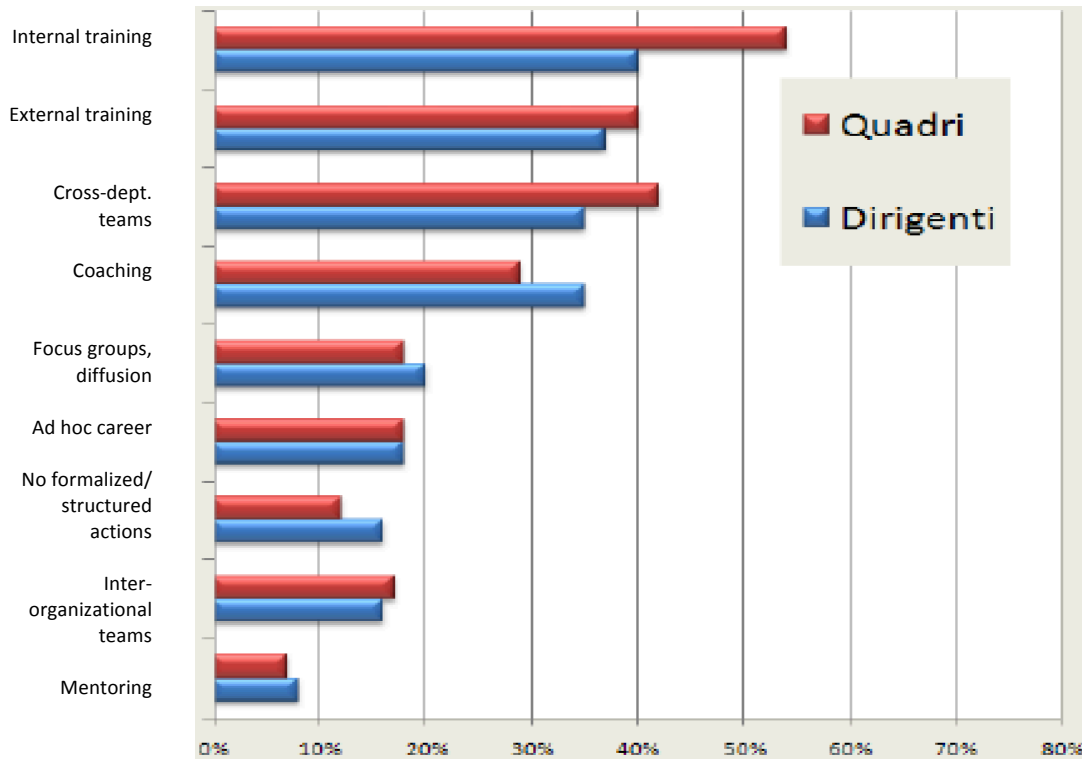

FIGURE 19: TRAINING AND DEVELOPMENT MECHANISMS ADOPTED BY COMPANIES [53]

4) Working environment. The final element of the model (Figure 20) takes into account the organizational climate, the support to the performance and the managerial styles.

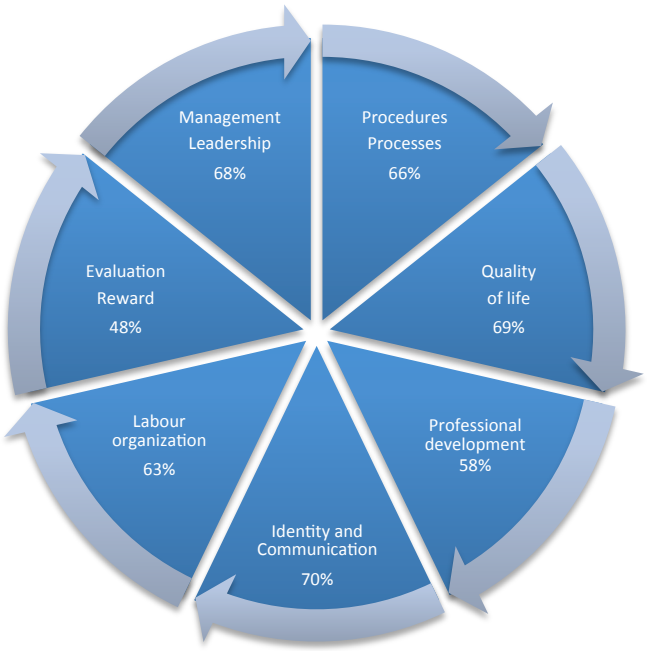

FIGURE 20: WORKING ENVIRONMENT AND OVERALL SATISFACTION WITH EFFECTS ON CLIMATE AND MOTIVATION (ADAPTED FROM [25])

The working environment is important as it is closely linked to climate and motivation [54].
In particular, it is possible to distinguish several specific areas that affect these aspects.
In summary, the overall model of the Total Reward System can be depicted as in Figure 21 [48].

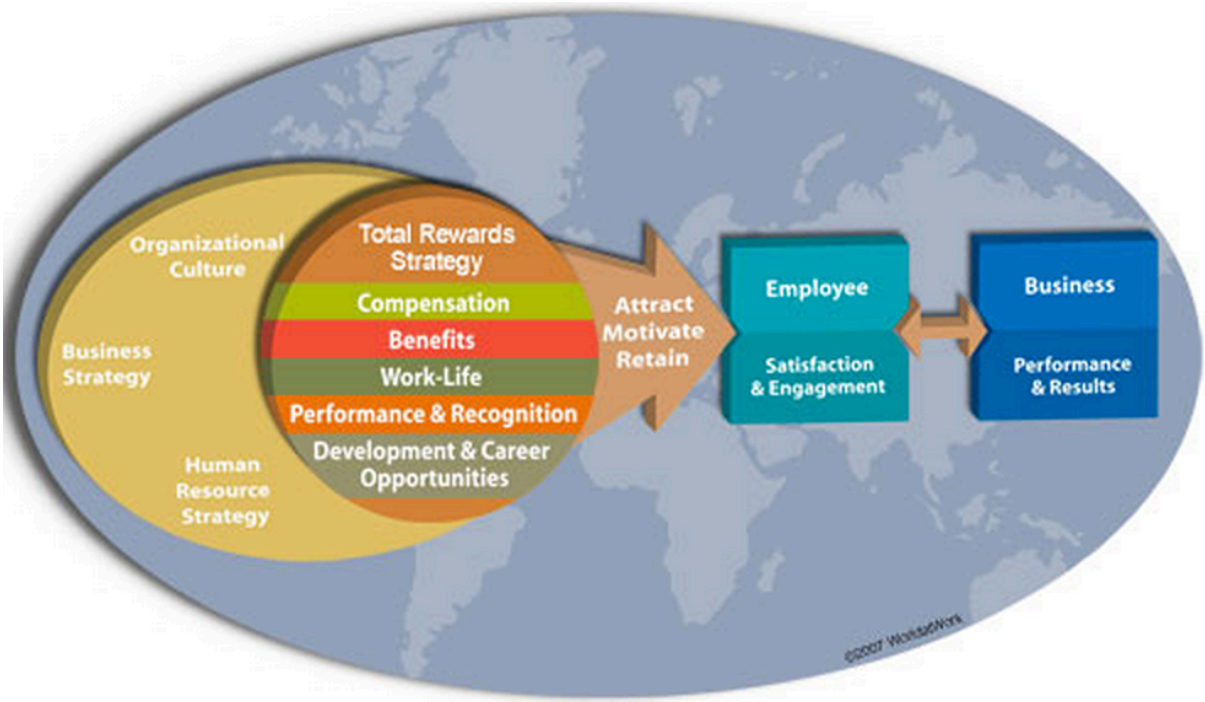

FIGURE 21: OVERALL MODEL OF THE TOTAL REWARD SYSTEM [48]

After defining the basic concepts and models of reference of the Total Reward System, it is helpful to understand what are the aspects of internal equity and market comparison.
The term "internal equity" (or "internal fairness") refers to the internal value of a job position and, therefore, to the set of information arising from the job analysis and job evaluation activities. On the contrary, the "external benchmark" associated with the Total Reward System means the reference to the market value of a given job position, which can not be obtained without a preliminary job analysis activity, as well as the analysis of competitors. The link between internal equity and external benchmark, on the one hand, and compensation policies, on the other hand, is clearly shown and explained in Figure 22 [45].

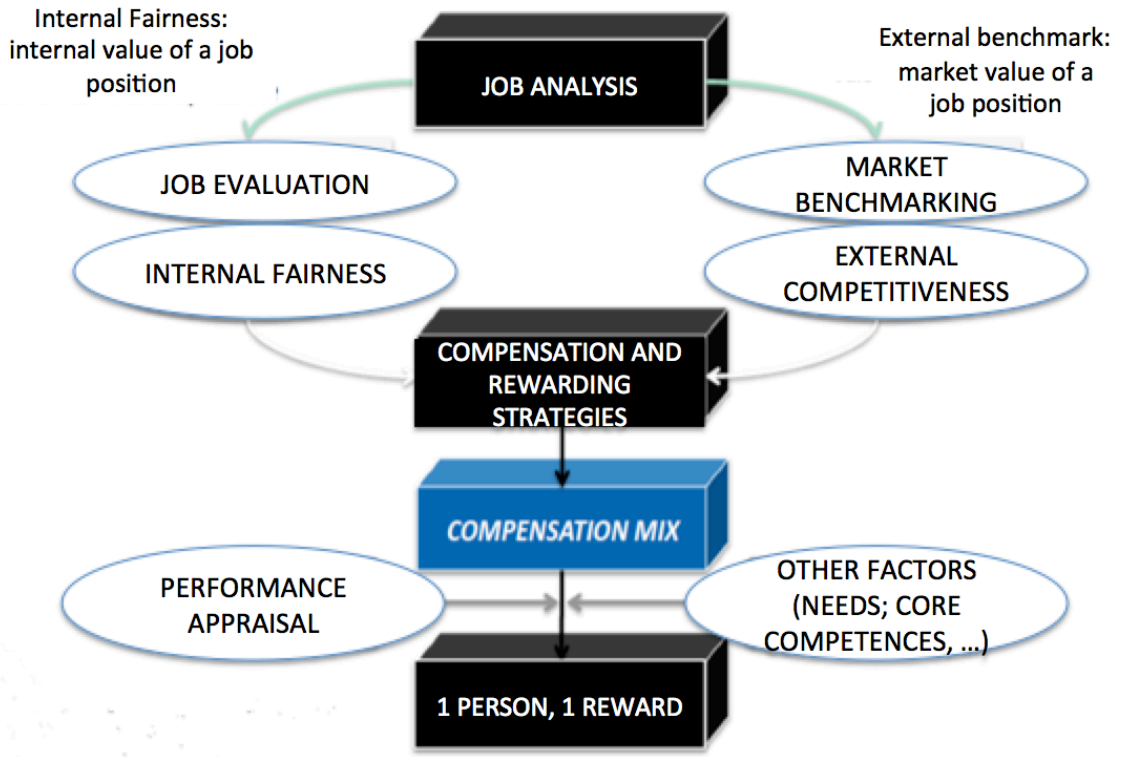

FIGURE 22: INTERNAL FAIRNESS, EXTERNAL BENCHMARK AND COMPENSATION POLICY [45]

Identification of deserving workers

The graph structure allows to represent a Social Network and provides the opportunity to determine the degree of relative importance of a user within the network.
For the purposes of a better understanding of the use and goal of the techniques described below it is worth pointing out how the data can be extrapolated in order to implement an advanced Rewarding 2.0 system.
In fact, the scope and intensity of social relationships that can be developed in a Social Network provide a starting point to identify deserving workers, grouping them according to

common features and criteria taken into account by the reward system and drawing up a ranking of workers.
The identification of the most influential users in an organization is important because it allows to allocate tangible or intangible, monetary or non-monetary incentives, to deserving employees. In addition, such benefits could also be determined on the basis of a specific profile of each user, making it even more effective to engage people on collaboration and knowledge sharing. These aspects are also the basis of the achievement of the company's competitiveness, as a more proactive worker determines a better quality of results and a better alignment between business goals and individual needs.
Finally, the company and individuals have the ability to identify those users able to steer in the right direction any decision-making process [1].

3.10 Network-based positioning techniques and centrality measures

The determination of user's position and degree of centrality in the network and, hence, the consequent identification as a deserving worker or not, are essential for the proper implementation of a rewarding system in business contexts.
The techniques that refer to the user's position in social networks in the literature are described below:

- Degree Centrality [17]. This measure of centrality is based on a fundamental assumption, namely that the node object of measurement has a degree of importance equal to the number of adjacent nodes (Figure 23 and Figure 24) according to the following formula:

$$CD(i) = c_i = \sum_j a_{ij}$$

where:
- CD (i) and c_i represent the degree centrality of the i-th node of the network;
- a_{ij} takes the values 0 and 1 and indicates the actual existence of the arc (i, j) in the network. In particular, it is zero if the arc does not exist, one otherwise.

FIGURE 23: DEGREE CENTRALITY: YELLOW ADJACENT NODES AND EDGES [17]

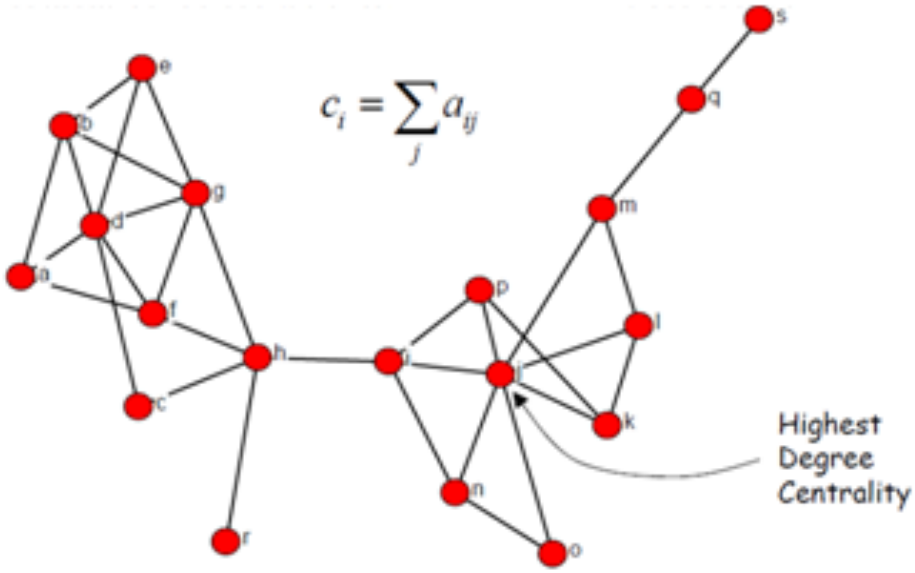

FIGURE 24: FINDING THE NODE WITH THE HIGHEST DEGREE CENTRALITY [16]

So, it is a purely quantitative measure and does not dwell on qualitative elements.
This technique of calculating the centrality assumes that there is only one criteria to be used for the identification of the most deserving users, namely having the maximum possible number of connections, without taking into consideration the nature and intensity of the social relationships established within the network.
Besides giving an indication of the quality of the connection of a node with the rest of the network, it aims to provide an assessment of the direct influence that a user is potentially able to exert on another member of the same network, as well as its communicative potential.
There are also different versions of degree centrality, in function of the fact that the graph we refer to is a "directed network" or not. If the lines are not specified on the

edges we have a directed network, otherwise it is necessary to calculate two different values of centrality:

- indegree centrality;
- outdegree centrality.

The level of indegree centrality gives cognizance of the number of direct relationships towards the node in question. On the contrary, the outdegree centrality calculates the number of outgoing edges from such a node [16].
If such links are related to positive aspects, such as friendship or simple professional networking, we can provide a further consideration:

- the indegree centrality is interpreted as a form of popularity of the node towards which is directed the "attention" of many other members of the community;
- the outdegree centrality is considered as a measure of how that node and, therefore, the corresponding user can be seen as gregarious or followers of other users.

Sometimes, it is interesting to determine not only the centrality of a user, but also of a portion of graph.
This is the case, for example, of clusters of users with common features within the network.
So, we can think of extending the concept of degree centrality from a single node to the entire graph.
For this purpose, assuming that c* is the node with the maximum value of degree centrality in the graph G, it is possible to define a portion of graph G' having a corresponding subset of nodes and edges:

$$G' := (C', A')$$

where:

- C' is the set of nodes corresponding to the graph G';
- A' is the set of edges of the same graph.

Furthermore, we assume that c'* is the node with the highest value of degree centrality in the graph G'.
We assume, also, that G' is such that it maximizes the following quantity:

$$H = \sum_{j=1}^{|C'|} (CD(c'^{*}) - CD(c'_j)$$

The value H is maximized when the graph G' is a star or when it contains a central node to which are connected all the other nodes of the network (Figure 25).

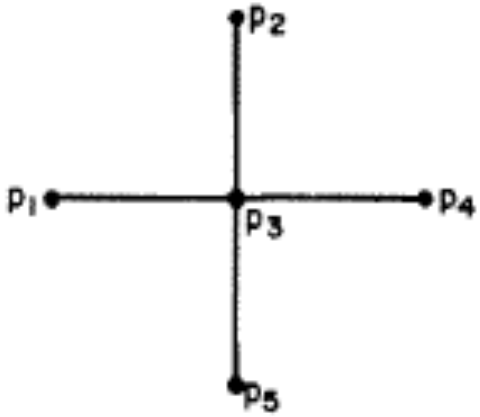

FIGURE 25: EXAMPLE OF A "STAR" OR "WHEEL" GRAPH [17]

Therefore, H is equal to (n-1) * (n-2).
Finally, by computing the degree centrality of the graph G we obtain:

$$CD(G) = \frac{\sum_{i=1}^{|C|} CD(c^*) - CD(c_i)}{H}$$

As an alternative to the determination of the degree centrality it is possible to calculate the "normalized degree centrality" of the i-th node, referred to as nCD (i) and obtained as the ratio (in percentage) between the value of the degree centrality and the maximum possible value of degree centrality, i. e. n-1, according to the following formula:

$$nCD(i) = \frac{CD(i)}{n-1}$$

- Closeness Centrality [18] [19] [20] [21] [22]. The concept of Closeness Centrality refers to the proximity between nodes in the same network.
  In particular, it refers to the geodesic distance, which identifies the shortest path between nodes (Figure 26 and Figure 27). More precisely, the closeness of a node with respect to all others in the same graph is measured as the inverse of the sum of the geodesic distances of such a node from all others. This amount is defined "farness", F (i), of the node.
  So, in order to calculate the closeness centrality of node i considering the geodesic distance, we obtain:

$$CC(i) = \frac{1}{\sum_{j \epsilon C \setminus i} d(i,j)}$$

$$= \frac{1}{F(i)}$$

As an alternative to the determination of Closeness Centrality, it is possible to calculate the normalized Closeness Centrality of the i-th node, shown as nCC (i). It is obtained as the ratio between the maximum possible value of the Degree Centrality of the i-th node and the sum of distances of node i from all the other nodes, i. e. the farness of node i:

$$nCC(i) = \frac{|C| - 1}{\sum_{j \epsilon C \setminus i} d(i,j)} = \frac{|C| - 1}{F(i)}$$

where:

- C is the set of nodes of the graph;
- d (i,j) is the distance between the nodes i and j.

This is equivalent to calculate the product between the Closeness Centrality of i and the maximum possible value of the Degree Centrality of the same node.
Even the Normalized Closeness Centrality is always expressed in percentages.
Consequently, the concept of farness of node i from all the other nodes can be expressed mathematically as it follows:

$$F(i) = \sum_{j \epsilon C \setminus i} d(i,j)$$

Moreover, it is worth to specify how, unlike the Degree Centrality, the Closeness Centrality is a measure of the inverse degree of centrality.

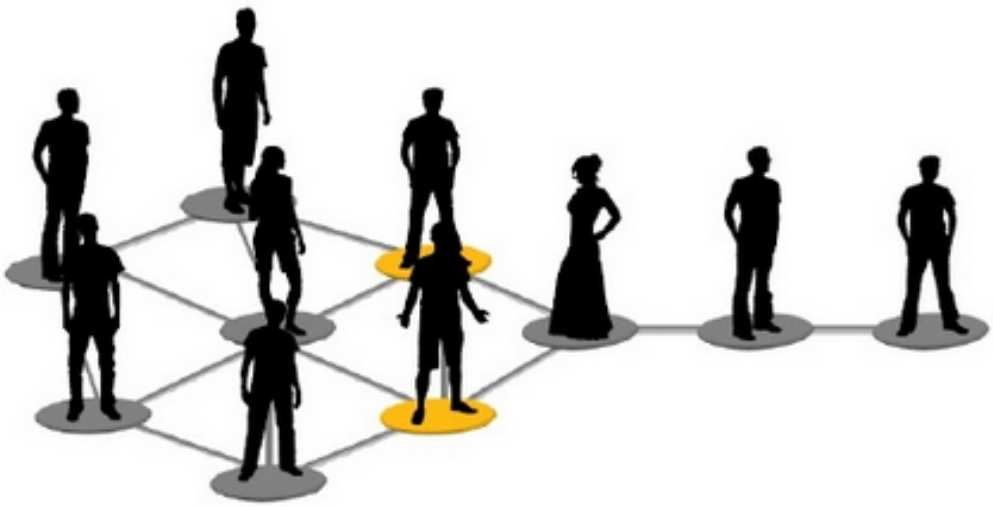

FIGURE 26: CLOSENESS CENTRALITY: YELLOW NODES [17]

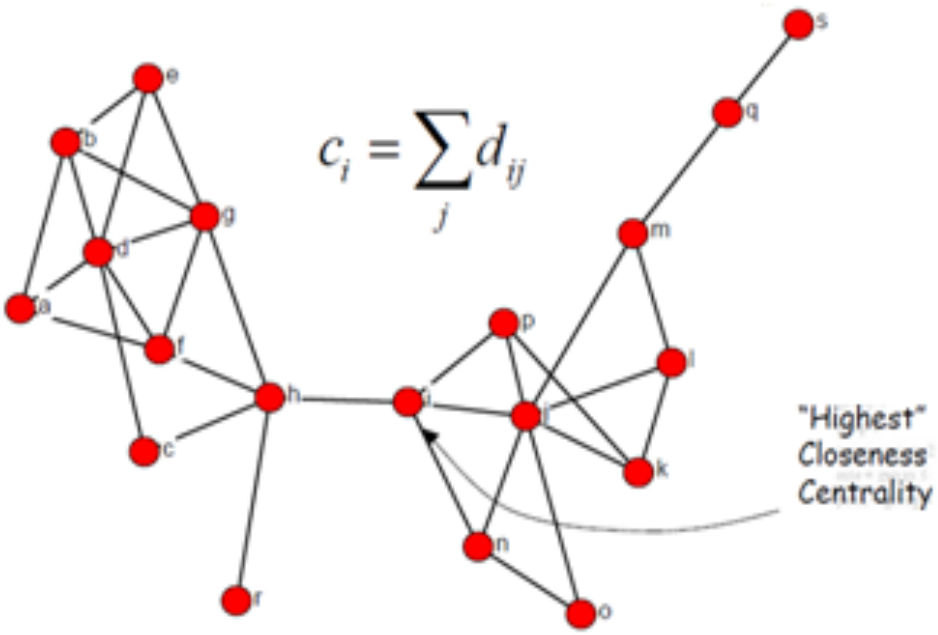

FIGURE 27: FINDING A NODE WITH THE BEST POSITIONING IN TERMS OF CLOSENESS CENTRALITY [16]

As in the case of the Degree Centrality, also for the Closeness Centrality some variants have been developed depending on the fact that the graph they refer to is a directed network or not. Like in the Degree Centrality, for non-directed graphs we calculate two different values of centrality that are defined:

- Incloseness Centrality;
- Outcloseness Centrality.

The level of Incloseness Centrality focuses on Closeness Centrality obtained by considering the shortest paths entering a specific node. On the contrary, the Outcloseness Centrality takes into account the shortest paths outgoing from a node [16].
In summary, the concept of Closeness Centrality is linked to the fact that the more a node is central in a network, the lower is the overall distance of such a node from all others in the network. The Closeness Centrality is seen as a measure of the speed with which it is possible to disseminate some information from node i to the rest of the network.
Moreover, it can be said that it is also a measure of the potential of a node to perform independent communication.
There are also other versions of Closeness Centrality adapted to specific scenarios, including:

- the random-walk closeness Centrality [23];
- Information Centrality [24].

In the first case it is a version of closeness centrality in which fails the condition of being able to always choose the shortest path reference, having to choose, then, for a random path within the network so that information reaches all nodes .
In this context, whereas a weighted graph, which is oriented or less, and the relative transition matrix M such that its elements mjk, j = 1, ..., n, k = 1, ..., n, quantifying the likelihood that the information that reaches the node, traveling casually, proceed just as casually toward the node j, it is possible to define mathematically the random-walk Closeness Centrality refers to the i-th node, CCRW (s), such as:

$$CCRW(i) = \frac{n}{\sum_{j=1}^{n} H(j,i)}$$

where:

- H (j, i) is the average number of steps to reach node j from node i for the first time.

In the second case, instead, it is worth to specify that the concept of Information Centrality introduced in [24] is similar to the above measure of centrality. In particular, it is based on the calculation of the harmonic mean related to the length of paths terminating in node i.
However, there is another problem for the determination of the closeness centrality, namely the one regarding the fact that some graphs are disconnected. Some specific studies have been carried out about it [19] [20] [25].
For example, Dangalchev [25] from Harvard University developed a formula that allows to overcome this problem:

$$CC(i) = \sum_{t \epsilon C \setminus c} 2^{-d_G(c,t)}$$

Another scholar, Opsahl [19], proposed a solution for graphs with disconnected components while maintaining the meaning and validity of the classic Closeness Centrality.
The main and the most common obstacle is that in the presence of disconnected graphs the farness appears to be infinite, thus eliminating the value of the closeness centrality [19] [20].
The solution is to limit the centrality measure to the largest portion of the disconnected graph, by measuring the closeness in a perspective limited to the intra-component context.
However, this issue highlights many important problems of inaccuracy [19].
Here is an example (Figure 28).

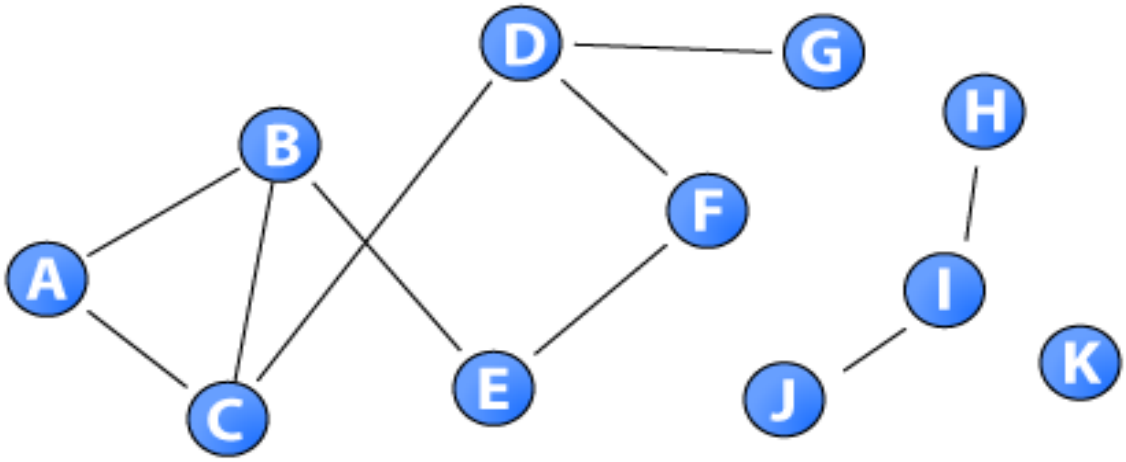

FIGURE 28: EXAMPLE OF A DISCONNECTED GRAPH [19]

The measurement of the classical Closeness Centrality is equal to infinity (Figure 29). In fact, we can notice that by considering the nodes belonging to different disconnected portions in Figure 28.

Furthermore, there is a disparity between the number of paths and, hence, of distances to consider for the different components of the disconnected graph.

A first observation is that nodes H, I and J will prove to be, in general, nodes closer to all the others of their disconnected component than, for example, to nodes A, B, C, D, E, F, and G.

Furthermore, the intra-component Closeness Centrality brings with it additional problems of selection of the portions of the graph to be taken into account for the calculation of the centrality [19].

	Nodes											All inclusive		Intra-component	
	A	B	C	D	E	F	G	H	I	J	K	Farness	Closeness	Farness	Closeness
A	...	1	1	2	2	3	3	Inf	Inf	Inf	Inf	Inf	Inf	12	0.08
B	1	...	1	2	1	2	3	Inf	Inf	Inf	Inf	Inf	Inf	10	0.10
C	1	1	...	1	2	2	2	Inf	Inf	Inf	Inf	Inf	Inf	9	0.11
D	2	2	1	...	2	1	1	Inf	Inf	Inf	Inf	Inf	Inf	9	0.11
E	2	1	2	2	...	1	3	Inf	Inf	Inf	Inf	Inf	Inf	11	0.09
F	3	2	2	1	1	...	2	Inf	Inf	Inf	Inf	Inf	Inf	11	0.09
G	3	3	2	1	3	2	...	Inf	Inf	Inf	Inf	Inf	Inf	14	0.07
H	Inf	Inf	Inf	Inf	Inf	Inf	Inf	...	1	2	Inf	Inf	Inf	3	0.33
I	Inf	Inf	Inf	Inf	Inf	Inf	Inf	1	...	1	Inf	Inf	Inf	2	0.50
J	Inf	Inf	Inf	Inf	Inf	Inf	Inf	2	1	...	Inf	Inf	Inf	3	0.33
K	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf	...	Inf	Inf	0	...

FIGURE 29: EXAMPLE OF A MATRIX OF DISTANCES REFERRED TO THE GRAPH IN FIGURE 24 [19]

Therefore, an alternative method would be to calculate the Closeness Centrality of i as the sum of the inverse of the distances to all other nodes:

$$CC(i) = \sum_{j} \frac{1}{d_{ij}}$$

The result allows to state that many of the problems mentioned above are overcome (Figure 30):

	Nodes											Closeness	
	A	B	C	D	E	F	G	H	I	J	K	Sum	Normalized
A	...	1.00	1.00	0.50	0.50	0.33	0.33	0	0	0	0	3.67	0.37
B	1.00	...	1.00	0.50	1.00	0.50	0.33	0	0	0	0	4.33	0.43
C	1.00	1.00	...	1.00	0.50	0.50	0.50	0	0	0	0	4.50	0.45
D	0.50	0.50	1.00	...	0.50	1.00	1.00	0	0	0	0	4.50	0.45
E	0.50	1.00	0.50	0.50	...	1.00	0.33	0	0	0	0	3.83	0.38
F	0.33	0.50	0.50	1.00	1.00	...	0.50	0	0	0	0	3.83	0.38
G	0.33	0.33	0.50	1.00	0.33	0.50	...	0	0	0	0	3.00	0.30
H	0	0	0	0	0	0	0	...	1.00	0.50	0	1.50	0.15
I	0	0	0	0	0	0	0	1.00	...	1.00	0	2	0.20
J	0	0	0	0	0	0	0	0.50	1.00	...	0	1.50	0.15
K	0	0	0	0	0	0	0	0	0	0	...	0	0

FIGURE 30: EXAMPLE OF CALCULATION OF CLOSENESS CENTRALITY ACCORDING TO THE REVISED FORMULA PROPOSED IN [19]. NORMALIZED VALUES ARE DEFINED IN THE INTERVAL [0, 1]. THE NULL VALUE IS ASSIGNED TO THE ISOLATED NODES, WHILE A VALUE OF 1 IS ASSIGNED TO THE NODES DIRECTLY CONNECTED TO EACH OTHER

In fact, it is able to get a value of Closeness Centrality for each node by considering the same number of distances and, therefore, of paths, irrespective of the size of the corresponding disconnected component.
Moreover, the nodes within the larger components are generally those that receive the greatest increase in value in terms of Closeness Centrality, since in a disconnected graph, they are more likely to reach a higher number of nodes.

- Betweenness Centrality [18] [19] [20] [21] [22]. The Betweenness Centrality is linked to the concept of potential of control of communication in a network. In fact, it

evaluates as more important those nodes that are more frequently placed on the shortest paths between two nodes of the graph.
The assumption behind this technique is consistent with the view that the central users of the network are those located in strategic locations to spread communications.
Moreover, in line with these observations, we must specify how users identified as central have to be considered as important intermediaries in the network (Figure 31 and Figure 32).

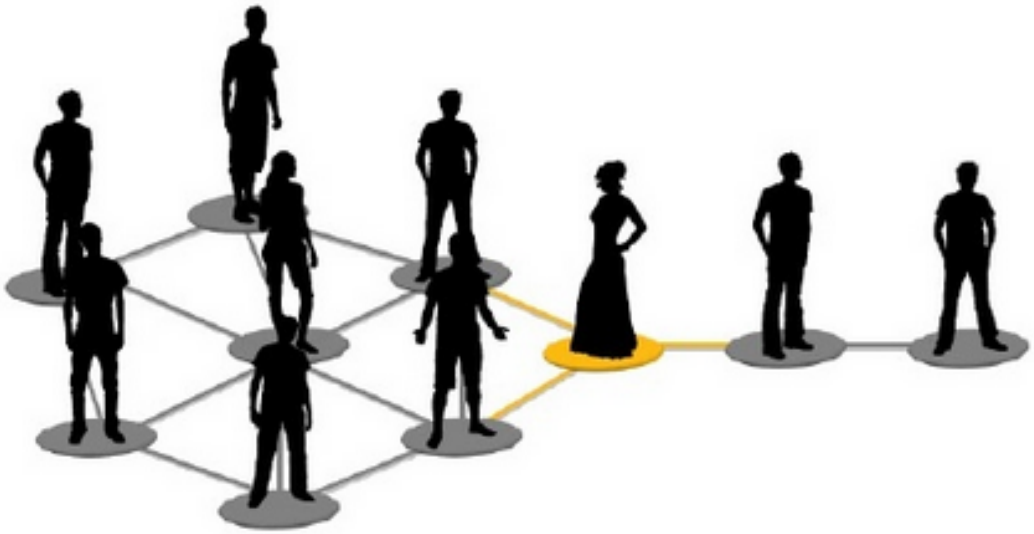

FIGURE 31: MEASUREMENT OF BETWEENESS CENTRALITY: YELLOW NODES CONSIDERED [17]

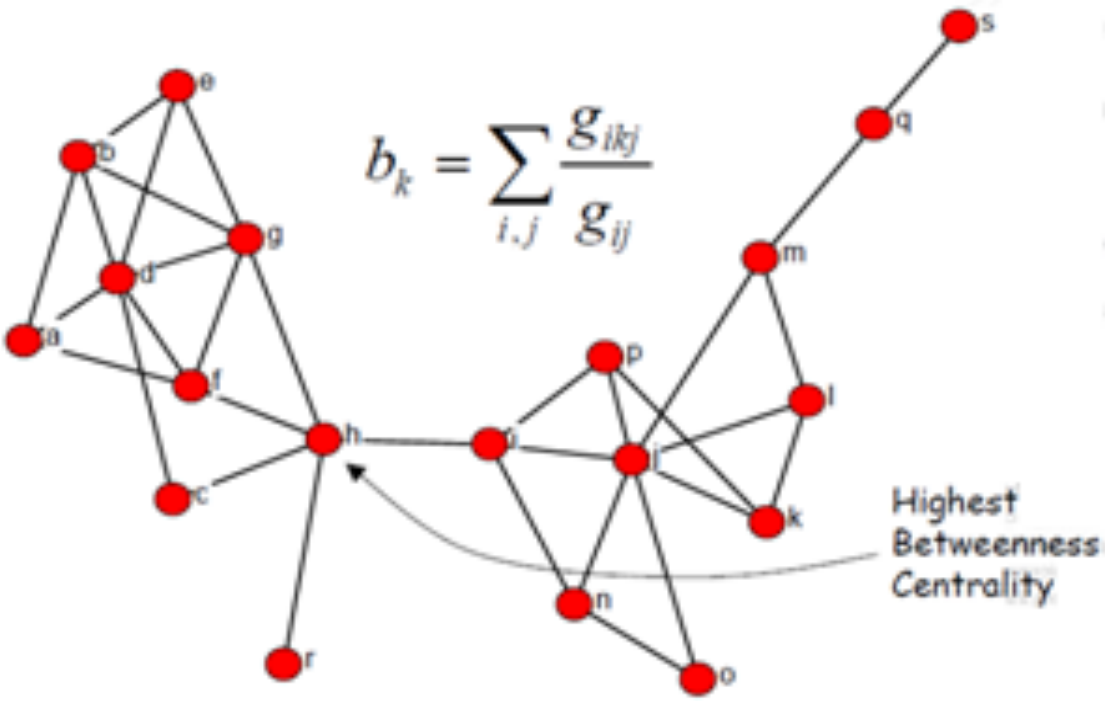

FIGURE 32: EXAMPLE OF FINDING A NODE WITH THE BEST POSITIONING IN TERMS OF BETWEENESS CENTRALITY [16]

In formulas:

$$CB(i) = \sum_{j \neq i \neq k \epsilon C} \frac{SP(i)_{jk}}{SP_{jk}}$$

where:

- SP (i) $_{jk}$ is the total number of shortest path between each pair of nodes (j, k) that passes through the node i, j, k ϵ C;
- SP_{jk} is the total number of shortest path between each pair of nodes (j, k), with j, k ϵ C.

