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A Business Model Approach of IT-based Services for Smart City Contexts

Dissertação de Mestrado

Mestrado em Sistemas de Informação

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This work is result of a somewhat long period of my life, dedicated to the finalisation of the beginning of a journey in the research and development universe. I daresay the beginning, for while it surely the end result of a two-year period of a Master in Science, might not be finalisation of my endeavours in pursuit of knowledge and specialisation.

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ABSTRACT

Smart City technological initiatives are currently a common place, however it is still frequent an IT solution being the driver of those initiatives and not the city needs. Considering the need expressed by the national government and international institutions to increase the efficiency in energy consumption, we have identified online auction services, which support decreased costs when acquiring retrofitting services, as suitable solution. This document provides an overview of the efforts to model that service, considering the problematic of the alignment of business and IT for a new service created within a smart city context. The service shall contribute to the improvement of efficient of energy consumption and the maximization of its added social and economic value to the city and service suppliers.

Within this context an opportunity was seen to propose a minor extension the previously defined PGR Approach to generate a new business model, in the form of a canvas, which supports the use of an online auction service to increase energy efficiency in what regards residential households. Additionally, the SusCity Project, an on-going smart city project, is considered as demonstrator for the model's applicability.

Besides that main work, an analysis of maturity models for smart cities is performed. The objective is to ascertain if existing models are able to measure the current maturity state of cities and identify needs to propose actions towards future evolution.

The main contribution is the proposal of a slight extension to the application of the PGR Approach, to cater for the generation of a Lean Canvas, considering a smart city context. Additionally, the analysis of maturity models based on design principles, provides an exploratory work towards the development or adaptation of maturity models for smart cities. While using the *SusCity* Project as demonstrator a new IT-based online retrofitting auction service is also modelled.

KEYWORDS: SMART CITIES, PGR APPROACH, BUSINESS MODELS, *SUSCITY PROJECT*

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Resumo

Iniciativas tecnológicas para Cidades Inteligentes são hoje em dia normais, no entanto ainda é frequente que uma solução TI seja o incitador das iniciativas e não as necessidades de uma cidade. Considerando necessidades expressas pelo governo nacional, assim como instituições internacionais, para aumentar a eficiência no consumo energético, foi identificado um serviço de leilão, que permite aquisição de serviços de retrofitting a custos mais baixos, como uma solução sustentável. Este documento reporta uma visão dos esforços realizados na modelação do serviço, considerando as problemáticas do alinhamento do negócio com TI, de um novo serviço criado em contexto de cidades inteligentes. O serviço contribuirá para a melhoria da eficiência no consumo energético, maximizando o seu valor económico e social para a cidade e fornecedores de serviços.

Neste contexto surge também a oportunidade de propor uma pequena extensão à previamente definida, Abordagem PGR, para a geração de um novo modelo de negócio, na forma de um business canvas, que permita a utilização de serviços de leilão online para melhorar a eficiência energética em edifícios residenciais. Adicionalmente também foi usado o Projecto SusCity como demonstrador da aplicabilidade do modelo, um projecto de cidades inteligentes a decorrer no momento de reporte deste documento.

Para além do trabalho principal, uma análise de modelos de maturidade para cidades inteligentes é também realizado. O objectivo da análise é verificar se os modelos existentes possibilitam a medição do actual estado de maturidade de cidades de forma a identificaram necessidades e proporem acções que levem à evolução.

A contribuição principal é a proposta de uma pequena extensão e aplicação da Abordagem PGR, que possibilite a geração de um Lean Canvas, considerando um contexto de cidades inteligentes. Adicionalmente, a análise de modelos de maturidade com base em princípios de concepção, estabelece um trabalho exploratório tendo em vista o desenvolvimento ou adaptação de modelos de maturidade para cidades inteligentes. No contexto do Projecto SusCity, como demonstrador, define-se também um novo serviço baseado em TI, na forma de um serviço de leilão de retrofitting.

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CONTENTS

List of Figures

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List of Tables

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List of Acronyms

BSI – British Standards Institution

BM – Business Models

BMC – Business Model Canvas

BMM – Business Motivation Model

BPMN – Business Process Model and Notation

BSC – Balanced Scorecard

CMM – Capability Maturity Model

CMMI – Capability Maturity Model Integration

DSR – Design Science Research

EIF – European Interoperability Framework

EU – European Union

H2020 – Horizon 2020

ICT – Information and Communication Technologies

IDC – International Data Company

IEC – International Electrotechnical Commission

IS – Information Systems

IT – Information Technologies

ITU – International Telecommunication Union

LC – Lean Canvas

SCMM – Smart City Maturity Model

SEI – Software Engineering Institute

SoaML – Software Oriented Architecture Modelling Language

UC – Use Case (diagram)

UML – Unified Modelling Language

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1. Introduction

This chapter intends to frame the context of this research work. It starts by introducing the concept of "Smart City", as the domain of application of this research, and relates with the research question: the alignment of business and IT to define a new service, IT-based, to enhance economic development as well as environmental sustainability in cities. Moreover, it describes the motivation for the research undertaken, and the research approach followed.

Chapter Contents

1.1 The Smart City Context

The "Smart City" concept is, nowadays, a main concern to city leaders and decision makers of developed and developing countries. This is by virtue of the development boost enabled by the Information and Communication Technologies (ICT) on the one hand, and need that a city has to be smart when dealing with an increasing number of citizens, resource depletion (Yoshikawa *et al.,* 2012), congestion and environment degradation (GVB03014-USEN-00, 2011), on the other hand. It is estimated that from 2011 until 2050 the urban population will increase from 52% to 80% (Norris, 2015). This raises the challenge of increasing the quality of citizen's lives, thus an engine for economic development and growth, as well as citizens' engagement and public participation. However, cities also need efficient resource consumption, be environmental friendly and endorse sustainability. Cities, therefore, need to rapidly adapt to meet these challenges. The ICT, together with human capital and changes in urban lifestyle (Neirotti *et al.,* 2014), can be a strategy to reach such smartness, thus achieving and maintaining the goals of being economically, socially and environmentally sustainable (IEC WP Smart Cities:2014-11(en), 2014).

Europe has defined mandatory targets to fight against environmental erosion and reaching climate sustainability. The "20-20-20" goals, 20% cut in greenhouse emissions, 20% European Union (EU) energy from renewable sources and 20% improvement in energy efficiency, must be reached by 2020[1]. These goals are to be ensured by bidding legislation to Member States. Portugal has defined a target of 25% reduction of primary energy consumption in the private sector and 30% in the public sector (Assembleia da República, 2010). Funding opportunities are also available for Member States to support those goals achievement. Some of those funding opportunities target smart city initiatives (new actions or enterprises initiated by governments or organizations to foster evolution in cities, as cities are the places where most of the pollution and energy consumption exists). Over the period 2014-2020 a minimum of €16 billion will be allocated towards sustainable urban development (Nuñez Ferrer *et al,.* 2013). Nevertheless, other funding opportunities exist within the H2020 *programme*[2]. It is thus essential to assure that actions are pursuit to achieve the defined goals, to bring forth the envisioned benefits. These goals have an impact on the improvement of quality of life of citizens. Additionally such actions are pursued in different locations, such as in India. The Indian government plans to develop one-hundred cities, towards the concept

[1] This information can be consulted on http://ec.europa.eu/clima/policies/strategies/2020/index_en.htm

[2] More funding opportunities and the detailed programme available at: https://ec.europa.eu/programmes/horizon2020/

of smart, within a period of twenty years, with investments reaching a whopping $638 billion (Sustainable Business Leadership Forum, 2014).

The evolution envisioned by governments brings transformation to a city and is a long term process. Therefore, cities need to be able to assess their current situation and optimize their decision making to manage city resources in an effective and efficient way.

Building on the objectives set by the EU, this work wants to be a minor contribution to their fulfilment. The main objective of the research work is applying and extending the PGR Approach, a method developed by (Salgado *et al.,* 2014b) to facilitate the creation of an IT-based service for a smart city. The choice of this approach is steaming from its double purpose. The first which is to allows the alignment of business and IT, thus ensuring that investments made in IT for cities reach its envisioned goals. The second purpose allows the definition of business models, which support the exploration of economic and business value of initiatives. Consequently, by ensuring a business and IT alignment, and defining a business model, the proposed service for smart cities will not only support the achievement of the National and EU goals of improving the energy efficiency, in this case in residential households, but also enables the creation of value in the city.

