Integrating Innovation and Technology: A Case Study

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Abstract

This paper explores a successful case of a product-service system (PSS). To meet the requirements of the client's needs and the existence of many technologies, business models and innovations involved in its conception and development, a conceptual framework of the ideation process is purposed to explain how the company met the requirements of such technical complexity, adding value to customers, stakeholders, and the company itself. Cases found in the development and implementation phase of the PSS displays the correspondence between the proposed framework and the case study. Furthermore, a relationship between creativity and systems' architecture is explored.

Keywords: Open innovation, Creativity, Product service systems

1. Introduction

Creativity has been defined in different ways in cognitive sciences' literature (e.g., Amabile 1996, Csikszentmihalyi 1996, Sternberg 1999, and Weisberg 2006). We see it as the ability to produce a product or a service, by a company, being both novel and appropriate for the market and in some extent, generate an innovation. The process of innovation in organizations is now a well-understood concept backed up by an extant and well-established literature (e.g. Crossan and Apaydin 2010, Tidd and Bessant 2009). Nevertheless, the fact is that the concept of innovation associated with creativity in companies is not so explored (DeGraff and Lawrence 2002) and worth of being further investigated. This fact is also absent in some of the relevant literature (Mont 2002, Brady et al. 2005, Morelli 2006, Vasantha et al. 2012) concerning "Product-Service Systems" (PSS).

In companies, a distinction between creativity and innovation is normally made (Amabile 1996, Davila et al. 2006). The term innovation is more frequently used, instead of the term creativity, to refer to the entire process by which new ideas are created and converted into original and useful products and/or services. On the other hand, creativity is recognized as a necessary building block to trigger new ideas, concepts and approaches to deal with existent or emergent problems, normally characterized by the efficient and aligned management of large amounts of creativity (DeGraff and Lawrence 2002) - creativity and innovation should be balanced to introduce value capture to the company. We also sustain that creativity is the building block of all innovations at companies nowadays.

Being much more than a simple product or service, Via Verde can be labelled a PSS. A PSS is regarded as a system of products/services with different technologies, business issues, equipment, interfaces, networks, organizations, and individuals that is designed to be competitive and satisfy customers' needs (see Oksana 2002, Morelli 2006, Vasantha et al. 2012). The above-mentioned domains of knowledge can be integrated (Howard et al. 2008), and in the authors' opinion, to explain the basic creative ideas behind any kind of innovation (Kelley and Littman 2004). One should consider, in general, the intersection between engineering design domains and cognitive psychology issues. Engineering design deals, for example, with the creative processes of innovation, such as the case of innovative PSSs, while cognitive psychology studies the process of creativity. The complexity of a dual cognitive-engineering perspective is normally difficult to

explain without a strong conceptual background that supports it. With the purpose of understanding the impact of creativity in the innovation of a PSS, the authors have developed a descriptive framework of the ideation process (Author et al. 2014), partly based on existing models from both fields (such as Hatchuel and Weil 2003, Hsiao and Chou 2004, Ogle 2007, Stefik and Stefik 2004, Lawer and Yazdani 1991).

The framework addresses the issue of modelling the ideation, representing the interface of cognitive psychology and engineering design. Three domains – inspiration, decomposition and integration – and three spaces – problem-space, idea-space and concept-space are described as elements of the framework. The iterative flow of the engineering design process passes through these domains in a semi-controlled way, through a sequence of process loops in – and between the spaces. This framework is proposed to describe the ideation process of Via Verde's toll collection system. As so, the main objective of this study is to make a correspondence between the proposed framework and a practical use case. Moreover, we intend to answer to the following two research questions:

1. Can we use a conceptual framework to explain an empirical creative outcome such as the case of "Via Verde" system?

2. What is the nature of a possible relationship between creativity and systems' architecture?

After the literature review and background on the proposed framework and related issues to product/service architecture, we will present the methodology of this study. Then, empirical findings of the case are presented. After, the discussion's section covers the correspondence between the ideation framework and the PSS. Conclusions are drawn at the end of this article. This document is a template for Microsoft Word versions 2000 or later. If you are reading an html version of this document, please save it as a Word file so that you can use it to prepare your manuscript.