The normalized Betweenness Centrality can be calculated as the ratio between the classical Betweenness Centrality and the number of pairs of nodes that does not include the i-th node | A \ {(i,.) (., i)} |.
In this case we must distinguish between undirected and directed graph:

- directed graph. The number of pairs of nodes that do not include the i-th node is equal to (n-1) * (n-2);
- undirected graph. The number of pairs of nodes that do not include the i-th node is equal to (n-1) * (n-2) / 2.

Therefore, the general version of the normalized Betweenness Centrality is:

$$nCB(i) = \frac{\sum_{j \neq i \neq k \epsilon C} \frac{SP(i)_{jk}}{SP_{jk}}}{|A \backslash \{(i,.),(.,i)\}|}$$

In the case of directed graphs:

$$nCB(i) = \frac{\sum_{j \neq i \neq k \epsilon C} \frac{SP(i)_{jk}}{SP_{jk}}}{(n-1) * (n-2)/2}$$

In the case of undirected graphs:

$$nCB(i) = \frac{\sum_{j \neq i \neq k \epsilon C} \frac{SP(i)_{jk}}{SP_{jk}}}{(n-1) * (n-2)}$$

This measure of centrality usually involves the computation of shortest paths in the network. In this regard different algorithms have been developed over time whose goal is to improve the computational burden of these measurements.

Here are three of the main algorithms proposed in the literature by some scholars [26] [27] [28] [29] [30] [31] [32]:

- Johnson's algorithm.

```
JOHNSON(G, w)
 1  compute G', where G'.V = G.V ∪ {s},
        G'.E = G.E ∪ {(s, v) : v ∈ G.V}, and
        w(s, v) = 0 for all v ∈ G.V
 2  if BELLMAN-FORD(G', w, s) == FALSE
 3      print "the input graph contains a negative-weight cycle"
 4  else for each vertex v ∈ G'.V
 5          set h(v) to the value of δ(s, v)
                computed by the Bellman-Ford algorithm
 6      for each edge (u, v) ∈ G'.E
 7          ŵ(u, v) = w(u, v) + h(u) − h(v)
 8      let D = (d_uv) be a new n × n matrix
 9      for each vertex u ∈ G.V
10          run DIJKSTRA(G, ŵ, u) to compute δ̂(u, v) for all v ∈ G.V
11          for each vertex v ∈ G.V
12              d_uv = δ̂(u, v) + h(v) − h(u)
13      return D
```

- Brandes' algorithm.

Algorithm 1: Betweenness centrality in unweighted graphs

```
C_B[v] ← 0, v ∈ V;
for s ∈ V do
    S ← empty stack;
    P[w] ← empty list, w ∈ V;
    σ[t] ← 0, t ∈ V;   σ[s] ← 1;
    d[t] ← −1, t ∈ V;   d[s] ← 0;
    Q ← empty queue;
    enqueue s → Q;
    while Q not empty do
        dequeue v ← Q;
        push v → S;
        foreach neighbor w of v do
            // w found for the first time?
            if d[w] < 0 then
                enqueue w → Q;
                d[w] ← d[v] + 1;
            end
            // shortest path to w via v?
            if d[w] = d[v] + 1 then
                σ[w] ← σ[w] + σ[v];
                append v → P[w];
            end
        end
    end
    δ[v] ← 0, v ∈ V;
    // S returns vertices in order of non-increasing distance from s
    while S not empty do
        pop w ← S;
        for v ∈ P[w] do δ[v] ← δ[v] + (σ[v]/σ[w]) · (1 + δ[w]);
        if w ≠ s then C_B[w] ← C_B[w] + δ[w];
    end
end
```

- Floyd-Warshall's algorithm.

Floyd-Warshall-Algorithm

Input: A digraph G with $V(G) = \{1, \ldots, n\}$ and weights $c : E(G) \to \mathbb{R}$

Output: An $n \times n$ matrix M such that $M[i,j]$ contains the length of a shortest path from vertex i to vertex j.

```
1  M[i,j] := ∞ ∀i ≠ j
2  M[i,i] := 0 ∀i
3  M[i,j] := c((i,j)) ∀(i,j) ∈ E(G)
4  for i := 1 to n do
5      for j := 1 to n do
6          for k := 1 to n do
7              if M[j,k] > M[j,i] + M[i,k] then M[j,k] := M[j,i] + M[i,k]
8  for i := 1 to n do
9      if M[i,i] < 0 then return('graph contains a negative cycle')
```

- Eigenvector Centrality [20] [33] [34] [35] [36] [37] [38] [39] [40]. The Eigenvector Centrality is also known as Rank Prestige. According to this measure the centrality of a node is determined as a function of the relationships that it has with the other nodes of the graph.
  Therefore, an edge is central if it connects central nodes. Likewise, a node is central if it is affected by central edges. This assumption is known as "mutually reinforcing relationship" [41].
  In summary, we can say that the Eigenvector Centrality can be seen as an iterative version of the Degree Centrality. In fact, in this case, the centrality of a node is proportional to the sum of the centrality of all the other nodes with which it has linkages in the graph, and this proportion is determined as a function of the centrality of such nodes (Figure 33).
  In order to better understand the importance of this measure, it is useful to refer to concrete examples.
  The Eigenvector Centrality considers, in fact, that is not so important how many people (other nodes) knows an individual (node in question), but how many people know the people with whom he/she is in direct contact.
  Google PageRank is based on a similar assumption [42], assigning a high appreciation of each page that is in turn connected to other pages with a high ranking.
  From the mathematical point of view, this kind of centrality is defined as the principal eigenvector of the adjacency matrix. An eigenvector of a symmetric square matrix is a vector that satisfies the following condition:

$$e_i = \lambda^{-1} * \sum_j a_{ij} * e_j$$

where:

- λ is a constant called eigenvalue;

- a_{ij} is the generic element of the binary adjacency matrix. It is 1 if there is a connection between nodes i and j, while it becomes zero if a such relationship does not exists;
- e_i provides the value of the centrality of the i-th node.

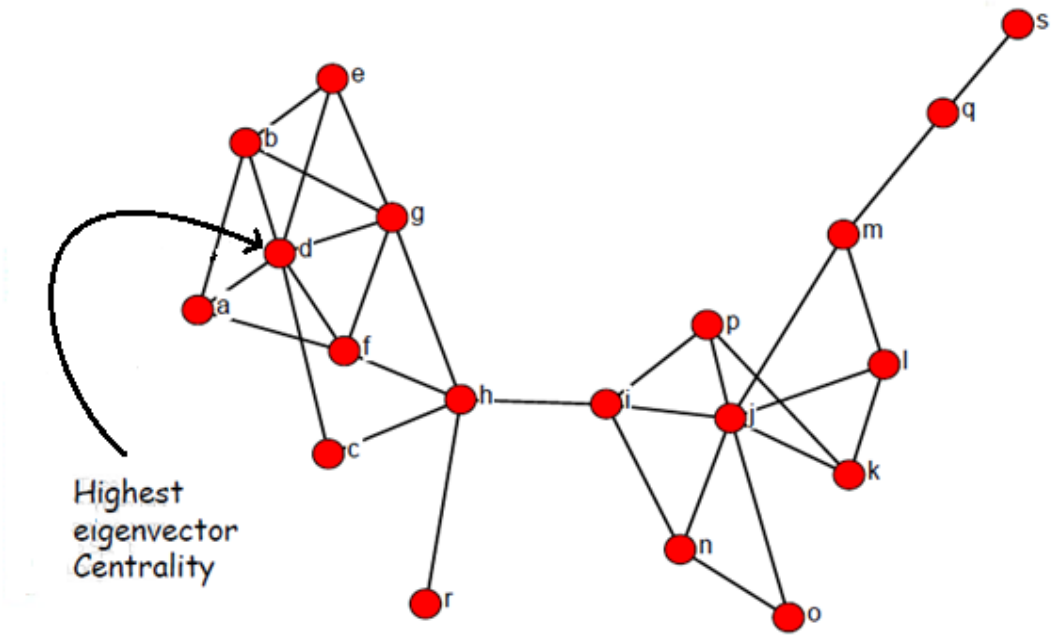

FIGURE 33: EXAMPLE OF FINDING A NODE WITH THE BEST POSITIONING IN TERMS OF EIGENVECTOR CENTRALITY [16]

Mathematically, the expression just introduced is equivalent to that shown below:

$$\lambda * e = A * e$$

where:

- A is the adjacency binary matrix. Its elements $[a_{ij}]$ is equal to 1 if there is a connection between nodes i and j, and assume zero value if no such relationship exists;
- e is the vector of the centrality of the nodes of the graph and eigenvector of A;
- λ is the eigenvalue and associated eigenvector.

Also, it is worth pointing out that you can get more eigenvalues for the equation just illustrated, but should also be considered that the eigenvector is positive.

Based on the considerations made so far is, therefore, possible to use the Perron-Frobenius theorem, according to which it is possible to obtain the eigenvalue with the largest value among all possible eigenvalues [43].
Therefore, the i-th component dell'autovettore provides the value of the Eigenvector Centrality of the node considered.
From the computational point of view, you often use the so-called accelerated power method. This algorithm is shown below:

Step 0. Set $e_i = 1$ for all i.
Step 1. Compute $e_i^* = \sum_j a_{ij} e_j$.
Step 2. Set λ equal to the square root of the sum of squares of e^*.
Step 3. Set $e_i = e_i^*/\lambda$ for all i.
Step 4. Repeat steps 1 to 3 until λ stops changing.

In regard to this, it is interesting to notice that the first step of the algorithm and the value e_i* is exactly equivalent to the Degree Centrality.
Further discussion regarding the Eigenvector Centrality can be done by extending the concepts just exposed to the context of the application of weighed multi-hypergraphs [37].
Formally, it is a pair H : = (V, E). It consists of a set of vertices V and a multi-set of edges E that includes non-empty subsets (hyperedges). Therefore, a subset can appear multiple times in E.
In each pair (v_i, E_j) | $v_i \in E_j$ is assigned a positive weight $w_{ij} \in R+$, where W = [w_{ij}] is the weighted incidence matrix such that its generic element $w_{ij} = 0$ if $v_i \notin$ Ej, while value 1 otherwise.
Even in the case of weighed multi-hypergraphs we can adopt the mutually reinforcing relationship. Therefore, an important hyperedge has important nodes, while an important summit belongs to many important hyperedge.
X_i is the importance of node v_i and y_i of the hyperedge E_j: the mutually reinforcing relationship can be written as it follows:

$$x_i = c_1 * \sum_{j=1}^{n} w_{ij} * y_j \qquad per\ i = 1, \dots, m$$

where $c_1 > 0$ is a proportionality constant independent of i;

$$y_j = c_2 * \sum_{i=1}^{m} w_{ij} * x_i \qquad per\ j = 1, \dots, n$$

where $c_2 > 0$ is a constant of proportionality independent of j.
In matrix notation we can write the following formulas:

$$WW^T x = \lambda\, x$$

$$W^T W y = \lambda\, y$$

where:

- $x = (x_1, ..., x_n)$;
- $y = (y_1, ..., y_n)$;
- $\lambda = c_1 * c_2$.

A solution is provided by imposing [37]:

- $\lambda = \lambda^*$, the dominant eigenvalue of WW^T and W^TW;
- $x = x^*$, non-negative eigenvector of WW^T nell'autospazio associated with λ^*;
- $y = y^*$, non-negative eigenvector of W^TW nell'autospazio associated with λ^*.

The measure of the Eigenvector Centrality of vertices (H, W) is called normalization of x*, while the measure of the eigenvector centrality of the hyperedges in (H, W) is called the normalization of y*.

3.11 Semantic SNA

Based on the operational scenarios defined within the automotive context, SNA techniques geared to identify central workers play an important role in the automotive Enterprise 2.0 model. As a matter of fact, semantic SNA integrate centrality measures and traditional rewarding mechanisms with tools able to assess the qualitative contributions provided by content authors/providers.
Recent studies [69] point to the possibility to apply the semantic perspective to the SNA techniques. The starting point is represented by ontologies for the organization of social data, particularly FOAF, SIOC and RELATIONSHIP. In this perspective, the data structures are no longer adjacency or incidence matrices, but RDF Graphs representing the most varied possible relationships between individuals.
Figure 34 shows a possible result from the combination of elements of RELATIONSHIP and FOAF.

FIGURE 34: EXAMPLE OF COMBINED USE OF FOAF AND RELATIONSHIP

A first feature of this model is the ability to extrapolate different degrees of relationship between people. Most of the properties defined in RELATIONSHIP are sub-properties of foaf:knows used to describe the following relationships:

- family: rel:siblingOf, rel:childOf, rel:parentOf, rel:spouseOf;
- emotional/relational: rel:friendOf, rel:lifePartnerOf, rel:neighborOf, rel:Hasmet, rel:enemyOf;
- professional: rel:workswith, rel:colleagueOf, rel:collaboratesWith, rel:apprenticeTo.

This means that you can manage relationships with different degrees of generality, sincewe can report that two individuals are related or also the nature of the relationship itself, determining how specific individuals are related. This meets one of the classic questions of the SNA: determining the "weight" of the relationship between two individuals.
Another useful combination is that between SIOC and FOAF, through which you can link a user-account to the individual who owns it. On the basis of this relationship SIOC provides a set of elements to describe resources generated by a user and the corresponding interactions. For example:

- SIOC:UserAccount: a class to define accounts;
- SIOC:Item: a class to represent the published resources;
- SIOC:has_creator: property defining the author of a resource. It has a SIOC:Item element as a domain and a SIOC:UserAccount as a codomain;

- SIOC:has_reply: a property defining the response to a post;
- SIOC:follows: the property indicating that a user is following another one;
- SIOC:topic: a property identifying a topic of a published content.

The elements of SIOC are sufficient to represent almost all of the content in the network. The correlation with FOAF allows to establish a deeper level of information thanks to which it is possible to correlate data representing the user in the network to those which characterize it from the social point of view.
For example, in Figure 35 a possible structure is shown. It includes SIOC to model the users relationships and their contents.

FIGURE 35: EXAMPLE OF A COMBINED USE OF FOAF, SIOC AND RELATIONSHIP

The model is able to correlate workers to each other, but also their contents.
At this point, the need of a semantic correlation emerges in order to link resources to each other. To this purpose we used the ontology SKOS in Figure 36, which indicates how it is possible to link two separated posts by grouping them by common concepts.

FIGURE 36: EXAMPLE OF A COMBINED USE OF FOAF, RELATIONSHIP, SIOC AND SKOS.

This link provides other interesting applications. For instance, an author of a content can be linked to a competence associated with such a content. This way it is be possible to structure a competence management system [70]. In Figure 36, both workers possess some expertise relevant to the process "Assembly Shop" and the pillar "Work Organization".

3.12 Semantic SNA and Rewarding

This model is therefore a good starting point for the centrality indexes described in above. SPARQL queries can be used for data extraction, but it is necessary to integrate them with aggregating functions in order to calculate centrality values [69]. To overcome this limitation, it is possible to use the CORESE platform, which provides extensions allowing to add aggregating and management functions of paths to the SPARQL syntax. With this technical solution it is possible to implement complex algorithms such as those determining the indexes of SNA, overcoming some syntax limitations of query languages.
In [69] it is proposed the implementation of some indexes in SPARQL, extended by CORESE, some indexes.

Implementazione

`select merge count(?x) as ?nbactor from <G>`
`where{`
`?x rdf:type param[type]`
`}`

`select merge count(?x) as ?nbactors from <G>`
`where{`
`{?x param[rel] ?y}`
`UNION{?y param[rel] ?x}`
`}`

`select merge count(?x) as ?nbsubj from <G>`
`where{`
`?x param[rel] ?y`
`}`

`select merge count(?y) as ?nbobj from <G>`

```
where{

?x param[rel] ?y

}
```

```
select cardinality(?p) as ?card
from <G>

where {

{ ?p rdf:type rdf:Property

filter(?p ^ param[rel]) }

UNION

{ ?p rdfs:subPropertyOf ?parent

filter(?parent ^ param[rel]) }

}
```

```
select ?x ?y from <G> where {

?x param[rel] ?y

}group by any
```

```
select ?y count(?x) as ?degree
where {

{?x (param[rel])*::$path ?y

filter(pathLength($path) <=
param[dist])}

UNION

{?y param[rel]::$path ?x

filter(pathLength($path) <=
param[dist])}

}group by ?y
```

```
select ?y count(?x) as ?indegree
where{

?x (param[rel])*::$path ?y

filter(pathLength($path) <=
param[dist])

}group by ?y
```

```
select ?x count(?y) as ?outdegree
where {

?x (param[rel])*::$path ?y

filter(pathLength($path) <=
param[dist])

}group by ?x
```

```
select ?from ?to $path
pathLength($path) as

?length where{

?from sa (param[rel])*::$path ?to

}group by ?from ?to
```

```
select pathLength($path) as
?length from <G>

where {

?y s (param[rel])*::$path ?to

}order by desc(?length)

limit 1
```

```
select ?from ?to count($path) as
?count

where{

?from sa (param[rel])*::$path ?to

}group by ?from ?to
```

```
select ?from ?to ?b count($path)
as ?count

where{

?from sa (param[rel])*::$path ?to

graph $path{?b param[rel] ?j}

filter(?from != ?b)

optional { ?from param[rel]::$p
?to }

filter(!bound($p))

}group by ?from ?to ?b
```

```
select distinct ?y ?to
pathLength($path) as

?length (1/sum(?length)) as
?centrality

where{

?y s (param[rel])*::$path ?to

}group by ?y
```

```
select ?from ?to ?b

(count($path)/count($path2)) as
?betweenness

where{

?from sa (param[rel])*::$path ?to

graph $path{?b param[rel] ?j}

filter(?from != ?b)

optional { ?from param[rel]::$p
?to }

filter(!bound($p))

?from sa (param[rel])*::$path2
?to

}group by ?from ?to ?b
```

The formulation of some indices has been revised to make align it perfectly with the characteristics of the model. Regarding the Betweenness Centrality, this index has not been implemented in [69], since it requires different stages of post-processing.
With regard to the data to populate the model, the majority of social networks can make it available a set of APIs predisposed for exporting usable data [69]. A specific ontology – i. e. SemSNA – was proposed: it includes all essential concepts of SNA and its indexes (Figure 37).

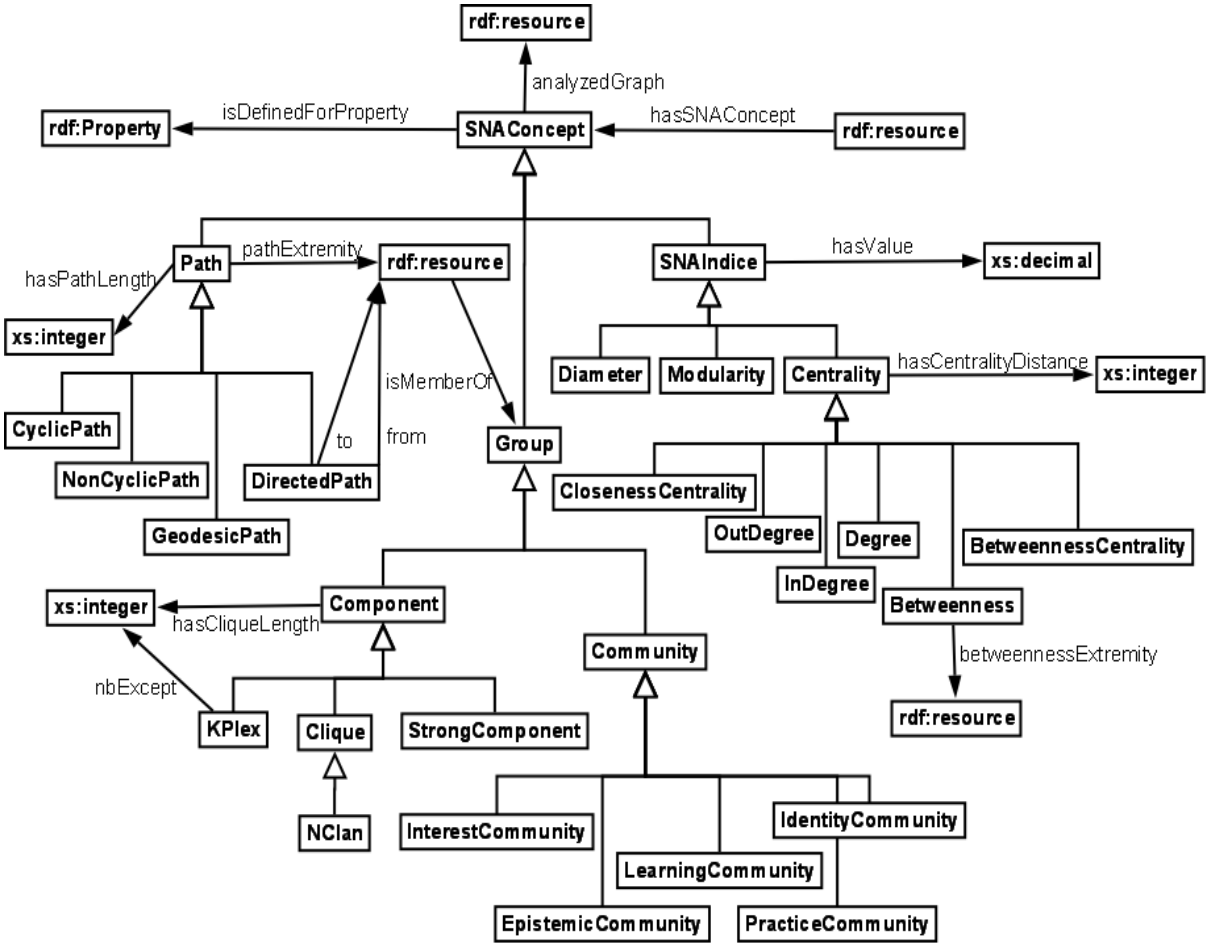

FIGURE 37: ONTOLOGY SEMSNA. TAKEN FROM [69]

Focusing on the performance of index calculation, it was made a simulation by creating an RDF representation of a possible social network consisting of 1,000 workers generating 5,000 posts. It is supposed the existence of 10 components, characterized by the presence of a number of nodes from 10 to 200. The central nodes of such components have been denominated workers Alpha ("Lavoratori Alpha"). For each post ("Post Alpha") a set of nested replies is considered. Among them a post King was identified that is a post having the highest number of replies.
In Figure 38 such a test is represented.

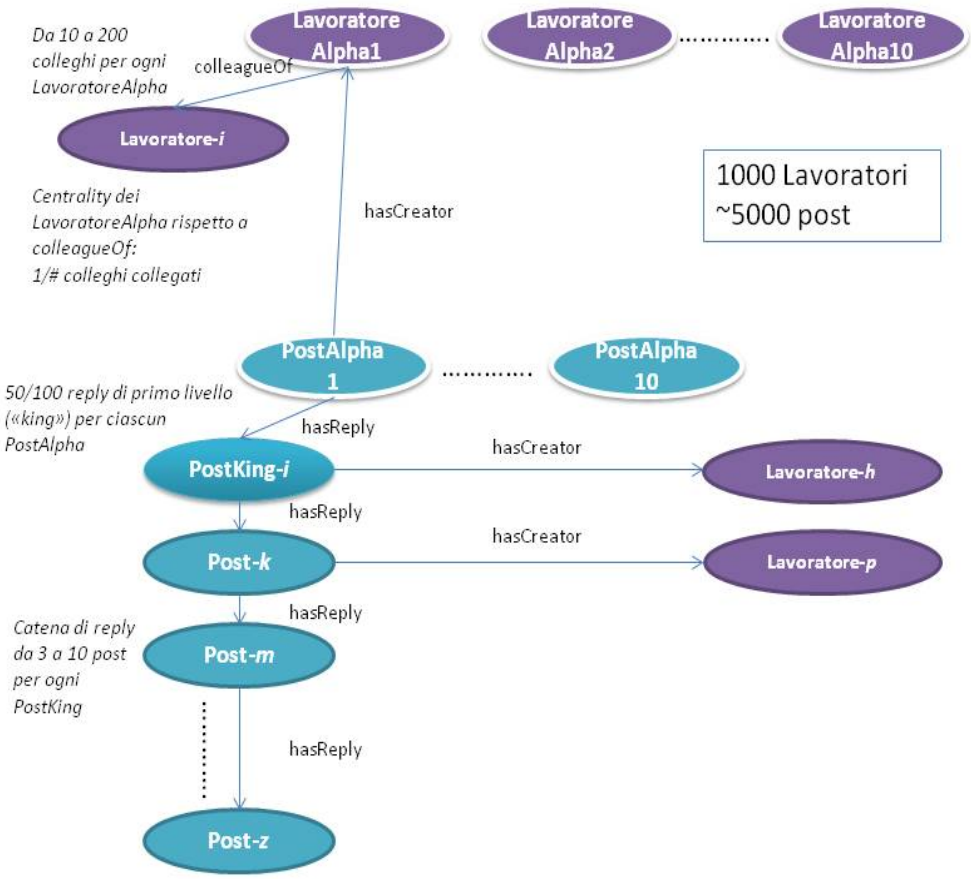

FIGURE 38: NETWORK TEST FOR THE TESTING OF THE SEMANTIC SNA INDEXES

In the following some results about execution tests are reported.

Data test machine: Intel I7 2860QM, 32 GB RAM, HD Intel 520 SSD, Java SE 6/Java EE 5 32 bit, Application server Apache Tomcat 5.5 32 bit, average workload of other processes, local execution (excluding network latency)	
Risultati	
Query	**Tempo di esecuzione medio (in secondi)**
Number of actors	0,03
Number of actors for each relationship	0,05
Number of subject actors	0,07

Number of object actors	0,15
Number of relationships	0,15
Component	3,16
Degree(y, dist)	2,15
In-degree(y,dist)	0,35
Out-degree(y,dist)	0,33
Geodetic(from,to)	0,39
Diameter	0,75
Count_Geodetic(*from*,*to*)	0,88
Count_Geodetic(*from*,*to,b*)	0,95
Closeness centrality	1,14
Partial_Betweenness(*k, from, to*)	1,34

3.13 The temporal SNA

An interesting approach is that of considering in the social data analysis even the temporal dimension [69]. Social networks are highly variable structures and the consideration of time is strongly relevant. For instance, we are able to analyze interaction changes as a result of a specific event or the change of an actor's position in the network. In [71] a temporal perspective on SNA is detailed. The proposed solution is to represent a graph as a sequence of time windows, each representing the network in a given time interval (Figure 39).

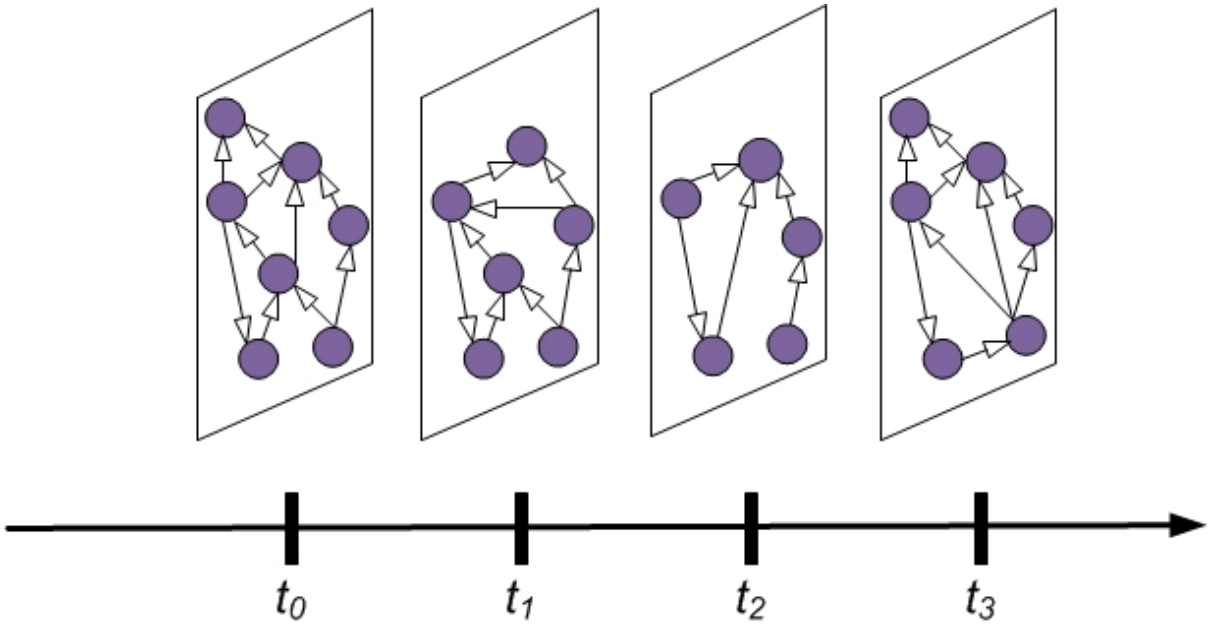

FIGURE 39: EXAMPLE OF A TIME GRAPH

In other words, given a set of time periods $t = \{t_0, \ldots, t_n\}$, a graph representing a social network is the set of graphs $G = \{G^t_0, \ldots, G^t_n\}$.

In the case of very short time windows, an immediate problem of implementation arises that is that one should "freeze" the social network at regular intervals, by storing the state in suitable structures. The RDF-based structure allows to enter time data directly in the class. For instance, the Dublin Core ontology contains the property dcterms:created defining the date of creation of a resource. Many ontologies, such as SIOC, re-use this property to introduce the element of time in the model. In this way, the RDF-based model allows to handle even this interesting time component without having to adopt complex or alternative structures.

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CHAPTER 4

SKILLS MANAGEMENT IN THE AUTOMOTIVE INDUSTRY: IDENTIFICATION, MAPPING AND UPDATING OF FACTORY WORKERS IN A MULTINATIONAL COMPANY [107] [108] [109]

4.1 Methods and techniques for the identification of skills

In order to identify a set of skills it is useful to adopt a mix of different techniques and methods. Such techniques and tools, if used jointly, allow us to obtain information in order to describe the skills needed for the job in question.

In Figure 40 identification methods and techniques are shown, also based on how they were defined and classified in the Italian automotive context.

Skills mapping methodologies		Methods, techniques and tools to identify skills		
		Methods	**Techniques**	**Tools**
	Business	Expert panel	-	Survey Expert systems Skills dictionary
	Processes	Expert panel	Repertory grid Direct observation	Survey Expert systems Skills dictionary
	Roles	Expert panel	Critic accident Job analysis Repertory grid Direct observation	Survey Expert systems Skills dictionary
	Best performer	Expert panel	Behavioural Event Interview Direct observation	Skills dictionary

FIGURE 40 - METHODS AND TECHNIQUES FOR THE IDENTIFICATION OF SKILLS

In the following some details about each method/technique/tool are provided:

- critic accident: developed by Flanagan in 1954, it is the most used to systematically identify psychological features or factors affecting performance. It is a very flexible technique and its wide use is probably due to the fact that it does not require a lot of training by the analyst, unless one wants to conduct a rather complex statistical analysis. It is important to notice that this technique will identify aspects of the job, not the skills needed to perform well in the job itself. It is expected that the interviewee (holders of the job, their supervisors or persons skilled in the role under analysis) is required to identify and describe the most difficult situations or problems that distinguishes the work. In particular, it requires the description of the activities and behaviors adopted by the role holder and an explanation of why the person is successful or not in achieving effective performance. The procedure is repeated until the respondent does not remember other situations.

- Behavioural Event Interview. The method developed by McClelland combines the critic accident method with the Thematic Apperception Test (TAT) developed by Murray at Harvard. McClelland and his colleagues realized many studies on motivation in organizational contexts. This research have enabled us to offer and validate the technique of behavioral interview on the episode. The TAT has allowed us to enrich the method with the most relevant features related to the human resources in terms of motivation, cognitive styles, ways of thinking that create "patterns" of behavior related to them. The principle at the basis of this technique is that what individuals think about their motivation or skills is not relevant for the identification of such skills. We should pay attention to the behaviors activated in critical situations that respondents face, finding out what people really do.
- Expert panel. This method is about the composition of a group of experts coming from the staff, supervisors and role holders with high performance and, possibly, with a clear vision of their own job evolution. Their task is to identify the ideal personal features of the employees in order to carry out tasks in the most appropriate manner.
Once the vision of the challenges to be faced in the future is shared through a discussion of the strengths and weaknesses, threats and opportunities (SWOT) of the company, the panel identifies for each job or family of jobs:

- the most important tasks, responsibilities and outcomes;
- the criteria for performance measurement to identify the best performer;
- the career paths to get to the job, the skills that people must possess to perform the tasks in an appropriate manner or to achieve a high performance.

If the Panel thinks that it is feasible, we can proceed to interview the owners with the highest performance in order to confirm the competencies identified by the panel itself.
All information obtained from the previous steps are analyzed to get a clear description of the skills that are going to build the model.
d) The model can be validated through a series of interviews with a new sample of medium and best performers, this will occur if the competencies identified by the panel are actually the skills that allow you to achieve superior performance.

4.2 Questionnaires/Surveys

The questionnaire is a tool widely used to collect information on skills. It asks respondents to assess, for each competency, its importance in relation to the role in question, whether it is discriminatory to distinguish superior performance from an average, if new employees can be provided, if it can be developed with training, and so on. The questionnaire is usually given to the holders of the job (but only to the best performers) and their leaders, and should not include more than one hundred questions. It is a tool that allows a quick and inexpensive collection of sufficient data to carry out statistical analysis. Its limit, since it is designed to be used in a wide range of tasks, is the lack of specific details. Important skills or new skills can be neglected because the collected data refer only to features that have been added.
- Expert systems. The analysis, assisted by a computer, is carried out with the aid of a database containing a set of the skills most frequently used. According to the answers to the questions posed, the software links the behaviours required to meet the organizational

requirements to generic skills located on the database. The questions are formulated by following a tree chart for which the positive response to a question triggers a whole series of other questions, while a negative response excludes them. The model generated automatically is checked and validated.
- Job analysys. The analysis of the functions and tasks can be performed using different techniques and tools: observation, questionnaires, individual and groups interviews. It asks employees or observers to list in detail the tasks, functions and activities carried out by the holder of the job in a given period of time. What is obtained is a job description that can be used for the analysis of skills. Tasks are identified by the fact that you can deduct the necessary skills to carry them out. Its limit is the focus on the job rather than the people who perform their job well.
- Repertory grids. This technique is derived from the personal construct theory by George Kelly. He arguments that the ways in which we see the world are constructs that is the concepts based on our personal interpretation. The way to make visible these constructs is precisely the interview with the repertory grid conducted by the supervisor or the leader of a group of people. It is asked to write on a card (one for each subject) the name of the subordinates. The procedure for deriving the constructs is the following:

• collect the cards with the names in two decks, one with the effective elements and another with the mediocre ones;
• the ruling class members take two cards from the first deck and one from the second, and the interviewer asks what is in common between the two in the same deck what and distinguishes them from the third card;
• after the response of the manager, the interviewer proceeds to a deeper understanding of the construct, so that behavioural statements are made for each construct;
• the three cards are placed back in the deck and the procedure starts again until there is no longer any construct.

- Direct observation. It involves the observation of employees while performing work. In the informal version it is used to obtain basic information about the reality of tasks or to confirm the information obtained through other instruments (questionnaires, interviews, etc.). If time is limited, the structured version is not recommended, since it involves the identification of sequences of behaviors observed in both the best elements and the mediocre ones. Direct observation inevitably leads to disadvantages: it can affect the way the person observed works, and in addition, it makes it difficult to observe all critical aspects of a job.
- Skills dictionary. It is a set of generic skills connected to superior performance in a variety of roles. It can greatly facilitate the process of identification of skills, providing a valuable source in a specific situation.

4.3 CV Analyzer

The identification of skills can also be done through the analysis of the CV. Competency is characterized by:

• Skill: skill possessed by the candidate;

• Knowledge: knowledge possessed by the candidate;
• Attitude: attitude of the candidate (e. g. creativity, initiative, results-oriented approach). The concept of attitude is typical of the ontological modeling of skills, but it is not extracted from the code due to the difficulty of identifying the section of the CV from which the information can be taken.
A preferred label and other alternatives are associated with each of these concepts (Figure 41).