1.2 Motivation and Problem Statement

A smart city is very much related to ICT, but also to the living in society with quality, global welfare and environmental sustainability. The energy production and energy consumption are dimensions putting too much stress in environmental sustainability. Cities are responsible for the depletion of natural resources, as well as the increased levels of pollution. Moreover, a smart city can also be perceived as a big organisation, in the sense that there is a common goal – evolution – which now, more than ever is highly impacted by ICT. Within this organisation, city leaders, together with public and private organisations and citizens, design and implement solutions, with a strong focus in information technologies, to support increased levels of quality of life and sustainability. It is within the domain of a smart city that the motivation to develop a business model for IT-based services, which aligns business and IT, to support improvement of energy efficiency arose.

In Portugal, the prices of residential energy are within the highest of the EU (Eurostat, 2015). A similar situation occurs with natural gas, leading to the majority of energy consumed an importation. So, it is important to be more efficient when consuming energy. Energy efficiency can be defined by the use of less energy to provide the same service standards (International Energy Agency, 2014a). The activity

sectors consuming the biggest shares are the transport, industry and residential (this sector remaining stable over the years). In Portugal the residential sector represents around 16% of the whole energy consumption (International Energy Agency, 2016a). The work here pursued targets the residential sector, of which the activities that consume most energy are space heating/cooling and lightning (International Energy Agency, 2014b). The same report refers the importance of policy making in recognising the residential sector as an important player in the energy market, and in the potential savings that could occur in the sector. The effects of such accomplishment could be seen in less expenditure, thus a potential to raise life standards, as well as lowering the emission of greenhouse gases.

One of the means to reach efficiency is by using certain type of equipment, or banning equipment or appliances that do not meet the minimum efficiency standards. The option of using certain type of equipment is here favoured, believing that home and office renewal initiatives can lead to increases in energy efficiency and a decrease of energy consumption, allowing to budgetary savings. These initiatives affect lightning appliances, as well as space rehabilitation (International Energy Agency, 2016b), and are considered retrofitting solutions. This reduction of energy consumption is also one of the objectives of the Portuguese National Energy Strategy for 2020 (Assembleia da República, 2010). The government has defined a reduction in 25% of consumption in primary energy consumption and 30% in the public sector.

This research activity not only contribute to the development and application of new approaches to align business and IT for services in a smart city context, but also provided an opportunity to deepen the knowledge in requirements engineering and business modelling fields.

The challenge and contribution of the research is the application of the PGR Approach to generate a business model, fulfilling the objective of aligning business and IT. Additionally, it proposes a minor extension to the PGR Approach to accommodate a different type of canvas as the output of its application. Therefore, the result objective is a business model, in the form of a lean canvas, which supports the alignment of smart city service business to its IT components. The service conceived via the PGR Approach contributes to two main objectives, on the one hand to promote a more effective management of city resources, and on the other hand to add economic value to the city and the society. These objectives were achieved due to the alignment that assures that the IT meets the city needs, as well as the defined business model, which allows focusing on the value creation.

The services to be developed in a smart city context need to serve the city objectives, which are closely tied to the service of its citizens. Investments in smart city initiatives should add value to the city as whole, need to be of service to city leaders, to citizens, and to the organizations marketing them. An initiative in

the context of this research work are the actions conducted with the purpose of improving the quality of life in the city. In order to better understand how to fulfil the objectives, questions emerge to guide the research:

Q1: What can make a city Smart?

This question supported initial research activities, allowing a better understanding of which objectives should the created service fulfil. In spite of being difficult to answer assertively to that question, knowing characteristics of what can make a smart city, lead to a second question, which was also the focus of this research:

Q2: Which are the needs of a smart city?

Since investments need always to have a clear purpose, it is also easy to ascertain that their benefits should outweigh the costs. When considering public budgets and citizen's money, the purpose of investment has a higher relevance. Investments should be made and money spent only if the benefits to the city are well identified, as well as verifying if the needs are covered. Therefore, it is argued that IT-based services created within the city should be well scoped and aligned with the business (needs), thus be designed with sufficient added value to be of service to the city, citizens and organizations, contributing to the main objective of a smart city, sustainability.

The research work focused on the definition of an IT-based service to fill an existing need to increase the efficiency in the energy consumption in residential buildings.

Following those two questions, which focused on providing the context of the research, two research questions are identified and raised, which pave the way to the contributions of this work:

RQ1: How to Achieve Alignment Between Business and IT in Smart Cities?

It is proposed the definition of a new service, residential home online retrofitting auctions. For that intent the PGR Approach is applied, and a slight extension proposed, to accomplish the needed alignment. However the application of the approach served an additional purpose, the definition of a business model to be of value to the city.

The work was conducted in the context of an on-going smart city project in the city of Lisbon, the *SusCity* Project. The project aims at developing and integrate innovative tools and services to increase urban resource efficiency with minimum environmental impact, and added economic value to the city. Since the service defined are part of the foreseen results of the *SusCity* Project, it was needed to ensure that it created value to the project stakeholders, the city. A second research question was raised:

RQ2: How to Create Value with New Services for a Smart City?

To answer this question, a set of heuristics are defined, that support the generation of a canvas following the PGR Approach. The heuristics ensure that the created service focus on the city and the objectives of the service.

Aligned with these research questions are research objectives, which created a roadmap of activities allowing its accomplishment and subsequently the fulfilment of the overall research objective.

The figure below provides a graphical representation of the global objective and research questions, and will be used throughout the document.

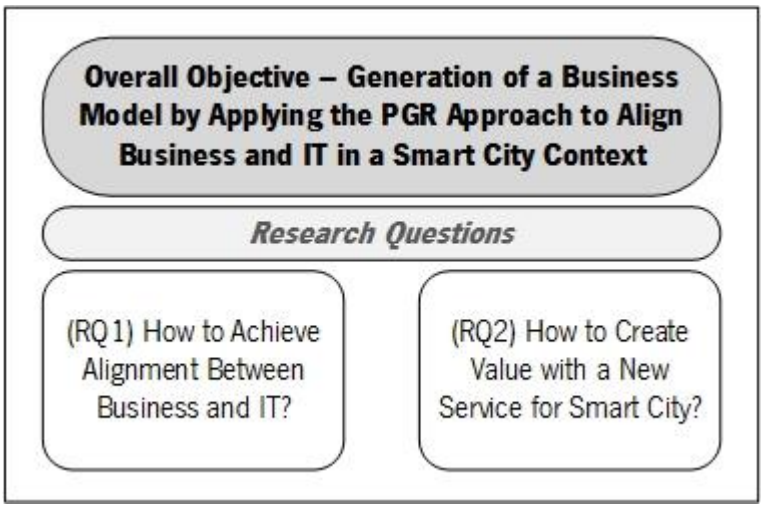

Figure 1: Research Questions

1.3 Research Objectives

This research proposes the application of an approach to define business models for new smart city services. This is considered the main objective, which is further explained below (Objective 1); nevertheless, two other intermediate objectives (Objectives 2 and 3), are also foreseen, which pertain to the characterization of what can be a smart city and the design of a retrofitting auction services using modelling notation. These will help pave the way towards the assurance that any developed artefact within this research is grounded, has quality and can fulfil its conception purpose.

01: Extension of the PGR Approach and the Generation of a Business Model

The achievement of this objective fulfils the main contribution of this work, dealing both with the alignment of business and IT, as well as the problematic of defining business models to create value in a smart city. Two other intermediary objectives are defined to support fulfilling this first, which are mentioned below

that ensure a more complete alignment of the service defined to the needs evidenced by the city (business).

O2: Characteristics of a Smart City

This intermediary objective pertains to the characterisation of what is needed to make a city smart. To comprehend how a city can develop towards being economically and environmentally sustainable, while supported by ICT. This allows the understanding in which city domains services can better serve the city.

It is important to identify the needs of different cities, as each city evolves towards an own defined paradigm towards a future city (Pereira and Machado, 2014). Therefore, by studying the sub-components of a city, being considered its dimensions, the odds of developing models that can be applied in relation to a city with good results are increased. This objective does not attempt to provide a flawless characterisation, nor address each and every dimension that could be considered for a city environment. It is about the identification of the important characteristics making a city smart, according to the specialised literature.

O3: Business Modelling of a Service for a Smart City

By addressing the need to provide retrofitting services at an affordable cost to citizens, an auction service was thought of a good means to achieve that end. Modulating functional and non-functional requirements using UML notation, more specifically use cases, allows the identification of processes, goals and rules, which are used to support the alignment of IT while considering the business. Furthermore, this intermediary objective feeds directly into the first objective of this work, the development of a business models, by providing information on the processes, goals and rules of the service.