2. Literature Review

Idea generation is the creative process of generating, designing, and communicating new ideas (Jonson 2005). It comprises all stages of a product-service life cycle, being relevant to this study the initial or, sometimes called, fuzzy front-end (FFE) phase of an innovative design process. The literature review of creativity and ideation in the front-end phase of design has already been underpinned by the authors (Marques et al. 2014) and a descriptive framework of ideation has already been established and validated (Marques et al. 2014, Marques, 2016).

The literature concerning practices in design and cognition is recent and reflects the work of how a designer achieved the best solutions for problem-solving based on synthesis focusing on the solution to a given problem. The design method relies on the identification of a need, conceptualization, feasibility analyses, and production and testing and its success of is dependent on the competences of each designer, his/her personal creativity, three-dimensional visualization, and the ability to present the ideas in sketches. Also, design frameworks are basically classified into two classes: prescriptive frameworks and descriptive frameworks. The prescriptive frameworks tend to take a broader view of the design process, while descriptive frameworks bring into consideration the actions and activities developed during the design process. The original solution passes through a process of analyses, evaluation, refinement, patching and repair, and development, being a heuristic process. In the last ten years, some relevant articles have been published in engineering design research and in the present article, one has only identified and focused on relevant work for laying the foundations for the framework (Marques et al. 2004).

Ideation is the creative process of generating, designing, and communicating new ideas, comprising all stages of a thought cycle and the fuzzy front-end phase. Gero and Kannengiesser (2004) proposed the function-behavior-structure (FBS) framework. The FBS situates the act of designing at the interfaces between an expected world, an interpreted world and an external world, linked by six fundamental design processes: formulation, synthesis, analysis, evaluation, documentation, and reformulation. Howard et al. (2008) presented a framework for the creative design process based on the integration of the engineering design and cognitive psychology fields. To close the gap between engineering design and cognitive psychology Howard et al. (2008) proposed an improved version of Gero's FBS framework. Three additional creative components were then mapped onto this framework: analyses of creative tasks, generation of ideas, and evaluation. The C-K design theory was presented by Hatchuel and Weil (2003) and is based around the interplay between two independent spaces: a concept-space and a knowledge-space. The interplay is mainly accomplished by moving from the concept-space to the knowledge-space. In the C-K theory, the concept-space holds ideas that are neither true nor false, meaning that they are exploratory concepts that will immediately pass onto the knowledge-space which holds a kind of

tacit knowledge. Chusilp and Jin (2006) proposed a cognitive activity framework of conceptual design based on four cognitive activities: analyzing, generating, composing, and evaluating the problem. Three important iteration loops were identified: problem redefinition, idea stimulation and concept reuse - creative design engages in more iterations than routine design. Hsiao and Chou (2004) developed a creativity method based on the sensuous skills of humans called the "sensuous association method" (SAM), allowing the production of creative ideas in a surrounding environment. The SAM consists of four intrinsic personal human behaviours derived from the senses: looking or information input, thinking or inference and re-association, comparing or extraction and restructuring, and describing or creativity output, and one extrinsic behaviour.

The framework to be presented intends to deal with three aspects of design: linear versus iterative processes, heuristic versus algorithmic search for new concepts, and the application of tools for decision-making with limited information. The first concern is directed at linear versus iterative processes - simple design processes shown a linear perspective while others can accommodate iteration - from the fact that design is evolutionary and needs to constantly loop backwards for redesigning and testing. Heuristics are not based on traditional mathematical grounds as algorithmic procedures are. The major concern of using algorithmic procedures in creative design is that the former typically converge to a single solution while the latter has no unique outcome. The third concern encompasses the inherent difficulty in evaluating half-baked ideas that emerge whenever an artefact is being designed. Again, the problem is generally solved in formal frameworks with the help of some algorithmic method when most of the time the right decision can be made with a simpler heuristic approach. Before moving on to the explanation of the proposed Ideation Framework (IF), it must be noted that the outcome of the framework is not a new product or service, but merely a new concept for a product or service (Marques et al. 20144). After the presentation of the framework, the authors diverge to a literature review that considers further considerations of the framework to innovation's outputs - regarding technology and business models- and a possible relationship to architecture's (product-service) issues.