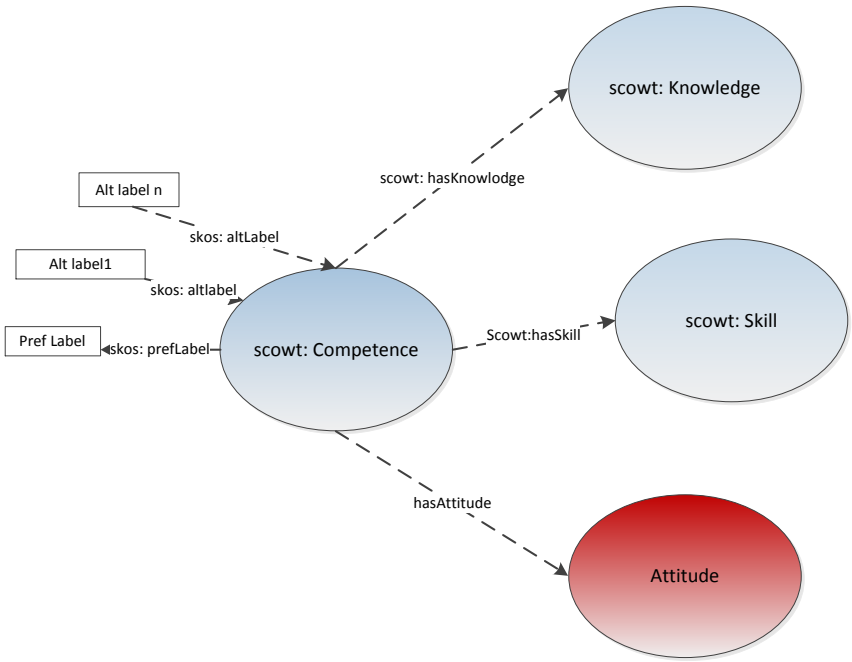

FIGURE 41: SKILLS MODELING

4.4 Centrality measures in social networks: supporting the mapping, updating and qualification of skills [72]

The communities of workers in various sectors are becoming more important and aim to produce new knowledge in a collaborative way and to encourage the development of new skills in specific areas of cognition or application domains. However, such collaboration, as in many social networks, is often hampered and few people work by sharing and collaborating in the development process of new knowledge and skills.
A community with a focus on skills is generally characterized by different themes and contributions provided by users of the social network that originate from and are strongly related to very different backgrounds [93].
Being informed about issues and authors that provide contributions aimed at developing certain business skills appears to be a fundamental aspect of such a community of users [70].
On the basis of these assumptions, it can be argued that the very concept of centrality is what allows us to better analyze the issues mentioned at the beginning of this paragraph, even by virtue of its main features [97].
However, there is no universally shared definition of what exactly the centrality of social networks is [41], so that there are several versions of centrality widely discussed in the literature.

For example, Closeness Centrality is based on the distance of a node from all others in the same graph, like Graph Centrality [82]. In contrast, Betweenness Centrality and Stress Centrality are based on specific measurements of relations between pairs of nodes [41]. Furthermore, there is another measure of centrality defined "Prestige Rank" or "Eigenvector Centrality", which is based on the assumption that a node is much more central as it is in relation with other central nodes [97] [12].
In addition, it should be specified as the models based on graphs are not suited to represent the complex relationships, such as those over-dyadic, up to the point of suggesting the adoption of hypergraphs as the basic logical structures to conduct this particular type of analysis [8] [13] [37]. In this perspective, the hypergraphs/multi-hypergraphs are the most appropriate to represent multiple and weighed relationships.
By using these logical structures it is possible, for example, to group the authors by category/cluster of skills/knowledge, encouraging, therefore:

- the identification;
- mapping;
- classification;
- updating;
- qualification.

of specific areas of expertise within an organization. To this end, it is extended both theoretical and practical application of Eigenvector Centrality, by proposing an algorithmic approach specifically aimed at promoting research, creating, sharing, evaluating and updating skills [93].
Below such an approach is introduced.
A multi-hypergraph is an extension of a multi-graph in which the edges, called "hyperedges", can connect any number of positive vertices [8]. A multi-hypergraph K is a pair (V, E) where $V = \{v_1, ..., v_m\}$ is the set of vertices, and $E = \{E_1, ..., E_n\}$ is the multi-set of non-empty sets V, said hyperedges.
Since E is a multi-set, a hyperedge can be contained several times in E.
In such a weighed hypergraph, each pair $(v_j, E_j) \in E_j$ is such that it can be assigned a positive weight.
Let $w_{ij} \in R^+$ the weight given to the pair vertex-hyperedge (vj, E_j) where $W = w_{ij}$, with $w_{ij} = 0$ if $v_i \notin Ej$ is an incidence matrix for the weighted vertex-hyperedge hypergraph K. Finally, W is the incidence matrix of classical weighted vertex-hyperedge for the hypergraph K when $w_{ij} = 0$ or when $w_{ij} = 1$.
At this point, in order to analyze the centrality of vertices and hyperedges in (K, W), we can make the well-known assumption of the so-called "mutually reinforcing relationship" [62]: "an important hyperedge is a hyperedge whose vertices are important elements; an important vertex is a vertex that belongs to many important hyperedges".
The mathematical expression of this assumption is shown below.
X_i is the importance of the vertex v_i and y_i the importance of the hyperedge E_j.

The simplest mathematical version of the assumption of "mutually reinforcing relationship" is found in the following equations [13]:

$$x_i = c_1 * \sum_{j=1}^{n} w_{ij} * y_j \qquad per\ i = 1, \dots, m$$

where the constant of proportionality $c_1 > 0$ is independent of i.

$$y_j = c_2 * \sum_{i=1}^{m} w_{ij} * x_i \qquad per\ j = 1, \dots, n$$

where the proportionality constant $c_2 > 0$ is independent of j.

In matrix notation, let $x = (x_1, ..., x_m)$ and let $y = (y_1, ..., y_n)$:

$$WW^Tx = \lambda x$$

$$W^TWy = \lambda y$$

where $y = c_1 * c_2$.

Furthermore, WW^T and W^TW share minimum eigenvalues (m, n), which are all non-negative. By the theorem of Frobenius-Perron it exists, therefore, an eigenvector of the maximum eigenvalue with only non-negative values [17].
Therefore, the linear algebra leads us to state that the system of equations above is a solvable system. One of its solution is given by:

- $\lambda = \lambda^*$, the dominant eigenvalue di W^TW (equal to the dominant eigenvalue of WW^T);
- $x = x^*$, a non-negative eigenvector of WW^T in the eigenspace associated to λ^*;
- $y = y^*$, a non-negative eigenvector of W^TW in the eigenspace associated to λ^*;

where:

- x * is defined as "a measure of normalization of Eigenvector Centrality" of vertices (K, W);
- y * is defined as "a measure of normalization of Eigenvector Centrality" of hyperedges in (K, W).

In essence, the concept of Eigenvector Centrality just introduced for the multi-hypergraph weighed is the extension of the same case of hyper-graph centrality [13]. In light of these results it can be concluded that in order to calculate the Eigenvector Centrality of vertices and

hyperedges in (K, W), the algorithm HITS (Hyperlinked-Induced Topics Search) of Kleinberg [62] can be tailored.
Below the basic algorithmic approach is showed.
In order to analyze the centrality of authors and topics in a social network where skills can be extrapolated, we consider a multi-hypergraph with weighted vertices and hyperedges. Its components are:

- $D = \{d_1, ..., d_p\}$: an ordered set of documents of various nature;
- $T = \{t_1, ..., t_m\}$: an ordered set of subjects/skills/knowledge;
- $R = \{r_1, ..., r_n\}$: an ordered set of publishers/content provider, or users spreading skills;
- $A \in R_{mxp}$: a binary matrix representing the relationships between authors and documents generated by them and published in the social network. The element $a_{ik} = 1$ if the user is the author of the document d_k, $a_{ik} = 0$ otherwise;
- $B \in R_{pxn}$: a non-negative matrix that provides a measure of how many papers are devoted to a particular topic/skill. The element b_{kj} measures the portion of the document d_k covering issues related to t_j and requires that $0 \leq b_{KJ} \leq 1 \ \forall$ j, k e $\sum_{j=1}^{n} b_{kj} = 1 \ \ \forall k$.
- $C \in (c_1, ..., c_p)$: a positive vector in which the generic element c_k provides a measure of popularity [43] of d_k within the social network.

By instantiating the model to the specific context, the hypergraph is to be described mathematically as follows:

$$K (R, E)$$

where:

- $R = \{r_1, ..., r_n\}$;
- $E = \{E_1, ..., E_n\}$ with $E_j = E (t_j) = \{r_i \in R: \exists \ k \mid a_{ik} = 1$ and $b_{kj} > 0\}$.

This model is based on the view that the expertise of a document reflects the interests and skills possessed by the authors of the article published in the social network. Also, the knowledge can be more easily identified, classified, clustered, updated, evaluated and shared within a group that shares specific skills.
Clearly, an author can appear in different groups of topics, that is having more skills and interests with respect to a specific topic, as well as several clusters of skills can have as protagonists the same set of user-authors. Precisely for these reasons, it is easily understood that K is a multi-hypergraph.
The analysis of the relationships between the various sets of skills (T), authors (R) and documents (D) shall be carried necessarily by means of techniques and models for analyzing documents and corresponding contents.
In order to assign weights to the model instantiated on the specific context, we must make some assumptions:

- the content of a document is due in equal measure to all the authors. The ratio a_{ik}/h_k, where h_k is the number of authors of d_k, aims to provide a measure of the portion of the document attributed to the user r_i and skills/topics of the document d_k most interesting to all the authors of that particular document;
- the product $b_{kj}*c_k$ measures the share of popularity of the document d_k attributed to the competence t_j;
- the mathematical expression $(a_{ik}/h_k)*(b_{kj}*c_k)$ gives cognizance of the contribution given by the portion of the document d_k attributed to the author r_i having competence t_j to the popularity of the same document d_k.

Based on these assumptions, it is possible to provide a mathematical formula for estimating the weight associated with the pair (r_i, t_j):

$$w_{ij} = \sum_{k=1}^{p} \frac{a_{ik}}{h_k} * b_{kj} * c_k$$

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SECTION III

CHAPTER 5

CREATIVITY-BASED AND KNOWLEDGE-BASED INNOVATION STRATEGIES IN THE TRANSPORTATION AND MOBILITY INDUSTRY: PRELIMINARY ANALYSIS FOR THE DESIGN OF A SOCIAL VEHICLE POOLING PLATFORM WITH OPTIMIZED ROUTING SOLUTIONS[a]

5.1 Introduction

This chapter contains the analysis of the state-of-the-art carpooling services in the scientific literature in order to identify all the features they have in common and possibly the distinguishing ones. In this document the conceptual and logical design of the technology platform is described and the functional requirements are detailed. Carpooling is a new way of traveling, it is a cost-effective alternative to the traditional ones and consists of using one's private car in order to share a trip together with other people.

5.2 Objectives

By analysing national and international solutions in this field, this document is geared to deepen all the shared functionalities of standard carpooling services and to identify innovation opportunities in order to provide some unique features and competitive advantages to the new platform. In the last decade one of the predominant elements that have guided the development of technology is undoubtedly mobility: the huge amount of private vehicles in circulation literally takes oxygen to the city with negative consequences in terms of traffic congestion and affects resource consumption and pollution. The progress of urban mobility for sustainability can only be achieved by adding the need to adequately promote and encourage new forms of public transport introduced in order to better respond to individual and/or collective needs for mobility, such as carpooling.

5.3 Unlocking value from Collaborative Consumption, Sharing Economy, Social Economy and Social Technology **[1] [2] [3] [4]**

In the last decade a shift towards a Collaborative Consumption philosophy is emerging. People are escaping from a hyperconsumeristic society [1]. The new approach to resource consumption is becoming an economic model based on sharing, exchanging, negotiating or renting goods, rather than buying their property [22]. Such an approach existed also before the formation of the Consumer Society, but it is furthermore boosted by the new opportunities provided by the Social Technology and the categorical imperatives about the current economic and environmental issues. Therefore, there is a continuous shift towards a new consumer model involving the concepts of trust and shared access. Such a model is a new way to reinvent creatively what existed before the arrival of the Consumer Society [23].

[a] The main sources for this chapter are: (1) Tafaro S. (2012), "Modelli di e-business e analisi di servizi per sistemi di carpooling", Università della Calabria, (2) INE – Instituto Nacional de Estatística, www.ine.pt, (3) Ferreira J., Trigo P. and Filipe P. (2009), "Collaborative Car Pooling System", World Academy of Science, Engineering and Technology, Vol:3 pp. 565-569, (4) McKinsey (2012), "The social economy: Unlocking value and productivity through social technologies", McKinsey Global Institute.

Benefits coming from the Collaborative Consumption are: reuse and recycle of goods implying the reduction of impacts on the environment and higher resource savings; creation of a new economic model by allowing people to earn by sharing, lending, donating, exchanging, negotiating or renting goods; resource sharing encourages people to meet and socialize in order to create new communities [24].
The definition of "Collaborative Consumption" was provided first by Marcus Felson and Joe L. Spaeth in their work "Community Structure and Collaborative Consumption: A routine activity approach" published in 1978 on the American Behavioral Scientist [25]. Afterwards, Ray Algar wrote the article "Collaborative Consumption" on the Leisure Report Journal in 2007 [1] and Rachel Botsman and Roo Rogers published "What's Mine Is Yours: The Rise of Collaborative Consumption" [26]. It is intended to be a social and economic revolution allowing people to create value from shared resources and aligning the pursuit of personal objectives with the well-being of a whole community. According to the TIME, in 2010 it was one of the top ten ideas able to change the world [27]. All the Collaborative Consumption variants are currently proposed in a new way by integrating also the opportunities coming from the new technologies in terms of time reduction and newly created distribution channels. In the following the steps regarding the development of Collaborative Consumption are detailed:

• product-service systems (PSS). In this context, people tend to pay for the access to the product rather than for its possession [22]. A lot of time public and private organizations adopted some sharing initiatives over time: libraries, laundromats, private reuse centers, public and private collective accommodations, bike sharing systems, commercial and exchange shops, peer-to-peer renting systems and product-service systems [28] in the neighbourhoods. This is provoking an escape from services provided by for-profit organizations [29];
• collaborative lifestyles. It is a set of systems based on shared interests among group of people. They aim at sharing and exchanging goods, especially the intangible ones. Participants are often among neighbours and share workspaces (e. g. Citizen Space, Hub Culture), gardens (e. g. Landshare), experiences (e. g. GuideHop), parking slots (e. g. ParkatmyHouse). They also involve peer-to-peer loans (e. g. Zopa, Lending Club) and travels (e. g. Airbnb and Roomorama) [29].

According to [26], it is possible to cluster all the initiatives in:

- PSS like Zipcar and Netflix;
- redistribution markets like Freecycle and Craiglist;
- collaborative lifestyles for intangible goods like TeachStreet and Quirky.

Another category is emerging that is the crowdfunding one including experiences like Kickstarter [24].
The main economic sectors currently covered by Collaborative Consumption initiatives are shown in Figure 42.A. For each sector some features are analysed that is typologies, categories, consumption modes, existing online initiatives [1]. It can be noticed how the

vehicle pooling experience such as SMOB and the CityRide platform proves to be highly innovative also because it embraces the whole transportation economic sector, thus including all of its typologies: carpooling, carsharing, bikesharing and taxisharing.

COLLABORATIVE CONSUMPTION SYSTEMS/ECONOMIC SECTORS MATRIX		COLLABORATIVE CONSUMPTION SYSTEMS			
		Typologies	**Categories**	**Consumption modes**	**Existing online initiatives**
ECONOMIC SECTORS	**Transportation**	Carpooling	Product-Service Systems	Synchronous	Zimride, Nuride, Liftshare, Carpooling, Caronetas, DuckSeat, RewardRide, Avacar
		Carsharing	Product-Service Systems	Asynchronous	Zipcar, GoGet, WhizzCar, Autoshare, Autolibre, Denzeldrive, Cambiocar, Zazcar, City Car Club
		Biklesharing	Product-Service Systems	Asynchronous	Velib, Bixi, Barclays Cycle Hire, B-Cycle, Call-A-Bike, CyclOcity, Niceride, HZ Bike, Social Bicycles
		Taxisharing	Collaborative lifestyles	Synchronous	Taxi2, TaxiDeck, TaxiStop, FellowCab
	Real estate	Flatsharing	Collaborative lifestyles	Synchronous	Flatshare WorldWide, Londinium, Roomorama
		Home exchange/ swaps	Collaborative lifestyles	Asynchronous/ Synchronous	Domus 2 Domus, Holswap, HomeForExchange, HomeExchange, Knok, Swapyourhome
		Timeshare property	Collaborative lifestyles	Asynchronous	Ivarta, Geenee
		Storage networks	Collaborative lifestyles	Asynchronous	StorPod, ShareMyStorage, SpaceOut
	Fashion	Fashion rental	Product-Service Systems	Asynchronous	Bag Borrow & Steal, Fashionhire, Dress Vault, Love Me and Leave Me, Rent The Runway
		Clothing swaps	Redistribution markets	Synchronous	Swapstyle, Clothing Exchange, Big Wardrobe, i-Ella, Mano Drabuziai

	Tourism	Peer-to-Peer travel	Collaborative lifestyles	Asynchronous/ Synchronous	CouchSurfing, Airbnb, Roomorama, Crashpadder, One Fine Stay, Bed And Fed, 9flats, iStopover
	Food	Social Food Networks	Collaborative lifestyles	Synchronous	Gobble, Grub.ly, GrubWithUs, EatWithMe, Wok 'n' Wine
	Work	Shared Studios/ Workshops	Collaborative lifestyles	Synchronous	3rd Space Studios, TechShop
		Coworking Space Finders	Collaborative lifestyles	Synchronous	Loosecubes, DesksNearMe, DeskWanted, CoLoco, OpenDesks, DeskSurfing
		Coworking Spaces	Collaborative lifestyles	Synchronous	Citizen Space, Hub Culture, The Hub, Vibewire Enterprise Hub, TechHub, NewWorkCity, StudioMates
	Household electrical appliances	Used Electronics	Redistribution markets	Synchronous	Gazelle, eBay Instant Sale, Apple Recycling Program
	Publishing/Music/ Film	Textbook Rental	Product-Service Systems	Asynchronous	Gazelle, eBay Instant Sale, Apple Recycling Program
		Swap sites for media	Redistribution markets	Asynchronous	Swap, Dig N'Swap, Netcycler, GaBoom
		Movies	Product-Service Systems	Asynchronous	Netflix, Quickflix, LoveFilm
	Retail	Toy Rental	Product-Service Systems	Asynchronous	Dim Dom, BabyPlays, Rent-a-toy, ToyLib, Speelotheken, Brinquedoteca
		Neighborhood Marketplaces	Redistribution markets	Asynchronous	EggDrop, Zaarly, Garage Sale Trail, Hey, Neighbor!
		Swap sites for baby goods and toys	Redistribution markets	Asynchronous/ Synchronous	Toyswap, thredUp, Swapitbaby, Tauschteddy
		Big marketplaces	Redistribution markets	Asynchronous	Craigslist, eBay, Gumtree
		Neighborhood Rental	Product-Service Systems	Asynchronous	Share Some Sugar, Neighborrow, Neighborgoods, The Sharehood, Frents, Friends With Things, Hey Neighbor!

		Peer-to-Peer Rental	Product-Service Systems	Asynchronous	Zilok, Rentoid, Ecomodo, HireThings, Rentalic, RentStuff, Open Shed
		General Online Rental	Product-Service Systems	Asynchronous	Getable, AnyHire
		Free/Gift Exchanges	Redistribution markets	Synchronous	Freecycle, GiftFlow, Ziilch, Exchango, Freally
	Knowledge	Skill sharing	Collaborative lifestyles	Synchronous	Brooklyn Skill Share,TeachStreet, TradeSchool, Skillshare, Skilio, WeTeachMe
		Unique Expertise Marketplaces	Collaborative lifestyles	Synchronous	Vayable, Gidsy, Sidetour
		Errand & Task Networks	Collaborative lifestyles	Asynchronous/ Synchronous	TaskRabbit, Zaarly, YourJobDone, AirRu, MyTaskAngel, Gigwalk
		Neighborhood Support	Collaborative lifestyles	Asynchronous	WeCommune, Share Some Sugar, Bright Neighbor, Hey Neighbor!, Streetbank,OhSoWe, ToolzDo
	Funds/Loans	Scoail Lending	Collaborative lifestyles	Synchronous	Zopa, Prosper, The Lending Club, Boober, Maneo, Qifang
		Social currencies	Collaborative lifestyles	Synchronous	Ven, Quid, TimeBanks, LETSystems, SPICE Timebank

FIGURE 42.A: "COLLABORATIVE CONSUMPTION SYSTEMS/ECONOMIC SECTORS" MATRIX [1]

5.4 Widespread features in carpooling services [1] [2] [3] [4]

In the following some very communal characteristics and functionalities of such services are reported.

Driver and passengers generally know before starting the trip that they will share it and the approximated time they will leave. Both the driver and the passengers are considered, generically, as "carpoolers". The service is based on a driver who offers a ride in his/her private car and some people that need a lift (riders).

Then, the carpooling is defined as an initiative of sustainable mobility aimed at reducing the number of low-occupancy private vehicles circulating along the main traffic tracks by means of the sharing of a trip by several people.

Sharing the use of a car with other people, with the same transportation requirements (time and place of departure/arrival, etc.) offers significant benefits for both the environment and for crew members as in the following:

• fewer vehicles on the road;
• less pollution;
• lower transportation costs, by dividing the cost of fuel and any tolls or parking fee between the traveling companions;
• less wear and tear issues for the private car, thanks to the possible alternation of private cars used by community members;
• less physical and psychological stress and decrease in the risk of accidents due to the possibility of resting and alternating drivers;
• improved parking facilities, due to the lower number of cars in circulation;
• availability of alternative service mobility for remote areas not or insufficiently served by public transportation systems if compared to the needs of citizens;
• high "flexibility" with respect to public transportation;
• socialization among traveling companions.

Also some issues inhibiting carpooling initiative exist:

• rigid planning;
• missing matching;
• missing commute trip flexibility;
• social issues and differences among systems of values.

It is increasingly widespread the belief that the adoption of a web platform that simplifies the use of services for potential customers represents one of the main factors for the success of such initiatives. In addition to the typical systems of carpooling platforms, also some non-functional requirements are necessary:

• performance. A system that operates in real time has to provide some suitable solutions within a reasonable timeframe;
• precision. All data relating to vehicles and users must be provided and maintained as accurately as possible (i. e. any georeferenced information);
• usability. The use of the platform should be intuitive even for users without a specific knowledge of the system;
• robustness. The system must be able to handle abnormal situations such as the lack of connectivity in the process of tracking between client and server;
• adaptability. The system should be easy to adapt, extend or modify in a variety of situations, such as the support of both occasional and regular travels, and long-distance travels. This way it can cope with extra-space issues for luggage, variable distance units (kilometers, miles), ability to change the unit of measurement used for payments (cash, virtual credits, etc.).

Web platforms in this context should provide the following features and information services in order to ensure the success of the initiative [1]:

• user-friendly interface;
• appealing graphic design;
• safety and security;
• usability;
• registration and authentication system;
• geo-spatial services;
• dynamic carpooling;
• specific pages devoted to special trips;
• matching software;
• different matching automation and transparency levels;
• feedback and rating systems;
• possibility to choose among a number of trip opportunities;
• creation of carpooling groups/clubs;
• cost sharing system;
• management of contacts among users;
• interactive maps;
• website handbook and helpers;
• campaign to raise awareness of potential carpooling users.

Carpooling services are internationally widespread, especially in Northern American countries and in Central and Northern European countries (e. g. Austria, Germany, Sweden, Norway) and in the Iberian Peninsula (e. g. Portugal).
Nonetheless, such a widespread service has many peculiar features characterizing each of its variants. In this way it is possible to generate a "characterizing factors/carpooling variants" matrix in order to realize a mapping of variants' main features and to understand how factors influence carpooling alternatives. In Figure 42.B such a matrix is showed [1].

CARPOOLING FACTORS/VARIANTS MATRIX		**CARPOOLING VARIANTS**			
		RANDOM	**CORPORATE**	**UNIVRSITY**	**FAMILY**
CHARACTERIZING FACTORS	**SOCIAL BENEFITS**	Medium	High	High	Low
	MONETARY INCENTIVES	High	High	High	Low
	PROGRAMMING	Medium	High	High	Low
	SPATIAL FLEXIBILITY	High	Low	Low	Low
	SOCIO-DEMOGRAPHICAL FACTORS	High	Low	Low	Medium
	POOL-SIZE EFFECTS	Low	High	High	Low
	TEMPORAL	Medium	High	High	Low

	CONFIGURATION				
	ROLE OF DISTANCE	High	Medium	Medium	Low
	CARPOOLER CATEGORIES	High	High	High	Medium

FIGURE 42.B: CARPOOLING FACTORS/VARIANTS MATRIX [1]

5.5 Preliminary analysis for carpooling initiatives **[1] [2] [3] [4]**

In order to choose the most suitable area to implement a carpooling service and determine the number of potential users, some preliminary analysis is required. First, it is important to take into account the peculiarities of the region, city or urban area, the existing facilities, the mobility patterns of citizens and the social target. In particular, the following elements must be thoroughly known and defined:

• the type of residential settlement and the population density in order to make an estimation of potential customers;
• the location of production activities;
• the status and availability of the road network;
• the analysis of mobility flows in order to determine the prevalent means of transportation and tracks (origin-destination matrix);
• the supply of public transportation services;
• the social and demographic analysis in order to perform a segmentation of citizens in specific targets;
• the existence of societal aggregators in the area (universities, community centers, stadiums, etc.).

Therefore, it is essential the interaction with public and private. For example, through the interaction with local public administrations (such as the offices of the city's urban planning and statistical offices, etc.), police, public transportation companies it is possible to get a set of information useful for the design of such a system. In fact, if the results of the analysis refer to a residential area characterized by widespread use of low-occupancy private vehicles and oriented traffic flows directed towards well-identified destinations, it should be well-suited for the implementation of such services.

5.6 Collaborative consumption: the economic model reflecting a "shared and sharing thinking" **[1] [2] [3] [4]**

In Italy and in Europe the idea of sharing goods, be cars, houses, knowledge, etc., is becoming a reality that involves tens of thousands of people daily. It is, thus, outlining a new way of thinking about our needs based on a "shared and sharing thinking": collaborative consumption, i. e. shared access to consumer goods. In parallel to the decline of some status symbol (like the car) and a new environmental awareness, accessing to a good becomes much more sought-after than its possession. The effectiveness and potential of collaborative consumption are due to the people who are part of a popular movement that guides their decisions in favor of a better use of resources.

The collaborative consumption is a real economic model that was born in the U.S.A. at the end of the last century and grew up since the beginning of 2000. The term was coined in 1978 by Marcus Felson and Joe L. Spaeth, in a paper entitled "Community structure and Collaborative Consumption: a routine activity approach". It is, at least initially, little more than a theoretical model. Only in recent years, the theory was applied to the analysis of concrete structures and models of a system able to revolutionize the way we consume. It was applied to current models and case studies also by means of the development in several technological fields: the Internet is one of the main tools that can put people in touch with each other, creating a new way of thinking dealing with changes to the traditional economic system. The collaborative consumption theory applied to reality allows individuals to create a shared value and it is expendable in a market with enormous size, an unthinkable opportunity a short time ago. Collaborative consumption is actually a multi-sectorial and constantly evolving philosophy: innovation in this field is continuously creating and redefining the business opportunity. Small start-up companies and large institutions (such as Harvard, MIT, etc.) are developing totally new forms of approach to current reality: agriculture (Growtheplanet, etc.), education (Coursera, EDX, Oilproject, etc.), housesharing (AirBnb, Bedycasa, etc.), ridesharing (BlaBlaCar, etc.), lending of money between individuals (Zopa, etc.), bikesharing (ToBike, etc.), etc..
The numbers of collaborative consumption contexts are growing and are getting increasingly large shares of their specific markets. It is an economy that makes sustainability its flag, a new way of rethinking consumption in which the protagonist is the individual.
At first in the English-speaking world and then throughout the rest of Europe, is therefore spreading a way to rethink the relationships between the actors of the market by redefining the modalities of exchange of goods and services and, in parallel, shaping new business models. It is a new model that places the individual at the center of the system and the Internet gives voice and power to the consumer, which becomes active in the market – i. e. no longer a subordinate actor.
It is a movement coming from common people and creating value where there are unexploited or wasted resources, about both intangible and tangible goods.

5.7 Carpooling service definition

In Italy carpooling services began as a kind of management system in business contexts and it was adopted by mobility managers in order to arrange home-to-work paths of employees. In this case, carpooling is a system of managed travel with only one relevant variable that is the arrival. Its scope was expanded overtime and today it can be useful for all kinds of mobility needs by means of sharing trips from a specified departure to a certain destination and in a given time interval. In fact, it is no longer connected (only) to a particular destination (such as a corporate headquarters), but (also) to a physical area or area of expertise, which can be limited to a local area or extended up to (inter)national boundaries, according to the targets and the critical mass that the service aims to achieve. The basic components of a carpooling service are: a database, a management software able to plan trips (optimizer), a web platform to post trip offers and requests for lifts and, of course, people (users) who want to share their private cars to offer a ride.

In general, carpooling services use a web platform as a meeting point between supply and demand (riders and drivers). The web platform becomes the place where customers manage their movements and update data about their trips. There are several web portals with different spatial scales, which over time have become widespread on the Internet:

• www.roadsharing.com (international);
• www.taxistop.be (international);
• www.blablacar.it (nationwide);
• www.carpooling.it (nationwide);
• www.salernomobilita.it/mercurio/ (local scale).

In addition to wall services, there are other additional services that exist in almost all carpooling platforms studied in the analysis of scientific literature:

• SMS service (Short Messaging System) and IMS service (Instant Messaging System) to facilitate contacts between users;
• the forum/blog in order to ensure a greater socialization among users.

Subsequent to a more detailed analysis, we can notice that only some platforms have, to date, even geolocating and georeferencing services of users on interactive maps through the availability of information technology and telematic devices such as GIS (Geographic Information System), GPS (Global Positioning System) and smartphones (which is usually provided for a specific app that integrates all the features), which allow to capture real-time data and update immediately the routes of vehicles. Only in some cases there is an integration of modules to optimize logistics issues or to merge carpooling platforms with social networking models. The logistics optimization systems play a key role in the process of reducing travel costs and the opportunity to become part of a social network helps to ripen the climate of mutual trust among the users of the system. The ability to assess the users' profile and selecting traveling companions with a focus on customer retention is one of the most innovative aspects of carpooling platforms, which aims at integrating the most advanced methods in the fields of Recommender Systems, RSS (Really Simple Syndication) feeds, Social Rating, Social Rewarding and Reputation Management.
In the scientific literature, systems of carpooling are classified into two different types: "flexible" and "dynamic".
The "flexible" carpooling works on tracks with high levels of traffic: along these routes there are collection (points of pick-up) and delivery (points of drop-off) points. Also some fixed points (points of interests) where all rides stop are considered. Carpooling is a flexible solution that provides a real opportunity for commuters that every day could share rides, since traditional solutions don’t work because of the different work schedules and the ever-changing travel needs [16].
The "dynamic" carpooling is a special implementation of a sharing service for vehicles and users that are suitable for the formation of the crew at very short notice, almost in real time. The organization of single trips is typical of this type of service, instead of recurring appointments like in the case of commuters. In this service configuration we can use mobile

smartphones for placing a bid or request via data service. There is also an instant and automatic matching of travels across a network service that compensates the driver with an integrated billing system [14].
One of the objective of an innovative system of carpooling is, in general, to realize the trade-off between the two systems, so as to encounter the favor of a greater number of users and to meet the different needs of possible stakeholders.
The creation of an efficient and innovative carpooling service requires the definition of the following:

• structure of the service. It is vital to plan the system in the context of the choices regarding the access to the system, the inclusion of requests, the travel search using sophisticated search criteria;
• how to access and register. It is necessary to define the personal information that the customer has to provide to sign up. It might be interesting to ask the age and the reason for the transportation request, as well as the name and address in order to do a statistical analysis on the target user. The rules on the processing of personal data must be consulted by service workers and accessible by users since they usually show to appreciate this feature. Reference standards are usually displayed clearly to customers. After the registration, the user must confirm to be a valid user by clicking on a link in the email sent by the system;
• uploading mode of travel request/offer. A clear and simple guide provides instructions to users about the data entry process. In order to insert data users usually have to specify the starting and destination point, the date and time of the trip. In addition, it may be useful to allow to specify the frequency of the movement and the reason for it;
• researching the compatibility of carpoolers. It is one of the most important steps of the service as the pursuit of compatibility must be designed providing different search options. Commuters can easily find other people with the same needs. The search should be performed in such a way to use filters based on users preferences, for example, the flexibility in terms of distance, time interval, but also compatibility level of riders and travels. The user, in fact, may find a total compatibility, compatibility only for the departure or arrival, or, also, for none of the two (in this case the search will display all trips in the day chosen by the user). It is more difficult, but very useful to increase the number of contacts, the search for compatibility for a whole planned trip. In order to support the launch of the service (in the first period, there are not so many demands/offers), it is important to provide potential users with an easy viewing database of all requests/offers available at any given time, also considering that the ultimate objective is the reduction of the number of vehicles on the roads. It is also strongly recommended the integration of a search algorithm able to combine the different requests within the system. Only in this case, in fact, it is possible to minimize the number of vehicles used and the actual number of kilometres. It is also suggested the creation of masks to show geographical maps and corresponding information about trips and crews;
• the management of contacts between driver and rider. It is important to establish a contractual and organizational model in order to regulate the exchange of personal data between the driver and the rider. It exists a double-face need: people should be able to contact each other and at the same time it must be ensured privacy. One solution could be that the contacts are established through the use of email messages: each user can contact another

user without the knowledge of the email address (the "from" field is visible, the "to" field is hidden) and if the recipient shows interest in the proposal, he/she can meet and agree on a journey;
• providing incentives and benefits for customers. Benefits for drivers can be set so as to encourage them to share their private cars to offer rides. Examples of incentive policies are distributing bonuses for parking permits in order to access to reserved parking, free access to the lanes, etc.. If the service is sponsored by companies or institutions, it is also possible to provide facilities for the first use of carpooling service;
• highlighting the benefits to the environment and society. Promotions are strongly recommended so that they make people sensible about benefits in terms of environmental sustainability of the carpooling service. For example, attention should be paid on the amount of carbon dioxide not emitted (saved). The latter can be calculated by multiplying the emission of a gasoline car of medium size for the length of the shifting that has not been carried out thanks to the sharing of the private car;
• establishing conditions for the use of the service. It is important to define the rules for the allocation of expenses among the crew. Cost allocation may be based on the contribution of all passengers on board, or it can be achieved by rotating each time the driver (only if all people have a car and travel periodically all together. In the first case the service provider of carpooling may provide a regulation that suggests some specific rules in order to calculate the contribution of each member of the crew. It calculates, for example, costs (fuel consumption, tire wear, maintenance costs and the amortization of the capital invested) that appear to be directly proportional to the trip distance. Operating costs such as insurance, stamp duty, etc. are not considered as costs are not proportional to the distance. The breakdown of expenditure between the crew must be calculated on the basis of part of the trip (in distance) performed by each of them. The possible highway toll is not included in the calculation of travel expenses, but must be shared equally among the crew. For the latter case, however, there are few examples in the literature about carpooling experiences explicitly created to reduce the cost of tolls in a period of ongoing work on the highway;
• promoting car pooling. It is very important for the success of the service promoting events for the dissemination, communications and providing information on insurance and legal aspects. If possible, you might want to give visibility to carpooling through attractive and comfortable meeting points located throughout the area;
• having a web portal. Any system supporting the carpooling services should be easy to use and with a user interface very user friendly and intuitive. It is strongly recommended to provide a "user's guide" available directly through the web. Portals of carpooling should be designed to reach and be reached by a large community of users. For this reason the creation of a web application seems to be the right approach.

The key aspects of a successful platform for car-pooling can be summarized as follows:

- be intuitive and easy to understand;
- have attractive graphics;
- make great use of geospatial services;
- provide advocacy to potential users;

- provide a schedule of carpooling (flexible and dynamic);
- be able to look for compatibility along spatial and social dimensions or on the basis of personal preference.