Therefore, it can be considered that the major research goal achieved was the application of artefacts, in the form of business models, to better align IT-based services to the city and the maximization of value of the service, both economically and socially, to their suppliers and the city citizens. These actions contribute to the adequacy of new services towards the evolution to the smart city envisioned paradigm.

1.4 Methodology

The main subject of this research relates three concepts in different fields of research. One in the field of IT pertains to the requirements engineering, more concretely modelling new services – another, the economic field, pertaining to service valuation in the context of Smart Cities, through the definition of business

models – the third concept – which encompasses the different components that need to work together in a harmony to reach a sustainable development, the alignment of IT to the smart city needs and constrains.

1.4.1 Research Approach

The junction of these three fields is very much related to living in society while highly impacted by IT. It has been referred by (Howcroft and Trauth, 2005) that the study of the relationship between IS and society in which they are embedded is a research challenge. Different research approaches could be used to frame this research, as the positivism or the interpretive or qualitative paradigm. Nevertheless, taking into account new developments in research methods applied to the research fields of IS, the social critical theory is best thought as a suitable approach.

The roots of the critical theory are found in Frankfurt, Germany (said to involve a group of scholars of the Frankfurt School) in 30's, concerned with the social problems of the decade (Kincheloe and McLaren, 2002). Theory developments came later, by the 60's, when scholars yearned to free academy work from the clutches of the capitalism power. Their vision, the reconstruction of social sciences, as a way to build a more equal and social democratic society (Kincheloe and McLaren, 2002). The critical social theory since its origins has had as main objective the improvement of human conditions; focused on breaking the chains from traditional hypothetical deductive methods, to build upon the construction of new social forms of life or their recreation (Ngwenyama, 1991) (Klecun, 2004).

It is important to notice, still according to (Howcroft and Trauth, 2005), that development activities and implementation and use of IS, together with the management of those who carry them out, are closely related to social and political power. During the 90's IS research begun to shift towards a critical research approach, leaving the common interpretative field (Richardson *et al.,* 2006). IS research can be classified as a critical research if its goals are the same of the critical research in general, aiming at acting upon changing social and economic conditions (Klein and Myers, 1999). Moreover, and following the works of (Howcroft and Trauth, 2005), IS research is generally related to five dominant themes:

- Emancipation – commitment to freeing individuals from power relations, as well as to eliminate causes of alienation and domination, both usually present within organizational life;
- Critique of tradition – disruption of the status quo, challenging what is established, encouraging dissent and interprets organizational activity, emphasizing change in a positive way;

- Nonperformative intent – rejection of the premise that action is driven only by economic intent and efficiency, but it is also concerned with social relations;
- Critique of technological determinism – rejection of the assumption that technology is an effective vehicle for social and organizational change;
- Reflexivity – distinction from mainstream IS research, which is traditionally positivist. Like interpretive research, it also commits to philosophical and methodological reflexivity. It is reflexive about the choice of research topic and the way the research is driven.

Ngwenyama also proposed that the requirements for a research in IS field to be adequate for a social critical approach are (Ngwenyama, 1991): (1) Practical oriented methods and focusing on change; (2) The support of inquiry into the organizational process and social context; (3) Sensitivity to individual and organizational needs; (4) Collaborative, by supporting free and open participants; (5) Being critically self-reflective.

Therefore, as a research themed within the concept of smart cities, where societal change, technology and citizen organization, better standards of life are the drivers, it is only natural that the research approach follows the social critical theory paradigm. The objectives are clear, application of an approach to define a business model to better fit and valuate new services in a smart city context, thus championing positive change. For such an achievement a sound research method, fitting them to the objectives of the research, needs to be applied.

1.4.2 Research Method

Information Technology (IT) can be defined as "*technology used to acquire and process information in support of human purposes*" (March and Smith, 1995). Smart Cities is a perfect example of a domain where the IT and Information Systems (IS) are used to support human beings. In this case IT is not an end itself (March and Smith, 1995) but a means to achieve the ends, city development and evolution. As a work performed within the field of smart cities, where IT can have a great impact, it is important to study such impact and to prevent errors. Thus it can be considered that this research will serve human purposes.

Within this objective several methods could be chosen. Two methods are considered as being suitable to fit in the approach above mentioned. Design Science Research and Action Research.

The Action Research combines action and reflection, in participation with others towards the achievement of solutions to problems concerning to people and community (Reason and Bradbury, 2001). It allows a

researcher to reflect and after act, involves cycles of action, reflection, development of questions, review of actions and drawing on experiences, after which conclusions are achieved and new actions are set (Brydon-Miller *et al.,* 2003). It is an iterative process and deals with the notion that knowledge is built within a society, with mutual acceptance of norms and values (Avison *et al.,* 1999). It promotes human interaction and challenges social and political systems and practices. Action research addresses issues confronting people's knowledge and their communities (Brydon-Miller *et al.,* 2003). Researchers test, refine principles, tools or methodologies to solve real-world problems (Harrison and Callan, 2013) (Avison *et al.,* 1999). It advocates that theory is generated through practice, and theory it is only useful if put in the service of practice to solve social change (Brydon-Miller *et al.,* 2003). Therefore, can be considered that action research is concerned with social problems, with their understanding, challenging them and bring about change; thus a research approach fitting within a social critical theory paradigm.

A research based on Design Science also serves human purposes, and offers prescriptions, as well as it creates artefacts that embody such prescriptions (March and Smith, 1995). Additionally, Simon (Simon, 1996) defines design science as a body of knowledge about design of artificial objects and phenomena (i.e. artefacts) designed to meet certain desired goals. Since the purpose of this dissertation is the development of models, thus the production of artefacts, the research method chosen and considered to be adequate to drive the work forward and fulfil the research objectives is the Design Science Research (DSR). The reason for the choice of the Design Science Research is mostly due to schedule of the research work. Within a research conferring a Master of Science degree, the available time to produce results is limited. Action Research builds and actively tests inferred results, while involving the interested parties in the testing process. Due to the premise that practitioners and researchers test, modify and test again, in an iterative process (Harrison and Callan, 2013), without a defined number of iterations, this approach is considered not to be the best suited for this research work. The required time that is needed to actively develop a solution, reflect upon it, test it, validate, modify, test again, confer, and possibly re-start the cycle over again, is not available. Therefore, the following sub-chapters will present the DSR, as well as the relevance of the method for the research work, and identify the process to be used to conduct the research.

The DSR according to (Hevner, 2007) is standing, as a research method in the field of information systems, in equal footing to the natural science research. Nevertheless, it is significantly different from the natural science research in the goals it pursues, as stated by Simon. Science design attempts to create in order to serve human purposes, whereas natural sciences tries to understand reality (Simon, 1996). Hence, frameworks have appeared to support the DSR method, of which, the IS research framework

developed by Hevner. The framework consists of three research cycles, Relevance Cycle, Rigor Cycle and Design Cycle (Hevner, 2007).

The Relevance Cycle deals with the environment where the research takes place, people, organization and technical systems and the way they interact towards a goal. It is within this environment that opportunities or problems arise, initiating a need for research. It is in this cycle that the research results are evaluated (Hevner, 2007).

The Rigor Cycle provides necessary foundations on which to ground the work being developed (Hevner, 2007). It provides the past knowledge to the project, to ensure that it will innovate, as well as supplies references to guarantee that the contributions are relevant research.

The third cycle, the Design Cycle, is responsible for the research activities which iterate in the production of artefacts, their evaluations and refining upon feedback being received. The cycle is also used to evaluate different alternatives against requirements until the projected design is achieved (Simon, 1996).

Hevner also proposed a set of seven guidelines for IS research. The guidelines are as follow (Hevner *et al.,* 2004):

- **Guideline 1: Design as an Artefact –** the DSR method results in an artefact. The main results of this research are an extension of the PGR Approach and the definition of a business model, in the form of a canvas.
- **Guideline 2**: **Problem Relevance –** the objective of the DSR is to construct an artefact with enough relevance to change the phenomena it addresses. The relevance of the artefact or the research performed is to the community.
- **Guideline 3**: **Design Evaluation –** the artefact needs to be demonstrated, rigorously, by evaluation methods. The artefacts can be evaluated in terms of functionality, completeness, consistency, accuracy, performance, and reliability, usability, fit for purpose and/or others. In this case, the model to be developed should be evaluated against its performance, functionality, completeness, consistency and if it is fit for purpose.
- **Guideline 4: Research Contributions –** an effective DSR method application should contribute to increase the knowledge in the areas of artefact design, or evaluation. In this case, it is foreseen that the main contributions are a systematization of smart city maturity models taking into account design principles for maturity models; the definition of a new IT-based service to support increases in energy efficiency, aligned with smart city needs through a business model;

and the extension of the previously defined PGR Approach, to cater for different canvas as outputs.