The ideation framework (IF) was developed by the authors and its conceptual background is to be presented elsewhere (Marques et al. 2014). The IF is visually represented in Fig. 1. The framework encompasses three important domains: 1) inspiration, 2) decomposition and 3) integration. A dashed line between the decomposition and integration domains means that there is no clear separation between the two. Within each domain, there are mechanisms, heuristics, methods (e.g. Rosenman and Gero 1993, Welling 2007, Linsey et al. 2008, Frey et al. 2009) that act upon the flow of ideas to come up with a creative concept. These domains will be briefly explained in the following paragraphs sections.

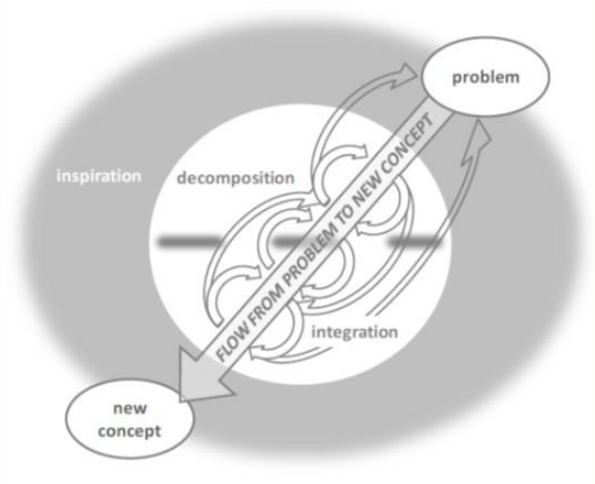


Fig. 1 General view of the IF (Marques et al. 2014).

The *inspiration* is a necessary source for designing new products and services. Inspiration is driven mainly by scientific discoveries, technology achievements and opportunities from business and market surroundings. In fact, different design teams will have different inspiration domains, depending on their educational and personal background and their lifelong experience. Within the inspiration domain lays not only the "problem-space" but also the "idea-space". The former encompasses the problem to be solved and all the information relating to it, while the latter accommodates all the possible ideas brought in to solve this problem. One can say that the idea-space needs at least to intersect the problem-space or no valid idea can be found to solve the problem at hand. We will call this intersection of problem-space and idea-space the "concept-space" Fig. 2 shows a schematic of the spaces superimposed on the IF.

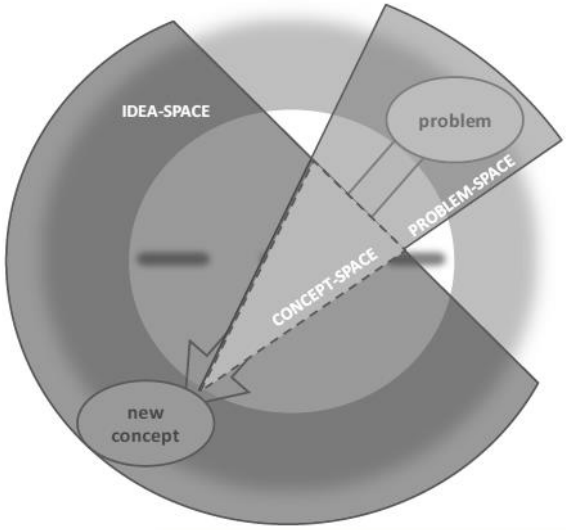


Fig. 2 The problem-, idea- and concept-spaces superimposed on the IF (Marques et al. 2014).