In order to meet these requirements it is important to take advantage of the latest technologies available for Web 2.0 and the major frameworks available for managing social networks and the management of the maps. The use of these instruments allows to speed up the development process and to obtain solutions distinguished by excellent quality both in terms of reliability and performance offered.
A key factor for the success of a platform for car-pooling is the integration of geographic maps useful for controlling and planning trips. Another important aspect of technology is the use of standards to ensure the proper functioning of the system regardless of the browser used. Taking this into account would generate a system that can reach a wider group of people through the pilot site, without incurring in problems of incompatibility or partial support, which contribute significantly to the decision by the user of a "second visit" to the site. Carpooling services must also present a user-friendly interface, intuitive and easy to use by all users. In this context, it is important to analyze the characteristics of accessibility, graphics and overall accuracy of the content. Also the choice of the brand and logo are essential to achieve a familiar service for customers. A user-friendly name is very much appreciated.
It may be provided a service of feedback in order to assess the fellow travellers. In this case, the assessment is based on the opinion provided by the customer leading to a classification of carpoolers in terms of punctuality and reliability. The evaluation (rating) helps to create a climate of trust within the community and, consequently, a greater use of the services offered. The management of a rating system is, therefore, useful for both users - because it enhances the feeling of confidence in his/her teammates – and service provider - because it provides useful data for statistics.
It can be also implemented a "black list" staff, where the user can enter the name of the people who does not like, and also the list of favourite traveling companions. The data provided by users who register on the system are used only for the operation of the system and the confidential information is protected from intentional, unintentional or misuse of disclosure. As for safety, the only mutual guarantee for the users is given by the registered name, last name and address. The "conditions of use" of the service shall state that if someone commits actions of abuse, harassment or other violations, he/she will be prosecuted by law and immediately deleted from the system.

5.8 Economic sustainability

Prior to the design and implementation of the service it is important to prepare a detailed business plan that takes into account the entire life cycle of the carpooling service. Particular attention should be given to the operational phase of the service, so that it is able to go beyond the experimental stage. In order to obtain a successful launch of the service it is suggested to identify a pilot institution that promotes a carpooling service for their staff. For example, you should include agreements with universities, hospitals, government agencies,

businesses, and so on. The main costs of carpooling are hosting system, routine maintenance, the cost of marketing activities and, of course, the cost of developing the platform.

5.9 Stakeholders

The main parties involved in the development of a carpooling service are the government supporting the service in their territory, the promoters of carpooling services, potential business users interested in the service, companies of Local Public Transportation (LPT) and, of course, the people who provide/need a ride. For the success of the service it is very important to create a network among key stakeholders, particularly between the local institutions promoting carpooling, for example by entering into appropriate agreements or through the organization of events.
The realization of such systems implies a set of advantages for the public administration, including:

• the reduction of fuel pollution, coherently with Kyoto Protocol and E.U. laws, with the possibility of obtaining a bonus if the city appears to be virtuous;
• more efficient use of private vehicles;
• improvement of road safety resulting from the decreased likelihood of accidents.

The promoter of the services of carpooling can also be a specialized manufacturer in this field or a mobility manager of a company. In the latter case, the benefits for the company are:

• the improvement of the corporate image through the company's commitment to environmental problems;
• the provision of a useful service for employees and regularity of arrivals;
• the reduction of the parking requests with the possibility of (partially) converting them into other functions (green spaces, aggregation centers, etc.);
• grasping the principles of corporate social responsibility to improve the whole territory with a concrete initiative in the area.

It may occur that some investors can benefit indirectly from the services offered by the platform. Just think of the possible business users or, for example, a rent-a-car company that decide to provide their vehicles to allow the sharing of trips even to those who do not own a car. The benefits for these subjects are:

• reducing the cost of advertising of their own services, as it exploits the visibility of the platform;
• the possibility to easily reach an additional critical mass of users actually interested in the service.

Additional benefits in the spread of carpooling services can also be found for the companies of the local public transportation (LPT), such as:

• the reduction of traffic congestion and therefore the possibility of increasing the number of bus rides;
• the possibility to cover remote areas not fully served thanks to the aforementioned, desirable increase in the number of races.

Finally, the benefits for people offering/looking for a ride are:

• the reduction of travel costs through the sharing of costs among users;
• the ability to reach easily and cheaply areas where public transportation is not sufficient;
• some special bonuses reserved to carpoolers;
• the opportunity to socialize with other people;
• the reduction of psycho-physical stress related to driving efforts in urban traffic;
• improving the quality of life and environment.

5.10 Carpooling experiences and best practices

At the national several and different carpooling services have been realized:

• commute pooling. It aims at providing a mobility service to commuters/students in some Northern Italian communities in order to reduce the traffic levels in some main tracks by means of the spread the concept of sharing mobility among citizens, cost sharing among users, access priority/exclusivity for carpoolers to some parking areas, etc.. Local authorities were able to develop a better relationship and institutional image perceived by citizens, a customized mobility strategy meeting local community needs, a reduction of parking areas, a different mobility solution, complementary to LPT and private transportation. It includes a logistics optimization engine;
• highway pooling. It was developed by Autostrade per l'Italia S.p.A. and focused on highways in Northern Italy in order to reduce traffic and pollution. It was designed with specific carpool lanes and discounts on the highway toll. It involved a lot of different institutional and corporate partners and aimed at providing carpoolers with a total estimated average saving of 70% of the standard costs. In this case, users proposing a trip could participate both as a driver or a rider;
• school pooling. It was developed in the area of Padova, Northern Italy. It aimed at reducing the use of private cars for family with members in schooling age. Parents agree and share their cars according to a algorithm included in the platform: it is able to suggest crew composition and ensure drivers rotation and also co-drivers if the drivers are missing. Costs are equally shared and a fixed driver can be chosen for a specific crew. By the social point of view, it ensures the opportunity to create a network of parents. Since many parents have known each other before the starting of the service, a high level of trust was easily achieved also on the platform;
• social pooling. A successful example is given by BlaBlaCar, a very young and intuitive platform with a first-generation logistics optimization engine. Social preferences of users about the way they like travelling are very important since they make it possible to ensure a high level of matching between socially-similar users. It suggests a price for passenger to pay the driver and allows users to know the exact points of pick up/drop off on the map, the

model and colour of the car, etc.. This way the system creates also an upper bound based on a certain percentage exceeding the calculated price;

• intercontinental pooling. Many of such experiences are located in the E.U. where more than 60% of people live in urban areas. Pollution is getting worse overtime and urban traffic is the most important cause of transportation pollution. Traffic jam also implies waste of time and 1% of E.U. G.D.P. - i. e. € 100 billions – is devoted to solve this problem. Nonetheless, the vehicle occupancy rate is still 1,06 persons/vehicle. Carpooling services leverages a collaborative environment in order to motivate users with a credit mechanism to convert in parking licensees, etc.. They also include Trust&Reputation Systems, billing services and real time functionalities devoted to highly connected users;

• metropolitan pooling [3]. The best experience is that of Lisbon, Portugal. It includes a credit mechanism for users about some parking facilities. The Metropolitan Area (LMA) was established by the Portuguese law n. 44/91. In this area, with the highest population density all over Portugal, the average commuting trip lasts about 35 minutes. In Figure 43.A the traffic distribution in the LMA is showed.

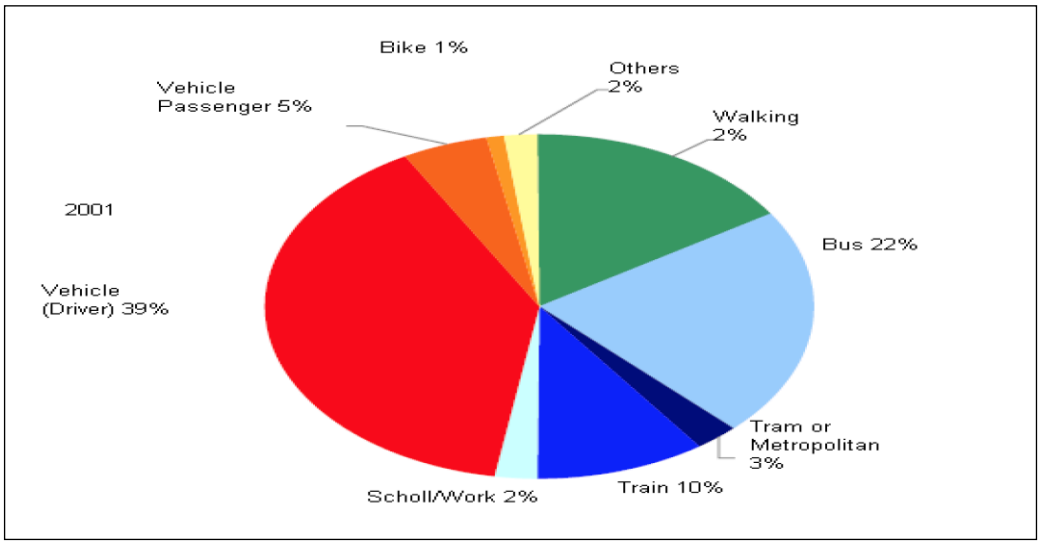

FIGURE 43.A: TRAFFIC DISTRIBUTION IN THE LMA IN 2001 [3].

In figure 43.B the flow composition of people shifting between Lisbon and the periphery is clearly shown.

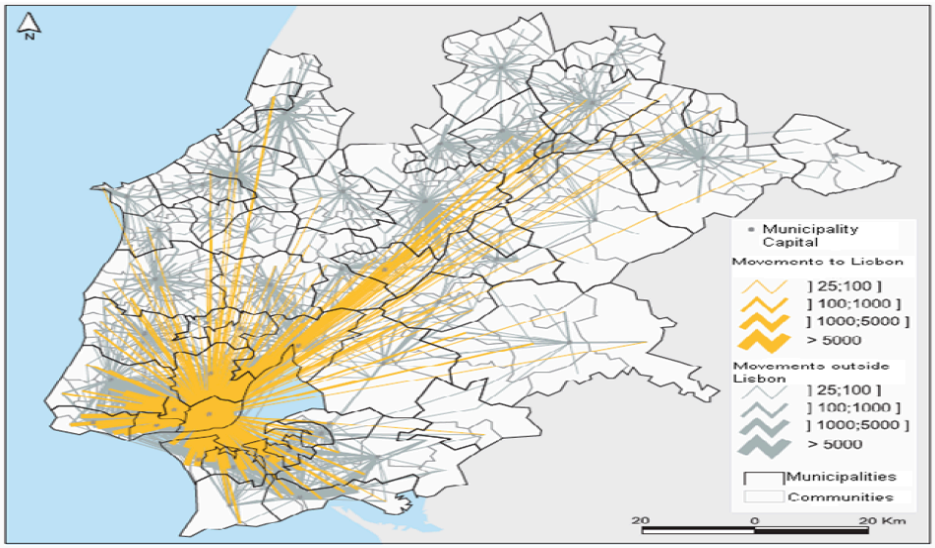

FIGURE 43.B: FLOW COMPOSITION IN THE LMA [3].

In Figure 44 the functioning graph with user preferences is shown.

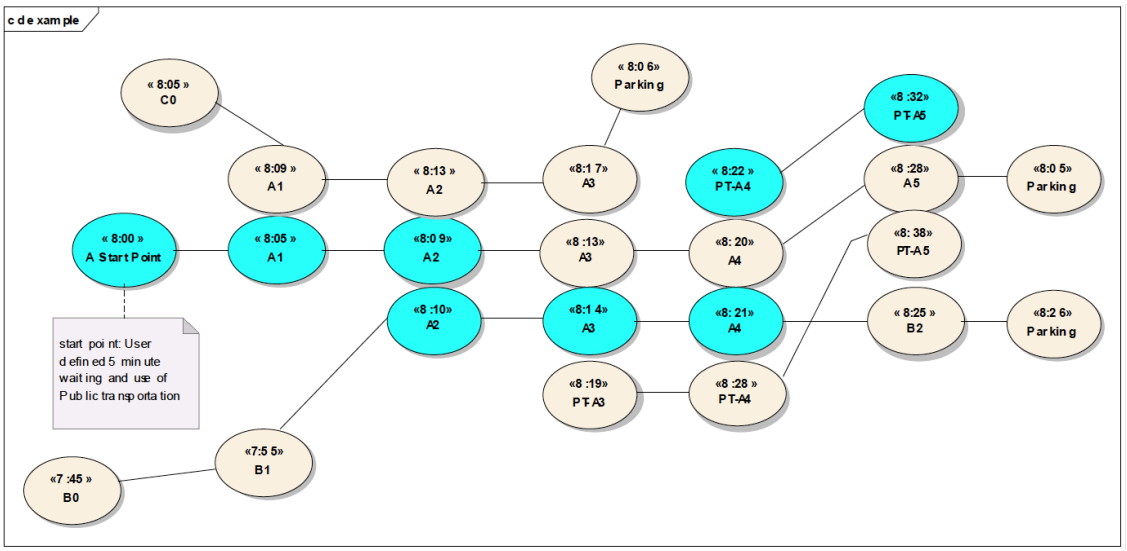

FIGURE 44: FUNCTIONING GRAPH WITH USER PREFERENCES [3].

In Figure 45 the logical architecture of the carpooling system is shown.

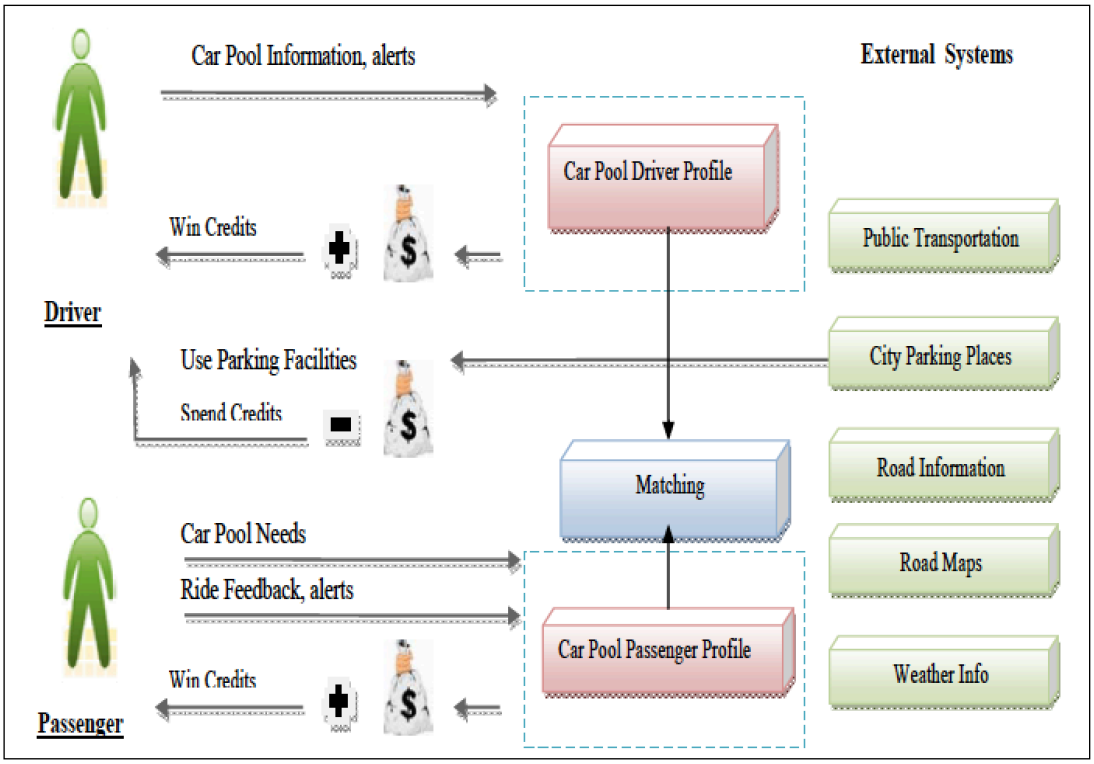

FIGURE 45: LOGICAL ARCHITECTURE OF THE CARPOOLING SYSTEM [3]

Information about time of public transportation, meteorology, parking systems and road network are continuously updated.

In the following the use cases for driver's and rider's profiles are shown (Figure 46 and 47).

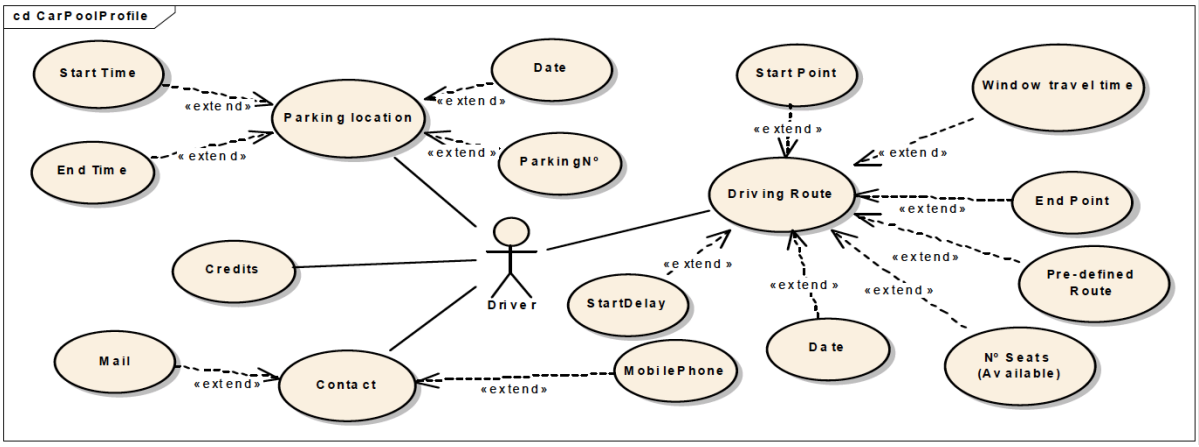

FIGURE 46: USE CASE OF DRIVER'S PROFILE

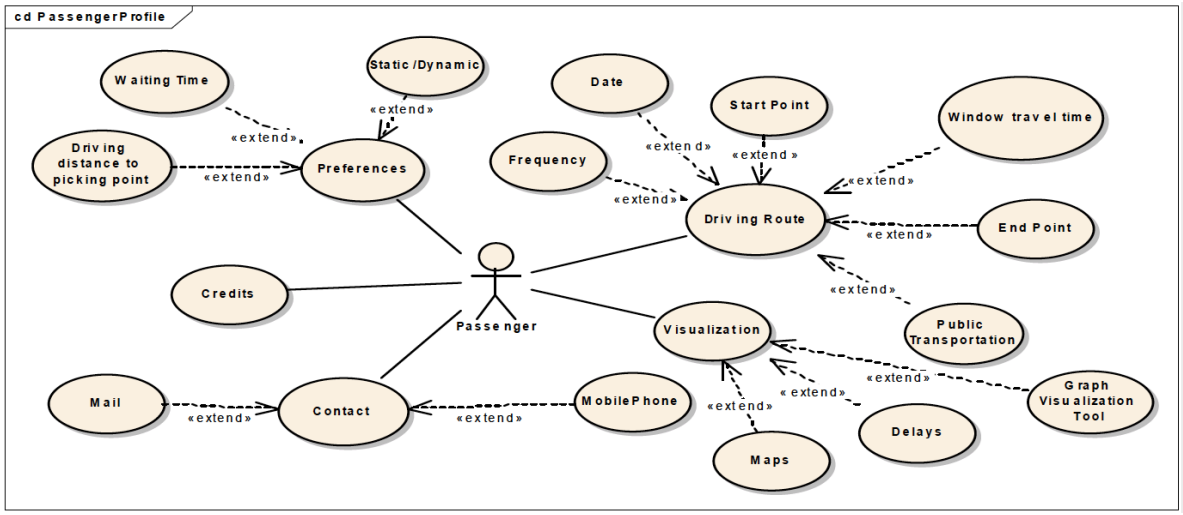

FIGURE 47: USE CASE OF RIDER'S PROFILE

Among the most peculiar and advanced functionalities we mention the possibility for the driver to know in advance where there are parking slots available and to send notifications about possible delays. On the other hand, the rider is allowed to set the acceptance for periodical notifications about a certain point of interest.
Moreover, a text-to-speech audio system is available in order to advise the driver when he/she is approaching the pick up/drop off point.
An one-time-password is generated by the notification module in order to allow drivers and riders to check in for the beginning of the trip. Also a GPS module is used in order to track shared trips.
In Figure 48 the profile matching functionalities are shown.

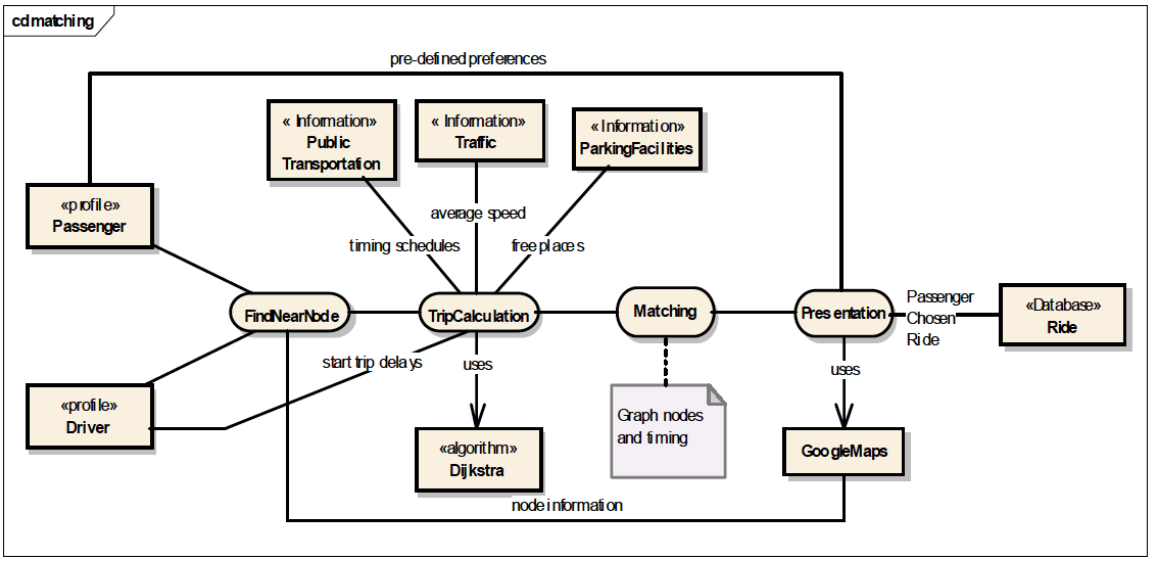

FIGURE 48: PROFILE MATCHING FUCNTIONALITIES [3]

Time and costs are estimated with the Dijkstra algorithm depending on the average rate of network congestion and eventual real time notification from users.

Agreements with local authorities interested in reducing CO_2 emissions can be exploited in order to obtain further funds to maintain and develop the carpooling platform.
The credit mechanism allows users to convert their credits in real money transferred on their bank accounts.

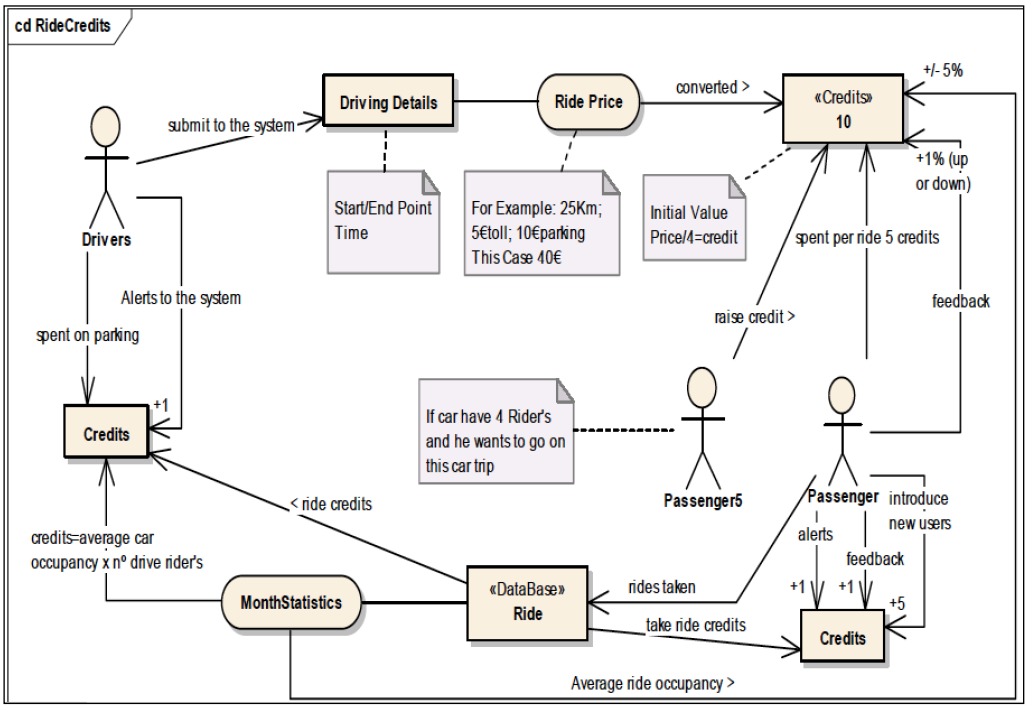

FIGURE 49: CREDIT MANAGEMENT SYSTEM [3]

• trust-based pooling society [7] [8]. Trust is a key element in the survival and competitiveness of carpooling systems. In the metropolitan areas of the U.S.A. the Single Occupancy Vehicle (SOV) is a widespread phenomenon: 90% of commute trips and 58% are realized in this way [8]. Therefore, carpooling proves to be a useful solution for cities in order to revise their own mobility system and provide their citizens with a more efficient and effective transportation solutions. In fact, the use of private vehicles is not sacrificed and its advantages are combined with those coming from a higher occupancy rate of vehicles.
The dynamic carpooling is an advanced variant of this kind of solution and it consists of a more flexible trip planning system. In fact, it works in real time and is able to define crew also a few minutes before the starting of the trip. Since this configuration is one of the less trusted by users, which may encounter people they never met before, it is necessary to adopt a trust-based system aimed at creating clubs of users. These clubs are not only virtual groups of users, but they can organize real meetings to facilitate socialization processes among users and increase clubs trust. Some studies by Krishnamoorthy [9] calculated a minimum rate of 80% of total users that should be involved in dynamic carpooling initiatives in order to obtain a successful launch onto the market. For example, Melbourne can be divided into several zones and all commute paths can be identified. Afterwards, the percentage of matched trips can be quantified as it follows:

$$S = 100 * \frac{(\#\ MATCHED\ OFFERS + \#\ MATCHED\ REQUESTS)}{(\#\ TOTAL\ OFFERS + \#\ TOTAL\ REQUESTS + \#\ AMBIVALENT\ OFFERS/REQUESTS\ )}$$

In this scenario a participation rate of 2,5% implies a success rate of 80%. Nonetheless, this result does not reflect attitudinal factors intended to be obstacles of the real ridesharing activities, so that the above expression ends up in reflecting only potentially matched trips, but really matched ones.

Achieving the critical mass is a key point for the success of the initiative, but by increasing also the likelihood of creating a greater network, the probability that unmet people may travel together grows up [13]. This way trust becomes even more important since more users tend to doubt about sharing a trip with unknown people. This psychological inhibition [10] is not completely overcome by adopting incentive and communication systems and requires the exploitation of users preferences in users matching (Figure 50). Desirability of trip sharing goes down with the increase in the number of unknown travel companions, especially for women.

Number of Riders	Respondent	
	Male	Female
Single Rider		
Male acquaintance	10.06	12.50
Female acquaintance	10.47	12.32
Male nonaquaintances	7.00	3.29
Female nonaquaintances	9.50	6.53
Three Riders		
Three acquaintances	10.76	12.15
Two nonacquaintances – one nonacquaintance	9.70	10.84
One nonacquaintance – two nonacquaintances	9.03	7.69
Three nonacquaintances	8.16	3.49

FIGURE 50: RELATIONSHIP AMONG SEX GENDER AND PRE-EXISTING ACQUAINTANCE OF TRAVEL COMPANIONS [10]

In conclusion, network size and users psychology are the most important factors determining success or failure of such systems. The club concept exploits both of these factors in order to maximize the number of people in each group and to increase their level of trust within the club netwotk. Such a solution is valid for both traditional and dynamic carpooling (Figure 51) [11] [12].

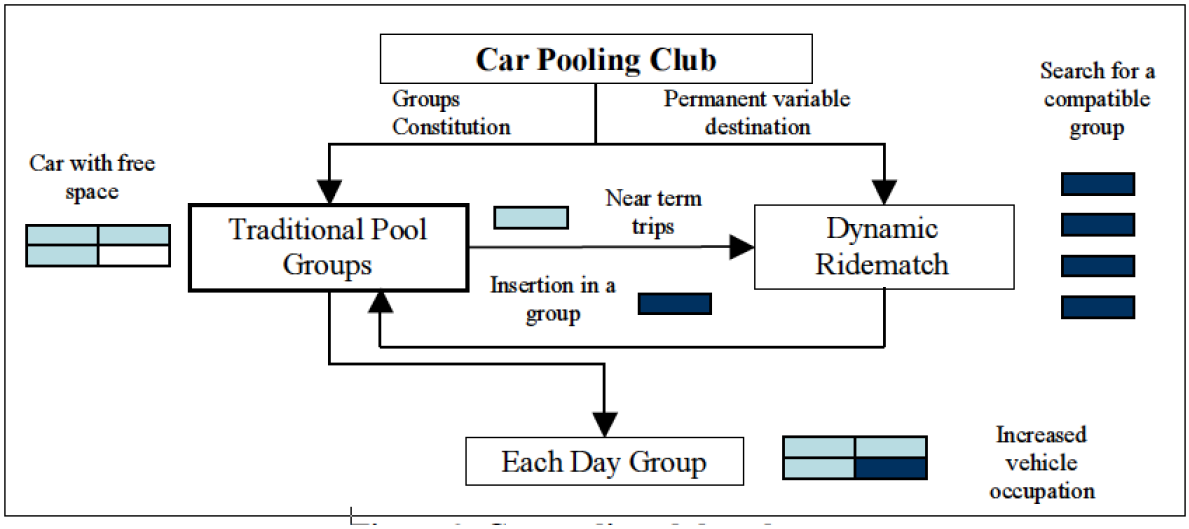

FIGURE 51: LOGICAL FRAMEWORK FOR CARPOOLING CLUBS [11]

5.11 Evaluation model

In the following an evaluation framework - i. e. "7C's model" [17] - aimed at analyzing the different features of several carpooling services is discussed. It includes seven evaluation components:

C1) Context: visualization mode and layout, trade-off between experiential and functional features of the platform;
C2) Content: information transmission system, mix in terms of products, services and information provided, mix of graphic design elements, mix of multimedia components;
C3) Community: information exchange among users:
C4) Customization: capability to provide a response to users needs and expectations thanks to personal relationships with them;
C5) Communication: information exchange between users and website;
C6) Connection: connection features of the website to other web pages;
C7) Commerce: online transactions.

Moreover, there are some specific functionalities aimed at supporting the online carpooling initiative. In this case the E-SQ tool [18] is adopted in order to measure the online service quality. Even if the total amount of dimensions proposed in the model is higher – i. e. eleven dimensions –, in this context we will consider only five dimensions because they are the pertaining ones to evaluation of the features of carpooling systems [1]. In the following the five dimensions are detailed:

F1) Efficiency. Functionalities to be used have an opportune structure and require the user to provide a minimum amount of information;
F2) Warranty/Trust. Trust perceived by users while interacting with the website. It is due to the website reputation and to the truth and clearness of information provided;
F3) Security/Privacy. Trust level perceived by users about protection of personal information;

F4) Price information. The extent to which users are able to determine the price or to know price sharing policies;
F5) Customization. Ease and ways to adapt the carpooling service to single user or collectives preferences.

In the following the results of the evaluation analysis are provided (Figure 52.A, 52.B and 52.C). They are based on the consideration of essential features and functionalities among those described above. They are conducted on nine of the most important players in the carpooling context worldwide [1].

C1	C2	C3	C4	C5	C6	C7
Userfriendly	Carpooling norms	Forum	Registration system	Email newsletter	Link popularity	Matching information
Navigation bar	Uploaded trips	Chat	Multilingual	Chat	Link to similar portals	Management of contacts between supply and demand
Internal search engine	Interactive maps	Connected blog	Customized services	FAQ	-	-
Ease of search	Carpooling news	Instant messenger	Profile creation	Information request module	-	-
-	Information videos	Social network	-	-	-	-

FIGURE 52.A: EVALUATED FEATURES [1]

F1	F2	F3	F4	F5
Ease of use of functionalities	Optimal reputation of the website	Anti-intrusion website	Price sharing	Groups/clubs creation
Minimum information request	Clear and true information	Decisive or intervention procedures	Multi-criteria choice	Rider-driver distinction
Simply and adequately structured	Feedback systems	Protected personal information	-	Adaptation to preferences
-	-	-	-	-
-	-	-	-	-

FIGURE 52.B: EVALUATED FUNCTIONALITIES [1]

WEB PORTALS	WEB INTERFACE							CARPOOLING FUNCTIONALITIES				
	C1	C2	C3	C4	C5	C6	C7	F1	F2	F3	F4	F5
Carpooling.it	H	H	M	M	H	H	H	H	H	H	H	H
BlaBlaCar.it	M	M	M	L	L	H	M	M	M	H	H	H

AutostradeCarpooling.it	H	H	H	M	L	M	M	M	L	M	M	L
Avacar.it	H	H	H	M	M	H	H	H	H	M	H	M
Bring-me.it	H	H	M	H	M	H	H	H	H	H	L	M
Carpoolworld.com	L	M	L	M	L	H	M	M	M	L	L	M
GoLoco.org	L	L	M	M	L	L	M	M	L	L	L	H
Taxistop.be	M	H	L	H	L	H	M	M	L	M	L	H
Carpool.UMD	H	M	H	L	M	L	M	M	H	H	L	M

FIGURE 52.C: EVALUATION RESULTS [1]. H = HIGH, M = MEDIUM, L = LOW

5.12 The application of the Canvas Business Model to deepen carpooling services

Canvas Business model [19] [20] [21] is a strategic management framework aimed at building up new or analysing existing models operating in business contexts. It deals with value proposition, infrastructure, customers and finance. It was developed based on the Business Model Ontology [20] and focuses on the relationships between elements with shared standards to analyze and develop business models. In Figure 52 the nine Building Blocks (BB) of the model are shown. They represent the logic of the company to make money and cover four areas: customers, supply, infrastructure and finance [21].

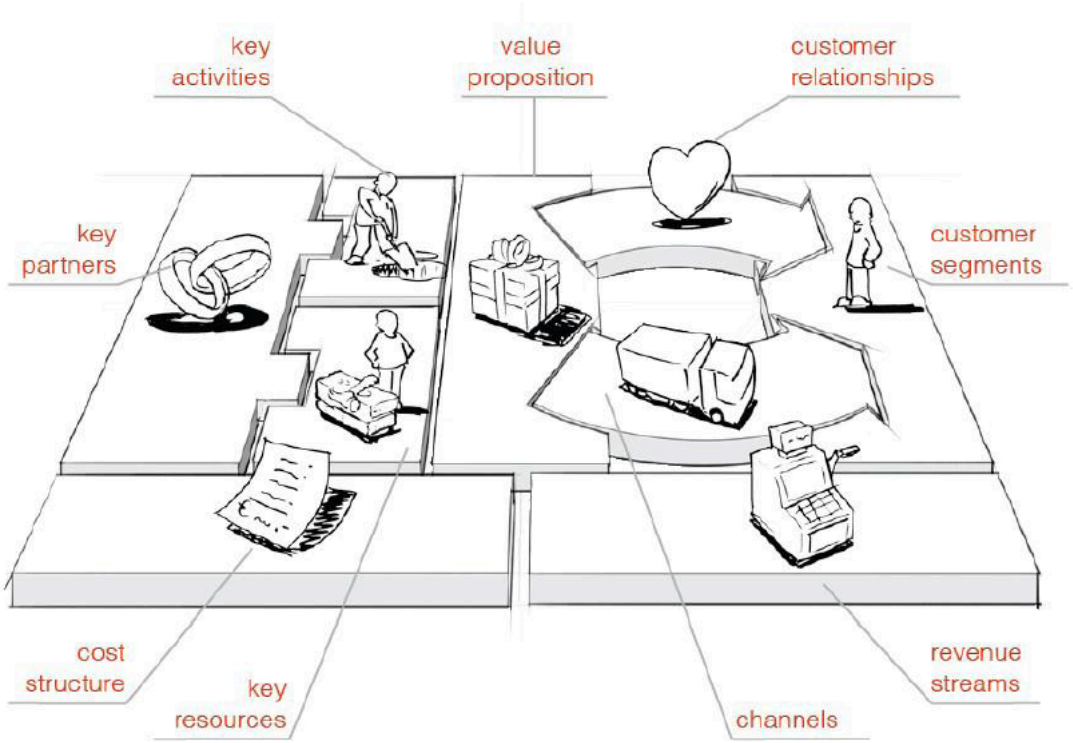

FIGURE 53: THE NINE BUILDING BLOCKS OF THE CANVAS BUSINESS MODEL [21]

It can be detailed as it follows [19] [20] [21] with some particular remarks about its application to the carpooling context [1]:

BB1) Customer segments. Definition of the different categories of customer groups or organizations to reach. They are key elements for the survival of the company. By

segmenting customers it is possible to better satisfy them and to understand also which clusters should be served by the company and which ones should be ignored. Afterwards, a business model can be designed in order to focus on a specific value proposition for the identified customer segments. Carpooling users can come from all countries and different segments can be identified such as: occasional trips, niche segments, young people on holiday travels, family holiday travels, university community trips, company commute services, routine travels in general, etc.. Currently active online users are clustered into: simplifiers, surfers, bargainers, connectors, routiners and sportsters. Segments are defined depending on the online behaviour of their of their members. This way, marketing specialists can customize company's attraction strategies based on segment-specific needs;

BB2) Value proposition. It aims at defining the whole range of goods launched onto the market by the company, based on the objective of value creation for customers in both a qualitative and a quantitative perspective. Each good is geared to solve problems of customers and meet their needs. Elements contributing to value creation are: newness, performance, customization, price, design, brand/status, convenience/usability, accessibility, cost reduction and risk reduction. The main value offered by a carpooling service is that of providing a contact place between riders and drivers in order to share trips. In very fews steps users can become part of a crew thanks to the matching system and they can save some money by sharing costs. Moreover, customers help reducing CO_2 emissions and become eco-sustainable. Also users are able to establish new relationships with unknown people and socialize with users having similar interest, not only about traveling. Finally, they can address the level of trust of the whole community of users and the underlying platform by giving a feedback about the trip. Such a feedback is elaborated and updates the system of recommendations provided by the platform;

BB3) Channels. It is about how goods with a certain value proposition can be delivered to customers. Value proposition incorporated in the company's goods should be delivered through fast, efficient and effective channels. In this context, distribution, communication and sales channels create an interface between the company and their customers, which is important in terms of what and how value proposition reaches its targets. ICTs provide a further tool in order to enlarge the range of channels to be used. In particular systems like carpooling platforms, the only and one channel is represented by the online website. It offers a lot of marketing channels provided by search engine marketing (SEM), paid search marketing or pay-per-click marketing (PPC), organic search marketing or search engine optimization (SEO), social media marketing, blogging, email and affiliate marketing. This way the platform is able to increase its online presence and to obtain a better image by means of online marketing channels. Moreover, all online channels are faster and easier to use. Many of them are also cheap or free;

BB4) Customer relationship. It is focused on the different kinds of relationships - i. e. personal assistance, dedicated personal assistance, communities, co-creation, automated services, self-service, etc. - that company handles with their customers with business survival and success goals. Automated or personal relationships can be triggered and managed on the basis of the following objectives:

- customer acquisition;

- customer retention;
- boosting sales (upselling).