- **Guideline 5: Research Rigor –** Application of rigorous methods in the construction and evaluation of the artefact. In the case of the research here addressed, the rigor shall be assessed with respect to the applicability of the model and its generalization. It is relevant to prove how well the developed model will work.
- **Guideline 6: Design as a Search Process –** The DSR is an iterative process, therefore aims at discovering an effective solution to the problem at hand. Solving the problem can be seen as the utilization of means at the disposal of the researcher to reach the ends, while satisfying the environment existing laws (Simon, 1996). In this case, the main problem is decomposed in several smaller objectives to be met in the path to reach the goal.
- **Guideline 7: Communication of the Research –** The DSR should be presented to the appropriate audiences. The communications should be detailed enough to allow reaping the benefits of the work done and expand the knowledge with further research in the area. In this case the research shall be communicated in appropriate forums, such as conferences and workshops, as well through the dissemination of the project results.

While the conducted research is framed by those cycles and following the stated guidelines, to ensure that there are no deviations from the proposed objectives; it follows also a process defined by (Peffers *et al.,* 2007). This allows keeping track of the required activities, while assuring quality, as well as the desired validity of the achieved results.

1.4.3 Research Process

The research process to be used within the DSR method is the one that has been proposed by (Peffers *et al.,* 2007).

Its approach is composed of six activities. These activities might not follow a sequential order, being dependent on the research context. In this case, the process starts with the first activity, since it is a problem-centred approach (Peffers *et al.,* 2007). Nevertheless, despite the sequence of activities shown below, as proposed by its author, during this research work, the communication activity occurred not only as the last activity, but also as intermediate activities, due to the submission of papers to different conferences in the IS field.

Activity one: Problem identification and motivation

This activity is straight forward and its main objective is to drive the research process. During this activity, the background knowledge from previous projects and works supported the identification of a problem, alignment of the IT created in a smart city context to its needs. This bridges two areas of research, Smart Cities and the problematic of business and IT alignment, creating an opportunity to further develop the integration of the two concepts.

Activity two: Objective identification for the solution

The objectives of the solution proposed should be defined following the definition of the problem. This activity is closely related to the previous one. While defining the problem, it is important to also define its resolution. That is what drives the research forward, finding answers. This is one of reasons which propelled the extension of the PGR Approach to consider a different canvas than the Business Model Canvas (BMC). The Lean Canvas (LC) (Maurya, 2012) is a business canvas that relies on the identification of a problem to define the solution and its added value. This activity, through the knowledge gathered up to this point, aims at defining achievable objectives, which will support the maintenance of the research direction.

Activity three: Design and development

This activity pertains the creation of the artefact, in this case in the form of a model. Through the literature review the main concepts should be reviewed and should be related. It creates the foundation to advance the knowledge (Webster and Watson, 2002), which is the aim of the research. Therefore, the design of the model shall be well grounded in what was learnt from previous works and research. The development of the model consider the best practices with concern to maturity models.

Activity four: Demonstration

It pertains to the demonstration of the model's performance. The objective is to assess if the model answers the problem defined in Activity one. This demonstration will take place within *SusCity* Project, currently underway, where the service design within this research will be used. It can be considered that the outcome of this research, the business model will be applied and help a real context and environment.

Activity five: Evaluation

Evolves the comparison of the objectives defined for the solution, with the observed results from the previous activity. This activity involves the possibility of starting an iterative process, should

the model not fit the desired solution. In that situation, the steps re-commence at Activity three, in order to change the model and submit it to a new demonstration.

Activity six: Communication

This activity pertains to the communication of the problem and the importance of the artefact developed to its resolution. The communication activity within this research will occur in two ways. Through the disseminations that will occur throughout the *Suscity* Project dissemination activities. Additionally different parts of the research work have been published and presented in one Information Systems conference, ITAIS2016, and has been submitted to an additional conference in the field, IESS 2017.

The process here described interacts with the cycles proposed by (Hevner, 2007) in the following way.

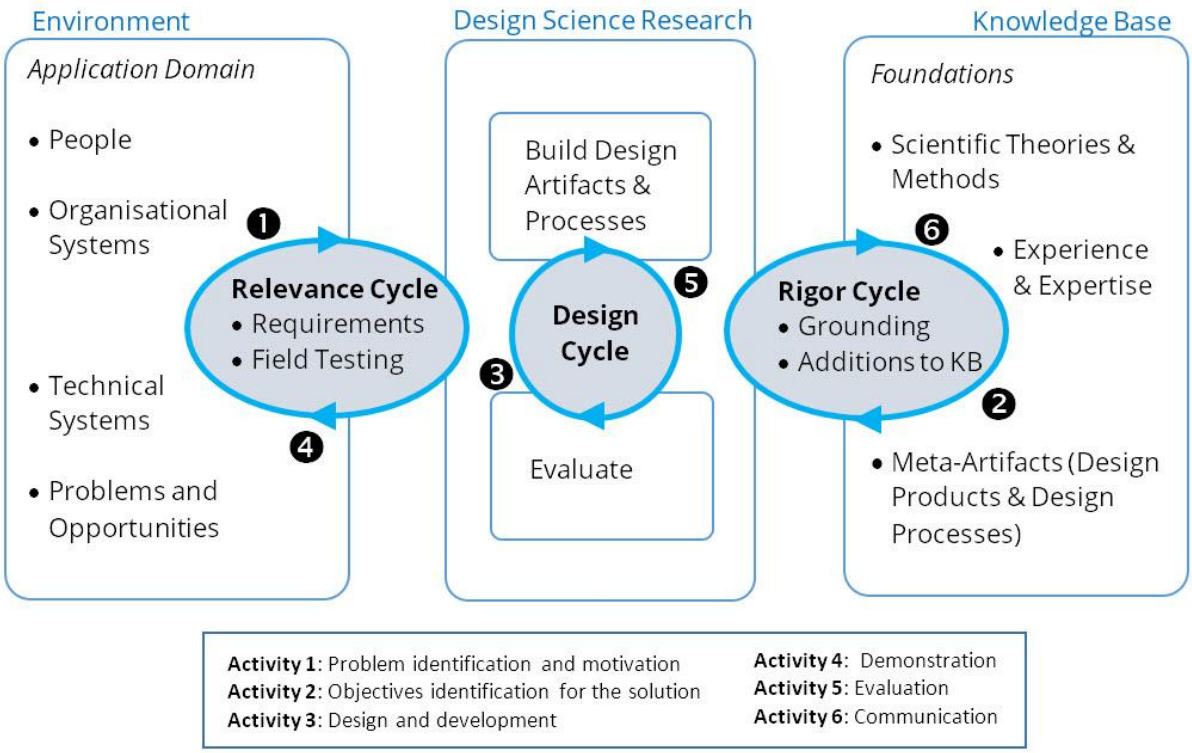

Figure 2: Interaction between Hevner Cycles and Peffers Activities (Adapted from (Hevner, 2007))

Moreover, the research process has been integrated in this research to allow a better perception of the path that was followed, as well as to make a sense of the interrelation of all the domains focused in this research work. Figure 3 depicts the research flow.