Within *decomposition*, a company essentially breaks the problems, ideas and concepts into smaller subsets - the decomposition can be an abstraction of the problem to be solved, ideally setting measurable goals for the design to be developed. In a typical engineering design process, this approach to decomposition would be like understanding and identifying customer has needs and consequently setting specifications as goals for achieving customer satisfaction. Decomposition can also be accomplished as idealized functional requirements that the product and/or service are expected to fulfil. An essential element of the IF process is that these abstract specifications or idealized functions will be taken up by the "integration" domain in the form of abstract information (Fig. 3). Much of the decomposition may take place in the problem-space, as a company may not be thinking at this point of a solution to the problem. If, however, a company is already at this stage imagining a solution to the problem and is using this to construct the idealized functions or target specifications, then we must place this activity between the problem-space and the idea-space. The integration domain uses all the information derived in decomposition to explore the idea-space in search of a solution to the problem (Fig. 4). The tentative ideas that are formed in this process constitute the concept-space. The concept-space is the part of the idea space that has relevant information to the problem at hand, so it is one of the possible intersections between idea-space and problem-space – in fact, every tentative idea is an intersection of problem-space and idea-space.

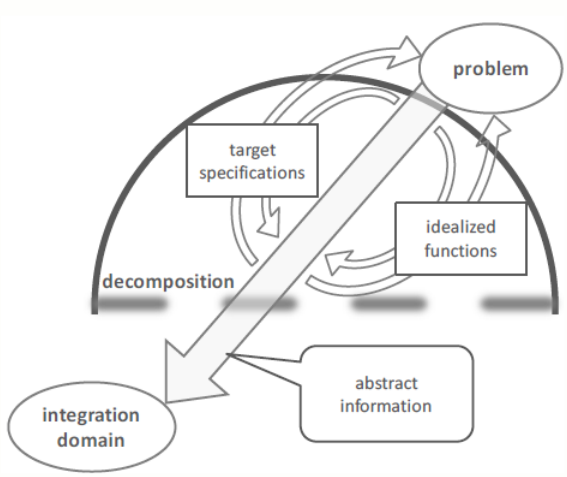


Fig. 3 Decomposition of the IF (Marques et al. 2014).

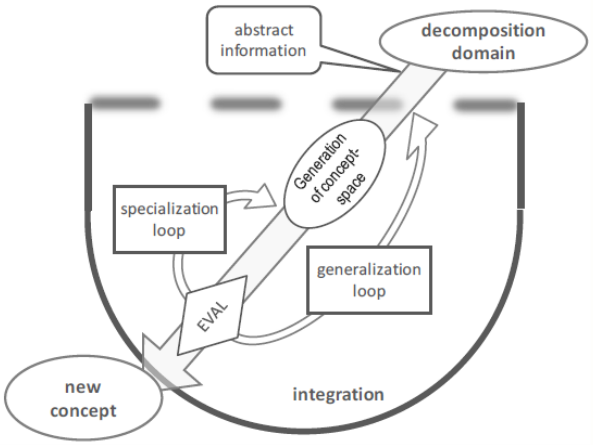
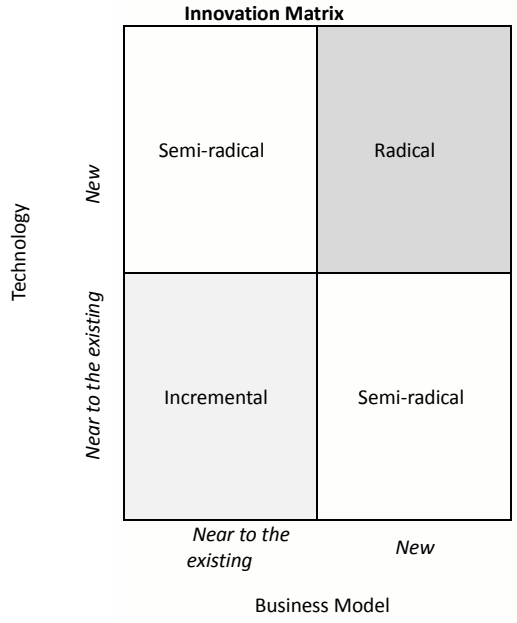


Fig. 4 Integration of the IF (Marques et al. 2014).