Carpooling platforms can improve their customer relationship effectiveness and efficiency by means of exploiting the ICT's potential. It is really important since customer relationships represent the way a company goes to market and approach their own customers. This way it is also possible to get a lot of valuable information from customers in order to use them for customizing and profiling activities in the customer relationship management. Also new business opportunities can emerge from such an information collection system. Carpooling websites provide some help pages for users in order to get information form their own market. Based on the collected information, companies are able to define loyalty and trust programmes;

BB5) Revenue streams. Creating and managing customer relationships with targeted segments based and delivering value proposition to them is not sufficient in order to achieve business survival or success. In particular, the firm has to be able to generate the right revenue stream for each customer segment with many possible pricing systems such as: fixed list of prices, bargaining, auctioning, market dependent, volume dependent, yield management. Revenue streams can be clustered into transaction revenues (one-time customer payments) and recurring revenues (including post-sale support). ICT enables the adoption of new pricing mechanisms. In regard to carpooling contexts, revenues are generated by advertising, users knowledge, percentage on cost sharing, partnerships, premium services, business users registration, etc.;

BB6) Key resources. It aims at identifying essential resources in order to accomplish to the previous building blocks' goals. They are involved in the creation of a value proposition to reach the market, create customer relationships and obtain revenues. They can be tangible or intangible, internally owned or externally acquired. The most important resource is the platform providing the most relevant asset in order to achieve company goals by means of the matching software and the quality infrastructure management;

BB7) Key activities. It is related to the main activities involved in the value proposition in order reach the market, create customer relationships and obtain revenues, like key resources. In the carpooling world, networking, matchmaking, maintenance, branding, service provisioning and platform promotion are the most significant activities;

BB8) Key partnerships. Defining a network of suppliers and partners makes it possible to obtain successful results on the market. Partnerships aims at optimizing operations, reducing risks or acquiring resources. There are four kinds of partnerships:

- strategic alliances between non-competitors;
- coopetition: strategic partnerships between competitors;
- joint ventures geared to new business development;
- buyer-suppliers collaborations geared to ensure availability of supplies.

There are three motivations to create partnerships:

- optimization and economy of scale;

- acquisition of specific resources and activities;
- reduction of uncertainty and risk.

Promoting the service by means of partnerships with local authorities, public and private actors operating in mobility-related contexts and other relevant stakeholders is one of the key elements in order to create and increase users involvement and, in turn, to be appealing for other partner's websites;
BB9) Cost structure. It refers to the descriptive analysis of corporate costs. They should be minimized. However, low-cost structures are not always the best solution for all business contexts. In fact, there are two possible cost structures: cost-driven and value-driven. All of them can have some common features such as:

- fixed costs;
- variable costs;
- economies of scale;
- economies of scope.

In the carpooling service, main costs are related to host and operating system maintenance, marketing and communications, operating personnel, Internet costs, etc..
In Figure 54 the Canvas tool is showed.

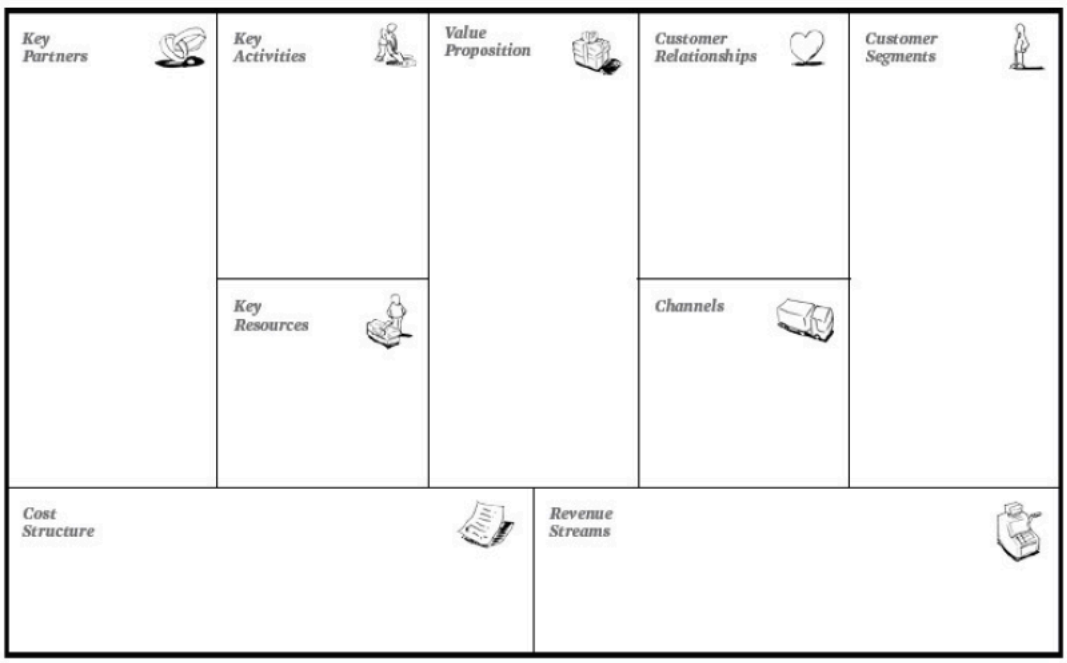

FIGURE 54: THE CANVAS TOOL [21]

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CHAPTER 6

THE SOCIAL VEHICLE POOLING REVOLUTION: EXTENDING CARPOOLING CONCEPT WITH CITYRIDE AND THE SOCIAL MOBILITY PROJECT[b]

6.1 Introduction

This chapter aims at detailing the design and implementation process of an advanced vehicle pooling platform. It takes as an inspirational source the development process of the CityRide platform realized by means of the Social MOBility (SMOB) project, that is a Social Innovation initiative realized in Calabria region (Italy). It is geared to be replied with adequate context-dependent adaptations in several and different areas in order to spread the awareness about the Collaborative Consumption and the Sharing Economy concepts.

6.2 Objectives

The main goal of this chapter is that of extracting the main features emerging from the social innovation research project, which can be intended as common elements of a vehicle platform and generalized in an ideal alternative mobility system. This way it is possible to highlight some components such as software architecture, main functional requirements, social networking modules and logistics optimization engine.

6.3 Software architecture **[1]**

A peculiar feature of the platform is the tight integration between the social and the logistics components representing the synthesis and strengthening of the best practices found in many existing carpooling systems. Figure 55 shows the logical architecture of the platform.

[b] The Social MOBility (SMOB) project (PON04a3_00164) and the resulting vehicle pooling platform, namely CityRide, is realized with E.U. funds thanks to the Italian Ministry of Education, University and Research (MIUR). It is the winner of the tender notice D.D. n. 84/Ric. – March 2nd, 2012 "Smart Cities and Communities and Social Innovation" of the "Research&Competitiveness 2007-2013" – Convergence Regions - National Operational Programme. The main source for this chapter is represented by such a project and the related platform.

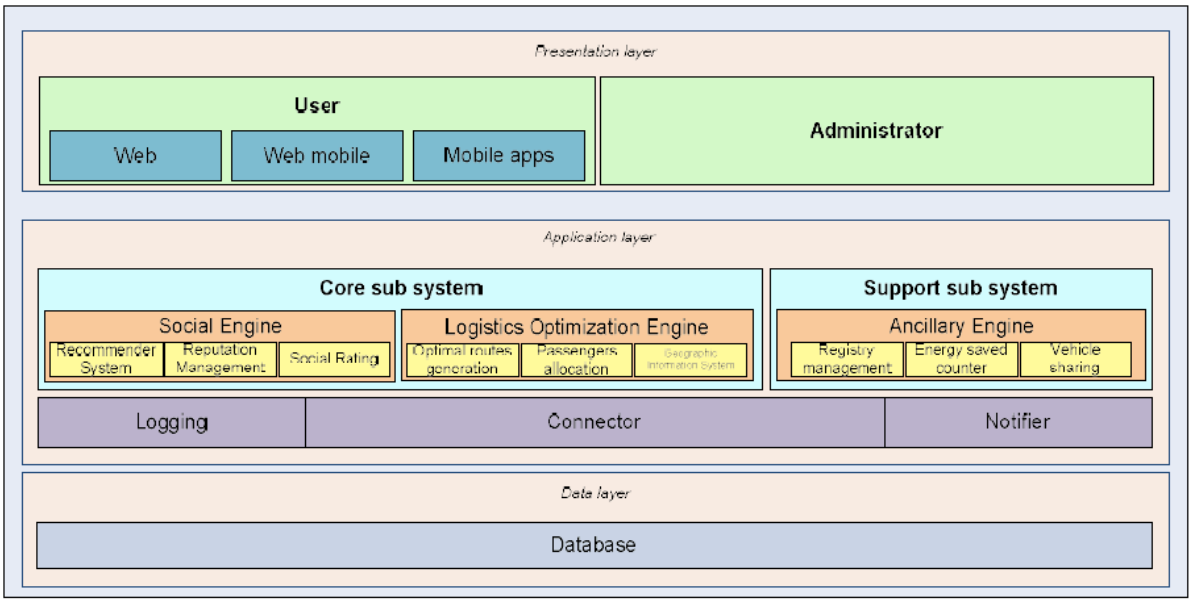

FIGURE 55: LOGICAL STRUCTURE

The objective of the Social Network component is to extend the assessment criteria through the implementation of specific reputation and recommendation algorithms. The platform is designed to become the community reference for vehicle pooling services offered in a given territory. The possibility of inheriting the social relations inside the most popular social networks – e. g. Facebook, Twitter – allows the platform to use pre-existing relationships on the platform in order to achieve a rapid growth of the internal social graph and a greater effectiveness of the solution provided. Each solution is always obtained through the cooperation with the logistics optimization component offering some complementary services (e. g. calculation of the shortest path between a source node and a destination node, display of the routes on georeferenced maps) and the provision of advanced vehicle routing algorithms. The problem of the assignment is addressed in an integrated manner involving the optimization problem intrinsic in the vehicle pooling process, i. e. the generation of routes to be carried from source to destination. The ability to manage on call services (i. e. dial a ride) completes the set of features offered by the system and granting it a strongly innovative connotation.

From the perspective of the software architecture model, it reflects the structure of the multi-tier applications accessible through the Internet and uses the mechanisms of inter-process communications typical of enterprise solutions. As illustrated in Figure 56, the choice was that of decoupling functionally independent components of the system. Internal communications are entrusted to a bus-based set of services available within the development frameworks (i. e. Switchyard JBoss 0.7.0 - SY7) of the logistics optimization component.

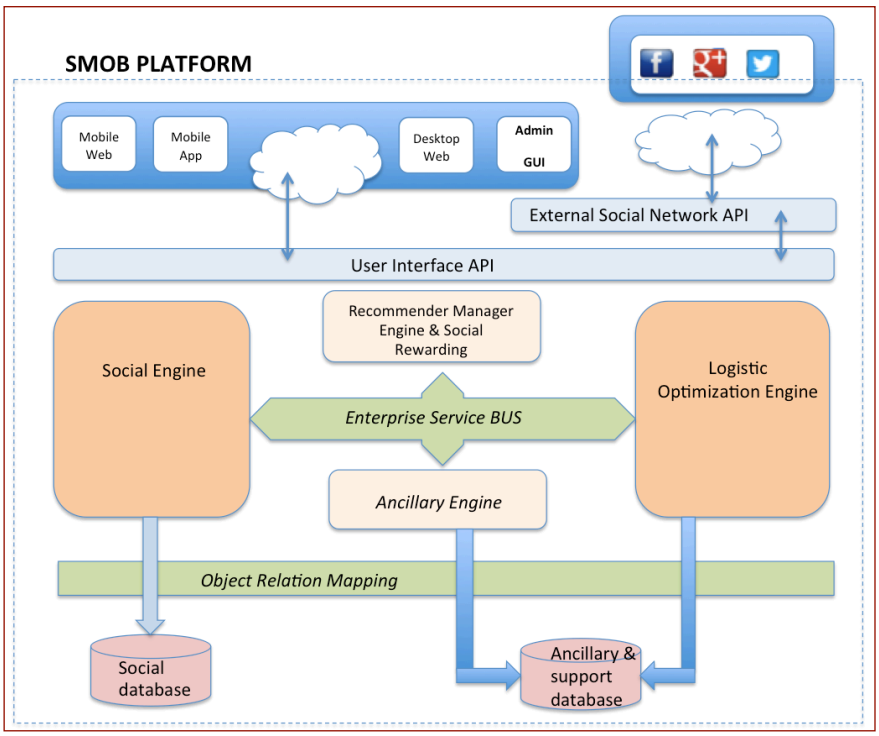

FIGURE 56: LOGICAL ARCHITECTURE

The dialogue towards users and external applications is handled by means of a specific software layer offering a set of primitives addressing all the features of the system. In particular, it is possible to implement the gateway to interface social network engines through the implementation of a specific Application Program Interface (API) with a level of abstraction higher than that provided by the programmable interface of the individual motors of social networking.
Regarding the expected level of data, the presence of a specific layer is designed to be the base of the dialogue between the business logic and the data model.

6.4 The Social Network component [1]

This component is developed on an open source software platform that provides the basic functionality in supporting all the features of the platform and it is characterized by the presence of a large community of developers.
From the logical point it is based on the architectural pattern Model-View-Controller (MVC). The MVC design pattern has its origins in the Smalltalk, where it was used to build the Graphic User Interface (GUI) for desktop applications. It is based on the concept of separation of data from their representation in order to avoid that the modification of one would automatically imply an update of the others. Therefore, the software system is constructed with a level-based architecture by decoupling data from their representation and by defining three components known as Model, View and Controller (Figure 57).

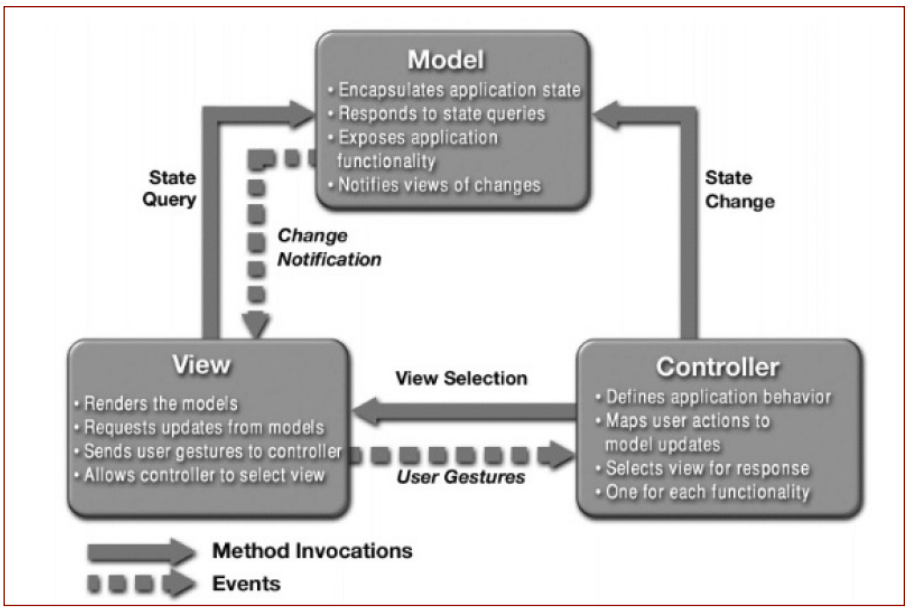

FIGURE 57: PATTERN MODEL-VIEW-CONTROLLER

The model is responsible for data management and application behaviour, coordinating the business-logic of the application, the means of access to the database as well as the implicit components of the system. It encapsulates the state of the application and exposes the functionality of the latter. It is independent in regard to specific representations of data towards the end user and the method of data input.
The model can be broken down into three purely conceptual sublevels (Figure 58):

• external interface: it is the interface through which the external code communicates with the model. Usually the external code is defined based on the type of framework used in the development of the web application;
• business logic: it is the central element of the model contains the code that implements the functionality defined in the application;
• data access: it aims at representing the code that allows access to data sources (databases, file systems, etc.).

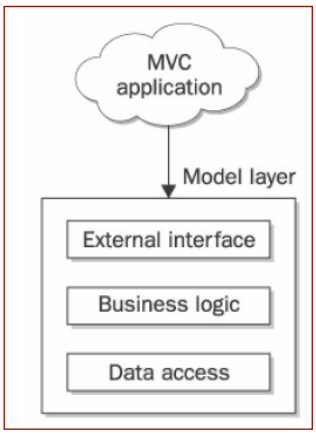

FIGURE 58: MODEL ARCHITECTURE

The three sublevels described do not necessarily represent some sets of separate classes but, rather, sets different responsibilities of the model.
The component of View enables the visualization and presentation of data to the user in different ways associated with the devices used to access the system (PC, tablet, smartphone, etc.). In summary, the same data is "rendered" in a different manner in order to obtain multiple views of the same model.
The Controller component defines the rules of communication between Model and View. It represents a logical connection between how the user interacts with the interface and the application services defined by the business logic in the back end of the system. The controller receives any request sent to the system, then individuates, within the Model, the component that will manage it. The result of this activity is managed by the same Controller, which determines which view is used for the final rendering of the data to the user.
Such architecture allows to separate the business logic, which is defined in the Model, the presentation layer, defined within the View, promoting the reuse of components and allowing changes to a level not affecting the other.

6.5 The Social Engine component [1]

Figure 59 shows the general description of the internal architecture of the module of social networking based on the above mentioned development framework and the architectural pattern MVC. Communications with Logistics Optimization Engine (LOE) module is entrusted to the services offered by the ESB and the MOM. The interaction with the modules of Social Rewarding and Recommender Manager is assigned to a server side API level. The objective of the module of Social Engine is the extension of basic mechanisms for the management of social graphs so as to model the relationships inherent to the activities of sharing travels through the platform. The Social Rewarding module is geared to the valorization of the behaviours of very virtuous users. The module of the Recommender Manager has to support decision making onto the assignment of users to vehicles, which characterizes the operation of the carpooling system.

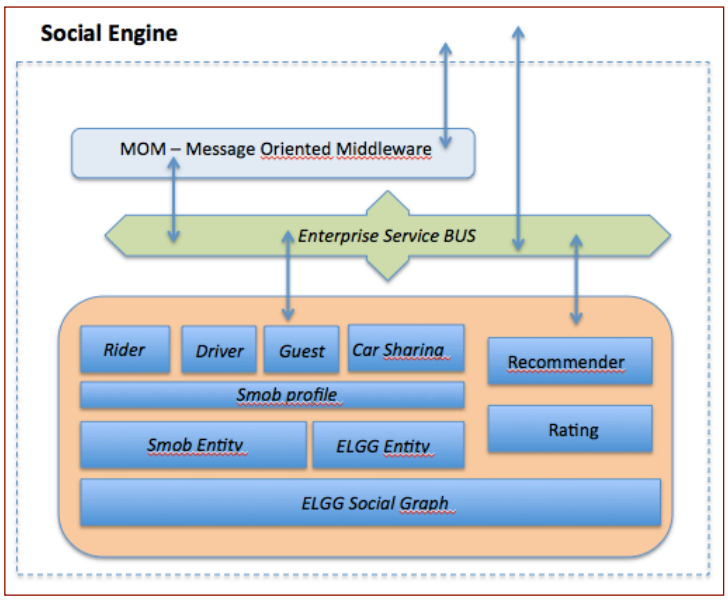

FIGURE 59: BLOCK DIAGRAM OF THE SOCIAL ENGINE COMPONENT

6.6 Routing and events [1]

The first phase of routing is handled by the Apache web server. Thanks to the rewrite rules the system maps a request with one of the primary handlers. The latter does the dispatch fo the request to the secondary handler.

An important part in the extensibility of the platform is represented by system events and hooks for any plugin. The framework calls the functions necessary to record an event or a hook when it is activated.

This feature is very important because through these callbacks we can extend the functionality of the social networking engine.

Each event notifies to the callback function what happened, while the plugin provides functions to change what was processed by the core part.

6.7 The communication interfaces [1]

Communication between the social networking module and other modules in the platform is be managed through the use of web services. The framework provides the ability to expose different functionalities to other modules (or any external applications) by using RESTful API.

Control over the access to the functions is provided by the API authentication in the platform. There are two ways to perform this authentication. The first is based on a key, similar to what is used by Google, Flickr and Twitter. Access is controlled by a key (random string) that is passed to each API authentication request. The keys are stored in the database and, if an API call is performed without (or with a wrong) key, the system denies its use by providing an error message. The second method is based on the HMAC type of authentication (keyed-Hash Message Authentication Code) similar to OAuth or Amazon S3 services. This approach provides both a public and a private key.

User authentication is based on the use of tokens. By providing a username and password, the user receives a token that can be used in a given period of time to authenticate API calls.

6.8 The Recommender Manager Module [1]

Recommender systems provide users with personalized recommendations regarding the usefulness of a set of objects belonging to a particular domain from the information available about users and objects. Objects can be intended, for example, as travels, drivers or riders.

The techniques through which it is possible to predict evaluations, unknown a priori, starting from the well-known ones, is a key issue in the light of which it is possible to characterize the systems themselves. In particular, there are different approaches for the definition of recommendation systems:

• demographic approaches: by using the demographic profile of the user, recommendations for different ranges of users are generated. A very simple and effective example is the display of the pages of a site based on the language of the user's nationality (demographic data extrapolated from the profile);

• cognitive approaches: the recommendations are generated based on chronologically earlier preferences expressed by the user. For example, it is possible to suggest objects similar to those appreciated in the past, by using a similarity measure between the objects themselves;
• collaborative approaches: the recommendations are generated based on the preferences of users with similar tastes (using, in this case, a measure of similarity between users). This method is also referred to as "people-to-people correlation" and is considered the most commonly used technique in Recommender Systems;
• social approaches: the recommendations are generated based on the preferences of friend-users with closest affinity to the target user (using, in this case, similarity measures between users related to each other by ties of declared friendship). This technique assumes that people tend to trust most of the suggestions of their friends and those provided by similar, but anonymous individuals;
• hybrid systems: the recommendations are generated by combining one or more of the approaches described above in order to exploit the advantages of a technique overcoming the shortcomings of another one. For example, methods for Collaborative Filtering suffer from problems in the first stage of assessment or suggestion that is the stage of identification of the elements still without an expressed evaluation.

The main functionality of the module of recommendation relates to provide a set of potential travel mates for a user.
In this case, to feed the Recommender System some explicit information is used. Information can be classified in two main categories:

• personal information, including information about user's preferences, trips, browsing and participation activities;
• social, which include information about the rating made by user's friends on trips, drivers, etc..

Based on these data user-to-user memory-based collaborative algorithms are applied, which calculate an index of utility for a user as the aggregation expressed by the utility for similar users.
Aggregate functions are the average of the ratings given to the user by other users or it is intended to be the average of the weighted ratings of the degree of similarity between users who provided an evaluation. The degree of similarity is calculated based on similarity measures such as cosine similarity or Pearson correlation coefficient.
Generating recommendations based on homogeneity among users allows for more accurate and less obvious suggestions, despite having to deal with any problems of sparsity or cold start, that occur in the early days of the launch of a system.
Besides considering generated recommendations as a source, the social activities of the users are identified and stored by the system in order to implement Social Rewarding mechanisms for the acquisition of credits and increase and promote social activities on the platform. Penalty mechanisms are also provided when some discomfort to others is provoked.

6.9 The Social Rewarding module [1]

Social Rewarding and Reputation Management systems measure the activity of each user in the social network on the basis of a defined set of actions. Every event and every action performed by a user of the platform is stored within the database through appropriate logging functions. This makes it possible to implement a model for identifying and classifying the activities of the users of the system and, above all, to allow the acquisition of credits and rewards needed to stimulate and promote social activities on the platform.
Every action is associated with a rating.

6.10 The Logistics Optimization Engine [1]

The logistics optimization component is the engine that concerns both the optimal allocation of passengers to vehicles and the determination of routes at the minimal cost. The LOE component fits within the architecture as a software module that can process independently and on the basis of a well-defined communication interface. It relies on the support of a set of open source frameworks, which support the realization of custom services that operate on the basis of a specific business logic. These services are provided to the technology platform on request.
The main feature of the optimization module is the ability to interpret the set of constraints arising from both the preferences expressed by users and the social activities. Through interactions with the modules of the Social Network component it is possible to identify a set of constraints derived from Recommender Manager and Social Rewarding systems. Among the explicit constraints arising from the profile information of users it is possible to highlight:

- type of vehicle;
- ability to load passengers;
- ability to load luggage;
- time windows;
- vehicle for smoking users;
- minimum rating for passengers;
- favourite users;
- black list.

The objective is to provide an optimization engine able to support in the search for a vehicle. Through different search mechanisms based on specific heuristic procedures, each specific request is evaluated on the set of available deals compatible according to the specified constraints.
The objective of the LOE is to maximize the quality of service perceived. This index can be considered as the level of quality of the travel experience that each participant, be it driver or rider, experiences and can be influenced by a number of measurable parameters. Among these parameters there are:

- cost, one of the most important metrics; usually a user is interested in minimizing travel costs, but often this logic collides with other types of metrics such as, for example, duration or total mileage;

• saving on the cost; in this context is generally referred to the possibility, for the driver, to reduce the costs of travel thanks to the payment received for the transport of riders, while the rider is referred to the possibility of obtaining a more convenient form of transport compared to others;
• duration of the trip; each user wants to reach the destination as soon as possible; many factors can affect the time dilation of travel, first of all the traffic must be taken into account;
• saving on travel time refers to the ability to shorten travel times compared to alternative modes of transportation, such as public transportation;
• distance covered; generally it is better to do the shortest distance possible, but everyone should keep in mind that this does not necessarily means a saving on travel time;
• reliability of the user is an indicator that is relevant for both drivers and passengers; it may be a single metric that summarizes the quality of the user in terms of reliability or a set of metrics differentiated by type as: reliability and compliance with commitments, punctuality and compliance schedules.

Moreover, some constraints can be defined as:

• change in the duration of the journey; a user may be interested in putting a limit to the change in total travel time compared to the direct estimated time between source and destination. As the routes are changed as a result of insertions or removals of passengers in vehicles, the duration of such trip routes changes as well; therefore, each total journey time of each user changes;
• variation on the distance; in this case a driver might be interested to put an upper limit on the variation of the total covered distance than the direct estimated path between source and destination. As the routes are changed as a result of insertions or removals of passengers in the vehicle, the distance covered changes as well.

Among the choices made in the architecture of the platform, it was decided to confine to an external module the management of all the trip requests/offers together with the state of the requests and the results of calculations performed. In particular, with regard to the requests the following information are identified:

• set of deals;
• set of travel requests assigned to a vehicle and confirmed;
• set of travel requests assigned to a vehicle, but not confirmed;
• set of travel requests unassigned.

Given the structure of the information related to the output produced by the optimization engine, it is necessary to prepare the data model so as to be able to manage a:

• set of travel requests assigned and confirmed;
• set of travel requests assigned, but not confirmed;
• set of travel requests unassigned;
• map data;

• operating parameters.

The activity of route optimization, depending on the size of the problem to be treated and the flow of requests, uses a time not compatible with a synchronous iteration between user activities online and LOE activities; it is, therefore, essential to establish a mechanism of asynchronous interaction, which must be suitably managed. Typically the response to a request of the LOE is deferred over time; it is a task of the system to retrieve this response and manage it appropriately.
The LOE provides the direct management of map data necessary for the elaboration of the solutions of vehicle routing; between the information managed indirectly by the optimization engine we have:

• geocoding and reverse geocoding;
• road graphs;
• verses of road edges;
• restrictions on the transit of vehicles;
• distances in kilometers;
• calculation of shortest paths.

Inside the LOE, the use of map data is finalized to the extrapolation of quantitative information that are used in the optimization phase, while the set of activities related to the display of interactive maps for visualization of routes is entrusted to a special external module. To meet the needs of manipulation of geographic data, it was considered essential the adoption of a tool able to provide high performance in terms of speed and reliability. Therefore it is expected to favour the use of a solution that provides a mapping system in-house, also accessible through a map-server properly configured that can use data in shapefile format. The services of displaying on a geographical basis the results obtained (for example, the path of the routes, the location of the points of pick-up, etc.) exploit the possibility of using, in the experimental phase of the initiative, the services offered by Google Maps that provides a limited number of daily transactions able to ensure a sufficient level of autonomy. The preparation of appropriate wrapper services is provided for the interoperability of the platform with other visualization engines of geographic data.
It is important to emphasize that the subsystem for the management of map data must be able to minimize the calculations made on the cartography, as the construction of the road graph and the calculation of the routes and distances between two points; in this respect, it is necessary to implement a cache mechanism for the data used.
The LOE requires the preparation of an integration layer based on Web services; the interaction with the external environment is of an asynchronous type and then it is mediated through the use of a Message Oriented Middleware (MOM), which takes over the communication activities between the LOE and the outside and vice versa.
In order to ensure the requirements of reliability, scalability and robustness of the component LOE it was decided to direct the development of the modules within an open source, but enterprise-oriented framework.
In particular, the module LOE:

• optimizes preconceived routes. The system may require optimization of a set of routes in which the crews are already formed. In this case, the LOE will simply have to find the best configuration of each route;
• optimizes unconfirmed requests. The system may require optimization of a set of pre-established routes and their crews can not be removed, and some requests are not confirmed. In this case, the LOE must find the best allocation of unconfirmed requests within the constraints specified in the data input;
• optimizes on-the-fly requests. The system may require optimization of a set of requests that require a dynamic allocation made in real time. In this case, the LOE must return the first feasible solution found;
• shows routes on the map. The system may require viewing a route on an interactive map, the LOE must return an instance of a map according to a viewable format on the web browser;
• calculates CO2 saved. The system may require the calculation of CO_2 savings for a given route, the LOE is able to return the calculation divided by geographic areas.

Thus, as shown in Figure 60, the component LOE exposes, via suitable web services, the set of features offered to the other modules of the system.

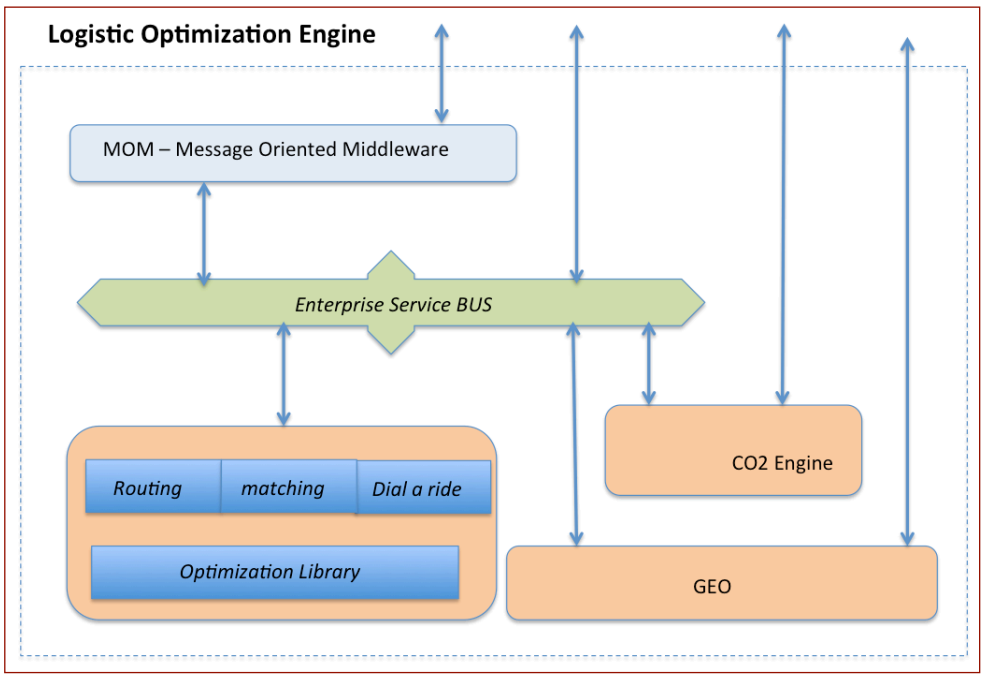

FIGURE 60: BLOCK DIAGRAM OF THE LOE

It is possible to interface from outside with the LOE by using Message Oriented Middleware, which allows the execution of asynchronous calls through messages: these are stored in appropriate queues until the service they refer to backs available. This mechanism hides the programmer the implicit nature of the client/server mechanism.
You can also use the Enterprise Service Bus, a software infrastructure that provides support services to SOA complex architectures.

Finally, it is possible to communicate in a direct way with the low-level modules (optimization engine, the module for calculating the CO_2 and GIS server) by using the APIs properly designed to allow interactions between the different modules.

6.11 The support subsystem [1]

The Support Subsystem (SS) module for the calculation of the CO_2 is located inside the LOE component. Prerogative of the subsystem is to provide the modules to support the activities of database management system in batch mode, implementing mechanisms for event notification and ensuring a log of events and activities with a high level of abstraction with respect to the nature of open source tools offering such a service (Figure 61).

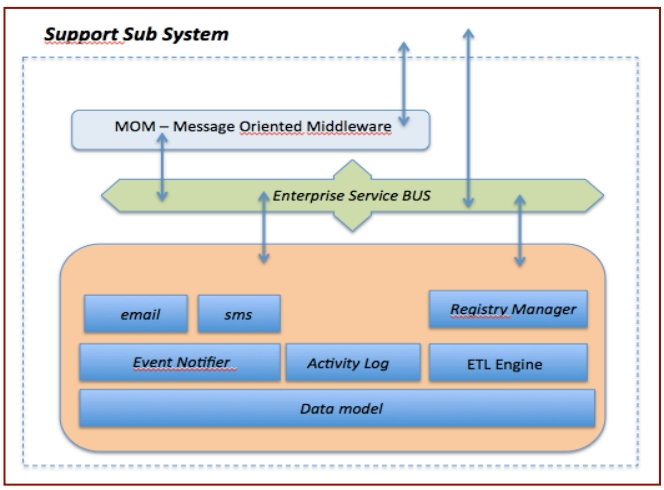

FIGURE 61: BLOCK DIAGRAM OF THE SS COMPONENT

The support modules will be designed and prepared to interact with the ESB and also to use specific interface routines. In particular, for the logging activities it is important to ensure the availability of a software library able to simplify their use and, at the same time, minimize the overhead deriving from its use. The module of event notification is positively affected by the presence of the ESB, since it is important in the communication between the different components of the system.