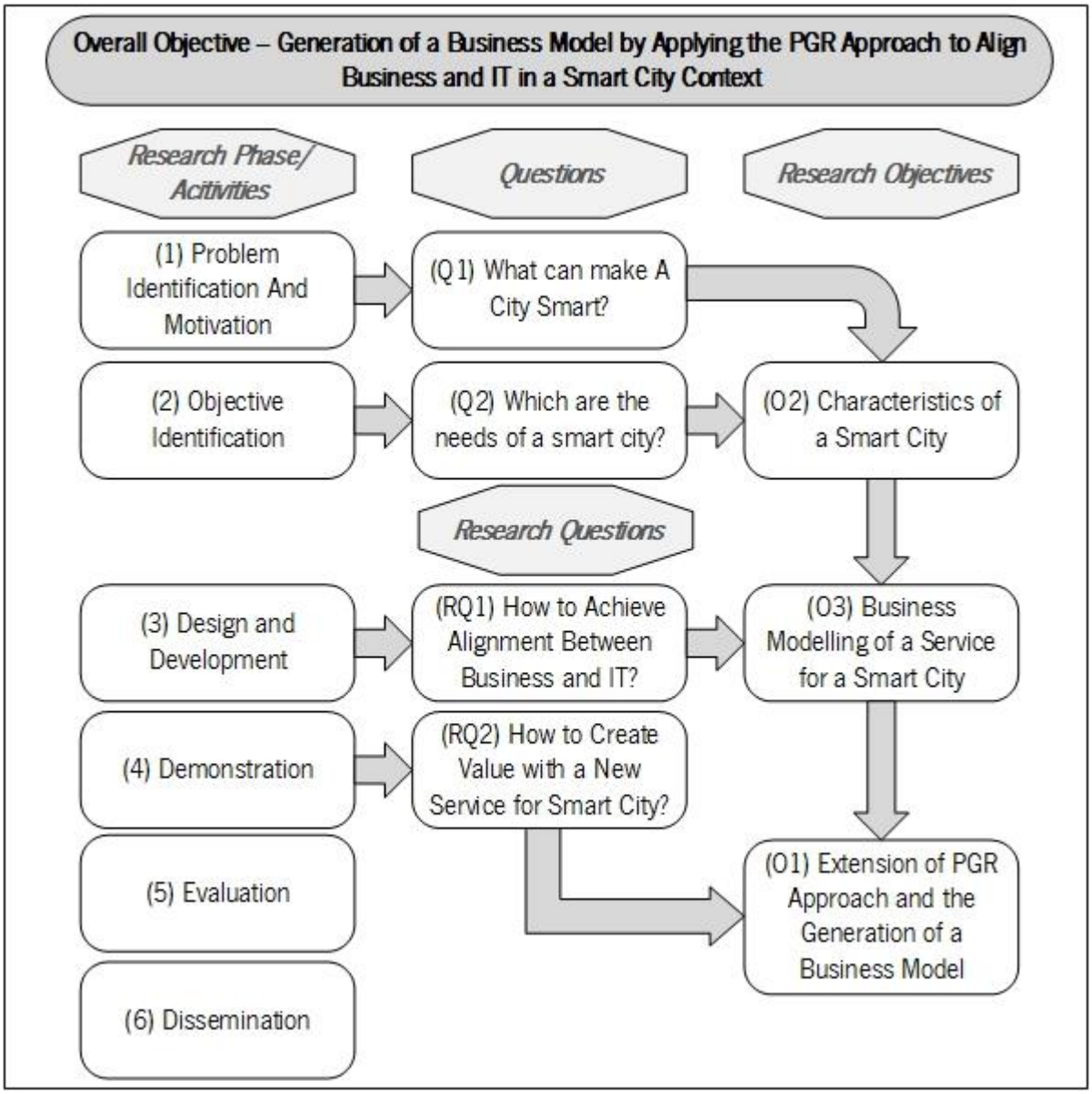

Figure 3: Integration of the research process with the research questions and objectives

1.5 Document Structure

This document is divided in five chapters. The first introduces the context and addresses the motivation and the objectives of this research. The second chapter reports the undergone research, and introduces the main concepts object of the performed work, smart city, business and IT alignment, requirements engineering and business models. Regarding the third chapter, maturity models for smart cities are analysed and a retrofitting auction services is conceived, including its requirements and service modelling. The fourth chapter presents the application of the PGR approach and the generation of a business model of the conceived service. The fifth and last chapter refers to the conclusions of the research work developed and explains future work to be continued.

The figure below depicts an interconnection between the document chapters, the questions raised and objectives to be achieved.

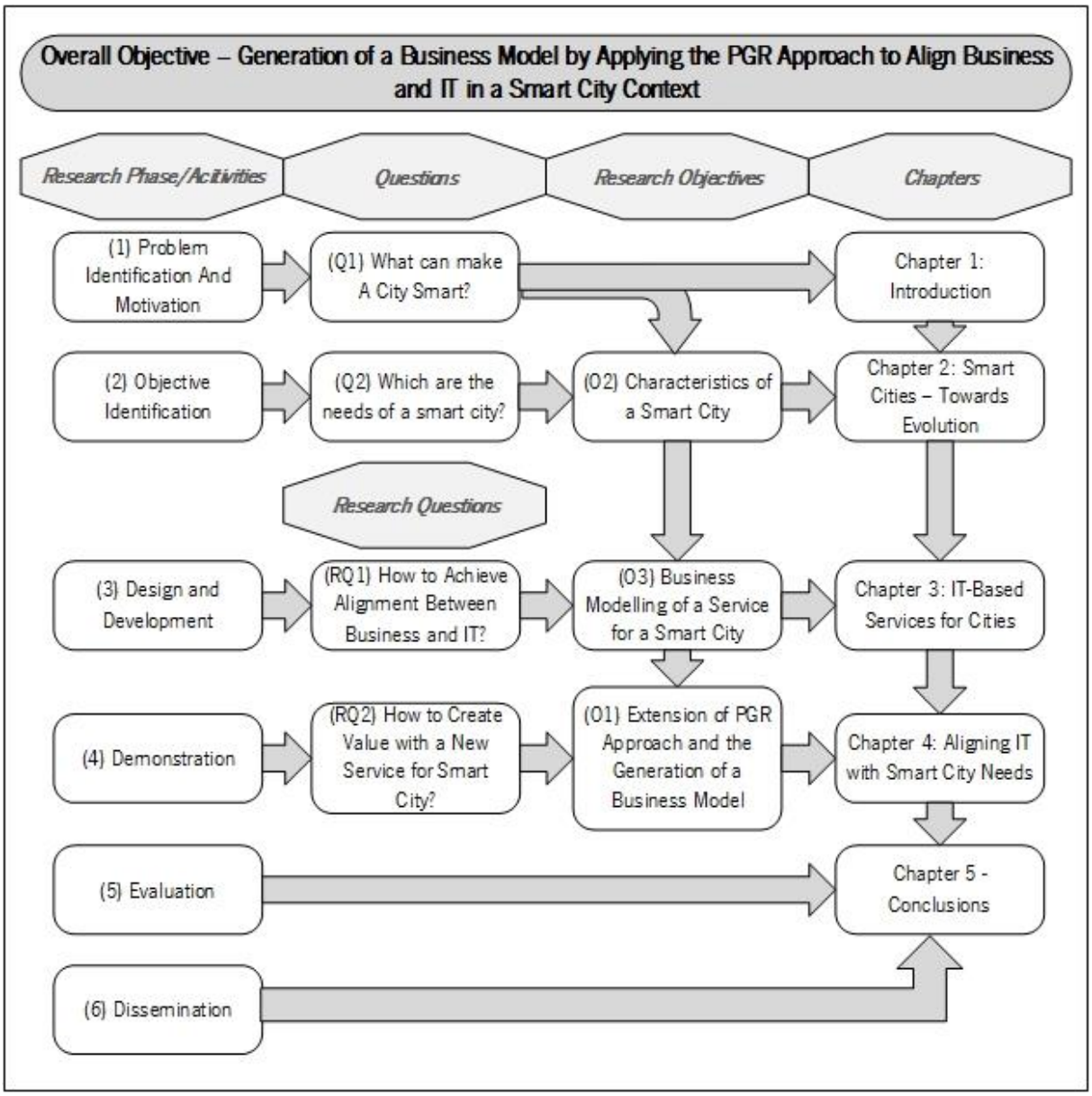

Figure 4: Illustration of the document structure and concept relationship

2. SMART CITIES – TOWARDS EVOLUTION

This chapter objective is to report the research performed, through literature review, of the main concepts relevant to the present work. At the same time it also aims at more clearly define the intent of the work performed.

Chapter Contents

2.1 Introduction

The research performed was based on a literature review, to understand the smart city domain, as well as the problematic of aligning business and IT. Moreover, the requirements engineering domain was addressed, since this work proposed the definition of new IT services to be made available within the *SusCity* Project. The following databases were used to perform the review: Google Scholar and B-On[3], additionally, to provide a broader scope, the search engine Google, was used. This allowed the retrieval of reports not always present in scientific databases.

To target the most relevant results for the purpose of the research, the concepts used during the searches were "smart city", "smart city paradigms", "smart city models", "business and IT alignment", "alignment of business with IT", "requirements engineering activities", "goal oriented requirements engineering", and "business models".