The evaluation is done by comparing the functions or the performance of the concept against the functions or the specifications derived earlier in the decomposition domain. This test can lead to three outcomes: first, the tentative concept shows all the functions and meets all the specifications, therefore becoming a possibly acceptable new concept; second, the tentative concept shows only partial fulfilment of both functions and specifications, but a company believes that the concept can improve with some refinement, therefore going backwards on a specialization loop within the same concept-space; and third, either the concept is completely off target or successive specialization loops have failed to bring it to fruition, and something more radical needs to happen – a company must form another con-

cept-space and start all over again, this is called the generalization loop. There is evidence of specialization, generalization and mid-term loops in the human mind (Ware, 2008) thus pointing out the inherent iterative nature of PSS design activities. This iterative nature of the design activity includes feedback loops: the specialization loop – typical of concepts that are incrementally derived from existing products and/or services within the same concept-space – and the generalization loop – typical of concepts that may constitute breakthrough innovations in different concept-spaces. A middle term loop is also most probable to exist to characterize what Davila et al. (2006) calls of "semi-radical innovation". The three types of innovation's outputs (proposed by Davila et al.) and used in this paper are summarized in Table 1.

Table 1 Innovation matrix (adapted from Davila et al. 2006).



Special attention to the gates (evaluation item in Fig. 4) in the IF that guide the specialization and generalization loop is necessary for possible implications of the IF on product/service architecture. There is a need to identify a possible saturation in the specialization loop, denoting that there are no other improvements at technological and/or business model levels, without changing the concept-space, or changing the architecture. In terms of a product/service's language, one is talking about improvements and optimizations preserving an architecture, which is, achieving a better product-service within the same concept-space. Theoretically, when the potential for improvement is saturated, innovation on the product-service needs breakthrough, which means novel approaches, requiring a paradigm shift and/or the replacement of items in the concept-space. More precisely, the generalization loop could be a change of a concept-space, but is also a change between different architectures. New product-services tend to have an integral architecture, however with the increasingly short life cycle, their architecture becomes modular over time, reducing cost and increasing product-service variants (Baldwin and Clark, 2000). This leads to the hypotheses that the framework should work in dissimilar ways for new products-services and for incremental ones, thus interfering with architecture decisions. Theoretically, product-service systems' architecture should be interconnected with creativity.

3. Methodology

This paper follows a case study research methodology (Yin 2009). Thus, we have defined the following assumptions and constrains for this case:

- Since the case study is interpretive, we rely on ours' observations and interpretations.
- Our main role, as researchers, was to access other individual's interpretations, thus filtering those opinions over a proposed conceptual framework.
- Not only individuals' responses will be limited and rationalized, but there is also interference from the researcher's subjective interpretations and questions.
- One should acknowledge that bias is present in both actors, particularly in a unique case study.
- During data gathering, the authors decided to be only external observers.
- The unit of analyses focused on the case of Via Verde system's innovation during the period between 1990 and 2010.
- The data collected was qualitative and considered more appropriate.
- Interviews were the primary data source.
- Other sources, such as web, project reports and two books (Brisa 2006, 2010) were used to triangulate information from the interviewed phase.

Regarding interviews: They were semi-structured and questions were defined according to each role of the interviewed person on the company. The following questions were asked:

1. "Via Verde" was born in 1991. What was the specific purpose for it? Could you please focus your answer on business and technology issues?
2. The name/brand "Via Verde" had an objective?

3. The idea of moving from an "opened toll system" to a "closed system" occurs with the massification of Via Verde in 1995?
4. In 2000, the idea of an "access service" occurs, however it fails. Was there a reason for that?
5. Within a paradigm of innovation, many projects were created, such as "ITS-IBus". Can you characterize them regarding technology and business models?
6. Is the company no longer dependent on software with the "ITS-IBus" concept? What kind of business model supports this technology?
7. Are open software/systems normally associated with "open innovation"? How do you characterize the architecture of Via Verde?
8. What are the plans for the company?

The interviews were transcribed to paper recurring to the notes that were taken during it. The number of interviewed persons was a total of six:

- From Brisa Innovation: The Director, the person Responsible for the Technological Development Process, one former Expert Engineer involved in the design of Via Verde system, and an Engineer involved in the innovation process.
- From ISEL (Polytechnic Institute of Lisbon), the Project's Coordinator between ISEL and Brisa.
- The Manager of an outsourcing company collaborating in different projects.