6.12 Mobile App [1]

From the point of view of the software architecture of the Mobile App, the main features are characterized by a high degree of modularity. In particular, we have identified the interface module to the external services, the interface module to internal services (GPS module and GPRS) and the module of user interface (Figure 62).

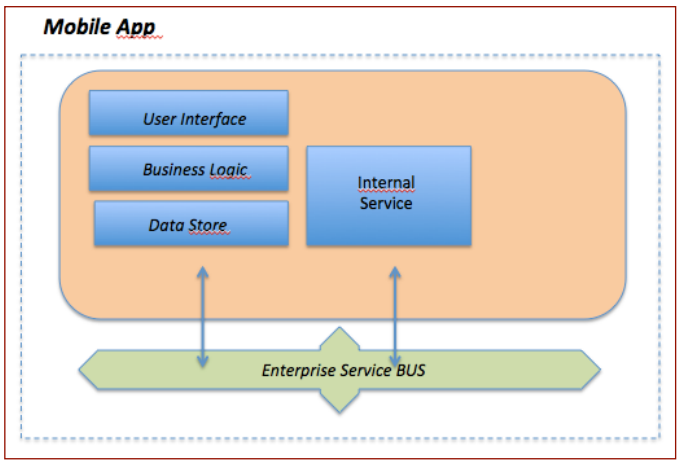

FIGURE 62: BLOCK DIAGRAM OF THE MOBILE APP

6.13 The interconnection module [1]

From the point of view of the logical architecture, communications between the different components of the system focus on the use of service-oriented infrastructures, which follow the pattern of the main best practices and patterns of integration (Figure 63).

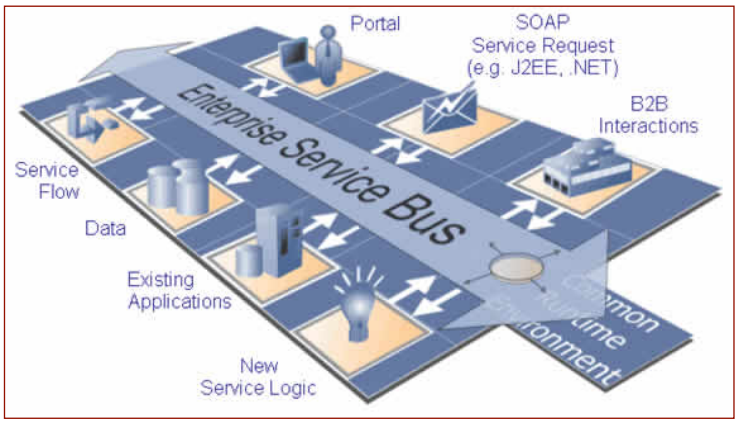

FIGURE 63: THE SOA ARCHITECTURE

6.14 Communication protocol between modules Social Engine - Recommender System [1]

As reported in the previous sections the communications between the module of Social Engine (SE) and the module of Recommender System (RM) are handled via web services. The table below shows, for example, the sequence diagram related to the case of insertion of a travel offer with invitations. In this mode the driver can directly invite users who belong to his/her own circle of friendship in order to make the trip with them.

The client requests the selection of users to be invited to a trip through a list to be generated based on user preferences of drivers. The module of Social Engine calls the proper function by passing as parameters the user identification code, as well as an API key authentication (to avoid unwanted access to the function). This key is generated from the module via the plugin Social Engine, which is charged to generate, for the call in question, a public key and a private key (in this case the authentication API is through sole use of the public key). The module of Recommendation will generate a list of userID to be proposed as possible traveling

companions according to algorithms of similarity between users (e. g. users with better evaluation in recent trips, users with similar travel preferences, etc.).
The response has two fields:

• suggested rider's userID;
• similarity in percentage.

The system retrieves data from the database for these users and renders them to the driver as a list with checkboxes. The choice is stored.

6.15 Communication protocol between modules Social Engine - Social Reputation [1]

Even the communication between the module of Social Engine and the module of Social Reputation (SR) is managed via web services with RESTful APIs.
The driver can release an evaluation of each crew member on the basis of the following parameters:

• punctuality: score from 1 to 5;
• respect for other participants: score from 1 to 5;
• respect for the vehicle: score from 1 to 5;
• comment: rating summary.

The Social Engine module invokes the function by passing as parameters the userID of the rider, evaluation parameters as integers (punctuality, respect, etc.), an optional text comment, as well as an API key authentication (to prevent unwanted access to the function).
The module of Social Reputation stores this data and updates the total score for each user subjected to feedback, releasing a response about what happened and communicating (via Social Engine internal notification service) to different users the inclusion of the new feedback. The Social Engine module communicates via the frontend interface about the completed insertion of feedback about the driver.

6.16 Communication protocol between modules Social Engine – Support Subsystem [1]

The logical architecture of the subsystem relating to auxiliary applications is part of the overall architecture. Communications with the subsystem include that for the calculation of the energy saved and happen via RESTful web services well-suited to stateless services. In Figure 64 the class diagram about energy savings is shown.

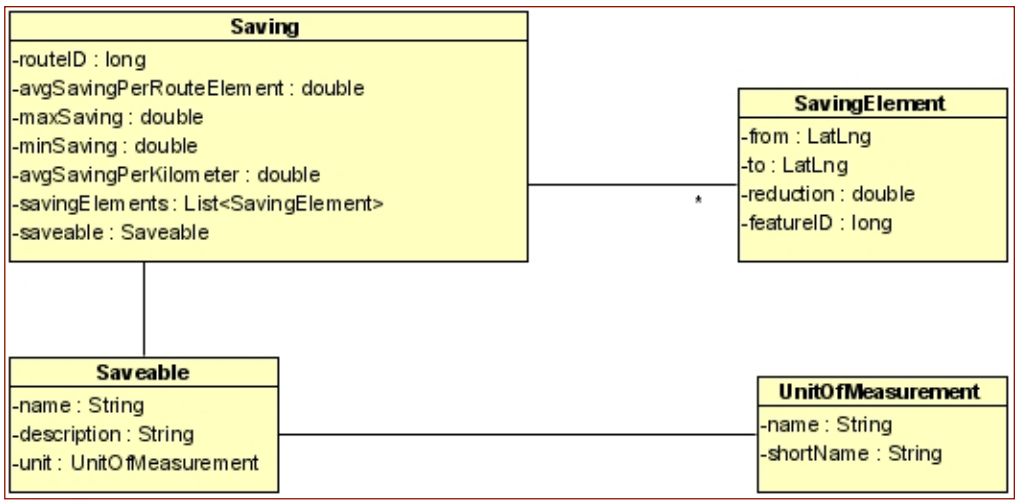

FIGURE 64: CLASS DIAGRAM ABOUT ENERGY SAVINGS

6.17 The advanced set of vehicle pooling functional requirements [1]

In the following the vehicle pooling functional requirements are detailed:

F1) Registry Manager; it includes the registration process of a new user profile with all user's data and the authentication process with username and password. It also includes the modification or retrieval process for forgotten passwords. The functionality works on both desktop and mobile devices. Users can complete the registration process by clicking on the URL link in the confirmation email. Users can register. Login and logout as totally new users or by using the Facebook or Twitter profile in order to import some data on the vehicle pooling platform. Users can decide to register alternatively like drivers, users, business users or administrator. Other than standard personal data, also data about vehicle typology, mobile number, profile photo, notification settings, travel preferences (e. g. music, discussion topics, smoking, animals) can be provided. Users can also be certified by the Administrator by uploading some additional data like, for example, an identity document. It must be noticed that all drivers have to provide their driving license in order to be registered and, hence, all drivers are automatically certified users. Sensible users' data become visible only after the trip matching is done. It is also possible for the Administrator to import users' data massively by uploading some available databases;
F2) Driver Management. It deals with the uploading of a trip offer by a driver. He/She specifies trip data and conditions such as data, time windows, source and destionation. Moreover, also data about space for baggages, vehicle typology, events linked to the trip, cost reimbursement, time tolerance, smoking, music and topics preferences, pink trips, religious trips for particular communities (e. g. Muslim and Jewish communities). Different kinds of trip offers are possible:

- reserved that is the possibility to decide a priori the set of users able to visualize the offer, some intermediate points, a cost reimbursement, the refusal of trip requests by riders, etc.;
- invite that is the possibility to determine a priori a set of invited users to be directly notified, time windows, intermediate points, etc.;

- match that is a kind of unconstrained offer. LOE is able to match users and allocate them to vehicles and trips;
- event-driven that is a match trip offer linked to a specific event (about culture, music, politics, sport, etc.);
- auction that is a trip offer with intermediate points defined a priori, but without a fixed reimbursement. In particular, the latter is determined by means of an auction. The resulting crew can not be refused by the driver;

Trip offers can be modified or cancelled. The beginning of a trip can be notified by the driver through the check in functionality. At the end, also the check out can be realized. Then, travel mates can release a feedback about the trip as a whole and each crew member. Since a driver can also participate as a rider, the trip search is also possible by using different search filters. A trip can pass through four different stages that is open (unassigned crew), scheduled (assigned crew), realized (check out done) and rated (feedback released);
F3) Rider Management; riders can insert data about match, auction or event-driven trip requests. The match one is uploaded by specifying temporal and spatial constraints, user preferences, etc.. The result is provided by LOE and users can also specify how they would have reached the destination without carpooling. This way it is possible to calculate the CO_2 emission savings. The event-driven request is an unconstrained request linked to an event. Requests can be modified or cancelled. The auction request is available on the platform by selecting a suitable offer of a driver. For both auction and event-driven categories of request are available the energy saved counting and the LOE matching. Also the trip search is available by using different search filters. This way riders can apply to be admitted to a crew and the corresponding shared trip. They can also apply to be decoupled from a trip, after they have been admitted to it. Users can also check in and check out and release feedback similarly to drivers;
F4) My Trip Area; users can manage all the profile-related information by means of this area. Users can manage message services, social network relationships, statistics, requested/offered/scheduled/participated/rated trips, invitations, CO_2 saved, activity report, etc.;
F5) Event Manager; an event is a sporting competition, a cultural exhibition, a music concert, a university exam/lecture, etc.. It is possible to link trips to events, modify or cancel them;
F6) Notify Manager; a rider can send a trip request to a driver or a driver can send a trip offer to a rider. Moreover, users can accept or refuse to travel with the other members of a crew determined by the system. The system is also able to manage a reminder service and other interactions (e. g. messages) requiring notifications between users or between the user and the system. In all these cases, a notify system is available;
F7) Recommender System; social activities are tacked and stored so that the most active and reliable users can be identified and also users profiles can be analysed. Social actions are associated with corresponding weights. They can be negatives if users perform negative behaviours. Therefore, it is possible to create and visualize rankings and reward the most deserving users;
F8) Logistics Optimization System; it includes a vehicle routing module and a crew matching system that is an optimization system aimed at determining the cheapest and/or fastest route

and the most suitable crew composition for each trip. In case crews are pre-formed it is possible to optimize only the corresponding route. In case of unassigned trip requests riders are assigned to the best trip/crew according to the alignment between rider preferences and trip/crew constraints. In case of real time requests the system is able to give an immediate response to the user needs;
F9) Map Data Management; by accessing the personal account, a user can visualize all the details about the paths of their trips. In particular, an interactive map is provided handling point of interests (POI), routes, data from a Web Feature System (WFS), etc.;
F10) CO_2 Emission savings Counter; it is able to provide an estimation about the CO_2 emission savings. The system is able to provide such data split by administrative territorial unit (municipalities, provinces, regions, countries, etc.). Such data can be aggregated also by user, vehicle, event, etc.;
F11) Real Time Management System; it deals with possible news provided by users about trip requests/offers or even about modifications due to unexpected events during the ongoing trips;
F12) Vehicle Sharing; also business users can adopt such a vehicle pooling platform. This way they can offer trips to riders by providing their vehicles. Such offers can be modified or cancelled. Business users can link their offered trips to events, sponsoring them;
F13) Mobile Apps; the main functionalities of the system have to be available also on the mobile apps. They are compatible with Android and iOS devices. Apps have to provide, at least, the following functionalities: creating trip offer/request; visualizing My Trip Area; accepting/refusing trip proposal; visualizing notifications; feedback management; check in and check out; Instant Messaging System.

6.18 Focus on the Social Engine algorithmic solutions [1] [2] [3] [4] [5] [6] [7] [8] [9] [10] [11] [12] [13] [14] [15] [16] [17] [18] [19] [20]

With regard to the Rating System, users express an evaluation about a certain trip based on a single criteria approach. It requires a synthetic evaluation. Moreover, also ratings about other users in the same crew are expressed with a multi-criteria approach (considering p = punctuality, rp = respect of other participants and rv = respect of the vehicle/drive style). Users can also release some textual feedback in order to enrich the whole set of evaluation data. Ratings are given with a Likert scale from 1 (very low) to 5 (very high). The user-to-user rating is calculated as the weighted sum of the three ratings inherent to p, rp and rv as in the following:

$$R_{ji} = a * p_{ji} + b * rp_{ji} + c * rv_{ji}$$

where R_{ji} is the overall rating expressed by user j on user i. The quantities a, b and c are the weights associated with percentage values. Such weights are initialized as it follows: a = 0,4, b = 0,3 and c = 0,3. The other quantities represent the ratings provided by user j on user i about each of the three above mentioned dimensions.
In the following the final formula is shown. It is geared to quantify the overall rating for user i obtained by considering all the evaluations of the users included in the set J_i:

$$RC_i = \frac{\sum_{j \in J_i} R_{ji}}{||J_i||}$$

where RC_i is the rating of user i received from all users $j \in J_i$, which expressed a rating on user i. R_{ji} is the rating based on the evaluations of the j-th user on the i-th user. $||J_i||$ Is the number of users in the set J_i that is the number of users which expressed an evaluation on user i. Moreover, the rating approach should be integrated with a report abuse functionality.In order to calculate the Reputation of users, it is possible to adapt the original version of the Hyperlink-Induced Topic Search (HITS) algorithm. Such an adapted algorithmic variant is proposed below:

1. Let W: W_{mxn} is the vertex-hyperedge weighted incidence matrix for a weighted multi-hypergraph $\mathcal{H}$.

2. Inizialize vectors x,y, where x_i represent the 'importance' of vertex v_i (i=1,..,m), and y_j be the 'importance' of hyperdge E_j. Start with each vertex and each hyperedge having an "importance score" of 1

   for (i from 1 to m) $x_i = 1;$
   for (j from 1 to n) $y_j = 1;$

3. Run the algorithm k times (c = 1,…,k) in order to calculate x,y vectors.

   for (c from 1 to k)

   Update x, y at each run of algorithm. In order to calculate the importance of each vertex and each hyperedge, we use *mutually reinforcing relationship* assumption. The importance of x_i at the step c, depends from the importance of x_i at the previous step (c-1) and from the weighted relationship between vertex i and all hypergedges j.

   for (i from 1 to m)

   $$x_i = x_i + \sum_{j=1}^{n} w_{ij}\, y_j \qquad // w_{ij} \in W$$

   In the same way, the importance of y_j at the step c, depends from the importance of y_j at the previous step (c-1) and from the weighted relationship between hypergedge j and all hypergedges j vertexes i.

   for (j from 1 to n)

   $$y_j = y_j + \sum_{i=1}^{m} w_{ij}\, x_i \qquad // w_{ij} \in W$$

   3.1 "Sum normalization". Normalize the values by dividing each vertex importance score by the sum of all vertexes importance score, and by dividing each hyperedge importance score by the sum of all hyperedges importance score.

$$Sx = \sum_{i=1}^{m} x_i ; \qquad Sy = \sum_{j=1}^{n} y_j ;$$

for (i from 1 to m) $x_i = \frac{x_i}{Sx};$ // for each vertex

for (j from 1 to n) $y_j = \frac{y_j}{Sy};$ // for each hyperedge

The Social Engine adopts a collaborative memory-based Recommender System consisting of algorithms based on the use of historical evaluation provided by users in order to generate future evaluations. Among such solutions, user-to-user and item-to-item algorithms are available. The first category is based on the utility of the i-th item for a user calculated as the aggregation of the utility expressed by other users similar to him/her. The second one is based on the utility of the i-th item for a user intended as the aggregation of the utility expressed by him/her about items similar to item i.
In the following the Item Recommendation (e. g. GraphChi's CLiMF Collaborative Filtering) and Item Similarity algorithms and formulas are detailed.
The Item Recommendation solution requires the calculation of the Reciprocal Rank (RR) as it follows:

$$RR_i = \sum_{j=1}^{N} \frac{Y_{ij}}{R_{ij}} * \prod_{k=1}^{N} (1 - Y_{ik} * I(R_{ik} < R_{ij}))$$

where:

- N is the number of items;
- Y_{ij} is the binary relevance score of the item j for user i (1 if it is relevant, 0 otherwise);
- Y_{ik} is the binary relevance score of the item k for user i (1 if it is relevant, 0 otherwise);
- I(x) is a function equal to 1 if the condition x is verified, 0 otherwise;
- R_{ij} is the rank of item j in the list ordered for user i;
- R_{ik} is the rank of item k in the list ordered for user i.

By approximating the I(x) function as it follows:

$$I (R_{ik} < R_{ij}) \approx g (f_{ik} - f_{ij})$$

where:

- $g(x) = 1/(1 + e^x)$; f_{ij} is the predictive function mapping the relevance score of parameters related to user i and item j.

Such a function is defined as factor model and it is expressed as it follows:

$$f_{ij} = <U_i, V_j>$$

where:

- U_i is an array of d-dimensional latent factors for user i;
- V_j is an array of d-dimensional latent factors for item j.

A further approximation is the following:

$$1/R_{ij} \approx g\,(f_{ij})$$

based on the assumption that the lower is the item rank, the higher is the predicted relevance score.
Thus, the final smoothed formula is:

$$RR_i \approx \sum_{j=1}^{N} Y_{ij} * g(f_{ij}) * \prod_{k=1}^{N} (1 - Y_{ik} * g(f_{ik} - f_{ij}))$$

Since its gradient's computational complexity achieves $O(N^2)$ and computational costs have a quadratic growth depending on the number of items, it is necessary to define a lower bound by assuming to have n^+_i items for user i. The parameters maximizing the functions are the following:

$$U_i, V = arg \max_{U_i, V} \left\{ \ln \sum_{j=1}^{N} \frac{Y_{ij}}{n_i^+} * g(f_{ij}) * \prod_{k=1}^{N} (1 - Y_{ik} * g(f_{ik} - f_{ij})) \right\}$$

The lower bound results:

$$\frac{1}{n_i^+} \sum_{j=1}^{N} Y_{ij} * (ln\, g(f_{ij}) + \sum_{j=1}^{N} \left(1 - Y_{ik} * g(f_{ik} - f_{ij})\right))$$

By ignoring the constant $\frac{1}{n_i^+}$:

$$\mathrm{L}(\mathrm{U}_i, \mathrm{V}) = \sum_{j=1}^{N} Y_{ij} * (ln\, g(f_{ij}) + \sum_{j=1}^{N} \left(1 - Y_{ik} * g(f_{ik} - f_{ij})\right))$$

By analysing the above expression, we can notice how it is balanced, since the maximization consists of the recommendation of relevant items by means of the learning of latent factors, according to the first addend, and by means of the learning of the latent factors of all other items, according to the second addend. Ultimately, the algorithm generates recommendations

when some relevant items for a user are in the top positions of the list. By adding a complexity control with the regularization coefficient λ, the objective function is:

$$F(U,V) = \sum_{i=1}^{M}\sum_{j=1}^{N} Y_{ij} * (ln\, g(U_i^T V_j) + \sum_{k=1}^{N} ln\left(1 - Y_{ik} * g\left(U_i^T V_k - U_i^T V_j\right)\right)) - \frac{\lambda}{2} * (\left||U|\right|^2 + \left||V|\right|^2)$$

In this final version ||U|| and ||V|| are the Frobenius norms of U and V, respectively, while M is the number of users in the data collection. It is possible to use gradient-based methods in order to determine the values of the model parameters U and V. For example, with the Stochastic Gradient Ascend Method we can obtain the following algorithmic solution reported in pseudo-code:

Input. Let Y the set of *binary relevance scores*, λ the regularization coefficient, γ the learning rate, *itermax* the maximum number of iterations.
Output. The learned latent factors U and V.
For i = 1,…, M: % Index on relevant items for user i; $N_i = \{j \mid Y_{ij} > 0, 1 \leq j \leq N\}$;
End.
Intialize $U^{(0)}$ and $V^{(0)}$ with random values, t = 0;
Repeat:
For i = 1,…, M: % Update U_i; $U_i^{(t+1)} = U_i^{(t)} + \gamma * \frac{\partial F}{\partial U_i^{(t)}}$

For j ∈ N_i: % Update V_j; $V_j^{(t+1)} = V_j^{(t)} + \gamma * \frac{\partial F}{\partial V_j^{(t)}}$

End.

End.
t = t + 1;
Until t ≥ itermax: $U = U^{(t)}$; $V = V^{(t)}$.

The Item Similarity algorithms are based on the pursuit of a solution to the following problem:

given a user-item matrix R and a basket U, identify an ordered set of items X such that
$X \leq N$ e $X \cap U = \varnothing$.

R is a binary matrix (user-item matrix) of dimensions n x m with $R_{ij} = 1$ if user i is associated with trip j, $R_{ij} = 0$ otherwise.
In the following a pseudo-code version of the adopted algorithm is reported:

For j → 1 to m:
For i 1 → to m:
If i ≠ j:
Then $M_{i,j} \rightarrow$ sim ($R_{*,j}$, $R_{i,*}$)

Else $M_{i,j} \rightarrow 0$

For i 1 → to m:

If $M_{i,j} \neq$ among the k bigger values in $M_{*,j}$

Then $M_{i,j} \rightarrow 0$

Return (M)

The algorithm receives in input the n x m user-item matrix R and the parameter k determining the number of item-to-item similarities to be stored for each item. The output contains in the j-th column the top k items similar to item j, with M_{ij} representing the similarity degree among items i and j. The way similarity is calculated is crucial for the algorithmic output and the model features. One point is to determine whether items similarity is symmetric or not that is whether sim(i,j)=sim(j,i) or sim(i,j)≠sim(j,i), respectively. The Cosine-Based Similarity deals with considering each item as an array in the space of users. Thus, item similarity is expressed as the cosine between the two arrays associated with such items:

$$sim(i,j) = \cos\left(\overrightarrow{R*,i}, \overrightarrow{RJ,*}\right) = \frac{\overrightarrow{R*,J} \cdot \overrightarrow{RI,*}}{||\overrightarrow{R*,i}||_2 \, ||\overrightarrow{RJ,*}||_2}$$

where the symbol . represents the vector dot-product. Such a similarity measure is symmetric. Nonetheless, it is possible to change this property by normalizing rows. Moreover, it is possible to subtract from each couple of items the user average as it follows:

$$sim(i,j) = \frac{\sum_{u \in U}(R_{u,i} - \overline{R_u}) * (R_{u,j} - \overline{R_u})}{\sqrt{\sum_{u \in U}(R_{u,i} - \overline{R_u})^2} * \sqrt{\sum_{u \in U}(R_{u,j} - \overline{R_u})^2}}$$

where $\overline{R_u}$ is the average of the u-th user's ratings. It is called Adjusted Cosine Similarity. Another similarity measure is the Conditional Probability-Based Similarity. It is an asymmetric measure based on the probability P(j|i) that a trip j is associated with a user, subject to the condition that another trip i is already associated with the same user. In mathematical terms, it is the ratio between the total number of users associated with both trips i and j that is Freq(ij) on the total number of users associated only with trip I that is Freq(i):

$$P(j|i) = \frac{Freq(ij)}{Freq(i)}$$

It is possible to notice that P(j|i)≠P(i|j). Moreover, it is possible to perform some normalization operations. For example, it is possible to divide P(j|i) by a quantity determined depending on the occurrence of item j. There are two possible alternative measures. The inverse-document frequency multiplies P(j|i) by $-\log_2(P(j))$. The secondo ne uses the ratio between P(j|i) and P(j). This way similarity returns to be considered symmetric, again. To overcome this problem, it is possible to move a step forward that is:

$$sim(i,j) = \frac{Freq(ij)}{Freq(i) * (Freq(j))^a}$$

with a between 0 and 1. If a = 0 we go back to the original formula, if a = 1 we obtain the previous normalization process described above. In order to provide a higher weight to users with a lower number of trips it is possible to normalize each row and, afterwards, to calculate similarity as it follows:

$$sim(i,j) = \frac{\sum_{\forall\, q \in R_{q,j}>0} R_{q,j}}{Freq(i) * (Freq(j))^a}$$

The change done in the numerator aims at counting and summing only not null elements of the matrix in j-th column. Moreover, it is necessary to show another similarity measure in order to understand which items should be included in the top-N recommendations for the active user. In this context, the Pearson Correlation-Based Similarity plays a key role. It is based on the determination of the Pearson-r Correlation $corr_{i,j}$. In order to ensure an accurate calculation of the similarity, co-rated cases must be separate since they represent both a rating on item i and a rating on item j. Such users form the set U. The final formula of similarity is:

$$sim(i,j) = \frac{\sum_{u \in U}(R_{u,i} - \overline{R_\iota}) * (R_{u,j} - \overline{R_J})}{\sqrt{\sum_{u \in U}(R_{u,i} - \overline{R_\iota})^2} * \sqrt{\sum_{u \in U}(R_{u,j} - \overline{R_J})^2}}$$

$R_{x,y}$ is the rating of user x on item y. $\overline{R_\iota}$ represents the average value of rating of the i-th item. In Figure 65 an example of the isolation of co-rated items is shown.

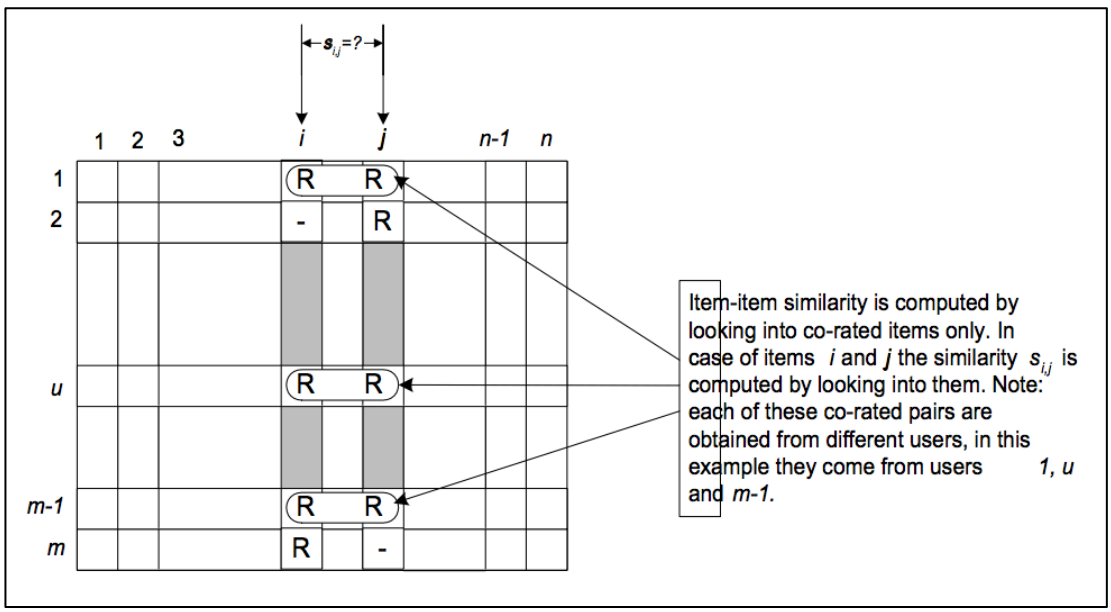

FIGURE 65: EXAMPLE OF ISOLATION OF CO-RATED ITEMS

After the calculation of the similarity rate, it is possible tomove a step forward by using the Weighted Sum methodology. In this case, the methodology allows to predict an item I for a user u that is $P_{u,i}$. Ratings of u about items similar to i are considered. Each item is weighted for the corresponding similarity $s_{i,j}$ between items i and j:

$$Pu,i = \frac{\sum_{all\ similar\ tems,N}(S_{i,N} * R_{u,N})}{\sum_{all\ similar\ items,N}(|S_{i,N}|)}$$

where N is the similar item. The alternative approach is based on the Regression that is an approximated calculation of ratings, instead of the direct one on similar items. In this case, $R_{u,N}$ is substituted by $R'_{u,N}$ that is the approximated value of the rating expressed by user u on item N, instead of the real one, $R_{u,N}$. It is obtained thanks to a linear regression model:

$$\overline{R'_N} = a * \bar{R}_\iota + b + c$$

where a and bare specific parameters of the regression model determined depending on the two arrays associated with the aforementioned items. The addend c is aimed at representing the error.

6.19 Focus on the Logistics Optimization Engine algorithmic solutions **[1]**

The Vehicle Pooling Problem of the platform has to be effective and efficient about computational complexity and costs. To this purpose the typo of problem chosen for this case is based no longer on the transportation flow of each vehicle on a specific edge of the road graph, but on the selected route for each vehicle. The approach is based on feasible routes generation and selection. They should be able to satisfy the maximum number of requests under operating constraints. Such an approach is composed of the following steps:

- individuation of requests from users and localization on the road graph;
- feasible routes generation subject to: vehicle capacity, maximum gap compared to the ideal path, compatibility among driver's and rider's time windows, compatibility among smoking and non-smoking users, trips only with friends, minimum values of ratings associated with crew members , possible pink trips;
- instantiation of the model with a subset of feasible routes;
- model resolution;
- validation of the solution and possible new resolution with a different subset of feasible routes.

Routes are generated as it follows:

- for each vehicle k, individuate the optimal path from source to destination

    - generate the route corresponding to the optimal banal path for vehicle k

- individuate c_k intended to be the residual capacity in terms of number of seats and d_k intended to be the residual capacity of the luggage compartment of vehicle k
- individuate the subset of trip requests, J_k, compatible with the driver k according to the following criteria: compatibility of time windows, compatibility among smoking and non-smoking users, trips only with friends, minimum values of ratings associated with crew members , possible pink trips

- for each request j in J_k, individuate the source and destination nodes of j and calculate the new optimal path
- if the new path does not exceed the maximum gap compared to the ideal path: generate a new route, update the subset of trip requests, J_k, and iterate until the saturation of the capacity c_k.

The optimization model is formulated as it follows:

- sets:

- K = set of vehicles
- R = set of routes
- I = set of drivers
- J = set of riders

- parameters:

- a_{rk} = 1 if the route r is associated with the vehicle k, 0 otherwise
- b_{jr} = 1 if the route serves user j, 0 otherwise.

- variables:

- x_r = binary variable related to the selection of the ruote r $\in$ R (univocally associated with a vehicle k)

- constraints:

- uniqueness of the route for a vehicle: $\sum_{r \in R} a_{rk} x_r = 1, \quad \forall k \in K$ **(1)**
- uniqueness of the service: $\sum_{r \in R} b_{jr} x_r \leq 1, \quad \forall j \in J$ **(2)**

- objective function:

- minimizing travel time and/or cost and maximizing users satisfaction:

$$\max_x f(x)$$

where:

$$f(x) = \alpha_1 f_1(x) + \alpha_2 f_2(x) + \alpha_3 f_3(x) + \cdots + \alpha_n f_n(x) + \alpha_p \left(- \sum_{j \in J} \left(1 - \sum_{r \in R} b_{jr} x_r \right) \right)$$

It is a convex combination of some functions. In the following each function is defined:

- total cost:

$$f_1(x) = - \sum_r cost_r \, x_r$$

where:

$cost_r$ is the cost of route r in terms of kilometres travelled multiplied by the average consumption of vehicle k associated with route r;

- total time:

$$f_2(x) = - \sum_r t_r \, x_r$$

where:

t_r is the travel time of route r;

- total kilometric gap:

$$f_3(x) = - \sum_r scost\_km_r \, x_r$$

where:

$scost\_km_r$ is the kilometric gap associated with route r;

- total time gap:

$$f_4(x) = -\sum_r scost\_t_r \, x_r$$

where:

$scost\_t_r$ is the time gap associated with route r:

- maximum degree of overall occupancy:

$$f_5(x) = \sum_r \frac{n\_pass_r}{cap\_res_r} x_r$$

where:

n_pass_r is the number of overall served passengers (riders and drivers) associated with route r;
cap_res_r is the capacity in terms of number of seats available in the vehicle associated with route r;

- maximum degree of overall social rating

$$f_6(x) = \sum_r rep_r \, x_r$$

where:

rep_r is the rating generated from Reputation Management activities of all passengers (riders and drivers) associated with route r;

- maximum degree of overall friendship

$$f_7(x) = \sum_r \frac{\sum_{j \in J} fr_{jr} * b_{jr} + fr_k}{n\_pass_r} x_r$$

where:

fr_{jr} is the number of the j-th rider's friends in the crew of route r;
fr_k is the number of driver's friends of vehicle k in the crew of route r;

Weights $\alpha_1, \alpha_2, \ldots, \alpha_n$ are specific for each objective and such that they ensure that $f(x)$ is a convex combination. The last term in the fucntion penalizes the existence of unsatisfied requests and is weighted by α_p.

Such a model can be solved by using the following approach:

- sets:

  - V = set of drivers' requests. $\rho(v_k)$ identifies the route associated with vehicle v_k;
  - R = set of riders' requests. Each request r_k is defined as a couple (p_k, d_k), which are the pick up and drop off points, respectively.

- algorithm:

$\forall r_k \in R$

a) $\bar{V}(r_k) = \emptyset$ (set of constraints already analyzed)

b) $\forall v_i \in V: v_i \notin \bar{V}$

I) If r_k can be assigned to vehicle v_i

1) M = set of possible combinations of insertion of r_k to the route of v_i

a. If M is empty, $\bar{V}(r_k) = \bar{V}(r_k) \cup v_i$

b. Otherwise select the best combination of insertion and apllyt it to the route of v_i

II) Otherwise $\bar{V}(r_k) = \bar{V}(r_k) \cup v_i$

6.20 Focus on the Support Subsystem algorithmic solutions **[1]**

One of the main features of SS component is the estimated calculation of the CO_2 emission savings. In order to do such an estimation, we start from kilometres travelled for each trip and consider the following indicators:

- actual kilometres for each trip;
- number of passengers;
- typology of vehicle used intended as vehicle segment;
- typology fuel used;
- transportation mode/means used.

We define:

- CV_i = consumption of the vehicle typology I (average value) [km/l], where I = 1, …, 6 represents the vehicle segment;
- P = distance travelled in the trip k [km];

- C_j = quantity of CO_2 emissions for each fuel typology j [gCO_2/l], where j = 1, 2, 3, 4 represents gasoline, diesel, hybrid natural gas/gasoline and hybrid LPG/gasoline, respectively;
- F_h = average emission factorvarying based on the different mode/means of transportation h declared by the rider;
- N_p = number of passengers including the driver.

Overall CO_2 emissions for each route travelled and each mode/means of transportation are:

$$E_h = P * F_h\,, \qquad \forall\ mode/means\ of\ transportation\ h$$

In the case the rider declares to travel by car – i. e. a very realistic scenario –, the formula is:

$$E_{car} = P * F_{car} = P * \left[\frac{c_j}{CV_i}\right],$$

If the vehicle has more than one user declaring to have the same travel habits that is a default car, we obtain:

$$E_i = Somm\,(P * F_i) = Somm\left(\left[\frac{c_j}{CV_i}\right]\right), \qquad for\ each\ passenger\ i$$

In particular:

$$E_{car} = P * F_{car} = P * \left[\frac{c_j}{CV_i}\right] * (N_p - 1),$$

If $N_p = 1$, we have a factor equal to 0 since the only traveller is the driver and, hence, there are no emission savings in the associated route. This way it is possible to calculate the overall amount of emission savings for each user. The general formula is:

$$R = \sum_{h=1}^{n} E_h = \mathrm{E}_1 + \cdots + E_h + \cdots + E_n$$

where:

- E_h = saving for each segment of the route. The number of passengers is not constant for the whole route, then it is necessary to calculate savings for each segment:

$$E_h = P * \sum_{j=1}^{k} F_j$$

with P = length [km] of the segment and F_j = potential consumption of each passenger calculated as it follows:

$$F_j = P * E_{v,a}$$

with F_j = quantity of emissions of CO_2 for each typology of fuel j [gCO_2/l], while $E_{v,a}$ = emissions for the couple *(v,a)*, where v represents the segment of vehicle and a the fuel typology.

In this way it is possible to calculate the total amount of savings related to a specific segment of a route or even to an administrative territorial unit (e. g. municipality, province, region, country, etc.).

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SECTION IV

CHAPTER 7

CREATIVITY-BASED INNOVATION STRATEGIES IN THE DANISH HIGHER EDUCATION: ANALYSIS OF THE NEW PRODUCT DEVELOPMENT PROCESS IN THE SUMMER SCHOOL "INNOVATION INSPIRED BY NATURE"[cd]

The obligation of strict confidentiality about some information and data related to this chapter is a precondition for the data collection and interpretation process. Therefore, such information and data have been treated confidentially in this chapter and must not be made publicly available or passed to a third party.