The smart city field of research is complex, since it does not deal with only one domain of knowledge but different domains, all interrelated. The purpose of having raised what was designed as the first objective of this research work, was to understand the concept of smart city by identifying important characteristics that a smart city has. Therefore, this chapter provides a review of the most important frameworks for smart cities, which consider a city as a multidisciplinary domain, with very different dimensions. The focus of the review of each framework was the understanding of what a smart city is, what it should be comprised of, whom are the main stakeholders, as well as its concerns.

Moreover it was also important to understand how to better serve a city with ICT, since the overall objective of the research work is to define business models for IT-based service for smart city. Being an IT-based service there is a need to assure that there is an alignment between the interests of the IT world, and the interests of the business world, the city needs. This chapter therefore, also has the objective of providing an overview of what is the business and IT alignment, and which frameworks or models can be used to achieve it. This alignment review was made because the focus of the research was the application of a framework to deal with that alignment. An understanding of the difference between the frameworks was undertaken to ascertain if the chosen framework could comply with the objectives at hand.

Its application is subject to a set of requirements that need to be overcome, the identification of business goals and rules of the service. This has a brought a new domain of intervention to the research activity,

[3] http://www.b-on.pt/ - an institutional database allowing research centers and universities unlimited access to a number of international scientific journals, thesis and e-books.

the requirements engineering domain. To infer the goals and rules that would allow the alignment and the definition of a business model for the new IT-based service, modelling of the service was required. This chapter has therefore, an additional duty of communicating the most important aspects of the requirements engineering domain, as well as introducing an overview of the importance of business models and their purpose.

To summarise, this chapter will be initiated with an overview of which are the main characteristics of smart cities. This knowledge supports the understanding of how can IT be better aligned with the city needs, which brings the reader to the topic of the existing frameworks of business and IT alignment. To apply the PGR Approach the author also needed to understand its requirements, therefore the final part of the chapter served the purpose of providing an important knowledge of requirements engineering and business models.

The main objective of this review of concepts was allowing the definition of a mind structure, which supported the writing of this research document, as well as providing the foundations that allowed the production of the remaining chapters, the integration of ICT in a city, leading to the definition of a new service for a smart city, and the alignment of IT to the business needs of that service.

2.2 Smart City Concepts and Paradigms

The smart city concept has been defined in numerous ways, and consensus is not always easy to be reached (Hollands, 2008). For the purpose of this document smart city is defined as the concept for the cities of the future. These are economically sustainable and evolved with the purpose of promoting increased life standards for its inhabitants, while environmentally friendly. It is a multidisciplinary domain, bridging together different knowledge areas and competences to achieve development. While at its core being supported by an ICT infrastructure and services, smart cities are strongly linked with efficient energy consumption, logistics and mobility, human capital and society, renewable resources consumption and economic growth. Moreover, they are supported by a strong sense of governance with citizen participation as an engine for a sustainable development.

It is argued that to evolve towards a city that is considered smart, nowadays cities need not only to understand how they can be supported by ICT. They also need to understand that ICT is not an end, but a means to achieve smartness (Hollands, 2008). It is important to define action plans to help monitoring the implementation of initiatives, as well as to measure the expected outcomes and benefits from the

initiatives. Cities will achieve a sustainable development, improving quality of life of citizens, if both citizens' needs are understood, as well as the city needs (Neirotti *et al.,* 2014). The need is an expression (of desire or wish) of something that is at a certain point in time deemed necessary. It lacks focus, specificity and measurability For that reason it is necessary to define requirements that describe functionalities or expected results, which the outputs when achieved will satisfy the expressed need (ISO/IEC JTC1 Information Technology, 2015).

Each city has an envisioned evolutionary paradigm (Neirotti *et al.,* 2014). Cities are different, thus their governance demands evolution designs towards the city of the future based on the current reality; and on which paradigm the city will achieve. Whether the city will focus its evolution on ICT, or have ICT supporting the evolution and be focused on smart communities (Hollands, 2008); or if the city will be carbon free by a given year, or be the most heavily industrialized city in the region; those are different paradigms that need to be taken into account.

Regardless of the different paradigms that can be chosen for a smart city, the literature points us to different characteristics that a smart city should have. The following subchapters provide a summarised overview of different perspectives.

2.2.1 BSI

The British Standards Institution (BSI) is a United Kingdom standardisation institute supporting development of standards country wide or internationally in industry or management standards. As a standardisation institute part their current activities is the development of new standards. The Smart City domain since it is new, and non-standardised, was also a target for the BSI.

The institute has published a framework for management of smart cities defining good practices for city evolution and strategy support (PAS181:2014, 2014). The framework, in the form of a report, defines the guiding principles that cities should follow and accomplish. The authors consider that cities should have a vision, be centred in citizens, be digital and collaborative. Moreover, BSI also defined a cross-city governance and delivery processes. They consider important the definition of a city vision, as well as operating models, which should focus on the citizens and business and not only on the organizational structure. Leadership and governance should be set up, as well as assurance of stakeholder collaboration. The procurement requirements should also be well defined and the interoperability and resource needs mapped into matrices. Roadmaps to assist service implementation and prioritization of actions, reference models and empowering stakeholder and city-led service transformation are also part of the governance

guidelines. On the ICT domain they define the needs for identity and privacy management, digital inclusion and service delivery channels, and additionally an open and service oriented city-wide architecture (PAS181:2014, 2014).

2.2.2 The Triple Helix Model

The Triple Helix Model, developed during the 90s as a relation between university, industry and government (three helixes), has also been applied to the context of smart cities (Lombardi *et al.,* 2011). The triple helix is a governance model that analyses the role between the interactions of the main helixes towards boosting innovation in a nation (Etzkowitz and Leydesdorff, 1995). The model was extended to the smart cities context, considering the helixes as the drivers to the city development. The proposed advanced triple helix model for smart cities also added an unifying factor, the local market and contour conditions, which enabled cities to create, diffuse and use new knowledge (Lombardi *et al.,* 2011). The market addition to the equation brought forth new dimensions such as, market governance, citizens' involvement, cultural and social capital endowments, which the authors considered as shaping factors to the relationship between the three helixes.

In a subsequent paper, the authors recognized that environmental sustainability was not taken into account in the governance model for smart cities (Lombardi *et al.,* 2012). The same claim about the importance of environment for the concept of smart cities is made by the International Electrotechnical Commission (IEC) in a report, addressing that the development of a city is related to the sustainability in the economy, society and environment (IEC WP Smart Cities:2014-11(en), 2014). The acknowledgement of several domains related to the concept of smart cities, resulted in the addition of a fourth helix to the advanced triple helix mode, the civil society. The revised model proposes that in an urban environment, civic involvement shape the relationship between government, industry and university (Lombardi *et al.,* 2012). The operationalization of the model linked it with the main characteristics of smart cities, as considered by the European Smart Cities benchmark[4].

[4] http://www.smart-cities.eu/

2.2.3 Smart City Infrastructure

IEC is an organisation having as main business the preparation and publication of international standards for electric and electronic related technologies. These standards are achieved from the consensus of key-stakeholders of every participating country in the IEC work. The broad dimension scope of a smart city includes all the city physical infrastructure, of which is part electrical, renewable, wind energy, lighting, sensors, wirings, heating and cooling infrastructures, to name a few, all within the domain of electronic technologies.

In a report prepared by the Smart City Project Team of IEC (IEC WP Smart Cities:2014-11(en), 2014), they proposed guidelines to set up the infrastructure of a city. The main aim of the report is answering the "what", "how" and "who" questions related to the smart city development. They consider that a smart city is not only the playground for the technology provision, but instead should be an environment where smart city solutions would be prone to appear.

That environment should be composed by the society, an important part of the development and evolution of a city, together with economy and environment. They argue that economic sustainability is the engine for wealth generation, and that all citizens need to have access to the basic services. Social exclusion should be avoided, and healthy living fostered, making a city sustainable for both the society and environment. Those pillars are chosen because all cities share those three common sustainability objectives. However, different cities have different challenges that they need to overcome, thus there is no specific path or formula to achieve the desired paradigm (Neirotti *et al.,* 2014).