4. Results

This section describes in detail the innovation process of "Via Verde". We first provide a short case summary. This is followed by a closer analysis of the type of innovation's output, based on the answers from the interviews and consulting other sources of information (web and reports/books), as well as a section highlighting key issues related to the framework.

Overview of the case company

Brisa was founded in 1972. In nearly four decades become one of the largest operators of toll motorways in the world and the largest transport infrastructure in Portugal. Today, Brisa has a market capitalization of around 3000 million Euros and its shares are listed on Euronext Lisbon, where it integrates its main index, the PSI-20. The company is also a part of the Euronext 100 - an index that includes the largest companies in France, Holland, Belgium and Portugal - and the FTSE4Good, the reference index in social responsibility. The main business area is the construction and operation of toll motorways and the remaining businesses consists of the provision of services associated with the safety or convenience of traffic road on the motorway and urban environments. In the international market, the company operates in the USA, Holland, Brazil, India and Turkey. Brisa Innovation is integrated in Brisa's Group that is strongly committed towards the promotion of mobility as a driver to create important economic and social benefits for the communities that it serves. Brisa Innovation mission is to research, develop, integrate, install and maintain technological solutions for ITS (Intelligent Transportation Systems), acting as competence state-of-the-art center, with a view to ensure maximum quality and efficiency in deployed solutions.

The first steps: incremental innovation as we see it

The company was pioneer in the development and implementation of a new automatic toll system called "Via Verde". Installed in 1991, in four toll plazas, by 1995 the system had extended to the national motorway network, with over a million users:

The extension of the national roadway system and the resulting vehicle flow raise granted us to search for the best practice for a new toll automatic collection solution…The goal was to work out on a toll collection model allowing the client to go throughout the toll gate, devoid of stopping the vehicle and using an access lane, correctly identified and equipped. (Former Expert Engineer)

For that purpose, before 1991, a company's teamwork composed by technical experts and commercial staff travelled to Norway (Brisa 2006) to visit "Q-Free" company, which had developed a simple system to control the access ways to a small city. The observation of the operating technology already developed, turned out to be the necessary inspiration to build an in house new system. Absent to the system in use, there was the need to identify the vehicles per class (four classes are used according to national legislation, book) by measuring physical parameters; a mission that would be possible by setting up sensors on the paved highways. An innovative challenge was the development of an algorithm for "Automatic Vehicle Classification" (AVC). The next step would engage the association of the vehicle's classification and identification by means of a device placed on its windshield. In 1991, the company's technical staff started developing equipment adapted for the national context. All the work performed allowed the company to classify the traffic that has passed through the tolls, as well as collecting the toll payments using a bank debit card – a system that was made feasible thanks to "SIBS" clearing company's know-how. The missing point was the name that would match all this technologies and business models

to release Via Verde in 1991. The inspiration came once again from outside – an analogy to the postal service "Blue Post":

Company's innovative system was green, representing lower levels of pollution, and the green light represents that you can go in a traffic signal. (Technological Development Process Responsible)

The next step consisted in the application of Via Verde to the "closed-system" applied over a bigger highway network (Brisa 2006). Subsequently, in 1995, Via Verde's second stage had taken place, and the company provided the necessary equipment to all the operating toll plazas (around 60). In 2000, Via Verde's autonomy from Brisa occurred as the company was under privatization. Two years later, the "access service", which consisted in a pack of benefits annually paid, including parking and petrol station payments as well as many insurance covers were released and not successfully achieved its objectives:

The public´s weak acceptance to this service, the lack of experience in the insurance universe, and the clear delay in technology led to its abandon…reconsidering new objectives in the market based on a new business model of the company, and most important the company's internal organization change (Former Expert Engineer)

The second stage: radical innovation?