7.1 Introduction

This chapter deals with the description and interpretation of data collected by observing groups of students aimed at developing new products during the summer school "Innovation Inspired by Nature" in Copenhagen. This work is realized in collaboration with the "Design and Innovation Group" (D&I) of the "Technology and Innovation Management Division" (TIM) at the "Department of Management Engineering" of the Technical University of Denmark (DTU) and, in particular, with Professor Jason Li-Ying and Professor Balder Onarheim. It was also possible thanks to Julie Ugleholdt Pedersen, researcher at the Copenhagen Institute of NeuroCreativity (CINC) and author of the original framework adapted to this specific context.

7.2 Objectives

The main goal of this chapter is that of organizing and elaborating observed data in order to identify interaction patterns among Creativity, Knowledge and Innovation at the group level. This is a key point in order to analyze CKI relationships in new product development processes based on creativity-based innovation strategies.

7.3 Content and learning outcome of the IIN summer school

In the following information about content and learning outcome of the summer school are reported [1]:

<<Throughout history, nature has continuously inspired humans to create better and new solutions to our problems. Among other things, it has inspired hunting strategies, modern technology, design solutions, business models, and even structures in social organization and communications. In the knowledge-driven societies of today and considering the big global challenges we face, innovation based on biology is becoming even more important in our transition towards a sustainable bio-based society. Innovation requires wedding

[c] "Innovation Inspired by Nature" is a three weeks intensive summer school organized by the Copenhagen University and the Technical University of Denmark. Many Danish companies are involved in orser to provide students with realistic case studies. Aslo students from other Danish universities and abroad attend it every year. On of the main sources for this chapter is represented by such a summer school. For more info: http://kurser.ku.dk/course/lfkk10412u/2013-2014 - http://kurser.ku.dk/course/lfkk10412u/2013-2014.

[d] One of the main sources of this chapter is represented by Julie Ugleholdt Pedersen's work "*Creativity in Innovation Processes. A Study of the Influence of Creativity in the Context of "Innovation Inspired by Nature"*", 2013, Copenhagen Business School.

multidisciplinary skills and competencies to imagination and thus demands that people from a variety of disciplines are brought together. This course will focus on innovative solutions inspired by nature in a multidisciplinary context. It will do so by bringing together both students and teachers from various disciplines, with different interests, and from a number of educational backgrounds (natural resources, biology, biotechnology, engineering, humanities, management, design and so on).
Students will work together over three weeks to develop innovative solutions to real problems provided by companies, non-profits, or governmental organizations. Selected partners from the service industry, private or public companies will challenge a group of students to create new solutions inspired by nature to a specific problem, process or design. Each group will meet the commissioned holder of their specific assignment a few times during the course. Facilitators will accompany the meetings and classes in general. […] The course will enable students to manage innovation processes based on inspiration gained from the plethora of highly evolved biological functions, systems and processes found in nature. They will gain a basic set of theories and tools in innovation and design. They will be able to create, select and transform ideas into e.g. a prototype, new process, design or method based on a specific assignment and they will be trained in multidisciplinary work. This will be complemented with knowledge on commercialization and implementation strategies for the problem providers from private, non-profit, or governmental organizations.
After completing the course the student is expected to be able to:
Knowledge

- Understand biology as a source for innovation
- Obtain an overview of concept and theory of innovation managements, innovation process models, exploitation and exploration, and creation
- Understand how to manage a collaboration process in a multidisciplinary setting

Skills

- Read and interpret specific articles and textbook chapters
- Describe and categorize biological solutions according to a specific assignment/topic
- Distribute tasks and responsibilities in a multidisciplinary environment
- Communicate ideas clearly, concisely and confidently in writing and orally to stakeholders

Competences

- Find and explain the evolved solution of specific issues
- Transfer biological knowledge into innovative solutions
- Ability to discuss, evaluate and decide among creative solutions
- Explain innovation models and use novel tools for innovative creation
- Ability to make use of own and other persons competences in multidisciplinary work>>.

7.4 Course teaching and learning methods

In the following information about organization and methodologies are provided [1]:
<<The course will draw on the expertise from teachers affiliated to both contributing Universities and/or faculties for lectures, exercises, expert panel and as facilitators. […] The teaching and learning methods will include: Lectures, e.g. on biological organisms and

systems - keystone to inspiration, bionics methodologies and innovation process. Exercise and practical assignments, e.g. on team work and communication. The major part of the learning will take place during group work where the students will have to develop an innovative model and learn how to work in a multi-disciplinary setting and how to unite the competences and backgrounds present in the whole group. Each student will be assigned to a group beforehand by the teachers taking into account their interests and background. Each group will have representatives from various Universities and disciplines and each group will get a facilitator. In addition it will be possible for the groups to book consultant hours from a panel of teachers with different expertise. Furthermore, students will give and receive feedback on their project work and will practice communicating their ideas through intermediary pitch talks and final presentations on the development of their venture idea. Preparation consists of reading of literature handed out before course starts (mandatory task)>>.

In Figure 66 a synthetic description of data about the course workload is provided [1]:

Category	**Hours**
Lectures	20
Guidance	20
Project work	120
Practical exercises	16
Exam	4
Preparation	26
Total	**206**

FIGURE 66: THE COURSE WORKLOAD [1]

Final exams are structured as it follows [1]:

<<a 5 page group report of the concept design; a 3-5 page individual report with reflection on group dynamics, the innovation process and communication>>.

7.5 Design of the data collection process

In order to collect data effectively and efficiently by observing different groups of students during the summer school, some frameworks for data collection have been realized before the beginning of the course. In Figures 67, 68, 69, 70 and 71 the ad hoc Observation Guides about Creativity, Knowledge and Innovation are provided. However, these frameworks have been realized depending on the factors selection process performed on the basis of the possible CKI interaction patterns involved in the group dynamics (Figures 72, 73, 74 and 75). Since the factors selection process identified some unobservable factors, a complementary survey was realized: groups were asked to anonymously provide further information about such unobservable data (Figures 76.A and 76.B). All data were collected under a specific agreement (Figure 77) and are shown in this work in a way that does not infringe it. Nine

groups (4 to 5 students each) were formed in order to solve a set of four case studies. The latter consisted of case studies realized in collaboration with industrial partners such as Kongskilde Industries A/S, Cumulus A/S, EWH Bioproduction ApS and I/S Vestforbrænding. The first partner identifies as the most relevant challenge the new tine and spring section designs. The second one is focused on setting up weather stations and their measuring equipment in a way that it is possible for the users to replace autonomously defect components also by simplifying establishment in field so that it is possible to pack and ship them. The third one is mainly centred on the production of Megoura Viciæ (hereinafter "Megoura") as a food source for Aphidoletes aphidimyza (hereinafter "aphids"): the problems are reducing the number of lost aphides during the harvest and the corresponding physical effort currently required. The last one is focused on reducing or eliminating maggots in the organic household waste put in the outdoor container. Due to the operating difficulties to observe all nine groups, the empirical context allowed to collect data only from two groups to be chosen among the pre-formed ones. The two groups to be selected have to be related to the same case study so that they ensure the possibility to realize comparative studies and to consider the CKI interaction patterns within the same context. According to this criteria, homogeneity is fully ensured. Among the four case studies, the first one was selected in order to observe the two groups geared to solve it. In fact, the other cases did not provide a broad perspective suitable to apply the theoretical model proposed in Chapters 1 and 2, and to analyze CKI interaction patterns and their outcomes according to the four perspectives of such a model. Moreover, creativity was strongly constrained by the guides associated with the company case studies, thus inhibiting the observation of an unconstrained new product development process and undermining the reliability and validity of research results.

In addition to information and data collected from the observations on field and transcribed on the Observation Guides in real time, also some pictures have been taken. In particular, 192 pictures about K4 group (i. e. the group with 4 students) and 162 pictures about K5 group (i. e. the group with 5 students) have been taken. Also 5 videos have been realized.

Moreover, all the documents provided by organizers, teachers, facilitators, companies and students have been elaborated for the data elaboration.

Since groups are set homogeneously thanks to the preliminary analysis of backgrounds, motivations, inclination to some disciplines, etc., they still ensure a strong focus on innovation, biology and the related interdisciplinary fields. This way group members ensure a shared working language and a mix of interlinked backgrounds and interests.

Ultimately, the same case study, context, curriculum, process, available resources, acquired knowledge, methods and approaches, etc. will characterize the two groups.

- DATE - TIME – BREAKS - NAME OF THE EXERCISE - DETAILS: lecturers, facilitators, guests

CREATIVITY

INPUT	What is the starting point / current status?	
INTENTION	What they want to do?	
EXERCISES / ACTIVITIES	Kind of exercise (brainstorm, evaluation, prototype, discussion&other)	
	It consists of	
	Introduced by who? (If applicable)	
	What is the group doing?	
	Facilitation (who is facilitating?)	Materials (post-it, cards, etc.)

FIGURE 67: CREATIVITY OBSERVATION GUIDE – PART 1

OUTPUT (Quality)	Kind of output generated (ideas, problem, criteria, other)	
	Themes considered	
	Theoretical/Operating output	
	Consequences: what do they agree to do next time? (If applicable)	
OUTPUT (Quantity)	Number of ideas, problem, criteria, other	
	Number of themes considered	

FIGURE 68: CREATIVITY OBSERVATION GUIDE – PART 2

KNOWLEDGE

EXERCISES / ACTIVITIES	Exceptions in terms of different knowledge backgrounds/perspectives available in the group (compared to the routine)	
	Type of different knowledge domains clearly used	
	Number of different knowledge domains clearly used	
	Transactive Memory System: members' ability of matching individual knowledge with knowledge holders (collective awareness of "knowledge map" among group members)	
	Acquisition of new knowledge from specialized members by means of knowledge sharing	
	Acquisition of new knowledge from other sources	Lack of knowledge (If applicable)

FIGURE 69: KNOWLEDGE OBSERVATION GUIDE – PART 1

OUTPUT (Quality)	Kind of output generated (new knowledge elaborated, knowledge sharing, conflict of different knowledge, other)
	Themes considered
	Theoretical/Operating output
OUTPUT (Quantity)	Number of themes considered
	Number of knowledge needs
	Number of new knowledge pieces elaborated/knowledge pieces shared/other

FIGURE 70: KNOWLEDGE OBSERVATION GUIDE – PART 2

INNOVATION

EXERCISES / ACTIVITIES	SEARCH To what extent are they exploring or searching for problems or ideas to work further with in the process?
	SELECT To what extent are they selecting either problems or ideas to continue with in the process?
	TEST & VALIDATE To what extent are they evaluating, testing or validating ideas or problems in the group or by externals?
	DEVELOP To what extent are they developing ideas by sketching or physical prototypes? What are they using for prototyping?

FIGURE 71: INNOVATION OBSERVATION GUIDE

FACTORS	SURVEY (LIKERT SCALE 1-5)	Not observable	Observable (Creativity guide)	Observable (Knowledge Guide)	Observable (Innovation Guide)	Where I can observe it? (If applicable)
Trust	There is a great level of integrity in my team	x				
	I trust people I work with in my team	x				
	There is a good team spirit in my team	x				
	There is a friendly atmosphere in my team	x				
	I am confident about sharing my ideas, knowledge, etc. with my team	x				
Network Ties/Tie Strength/Density of Relationships	I have good social relationships with some team members	x				
	I have also personal relationships with some team members	x				
	I have some close friends	x				
	I spend a lot of time communicating/interacting with them		x	x	x	What they do
Transactive Memory System	Some team members provides specialized knowledge to the group			x		Knowledge Input
	Each team member brings a different background/expertise/perspective			x		Knowledge Input
	Several different specialized knowledge were needed in order to achieve project goals			x		Knowledge Input
	I accepted suggestions from other team members			x		Transactive Memory System and knowledge bodies used
	I trusted knowledge of other team members			x		Transactive Memory System and knowledge bodies used
	The team was able to retrieve effciently the most useful knowledge of some members, when it was needed			x		Transactive Memory System and knowledge bodies used
	Team activities were well-coordinated	x				
	Team activities were well-integrated	x				
Individual Commitment	I am involved/attracted to group-task	x				
	Group tasks are very similar/close to each other			x		Knowledge bodies used
	I feel accepted and interact socially within the team	x				
	There are very close social relationships within the group	x				
Group Cohesiveness	The team has a strong inclination to stick together	x				
	Team members communicate/interact frequently		x	x	x	What they do
	We act as if our actions were connected to each other	x				
	We show a significant willingness to work together	x				
Collective Mind/Creative Synthesis	The team has a global picture about the overall integrated effect of members' decisions and the relationships among them	x				
	Team members attempt carefully to interrelate their actions to each other	x				
	Team decision-making aims at maximizing the overall team performance	x				
	Team members gained an understanding of how to coordinate overall team activities	x				
Idea Sharing	Members share their ideas with the team		x			# Ideas
	I am confident about sharing my ideas with the team	x				
Idea Generation	A lot of ideas generated		x			# Ideas
Divergent Input/Backgrounds/Perspectives (Team Composition)	Each member brings a background which is different from any other member's background in your team			x		Knowledge Input
Divergent Thinking - Idea Centrality (mutuated from SNs)	Ideas generated can be regarded as divergent		x			Centrality and Ideas/Themes Ratio
	Ideas generated are not linked to each other		x			Centrality and Ideas/Themes Ratio
	There are several divergent ideas generated that can be regarded as relevant		x			Centrality and Ideas/Themes Ratio
Knowledge Sharing	I share my work documents with the team			x		Acquisition of knowledge
	I share my own techniques, methodologies and models with the team			x		Acquisition of knowledge
	I share my expertise, experience and know-how with the team			x		TMS and Acquisition of knowledge
	I share my know-where and know-whom with the team			x		TMS and Acquisition of knowledge
Knowledge Generation	A lot of new knowledge pieces elaborated			x		
Innovation stage identification	Many ideas/concepts were "found" in the search stage				x	Innovatio Stage
	Many ideas/concepts were selected afterwards				x	Innovatio Stage
	Many selected ideas/concepts were tested/validated/evaluated				x	Innovatio Stage
	Many ideas/concepts were developed				x	Innovatio Stage
Team Performance	Members' deliverables are high-quality	-	-	-	-	FINAL GRADE (from external data)
	Team goals have been achieved		x	x	x	Input vs Output
	Team process was successful		x	x	x	Input vs Output
	Members are able to manage time efficiently	x				
	Members are able to meet deadlines			x		Number of knowledge pieces elaborated
	Team work can be regarded as effective		x	x	x	Input vs Output
Place/Environment	The place in which team members meet enhances creative inspiration	x				
	Rooms and devices made available by the organizers foster idea generation, knowledge sharing, innovative activities		x			Materials

FIGURE 72: FACTORS SELECTION PROCESS – STEP 1

FACTORS	DETAILED NOTES	SURVEY (LIKERT SCALE 1-5)	Not observable	Observable (Creativity guide)	Observable (Knowledge Guide)	Observable (Innovation Guide)	Where I can observe it? (If applicable)
Trust		There is a great level of integrity in my team	x				
		I trust people I work with in my team	x				
		There is a good team spirit in my team	x				
		There is a friendly atmosphere in my team	x				
		I am confident about sharing my ideas, knowledge, etc. with my team	x				
Network Ties/Tie Strength/Density of Relationships	Time spent together, emotional intensity, intimacy between members, reciprocal services	I have good social relationships with some team members	x				
		I have also personal relationships with some team members	x				
		I have some close friends	x				
Transactive Memory System		Team activities were well-coordinated	x				
		Team activities were well-integrated	x				
Individual Commitment	4 dimensions (individual attraction, group integration-task, individual attraction to group-social, group integration-social)	I am involved/attracted to group-task	x				
		I feel accepted and interact socially within the team	x				
		There are very close social relationships within the group	x				
Group Cohesiveness		The team has a strong inclination to stick together	x				
		We act as if our actions were connected to each other	x				
		We show a significant willingness to work together	x				
Collective Mind/Creative Synthesis	Attraction to group-task, better coordination and integration of members' perspectives/activities	The team has a global picture about the overall integrated effect of members' decisions and the relationships among them	x				
		Team members attempt carefully to interrelate their actions to each other	x				
		Team decision-making aims at maximizing the overall team performance	x				
		Team members gained an understanding of how to coordinate overall team activities	x				
Idea Sharing		I am confident about sharing my ideas with the team	x				
Team Performance		Members are able to manage time efficiently	x				
Place/Environment	Supporting and motivating setting	The place in which team members meet enhances creative inspiration	x				

FIGURE 73: FACTORS SELECTION PROCESS – STEP 2

FACTORS	DETAILED NOTES	SURVEY (LIKERT SCALE 1-5)	Not observable	Observable (Creativity guide)	Observable (Knowledge Guide)	Observable (Innovation Guide)	Where I can observe it? (If applicable)
Trust		There is a great level of integrity in my team	x				
		I trust people I work with in my team	x				
		There is a good team spirit in my team	x				
		There is a friendly atmosphere in my team	x				
		I am confident about sharing my ideas, knowledge, etc. with my team	x				
Network Ties/Tie	Time spent together, emotional intensity,	I have good social relationships with some team members	x				
Transactive Memory System		Our activities were well-coordinated	x				
		Our activities were well-integrated	x				
Individual Commitment	4 dimensions (individual attraction, group integration-task, individual attraction to group-social, group integration-social)	I am involved/attracted to group-task	x				
		I feel accepted and interact socially within the team	x				
		There are very close social relationships within the group	x				
Group Cohesiveness		The team has a strong inclination to stick together	x				
		We act as if our actions were connected to each other	x				
		We show a significant willingness to work together	x				
Collective Mind/Creative Synthesis	Attraction to group-task, better coordination and integration of members'	We attempt carefully to interrelate our actions to each other	x				
		We gained an understanding of how to coordinate overall team activities	x				
Team Performance		We are able to manage time efficiently	x				

FIGURE 74: FACTORS SELECTION PROCESS – STEP 3

FACTORS	DETAILED NOTES	SURVEY (LIKERT SCALE 1-5)
ABOUT ME		
Network Ties/Tie	Time spent together, emotional intensity,	I have good social relationships with some team members
Trust		I trust people I work with in my team
		I am confident about sharing my ideas, knowledge, etc. with my team
Individual Commitment	4 dimensions (individual attraction, group integration-task, individual attraction to group-social, group integration-social)	I am involved/attracted to group-task
Individual Commitment	4 dimensions (individual attraction, group integration-task, individual attraction to group-social, group integration-social)	I feel accepted and interact socially within the team
ABOUT MY TEAM		
Trust		There is a great level of integrity in my team
		There is a good team spirit in my team
		There is a friendly atmosphere in my team
Individual Commitment	4 dimensions (individual attraction, group integration-task, individual attraction to group-social, group integration-social)	There are very close social relationships within the group
Group Cohesiveness		The team has a strong inclination to stick together
		We act as if our actions were connected to each other
		We show a significant willingness to work together
Collective Mind/Creative Synthesis	Attraction to group-task, better coordination and integration of members'	We attempt carefully to interrelate our actions to each other
		We gained an understanding of how to coordinate overall team activities
ABOUT STRUCTURE		
Transactive Memory System		Our activities were well-coordinated
		Our activities were well-integrated
Team Performance		We are able to manage time efficiently

FIGURE 75: FACTORS SELECTION PROCESS – STEP 4

SURVEY

Dear participant, in the following you can find an anonymous survey focusing on some aspects of the the teamworking process. Collected data will be used only for research purposes and will remain anonymous.
Please, indicate to what extent you agree/disagree with each statement by selecting a value from 1 to 5 in the "Likert Scale" column: **1 = I strongly disagree; 2 = I disagree; 3 = I neither agree nor disagree; 4 = I agree; 5 = I strongly agree.**
Please, make sure that you have filled in each statement row. Thank you.

STATEMENTS	LIKERT SCALE (1 to 5)
ABOUT ME	
I have good social relationships with some team members	1 2 3 4 5
I trust people I work with in my team	1 2 3 4 5
I am confident about sharing my ideas, knowledge, etc. with my team	1 2 3 4 5
I am involved/attracted to group-task	1 2 3 4 5
I feel accepted and interact socially within the team	1 2 3 4 5
ABOUT MY TEAM	
There is a great level of integrity in my team	1 2 3 4 5
There is a good team spirit in my team	1 2 3 4 5
There is a friendly atmosphere in my team	1 2 3 4 5
There are very close social relationships within the group	1 2 3 4 5
The team has a strong inclination to stick together	1 2 3 4 5
We act as if our actions were connected to each other	1 2 3 4 5
We show a significant willingness to work together	1 2 3 4 5
We attempt carefully to interrelate our actions to each other	1 2 3 4 5
We gained an understanding of how to coordinate overall team activities	1 2 3 4 5
ABOUT THE STRUCTURE	
Our activities were well-coordinated	1 2 3 4 5
Our activities were well-integrated	1 2 3 4 5
We are able to manage time efficiently	1 2 3 4 5

FIGURE 76.A: THE SURVEY STRUCTURE

STATEMENTS	LIKERT SCALE (1 TO 5)																	
(Group K4 = group of 4 students; Group K5 = group of 5 students)	Group K4 - WEEK 1				Group K4 - WEEK 2				Group K5 - WEEK 1					Group K5 - WEEK 2				
ABOUT ME																		
I have good social relationships with some team members	4	5	5	4	4	5	4	5	5	5	5	5	5	4	5	4	4	5
I trust people I work with in my team	4	5	4	4	4	4	4	5	5	5	5	5	5	4	4	3	3	4
I am confident about sharing my ideas, knowledge, etc. with my team	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	4	5	5
I am involved/attracted to group-task	5	5	4	3	3	5	4	5	5	4	3	4	5	3	2	4	4	4
I feel accepted and interact socially within the team	5	5	5	4	4	5	4	5	5	5	5	5	5	4	5	4	5	4
ABOUT MY TEAM																		
There is a great level of integrity in my team	4	5	4	4	4	4	3	5	4	4	5	4	4	4	4	3	3	4
There is a good team spirit in my team	4	5	4	4	4	4	4	5	5	4	5	4	4	4	4	4	4	4
There is a friendly atmosphere in my team	5	5	5	3	5	5	4	5	5	4	5	5	4	4	5	4	5	4
There are very close social relationships within the group	3	5	3	2	4	4	2	4	4	5	3	4	4	3	2	3	3	3
The team has a strong inclination to stick together	3	5	3	4	4	3	3	4	4	5	2	4	3	3	3	3	3	3
We act as if our actions were connected to each other	1	5	4	4	3	3	1	3	3	4	4	4	4	3	2	3	5	4
We show a significant willingness to work together	4	5	4	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4
We attempt carefully to interrelate our actions to each other	3	5	4	4	4	4	4	4	4	4	3	3	4	4	3	3	3	3
We gained an understanding of how to coordinate overall team activities	4	5	5	4	4	5	4	4	4	5	4	5	5	4	4	3	4	2
ABOUT THE STRUCTURE																		
Our activities were well-coordinated	4	5	5	3	4	3	4	4	4	4	5	4	4	4	4	3	2	4
Our activities were well-integrated	4	5	4	4	4	3	4	3	4	4	4	4	4	4	4	3	3	3
We are able to manage time efficiently	4	5	5	4	4	4	4	4	5	3	5	5	5	4	2	4	1	3

Δ (WEEK 2 - WEEK 1)				TOT.
0	0	-1	1	0
0	-1	0	1	0
-1	0	0	0	-1
-2	0	0	2	0
-1	0	-1	1	-1
		-		
0	-1	-1	1	-1
0	-1	0	1	0
0	0	-1	2	1
1	-1	-1	2	1
1	-2	0	0	-1
2	-2	-3	-1	-4
0	-1	0	0	-1
1	-1	0	0	0
0	0	-1	0	-1
		-		
0	-2	-1	1	-2
0	-2	0	-1	-3
0	-1	-1	0	-2

Δ (WEEK 2 - WEEK 1)					TOT.
-1	0	-1	-1	0	-3
-1	-1	-2	-2	-1	-7
0	0	-1	0	0	-1
-2	-2	1	0	-1	-4
-1	0	-1	0	-1	-3
		-			
0	0	-2	-1	0	-3
-1	0	-1	0	0	-2
-1	1	-1	0	0	-1
-1	-3	0	-1	-1	-6
-1	-2	1	-1	0	-3
0	-2	-1	1	0	-2
0	0	0	0	1	1
0	-1	0	0	-1	-2
0	-1	-1	-1	-3	-6
		-			
0	0	-2	-2	0	-4
0	0	-1	-1	-1	-3
-1	-1	-1	-4	-2	-9

FIGURE 76.B: THE SURVEY DATA

CONTRACT FOR DATA COLLECTION

On behalf of the group of scholars aimed at collecting data only for research purposes, the undersigned, [redacted] hereby declares that all the data and information gathered about the activities of the summer school "Innovation inspired by nature 2014" will remain strictly anonymous. The research group will access only the data and information about the background of participants and will neither collect nor use personal data and information.

The undersigned participants hereby agrees to the above data collection activities upon condition that personal data and information remain anonymous and are neither collected nor disclosed.

PARTICIPANTS	FIRST NAME	LAST NAME
1		
2		
3		
4		
5		

[redacted]

[redacted]

Participants' signatures

……

……

……

……

……

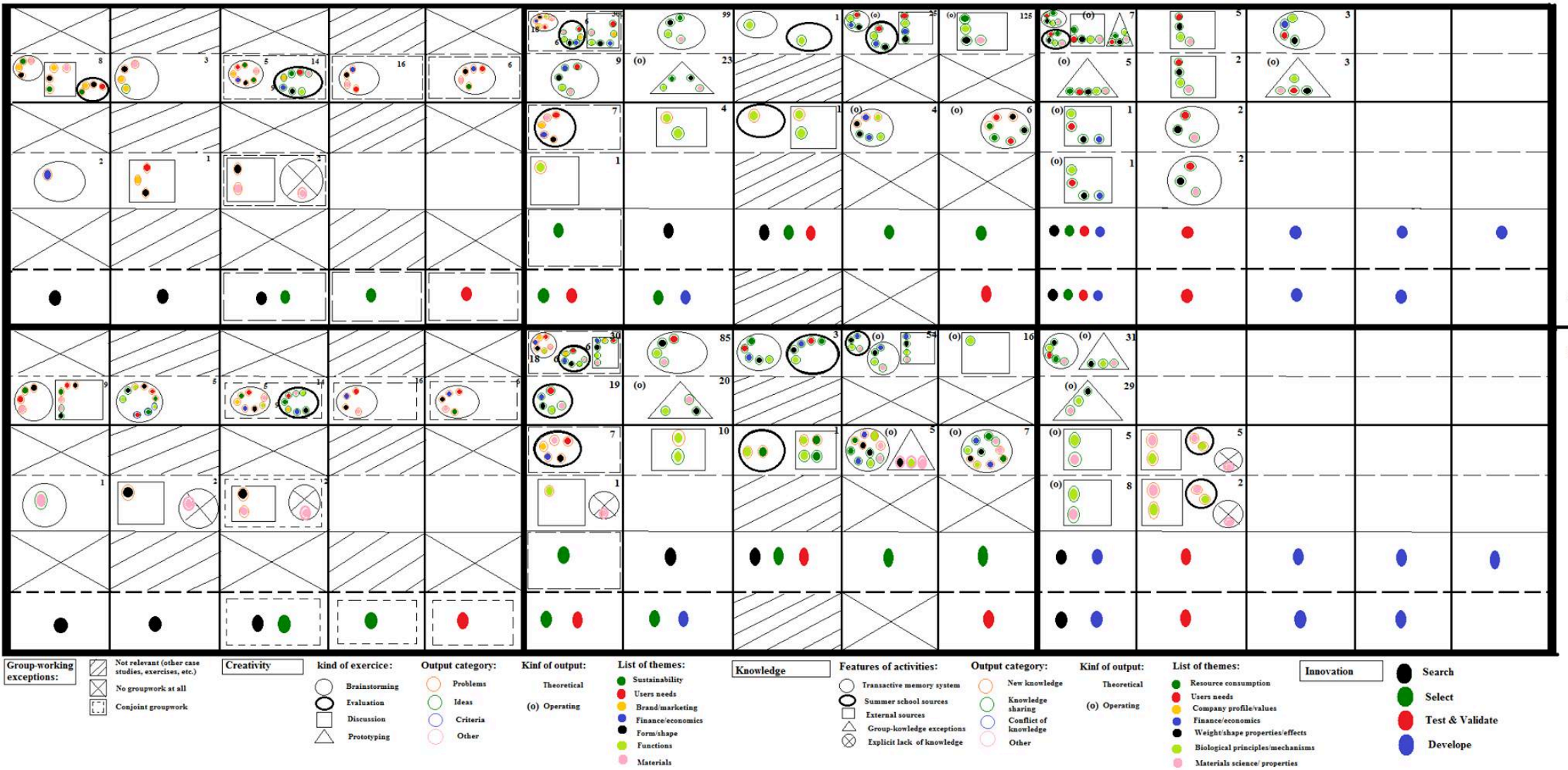
……

FIGURE 77: THE CONTRACT FOR DATA COLLECTION

7.6 Methodology

Participant Observation is a methodology proposed first in [3] [4] [5] [6] and it was geared to some studies conducted in the same field of the case study that is the tillage one. In particular, an observation methodology has been adopted, which is specifically aimed at analyzing social complex problems. It is the Engaged Scholarship proposed in [7] [8] and requires that scholars have to participate and be strictly involved in the research context in order to really understand it [9]. In this research context, a mixed, deductive and inductive, approach is adopted. The research starts from theories detailed in literature in order to focus on specific elements of the process and it is combined with an empirical set of data to be elaborated and abstracted into theoretical contributions [10].

The framework adopted in order to organize and elaborate data from observations (Figures 78, 79, 80.A and 80.B) has been adapted from [2]. It is composed of a sub-framework devoted to represent data for each group – i. e. K4 group and K5 group. For each group and each day there are six blocks identifying possible Creativity, Knowledge and Innovation sessions, both in the morning and in the afternoon. The total amount of blocks is equal to 180.


K4
K5
Group-working exceptions:
Not relevant (other case studies, exercises, etc.)
No groupwork at all
Conjoint groupwork
Creativity
kind of exercice:
Brainstorming
Evaluation
Discussion
Prototyping
Output category:
Problems
Ideas
Criteria
Other
Kinf of output:
Theoretical
(o) Operating
List of themes:
Sustainability
Users needs
Brand/marketing
Finance/economics
Form/shape
Functions
Materials
Knowledge
Features of activities:
Transactive memory system
Summer school sources
External sources
Group-kowledge exceptions
Explicit lack of knowledge
Output category:
New knowledge
Knowledge sharing
Conflict of knowledge
Other
Kinf of output:
Theoretical
(o) Operating
List of themes:
Resource consumption
Users needs
Company profile/values
Finance/economics
Weight/shape properties/effects
Biological principles/mechanisms
Materials science/ properties
Innovation
Search
Select
Test & Validate
Develope

Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7 Day 8 Day 9 Day 10 Day 11 Day 12 Day 13 Day 14 Day 15

CREATIVITY

Morning

30 99 1 25 125 7 5 3

Afternoon

8 3 14 16 6 9 23 5 2 3

KNOWLEDGE

Morning

7 4 1 4 6 1 2

Afternoon

2 1 2 2 1 2

INNOVATION

Morning

Afternoon

Day 1 Day 2 Day 3 Day 4 Day 5 Day 6 Day 7 Day 8 Day 9 Day 10 Day 11 Day 12 Day 13 Day 14 Day 15

CREATIVITY INDUCATORS

Themes

- Sustainability
- User needs
- Brand / Marketing
- Finance / Economics
- Form / Shape
- Functions
- Materials

Themes category

- Problems
- Ideas
- Criteria
- Other

Activities

- Brainstorm
- Discussion
- Evaluation
- Prototyping

KNOWLEDGE INDUCATORS

Themes

- Resource Consumption
- User needs
- Company profile / values
- Finance / Economics
- Weight / Shape - Properties / effects
- Biological principles / Mechanisms
- Materials

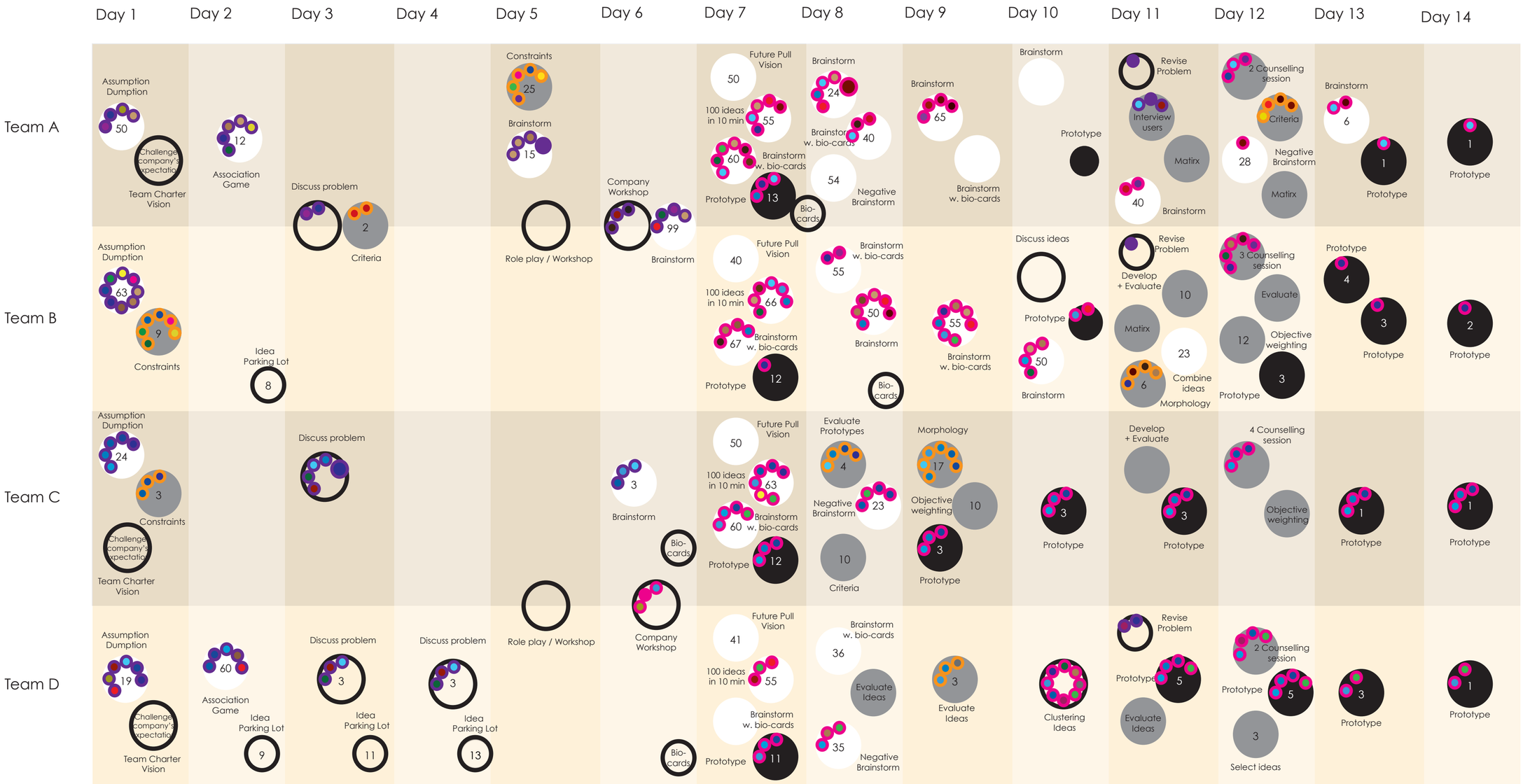
Activities

- Use of members knowledge / Transactive memory system
- Exceptions in the group knowledge compared to the routine
- Acqusition from external sources - External to summer school
- Acqusition from external sources - Internal to summer school
- Explicit lack of knowledge

INNOVATION INDUCATORS

- Search
- Select
- Test & Validate
- Develop

CREATIVE ACTIVITIES & EXERCISES



Exercises & Activities

Brainstorm
Evaluation
Discussion & other
Prototyping

Themes catagory

Problems
Ideas
Criteria

List of themes

Team C + Team D

Product
- Lifetime
- Function
- Materials
- Surface/friction
- Form
- Heating/cooling
- Wearing

Users / Usage
- Users
- Changing

Company
- Brand
- Compny solving own problem
- Lack of innovation

Sales
- Sales
- Marketing

Sustainability
- Soil
- Recycle/waste

Fun
- Fun

Additional function
- Additional function

Team A + Team B

Physical Function
- Roof
- Location
- Meeting room
- Walls
- Boundaries
- Furniture
- Flexible