Nevertheless, the report considers that it is important for a city to have the ability to transform and replace its infrastructures, taking into account the needs of its citizens and vision of the city. The ICT supports the evolution towards a smart city, due to the interoperability solutions made possible, enables faster and more reliable decision making, and more competitive solutions. To achieve that interoperable environment, cities need to be horizontally and vertically integrated. In other words, the different city systems, from public services, to infrastructure or residential buildings need to be communicating and exchanging data, a horizontal integration; concurrently a vertical integration needs also to happen. Top-down and bottom-up approaches to information flow need to be in place, to involve city decision makers, key industry stakeholders and citizens Consideration should thus be given to the involvement of different stakeholder to support the city evolution and development, in the context of smart cities (IEC WP Smart Cities:2014-11(en), 2014).

2.2.4 Cisco Vision of a Smart City

Cisco is an IT company providing communication, network and security, among other solutions. As a smart city is a communication and security infrastructure dependent, and CISCO providing solutions in that area, they released their vision of a smart city in a report. To plan the evolution of a smart city, they considered pertinent to understand how a city operates, which the main objectives are and what the role of ICT is. Moreover a decision makers should also be able to answer three questions (Falconer and Mitchell, 2012):

- Why is a Smart City initiative good for a city?
- What should we do? (Which solutions to deploy, actions to take and which projects and initiatives are crucial)
- How do we implement solutions?

While the Cisco framework answers the "*how"* question and academy generally studies the "*why"* (Falconer and Mitchell, 2012), different frameworks are able to answer the *what*, by proposing roadmaps, monitoring tools or guiding decision makers and city leaders on what to do. The different reports analysed within this chapter provide some insights to what. Moreover, maturity models, analysed in the following chapter, are also able to provide an answer to "*what*?" Nonetheless all three questions are managed within the governance of a smart city.

The *"why"* results from the needs of business and citizens within the city, the "*what"* and the "*how"* can be solved through the application of tools and frameworks. The framework proposed by CISCO is composed of four layers. The first recommends that city should define objectives for each of its dimensions, economic, social and environmental. Indicators and measures should then be define for each dimension. A third layer deals with smart city initiatives and the understanding of requirements, forming the components layer. The last layer is comprised of the best practises in domain, identification of similar solutions that were deployed and understand them to foster a successful implementation (Falconer and Mitchell, 2012).

A maturity model applied to the smart city context can also support the answering of "*what"*. A maturity model when defined by the Software Engineering Institute had has main objective to support organizations attaining better quality in the services they provided (CMU/SEI-2006-TR-008, 2010). By providing guidance and mapping processes for improvement, as well as setting goals to be achieved, a maturity model can answer the "*why"*. It sets a framework for leaders to assess, benchmark and define priorities for

investments in a city. Part of the work performed within this research focused on the analysis of maturity models for smart city. The next chapter provides that overview.

2.2.5 ITU

The International Telecommunication Union (ITU) is one entity composed of several institutions from different countries forming a specialised agency in the field of telecommunications and information technologies.

This agency has created one focus group dedicated to smart cities, the Focus Group on Smart and Sustainable Cities. The focus group is responsible for studying and contributing to the definition of practises and standardisation of activities in the smart city domain. Through a series of different reports in the domain they define and characterise what a smart city is, provide guidance and recommend roadmaps and frameworks to transform a city into smart city, as well as, explain the importance of smart cities in today's world.

In (Focus Group on Smart Sustainable Cities – WG1, 2014) the authors define that a smart city should be sustained in four pillars: Economy, Governance, Environment and Society. These four pillars are seen as basilar due to theirs aspects. The ability that has city should have to generate income and employment conditions, thrive, is the focus of the economy pillar. Ensuring well-being is the focus of the society and social pillar, as the city is for the inhabitants. The environment is important because a smart city should be environmentally friendly, and rationalise resource consumption, allowing a steady rate of renewal of its resources, and provide for future generations. The governance aspect to maintain the social cohesion and ensure stability, democracy and justice to all citizens (Focus Group on Smart Sustainable Cities – WG3, 2015).

Within these pillars are dimensions of a city, which are composed of attributes, having those a series of components that should be measured. The dimensions are (1) environment and sustainability, (2) city level services and (3) quality of life. The environmental sustainability is deemed critical since cities are responsible for 75% of the energy consumption and 80% of the CO2 emissions (Focus Group on Smart Sustainable Cities – WG1, 2014). The city level services are comprised of the technology and infrastructure of the city as well as its governance and economy. The quality of life is very much related to the previous dimensions, and refers to the perception of citizens of their own well-being, and represents the basic needs of citizens that need to be fulfilled.

While ITU considers that ICT is of paramount importance to a city development and evolution towards being smart, they should be considered as enablers and means to reach smartness and to be the drivers

(Focus Group on Smart Sustainable Cities – WG1, 2014). As a digital infrastructure, the ICT provides the means to facilitate an efficient operation of the city by aggregating information, analysing and exchanging data from various services and city infrastructure to optimise decision making. A city is therefore smart, not if is technologically advanced, but if it can manage its resources efficiently, providing a cleaner environment for its inhabitants and deliver better quality of life to its citizens by a smarter governance, being at the core of all the infrastructural elements of the city and acts as the nerve centre (Focus Group on Smart Sustainable Cities – WG1, 2014).

ITU also suggested a roadmap for a city leader, defining it as the master plan. The plan supports the development of the city taking into account the identified pillars and is divided in four phases (Focus Group on Smart Sustainable Cities, 2015). (1) Phase one requires municipalities and cities to gather knowledge of their strengths and weaknesses, so opportunities and challenges can be identified and projects initiated. (2) Phase two is the strategic intent and planning for the city. Requires the definition of a vision, identification of key stakeholders and civic participation and agreement on priorities. (3) Phase three deals with the action plan, it identifies which initiatives should be developed and how will the ICT support the city smartness. In this phase city services (such as waste, energy, water, etc.) should also be integrated in the overall city planning, thus reaching a horizontal integration. The technology needed to support, integrate and articulate with the city development is within this phase identified. (4) Phase four is related to the governance plan of the city, the monitoring tools and system to evaluate performance, hence the definition of KPI for the different dimensions and the financing modalities that the city will choose to facilitate the implementation of initiatives.

2.3 Business and IT Alignment for Cities

The issue of business and IT alignment is ever present in the minds of every organization dealing with information systems and information technologies. The city, as an aggregate of different institutions, people and governing processes, which uses information systems, also needs to deal with the business and IT alignment.

The business and IT alignment is the concept used to address the way an organization align its investments in IS and IT to support the strategy and goals of the business (Silvius, 2009). It is an important concept because it affects both the agility and the flexibility of organizations, their efficiency, effectiveness, costs and performance (Carvalho and Sousa, 2008). The concept has been around for decades, having

had its first incursions in the 70s, when the literature started addressing the need for managing information systems, considering long term planning of information systems and the strategic fit in the organization (Mclean and Soden, 1976).

Guides and approaches have been published and proposed to support organizations with short and long term planning of the implementation of information systems, and thus assessment of needs and maximization of their potential and service to the organization goals (IBM, 1981).

Different enablers, or critical success factors, have also been identified, such as management support for IT, IT being involved in strategy definition, IT understanding the business, well prioritized IT projects (Luftman and Brier, 1999). Nevertheless the misalignment was also object of studies. Misalignment can be seen as factors that organizations suffer during their business as usual, preventing reaching a full potential. The Business and Information System Misalignment Model - BISMAN (Carvalho and Sousa, 2008) proposed a misalignment conceptualization. By combining the misalignment and with the medical sciences approach, the promoted the closing of an existing gap in models related to business and IT/IS alignment. Organisations could understand how the alignment occurred, but could not contribute to the identification and correction of the misalignments. The BISMAN proposes a classification of concepts that will support the management of misalignment, thus proposing a nomenclature for the area. The classification was made via the architectural system it affected, the misalignment symptoms and its effects or aetiology. The management of misalignment was achieved through the relationship between the affected system, its symptom and effect, enabling the understanding of should be changed (Carvalho and Sousa, 2008).

Moreover, (Amaral, 2005) also states that the management of information systems is not always a role performed by someone who can conduct the adoption of IT in an organization, thus able to deal with the business and IT alignment. Such a role, the manager of information systems, should comprise a set of activities to ensure the proper fit of IT in the organization and its strategy: (1) the planning of information systems; (2) the development of information systems and (3) the exploration of the information systems (Carvalho and Amaral, 1993).

The alignment of business and IT is also an object of the definition of different support models. The first works that were translated into a model that supported the business and IT alignment was the Strategic Alignment Model (SAM) proposed by (Henderson and Venkatraman, 1990). The model considers that a strategic alignment is based on the strategic fit and functional integration in an organization.