In 2002, the creation of a "Direction of Innovation and Technology" (DIT) clearly showed the acknowledgment of the importance to promote and develop innovation policies. A pilot project (a+) was taken into practice with the objective of creating good conditions to the generation of new ideas and build an innovation culture (Brisa 2010):

The project (a+) is the concretization of Brisa's innovation model. The innovation was developed jointly with start-ups…mainly driven by the necessity of strengthen the research, development, and innovative solutions for toll equipment plazas, access control to parks, and payment systems in services stations (ISEL Coordinator)

Based on collaboration between Brisa and ISEL, a new project contributed considerably to the innovation of "Via Verde". The project is the recognition of three crucial points: the launch of an infrastructure with open protocols and interfaces (standards); a new incorporated payment system; and the enlargement of Via Verde's business model to other areas. The project aimed the development of an infrastructure with open interfaces and protocols that can integrate internal and external business processes, relating dissimilar companies or organizations:

The solution is based on ITS-IBus (Intelligent Transport Systems Interoperability/Integrative Bus) project concept…this idea supports the normalization of services and interfaces based on interoperability, representing the shift from a monolithic approach to automation islands in infrastructures, from closed systems to open ones. (Outsourcing Manager)

As a result, clients will organize their services according to their exact needs, while the company organizes it in terms of business processes, technical resources, and flexibility in using equipment from different contractors. The project also catalyzed other forecasts such as automatic systems for toll collection beyond Via Verde's system, and the redesign of toll cabins in terms of modularity and ergonomics (Brisa 2010). In summary, "Via Verde" PSS started in a "closed innovation context". That was visible in the intention of building an in-house system, reinforced with the difficulties in acquiring sufficient mass technology from suppliers in its second stage. With the creation of the DIT, the situation has radically changed. The ISEL collaboration in the ITS-IBus project "is an excellent case of openness":

The constitution of an innovation network that allows the transference of knowledge reflects a new paradigm…Spin-offs were created and different partnerships achieved…With open innovation, open source or free software taxonomy is also present. (Director)

5. Discussion

Based on the case presented, we can now propose a matching between it and ours' ideation framework. Keywords from the previous section allow us to start identifying, at least, the inspiration domains, and the problem-, idea-, and concept-spaces of the PSS. Via Verde is a typical case of applied creativity that can be explained by the proposed ideation framework. The "inspiration" domain is visible in the initial solution required to avoid long-time waiting lines in the national highways (opportunities from business and market surroundings) and the existent Norwegian's Q-Free system (technology achievements and further improvements). Within this inspiration domain, lays not only the problem-space but also the idea-space as we have mentioned before (see literature review). The problem-space, in the first stage, is characterized by the need of developing and implementing a new automatic toll system. The idea-space is characterized by a solution that allows people to go throughout a tollgate, devoid of stopping the vehicle and using an access lane, correctly identified and equipped. Within this intersec-

tion of problem- and idea-spaces lies the concept-space(s). In the first stage, it be the need to identify classes of vehicles, the development of an algorithm for AVC, and the association of the vehicle's classification and identification. This is in terms of design of PSS quite like the understanding of needs/requirements translated into setting up product/service's specifications. In terms of the integration domain, we can draw the following considerations: Before 2002, one can characterize Via Verde's PSS as being not much more than a group of incremental solutions. The idea behind "Via Verde" was based on a technological incremental innovation and on similar business models. In 2002, the DIT was created and has coincided with the failure of the "access service". It is also by that time that we can sustain the thesis that "Via Verde" started to shift from an "incremental" innovating context into a more "radical" innovation new paradigm (between these two stages semi radical innovations occurred, but with difficulties in identifying precise periods or situations). Considering an analogy to ours' framework, one might precise that the initial "specialization loop" of the integration domain was becoming saturated at both technological (e.g. lake of interoperability, great dependence on suppliers of technology) and business model (e.g. extended services, lake of partnerships and networking communities) levels. Thus, in 2003, "Via Verde" started the implementation of the ITS-IBus project. The PSS entered a new cycle due to costs reduction and the independence from their suppliers of technology. This situation allows new developments in emerging technologies supported by new business models. For example, the technology/concept/process behind the ITS-IBus enabled other expertise in a favorable "opened" world context. Indeed, nowadays, Brisa manages and owns the technology behind Via Verde and all associated services to the system with a new value propositions. Which regards the possible connection between creativity and system's architecture we can enunciate the following hypothesis: The new extended Via Verde concept, prior to a lock-in system, is now agreeing open protocols and standards, disintegration and interoperability, contributed this way to a shift of the PSS's architecture:

Brisa is nowadays seen as an integrator of systems based on a plug-and-play architecture. (Innovation Engineer)

The former sentence is what we can call a fundamental characteristic of modular architecture (Ulman 1997, Yu et al. 1999, Baldwin and Clark 2001). In other words, Brisa's Via Verde system has overcome from an initial integrative architecture to a modular one, as displayed in Fig. 5.

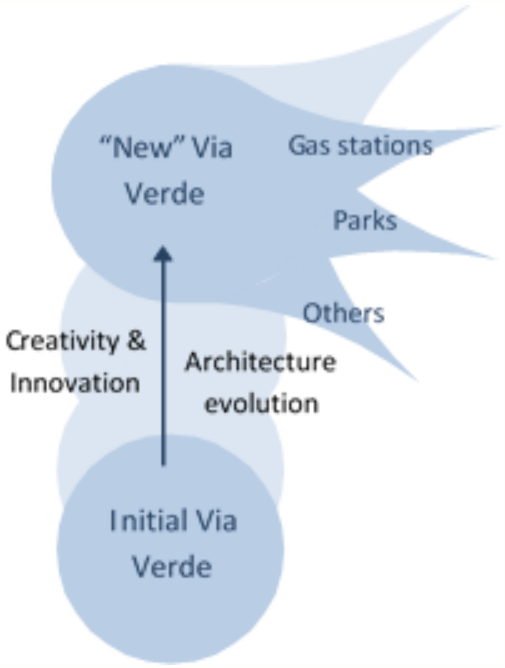


Fig. 5 Via Verde system's architecture evolution over the period of 1990-2010.

Lastly, one should notice that the IF was first developed for academic proposes and this is the first attempt to use it in a real case study - our future goal is to turn it on a prescriptive framework of creativity and innovation for successful companies. Based on that, managerial implications are expected if regarded as guide for good practices.

6. Conclusions

The main objective of this paper was to make a correspondence between a proposed framework of the ideation process and a case study in the industry that we believe to help explaining how creativity contributes to the different types of innovations in companies. To address that objective, we have evaluated the innovation of a specific PSS and compared it with the framework, answering this way to the two research questions. First, the ideation model appears to be consistent with the empirical findings concerning the spaces and the domains of the framework. Additionally, and as observed, the specialization loop is typically used to generate incremental outcomes, while the generalization loop typically represents breakthrough innovation. Secondly, and in the case of a blocking situa-

tion in terms of technological and/or business model's innovation, we believe that the framework shifts its approach from a specialization loop into the generalization one. By other words, this is equivalent to say that for this PSS a change from an initial integrative architecture to a modular one has existed, which then allows innovation to occur. There have been studies in recent years on product/service architecture and its implications in design (Stone et al. 2000, Dahmus et al. 2001, and Yassine et al. 2003, Tyson 2009) and the recognition of a hypothetical connection between the constant change of the design and the changes enforced in the final product/service architecture. The study conducted so far presents limitations to the above findings. They rely on in-depth case study of one industrial company operating in the highways industry. Thus, the findings should be considered as applying first to contexts characterized by similar conditions. For instance, a PSS transition that lacks an installed base logic would probably look different. Furthermore, given that the findings are based on one case, replication across more cases enhances their generalization. Finally, the use of "near-to-existing" and "new" without any real attempt to make this measurable is also a matter of great discussion. There is a smooth distribution of change ratios and not only three types as invocated in the paper. The change ratios are dependent more on the technological/business model area than they are on the level of novelty or on any ill-defined innovation type. To go over this problem, we propose the future use of modulation's trend of the framework, allowing inputs and outputs to be probabilistic and continuous.

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