Emotional Function
- Art/cool
- Comfort
- Social
- Connectivity
- Home
- Ownership
- Play
- Unique
- identity

Climate
- Temperature
- Light
- Noise
- Sound
- smell
- Isolation

Brand
- Company's expectations
- Values
- Partners

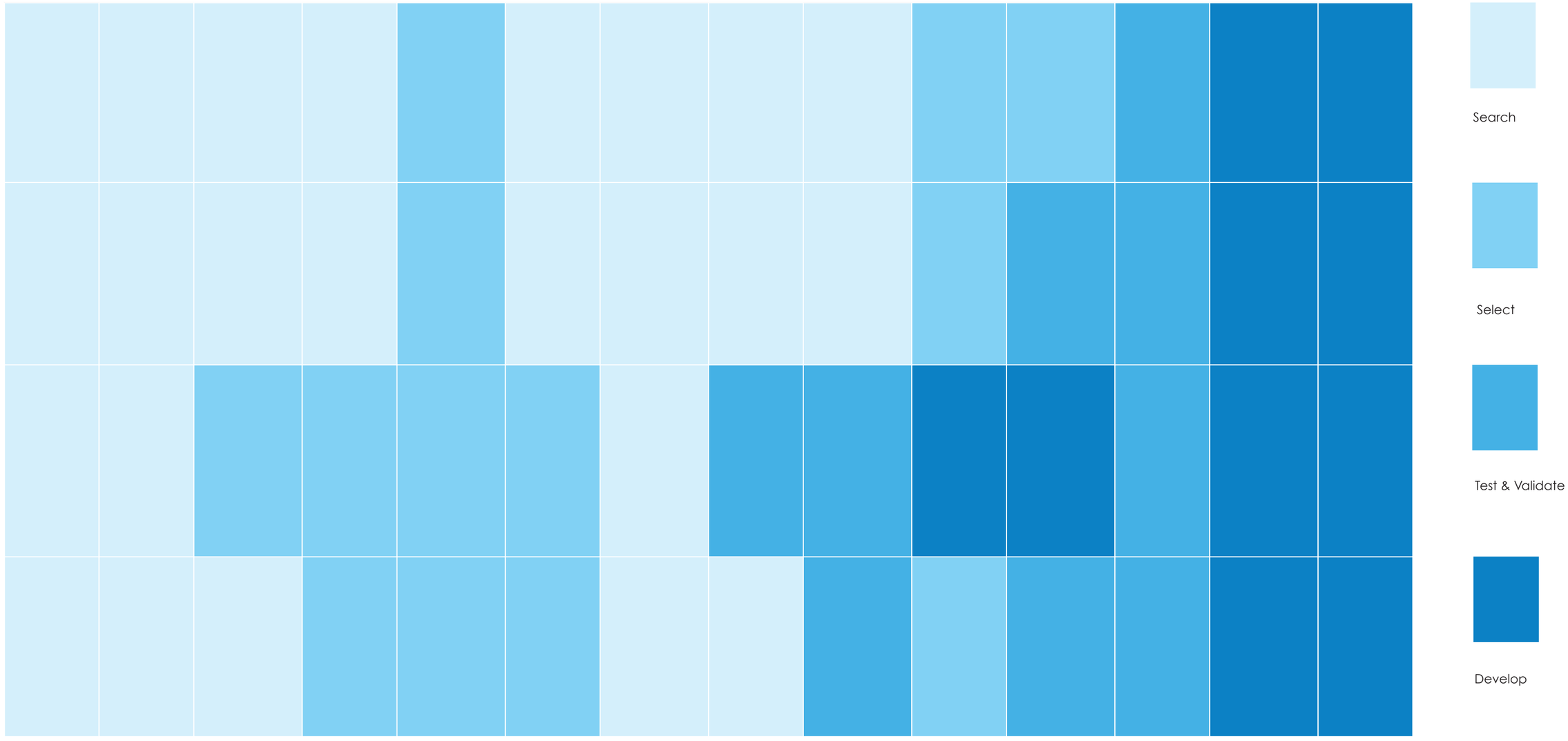
Users / Usage
- Users
- Usage

Budget
- Budget

Sustainability
- Sustainability
- Nature

No Problem
- No Problem

INNOVATION TRACKS



FIGURES 78, 79, 80.A AND 80.B: THE TWO VERSIONS OF THE ADAPTED FRAMEWORK AND THE TWO ORIGINAL SKELETONS, RESPECTIVELY [2]

For Creativity and Knowledge sessions, each figure in the blocks represents a different kind of Creativity or Knowledge activity. Internal coloured balls in the figures identify different themes/topics discussed in the group, while their external coloured circles identify the themes category of such themes/topics. For Innovation sessions, coloured balls in the blocks identify the Innovation stage. Numbers in each figure in the blocks identify how many Creative or Knowledge outputs have been generated in the specific activity, while the top-right corner of the blocks contains the total amount of Creative or Knowledge outputs generated in the overall session. Finally, the (O) symbol indicates that the output is operating, otherwise it is theoretical.
In the following the group deliverables structure for each week is reported [1]:

<<Deliverable for week 1:
Problem understanding, contextual analysis and workshop design
Deliverable
For the partner team presentation in plenum on Friday this week the teams will be presenting their understanding of the company case challenge, a contextual analysis and a workshop design. The two teams with the same case will partner up and do the presentation together. The teams are to consider which areas in particular they need to receive feedback on from the other teams, facilitators and teachers.
The presentation of this week's deliverable serves as a preparation for the workshop with the company on Monday morning.
The deliverables for this week are the following:

1. Problem understanding revised

The team presents their problem by:

- Specific problem formulation, which might still be the original problem formulation, is provided by the company or an altered version of this.
- General problem statement which is formulated as a question (or several sub questions) and will be used for the search of solutions in nature. [b]
- The evaluation criteria for the solution to the problem

2. Context map

Visually describing the context of the case. The groups have been handed a template for a context map, which they are to fill out illustrating their research and assumptions about the context related to their case.

3. Workshop design

[b] For inspiration on how to do this see page 4 in the chapter "3.2 Problem definition phase" in Lenau, T et al.: "Engineering Design of an Adaptive Leg Prosthesis Using Biological Principles", from *International Design Conference 2012*.

The team presents a playbook describing a workshop which the two teams facilitate with the company about the two areas mentioned above. The workshop should entail activities with the company where questions revolving the two areas are answered.

Deliverable for week 2:
Innovation themes and prototypes
Deliverable
For the team presentation in plenum on Friday this week the teams will be presenting a revised company case challenge and contextual analysis in addition to the innovation themes and a range of prototypes. The presentation will be for other three teams (NOT working on your case), facilitators and teachers.
This week's deliverable serves as a foundation for a discussion about the potential of the ideas which have been developed so far in addition to the research conducted by the team. The deliverables for this week are the following:

1. Problem understanding revised

The team presents their problem by:

- The specific problem definition (which might still be the original problem definition provided by the company) or an altered version of this.
- A general problem statement, which is expressed as a question (or several sub questions) and will be used for the search of solutions in nature.[c]
- The evaluation criteria for the solution to the problem

2. Context map revised

Visually describing the context of the case. The team presents the updated context map based on the research of the last two weeks.

3. Bio-cards

An overview of the bio-cards showing the biological principles and mechanisms, which have inspired the development of ideas.

4. Innovation themes

All the ideas – at least 100 - developed by the team clustered into relevant innovation themes.

5. Prototypes and of selected ideas

The 3 most promising ideas illustrated via prototypes for each idea.

Deliverable for week 3:
Final Concept and prototype
Deliverable

[c] For inspiration on how to do this see page 4 in the chapter "3.2 Problem definition phase" in Lenau, T et al.: "Engineering Design of an Adaptive Leg Prosthesis Using Biological Principles", from *International Design Conference 2012*.

For the team presentation in plenum on Friday this week the teams will be presenting the final concept and prototype in addition to the revised company case challenge and contextual analysis. The presentation will be for the company representative, teachers, facilitators, all the teams and others who might be interested.
The deliverables for this week are the following:

1. Problem understanding revised

The team presents their problem by:

- Specific problem formulation, which might still be the original problem formulation is provided by the company or an altered version of this.
- General problem statement which is formulated as a question (or several sub questions) and will be used for the search of solutions in nature. [d]
- The evaluation criteria for the solution to the problem

2. Context map revised

Visually describing the context of the case. The team presents the updated context map based on the last three week's research.

3. Final concept

The team presents a description of the final concept.

4. Prototype

The team presents a prototype, which illustrates the functionalities and value creation of the final concept.>>

In the following the individual logbook template for each week is reported [1]:

<<Log book template for week 1
The log book is your own personal document, which you can use to keep journal of the thoughts you have during the summer school. The log book template helps you address subjects that are relevant to reflect upon in relation to the individual report that you are to hand in after the course. The individual report should consist of 3-5 pages. Subjects that you can reflect on in regards to the activities of week 1 are described below.

1. Interdisciplinarity

What are your reflections on the collaborative process in your team and your own role in the team so far?

[d] For inspiration on how to do this see page 4 in the chapter "3.2 Problem definition phase" in Lenau, T et al.: "Engineering Design of an Adaptive Leg Prosthesis Using Biological Principles", from *International Design Conference 2012*.

2. Biomimicry
What are your thoughts on bio-inspired design and implementation of biological knowledge in regards to your case challenge?
3. Innovation
What are your reflections on the process you have been through so far and the tools and methods you have applied?

Log book template for week 2
The log book is your own personal document, which you can use to keep journal of the thoughts you have during the summer school. The log book template helps you address subjects that are relevant to reflect upon in relation to the individual report that you are to hand in after the course. The individual report should consist of 3-5 pages. Subjects that you can reflect on in regards to the activities of week 2 are described below.

1. Interdisciplinarity
What are your reflections on the collaborative process in your team and your own role in the team so far?
2. Biomimicry
What are your thoughts on bio-inspired design and implementation of biological knowledge in regards to your case challenge?
3. Innovation
What are your reflections on the process you have been through so far and the tools and methods you have applied?

Log book template for week 3
The log book is your own personal document, which you can use to keep journal of the thoughts you have during the summer school. The log book template helps you address subjects that are relevant to reflect upon in relation to the individual report that you are to hand in after the course. The individual report should consist of 3-5 pages . Subjects that you can reflect on in regards to the activities of week 3 are described below.

1. Interdisciplinarity
What are your reflections on the collaborative process in your team and your own role in the team so far?
2. Biomimicry
What are your thoughts on bio-inspired design and implementation of biological knowledge in regards to your case challenge?
3. Innovation
What are your reflections on the process you have been through so far and the tools and methods you have applied?>>

In the following the report requirements are reported [1]:

<<Group report (5 pages)

Within the group report the following elements should be included and detailed based on your team's case:

1) Introduction of the case
2) Process

    a. Creative processes
    b. Bio-inspired design processes

3) Concept/prototype

Individual report (2-5 pages)
Within the individual report you are expected to:

1) Explain on your role within the team and your contribution to the interdisciplinary nature of team in relation to your own academic background;
2) Reflect on your own personal and academic development over the course of the three weeks, as well as your own personal evaluation of what your newly gained knowledge and experience can be used for in the future.>>

In the following the workshop design requirements are specified [1]:

<<Workshop design
The task
The task is to develop a workshop for relevant stakeholders from your case company, and you are to plan and facilitate the workshop together with your partner case team. The workshop design is part of the deliverable to be presented this Friday.
Purpose of the workshop
The purpose of the workshop is to investigate your problem understanding and contextual analysis (the context map) in a workshop with you case company. In the workshop each partner case team might have different problem understandings/project scopes that they wish to examine, but you are to share the research related to the context map.
Format and requirements
The workshop shall entail an engaging dialogue with stakeholders at the company about the problem understanding and the team's context map. It is up to the teams to determine how to make the workshop as engaging and interesting as possible. Keep in mind that in a workshop the participants are to be active and deliver input in a very collaborative setting – as opposed to e.g. a normal meeting.
It is required that you describe your workshop by the following:

- Concept and name for your workshop
- Purpose and expected output of your workshop
- Participants from the company
- A playbook showing a timeline of activities that you have planned for the workshop

- Roles: description of who's responsible for facilitation and documentation (photos and notes)>>

In the following the context map structure [1] is represented (Figure 81.A):

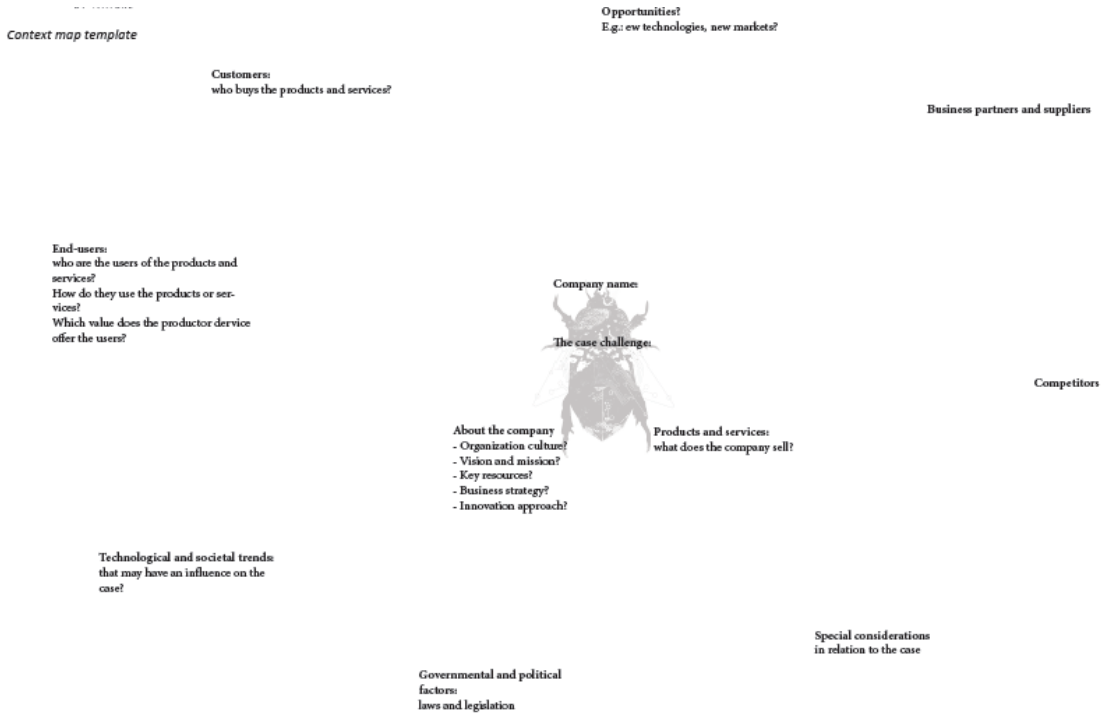


FIGURE 81.A: THE CONTEXT MAP [1]

Finally, the Double Diamond process [1] is reported (Figure 81.B):

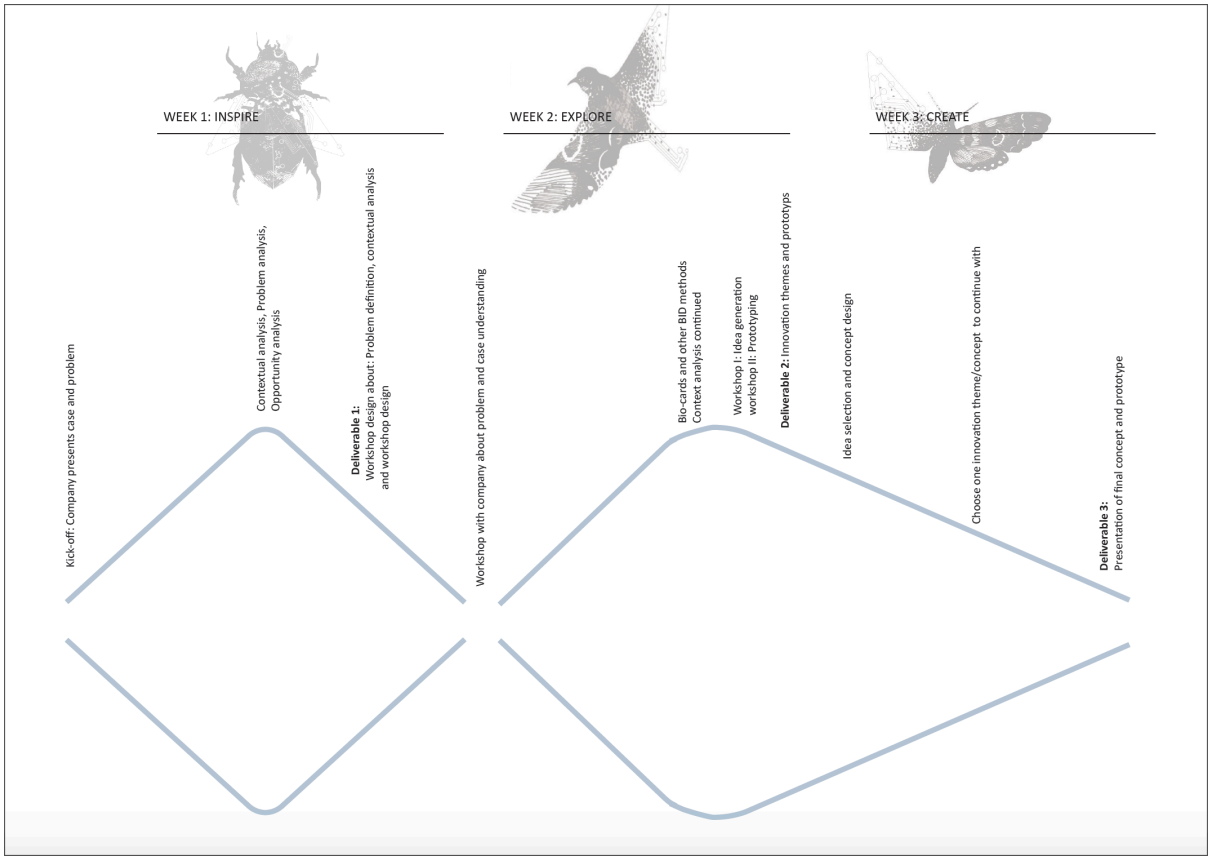


FIGURE 81.B: THE DOUBLE DIAMOND PROCESS [1]

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SECTION V

CHAPTER 8

CONCLUSIONS

8.1 Theoretical conclusions [1] [2] [3] [4]

This thesis is an attempt to move forward the current state of the art as far as mutual relationship among creativity, knowledge and innovation are concerned. Existing literature investigating such interactions remains focused on a one-to-one base of analysis, whilst a more comprehensive cause-effect framework focusing on CKI dynamics and leading up to the outcome of the innovation process is missing. In order to help filling this gap, Section I is organized as follows. Initially, a synthetic review of existing literature is proposed in order to pick out fundamental concepts. As a second step we propose a framework - the CKI Triangle - which proves useful for widening the analysis to some fundamental paths across the three variables. At this stage, in particular, the work focuses on those two approaches – creativity-based (CKI) and knowledge-based (KCI) – which allow analyzing the dynamics that can be established between creativity vs. knowledge resource policies and innovation goals. Subsequently, based on the CKI triangle, a new model - the CKI triangle model – is introduced whose aim is to provide a more advanced framework where the analysis of CKI interactions is extended to their circular nature and their multiple outcomes are inquired and defined. The model is also endowed with a set of indicators available in literature which may help assessing such an outcome in terms of incremental value to stakeholders. This set of indicators is helpful in justifying the CKI triangle model as well. The proposed indicators may be used to investigate tangible and intangible impacts of innovation plans and operating actions implemented by governments and organizations at any level from four complementary perspectives: macroeconomic, institutional, socio-cultural and corporate. The complementarity of this set of indicators is likely to prove very helpful in supporting decision making and control tasks within operating contexts. For example, managers pursuing corporate success can get useful information from the remaining perspectives, whereas governments can develop more effective, strategic guidelines and recommendations based not only on the current and/or prospective institutional, macroeconomic and socio-cultural conditions, but also on the auxiliary information pertaining the corporate perspective. Furthermore, since these indicators can measure performance of implemented actions as well as forecast outcomes of tentative programs, they can be used in order to help better analyze relationships within a specific CKI interaction system, set up innovation plans geared to achieve an incremental value to stakeholders, implement successful actions in order to favour a more sustainable growth of countries and a higher competitiveness and survival rate of organizations in the long term, control the accurate realization of those actions and, in case, make proper changes, evaluate ex post the achievements of a CKI interaction system in terms of incremental value to stakeholders.

Despite its plainness the CKI triangle model – especially if compared to existing tools - provides a more powerful operating guidance for all those individuals and/or organizations concerned with planning, monitoring and evaluating innovation processes with a special focus on incremental value provided to stakeholders. On the whole, since a well-implemented CKI interaction system may lead to higher outcomes for both business organization and

society stakeholders, in our opinion this work also provides some strategic tools geared to governments and business managers. In fact, it advances some key element to be considered in order to contributing to a sane and sustainable economic growth and to an increase of competitiveness and survival rate respectively. Finally, this work also allows academicians and researchers to conduct more comprehensive surveys aimed to further deepen CKI relationships and their impacts on incremental value. As a consequence, the entire Innovation Management disciplinary profile should be integrated by means of the adoption of a more extensive approach, including all the CKI perspectives.

8.2 Case study comparison and deriving empirical conclusions

In this paragraph we refer to the case study in Chapters 2, 3 and 4 as "Automotive", to the case study in Chapters 5 and 6 as "Vehicle Pooling" and to the case study in Chapter 7 as "Educational".

Such case studies are analyzed in the following based on the creativity-based vs. knowledge-based resource policies as they were discussed in Chapter 1 by a theoretical point of view. Afterwards, based on the three empirical innovation contexts, also the four perspectives of analysis of the CKI model are taken into account in order to deal with the outcomes in terms of Incremental Value to Stakeholders.

In Figure 82.A a mapping of the creativity-based and knowledge-based issues and features affecting each case study is proposed. The degree of correspondence between the theoretical issues and features and the innovation contexts is represented by "H" ("High"), "M" ("Medium") and "L" ("Low"). The evaluations are provided based on the adoption of a panel of experts for each case study, since the contexts considered require specific levels of expertise and seniority in each field and also a high level of participation in the related processes in order to capture some features, activities and stages unobservable from outside.

RESOURCE POLICY	ISSUES AND FEATURES	CASE STUDY		
		AUTOMOTIVE	VEHICLE POOLING	EDUCATIONAL
CREATIVITY-BASED	Unpredictability of objectives in advance	L	L	H
	Possible new business lines	L	M	M
	Radical innovation	L	M	H
	Divergence from innovation purposes	L	L	H
	High uncertainty and failure risk	L	M	H
KNOWLEDGE-BASED	Incremental innovation	H	M	L
	Initial anchorage and psychological	H	M	L

	inertia			
	Low uncertainty and failure risk	H	M	L

FIGURE 82.A: MAPPING CASE STUDIES DEPENDING ON CREATIVITY-BASED AND KNOWLEDGE-BASED POLICIES

In the following the results from Figure 82.A are up for discussion. In particular, we can notice that the Automotive case is clearly centered on knowledge-based innovation strategies that is the main object of the project is explicitly finalized in advance. As a matter of fact, managers, project designers, researchers, developers and practitioners working on it already know the specific organizational context, have very strong and differentiated backgrounds about all the knowledge-domains involved and matured a relevant seniority related to the realization of such initiatives. The Automotive case is very similar to the Amazon Web Services one, since people working on it are only trying to combine what they already studied in previous professional experiences in a creative way in order to develop a model of advanced Enterprise 2.0 platform, which is well-defined a priori. This way the whole members of the partnership know what hey will carry out of the project. In fact, final results are perfectly compliant with what they expected to obtain. This means also that it is not very likely the generation of new business opportunities and business lines, especially if they are far from the current core business of the company. This finding is extremely coherent with the Automotive scenario: the main outcome in this case is that of setting a new organizational paradigm and introducing social and semantic techniques so that internal processes can benefit from the application of Web 2.0-based technologies in the corporate context. The explicit aim of the project is that of determining an increase in the overall productivity and efficiency of the production line by means of social and semantic methods and technologies. This tends to exclude the possibility of generating radical innovations and facilitates incremental ones. Also the low inclination to diverge from the pre-defined goals of the project is a key feature of such a project, since it is strongly based on a well-consolidated set of knowledge bodies and expertise in the related fields. This point recalls the concept of anchorage to the corporate knowledge, which has an overall positive effect in this specific case. Since the magnitude of changes brought is not significantly big, it is difficult to create new business opportunities, the innovation process does not tend to diverge and its end result is predictable at some extent, the level of uncertainty and failure risk is quite low. On the contrary, the Educational case is strongly centered on creativity-based innovation strategies that is the innovation process in the summer school is highly dependent on creative inspirations coming from natural and biological mechanisms by means of bio-cards, bio-inspired design and bio-mimicry [4]. In this context we can notice that a consolidated domain-specific knowledge is missing, since students involved in the innovation-oriented groups ignore almost all the basic concepts related to bio-cards, bio-inspired design, bio-mimicry, etc.. In particular, it can be noticed how students are led to use creative sources, since they can not rely upon consolidated knowledge resources. In this context, creativity plays a key role in the first stage of the innovation process and tends to provoke a high level of divergence associated with a missing definition of the expected results in the beginning. As a matter of fact, the Double Diamond model [4] describes the innovation process designed

for the summer school and exploited by students: they showed the ability to go through a double "converge-diverge" step. Being associated with unpredictability of objectives and divergence from innovation goals, uncertainty and risk are clearly higher than in the Automotive case study. In fact, the observations highlighted how a positive end result and the capability to meet the intermediate and final deadlines were not taken for granted during the whole innovation processes of both the chosen groups of students. However, the high level of creativity showed how radical innovations are generally fostered in this context. In fact, the group K4's solution was based on a kind of "click thing" able to ensure rigidity of the spring section and flexibility of the tine as a whole, based on the re-design of product with a linear shape linked to a system of coil springs. This solution was developed by combining some partial and quite radical innovations into only one concept. The second team, namely group K5, was even more innovative and created three possible concepts: the first one was based on the adoption of the principle of palm tree fibres in order to lighten the overall structure and reinforce it at the same time. In this case, the carbon fibers replaced the natural inspiration based on palm tree fibers; the second solutions aimed at adopting a kind of long and strong spiral with a central body similar to the group K4's concept; the third solution was based on the horse bone structure, in particular, the knee joint able to avoid cracks by distributing forces around the central part of the bone. Finally, they ended up joining the first and the third ideas, thus shifting radically from the traditional tines and soring sections. Nonetheless, the likelihood concerning with new business opportunities is not very high, since the relevant dose of creative inspiration in the beginning is strongly compromised by the specific constraints provided by the company, which aim to develop a new product with functionalities very similar to the old one. This results in a kind of "creativity-under-constraints" innovation process that is a very peculiar context, typical of the context in question. The Vehicle Pooling case study is right in the middle: it represents a context characterized by an average degree of radicality, since it aims explicitly at realizing a very advanced platform for alternative mobility solutions, but it is based on already existing basic concepts coming from the philosophy of Collaborative Consumption. Another innovative point is the introduction of such an initiative in low-income macroeconomic agglomerates, thus providing the opportunity of generating new ideas and business lines due to the different community and competitive scenarios: (a) the "religious trip", adopted from the "pink trip" reserved to women, which ensures Jewish and Muslim women to reach autonomously their religious houses and participate freely in traditional ceremonies; (b) the vehicle sharing module for business users like passenger transportation companies aimed at exploiting a consumer base already available thanks to the platform; (c) the CO_2 emission savings counter focused on providing also an estimation of savings for administrative territorial units aimed at showing their governmental efforts about environmental improvement; (d) the management of real time request, which is hitherto nearly unexplored in competitive initiatives; etc.. Nonetheless, the new business generation is always related to the mobility industry and, in particular, to the application of Collaborative Consumption principles into the eco-sustainable and social transportation systems. This is, again, the result of a constraint given by the tender notice behind the project idea, which could not be easily circumvented, on pain of funds reduction. For the same reasons, also unpredictability of objectives and divergence from innovation goals are in the middle if compared to the Automotive and Educational cases. The

intermediate degree of radicality and the new business opportunities are balanced by the low inclination to diverge and achieve unpredictable goals. Therefore, the overall level of uncertainty and risk tends to be perceived as medium. Also the use of and even the anchorage to pre-existing knowledge contributed strongly to the development of algorithmic solutions for the Logistics Optimization Engine, the Social Rating system, the Reputation Management module, the Recommender System and the Rewarding solutions, while many ideas about new business opportunities, the adaptation to the low-income communities were generated thanks to recalling the creative potential incidental to the even more emerging concepts of Collaborative Consumption, Sharing Economy, Social Technologies and Social Innovation Economy as they were cited in Chapter 7. This combination between creativity and knowledge balanced the two innovation strategies in this case study.

By discussing the empirical results related to creativity-based vs. knowledge-based innovation strategies, it is possible to notice how remarks led to embrace a broader perspective than the traditional one and involved in many occasions the external environments as a complementary topic of discussion.

This makes it necessary to explore deeply how the four macroeconomic perspectives representing different stakeholders' environments are linked to each case study. Such an a analysis is carried out with the same methodology used for the above comparison between creativity-based vs. knowledge-based resources.

In Figure 82.B a mapping of the four perspectives affecting each case study is proposed. It shows to what extent the Incremental Value to Stakeholders according to a certain perspective is interlinked to a specific case study. In particular, "P" ("Primary") indicates that the outcomes in terms of Incremental Value to Stakeholders related to a certain perspective are central for the case study in question, while "S" ("Secondary") means that such outcomes should be considered as a secondary result of the case study considered. Finally, "T" ("Tertiary") refers to case studies having a really low impact on the corresponding perspectives.

PERSPECTIVE	CASE STUDY		
	AUTOMOTIVE	VEHICLE POOLING	EDUCATIONAL
MACROECONOMIC	S	P	T
INSTITUTIONAL	T	P	T
SOCIO-CULTURAL	T	P	P
CORPORATE	P	P	P

FIGURE 82.B: MAPPING CASE STUDIES DEPENDING ON THE FOUR CKI PERSPECTIVES

The Automotive case involves mainly the corporate perspective, since corporate stakeholders are the ones expecting the most relevant improvement in terms of incremental value. In fact, such a project aims at increasing productivity and efficiency in production lines of automotive plants worldwide. This means that innovating the corporate context ends up in providing an incremental in both the internal corporate environment and also the spin-offs and the satellite activities operating outside the company, but still tightly interlinked and subject to its core business. As a matter of fact, such an initiative is geared to ensure higher

profits, market share and innovation turnover and to provide additional financial resources for investments in innovation, while it is not directly and significantly interlinked with the corporate image perceived by stakeholders in terms of Corporate Social Responsibility. The macroeconomic slant implies also some positive secondary effects because the increase in terms of productivity and efficiency generates a kind of cascade effect impacting also on the satellite activities. This means that a whole industry of a macroeconomic aggregate (e. g. country, region) can experience an improvement in terms of economic growth and increase, for example, G.D.P., import, export and balance of trade indicators. Also an improvement of the "3Ts" model indicators can be achieved, since by boosting corporate and spin-offs performance the local community results to be more appealing for talents and companies operating in the area are able to provide more convenient job offers and nicer workplaces than other social and geographical contexts. Moreover, they tend to attract the best or unique experts in specific fields and to create a breeding environment for the development of creative and innovative solutions, also in the technology field. Such an inclination to attract and retain valuable human resources with different backgrounds and cultural values facilitates also a higher level of tolerance in the company and in the local community as a whole. In regard to the institutional perspective, we can notice that Automotive exploits public funds originally coming from the E.U., thus implying an increase in terms of GERD, but it does not involve any relevant growth of BERD. Also regarding the HDI there is not a significant positive effect, since the health and education indicators are not affected at all, while the living standards (i. e. G.D.P. per capita) are influenced only for the limited group of stakeholders experiencing some possible benefits due to the improvement of corporate performance. We can refer to the same argumentation about the socio-cultural perspective, especially about the HDI and "3Ts" model indicators, while we have no impacts on the Internet Connectivity indicator, thus showing a very low level of involvement of the institutional and socio-cultural perspectives in this case study. The Educational case study has very high corporate impacts, since the two solutions provided have been really appreciated and furthermore developed by the company. Moreover, the solutions provided the company with the possibility to identify latent business opportunities, hitherto unexplored. In particular, it can exploit the material science field in order to find new materials or new combination of existing materials and to develop radically new concepts for the primary sector. Ultimately, the new product development process can generate a uniqueness for the company (in terms of acquired knowledge, competences and experience) about the application of the material science to the specific industry, thus allowing to starting up a new consulting business unit for potentially interested suppliers, customers and even competitors [4]. Such positive effects may give a boost to company profits, market share, innovation turnover, investments in innovation and even Corporate Social Responsibility as the solutions provided are economically and environmentally sustainable, improve and make safer the tillage process of farmers, are totally inspired by nature and tend to reduce both resource consumption and pollution [4]. Also by the socio-cultural point of view, stakeholders may experience a strong inclination towards the principles of bio-inspired design, bio-mimicry, etc.. This may encourage people to open their minds by a socio-cultural point of view, to develop more knowledge and competences and to make them aware of the above mentioned fields, to increase their life expectancy and their living standards, thus impacting positively

on all the HDI indicators. Moreover, an organization or a community may become more appealing for talents by focusing on very creative inspiration processes coming from nature. This endows the above case study with a positive performance in terms of "3Ts" model. Nonetheless, it is not aimed at increasing the Internet Connectivity indicator. The overall contribution to the macroeconomic and institutional slants is very low, since the proposed ideas and solutions can be intended only as prototypes to be further developed by the company and have no direct impact on G.D.P., import, export and balance of trade indicators. Only the "3Ts" model is directly involved, given the increased appealing of the local community for talented workers, as we argued above. Similarly, regarding the institutional perspective it is not possible to notice any growth in terms of BERD or GERD, since companies exploit the free contributions of groups of students. Only the HDI indicators are affected positively, as we argued above. The Vehicle Pooling initiative primarily affects the macroeconomic, institutional and socio-cultural perspectives. In fact, it is geared to provide a solution to mobility issues of the whole community of users at the urban, regional and (inter)national levels. According to [5], road congestion costs 130 billion Euro per year and generates 23,52% of CO_2 emissions only in Europe, Hence, increasing overall pollution and E.U. fuel bill by 6%. The overall social cost achieves 4% of Europe's G.D.P.. Therefore, by reducing the loss of financial resources, it is possible also to invest them in production activities able to obtain an increase of the value added for entire macroeconomic agglomerates that is an increase for G.D.P.. Similarly, such investments may lead to improve import, export and balance of trade indicators. Moreover, it is possible to attract and retain talents from other regions or countries thanks to better economic conditions, thus increasing tolerance indicators and possibly developing new technologies. This leads to an overall increase of the "3Ts" model indicators. The impacts on the institutional slant are very relevant, since such a mobility solution aims at improving the life expectancy and the living standards – i. e. HDI indicators. In fact, [5] shows how institutions at the urban, regional and (inter)national levels are able to reduce their CO_2 emissions and the phenomenon of road congestion, which counts for one third of car accidents and more than 13,000 died in Europe yearly and many wounded with utterly unacceptable human and economic costs. Moreover, BERD and GERD are positively affected, since E.U. funds provided to such initiatives encourage (equity) co-investments on R&D activities made by private investors – i. e. BERD – and tend to create a virtuous cycle involving even more financial resources given by public authorities – i. e. GERD. Similarly to the institutional and macroeconomic perspectives, also the socio-cultural one is primarily affected by the Vehicle Pooling initiative, since it is mainly related to the HDI and "3Ts" model indicators discussed above. A high level of Internet Connectivity is a necessary condition in order to benefit from the services available on the platform, but the latter does not contribute to an increase of the number of people with access to the Internet. Finally, the Vehicle Pooling initiative has a key role also on the corporate level that is the possibility to create a start up, to identify new business lines or opportunities (e. g. the religious trip, the vehicle sharing module for business users, the CO_2 emission savings counter for administrative territorial units) and to develop innovative services. Therefore, such a platform may lead to achieve relevant levels of profits, market share, innovation turnover and investments in innovation. Given the green-oriented and sustainable

approach of this initiative, it ensures also an improvement in terms of corporate image – e. g. Corporate Social Responsibility.

In conclusion, it is worth it to notice that Vehicle Pooling has primary impacts on all the CKI perspectives mainly because it is the only one case study endowed with a very broad slant since the design stage. As a matter of fact, project designers took into account in advance all the possible outcomes in terms of Incremental Value to Stakeholders related to the macroeconomic, institutional, socio-cultural and corporate perspectives. This shows how approaching the Innovation Management discipline should imply the adoption of a broader perspective in order to develop win-win innovations. Finally, also a well-balanced combination between creativity-based and knowledge-based innovation strategies tends to lead to less uncertain and risky processes, but still able to generate highly profitable and quite radical innovations impacting on the community as a whole.

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