2.3.1 Strategic Alignment Model

The SAM considers both the internal and external domain of an organization. While the external domain relates to the environment in which an organization operates and competes, the internal domain pertains to the management and administrative logics of the organization. The authors argue that the IT domain and strategy is equally important as the business domain in the external and internal strategic fit of an organization. From then onwards they propose the model which suggests the need for alignment of the internal and external domain of IT, as well as the integration of business and IT in the organization. Therefore, the authors suggest a strategic fit between internal and external domain, both for the business and IT, as well a functional integration, between business and IT. Figure 5 illustrates the dynamic of the model.

This model is a conceptual representation of the linkages between business and IT, treating IT from an organizational high-level perspective and not detailing system requirements. Therefore, new models have been proposed, taking requirements into account. One of such models is the goal modelling towards the alignment of organizational strategy with IT requirements (Bleistein *et al.,* 2006).

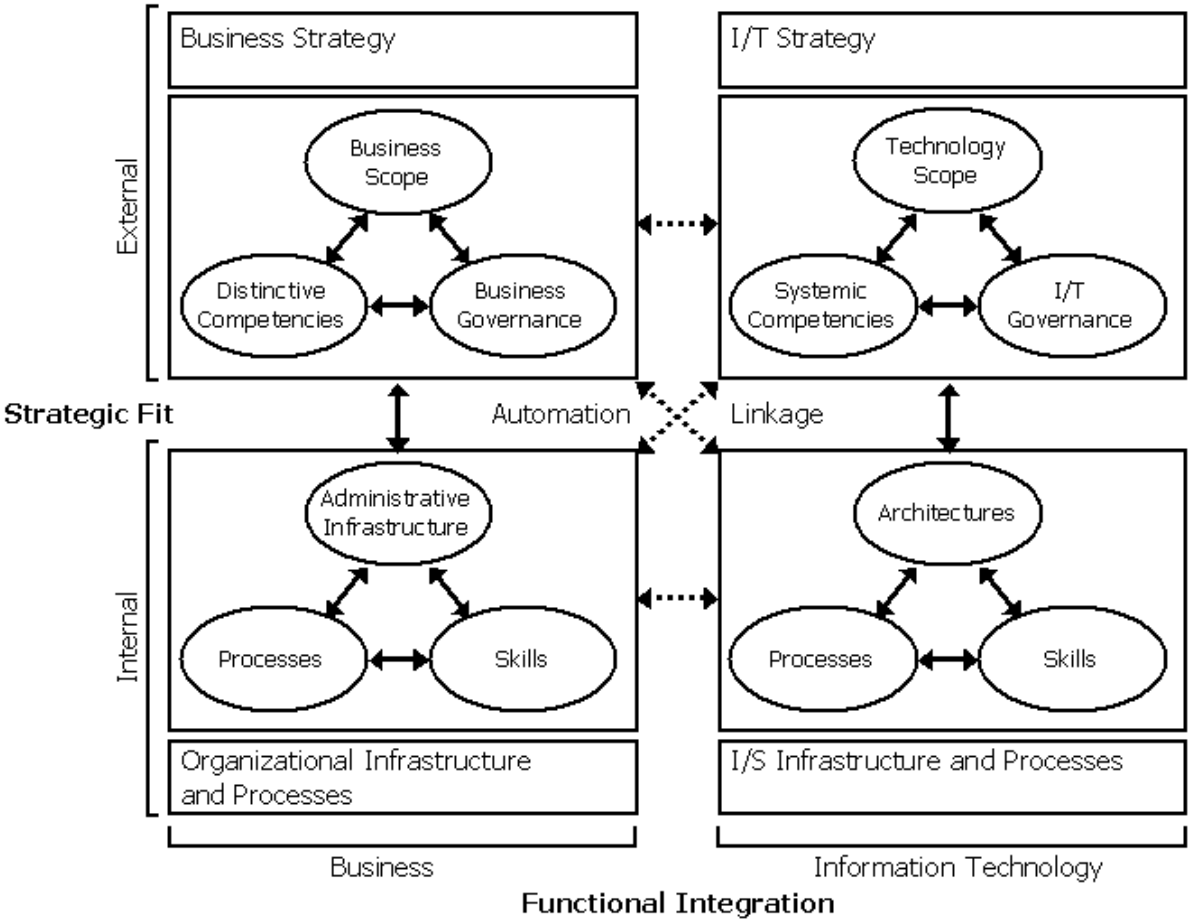

Figure 5: Illustration of the Strategic Alignment Model (Source: (Henderson and Venkatraman, 1990))

2.3.2 Goal Modelling and Alignment

The authors argue that problem diagrams can represent organization's business strategy and analyse requirements (Bleistein *et al.,* 2006). These diagrams transform business strategy in systems requirements by considering the process domain context analysis and the requirements analysis. The decomposition of the domain context refines into requirements, progressing to lower levels of abstraction. However, to ensure traceability between of the requirements to the business they opt to make use of goal modelling. Therefore, into the equation is added the VMOST analysis and the BRG-Model[5], which gave way to the Business Motivation Model (BMM)[6]. Whereas the VMOST analysis enables decomposition of business strategy into vision, mission, goals, strategy, objectives and tactics, the BMM supports an organization model its systems to align with the business motivation. The BMM describes different rules by which an organization relates business components towards reaching goals (ends), taking into account mission, strategy and tactics (means). By analysing the business with the VMOST analysis and constructing a goal model based on the BMM taking into account the business, the authors arrive at a requirements engineering framework. Figure 6 provides an illustration of the model, where the different depicted goals are retrieved from the VMOST analysis.

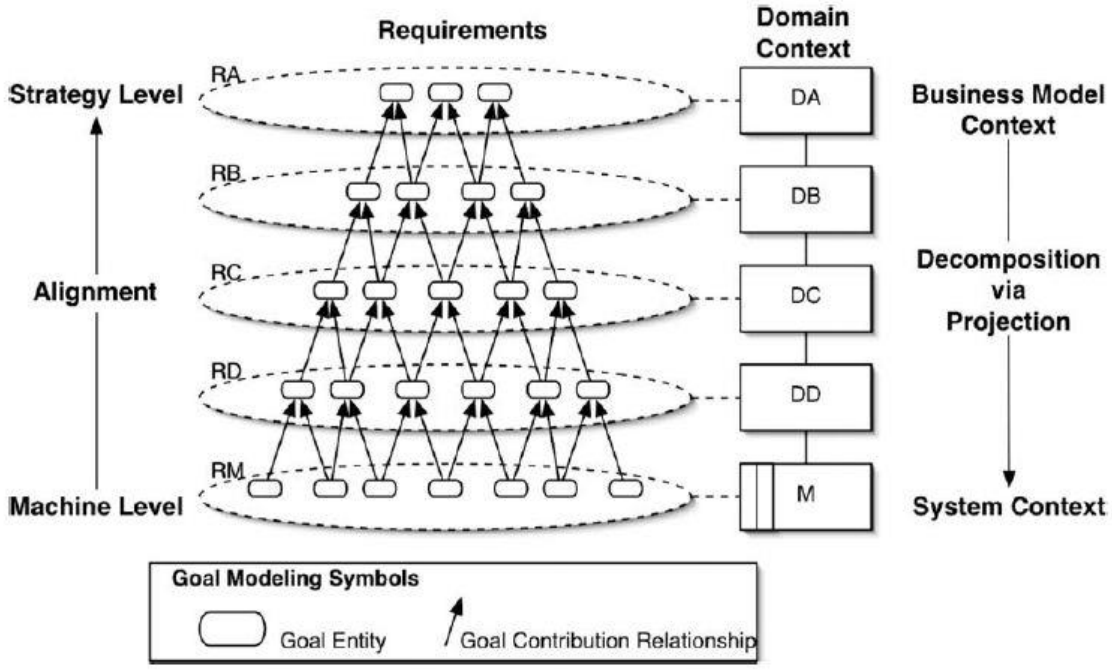

Figure 6: Integration of goals model with problem diagrams (source: (Bleistein *et al.,* 2006))

[5] http://www.businessrulesgroup.org/bmm.shtml
[6] http://www.omg.org/spec/BMM/1.3/

The authors consider that the framework does not allow for a straightforward modelling of business strategy with goals, finding that steps had to be repeated several times. Moreover they also agree that the framework fails to address changing requirements (Bleistein *et al.,* 2006). Additionally the relationship of the VMOST analysis and the BMM is not always possible, so different means of eliciting the organization motivation may be needed. Nevertheless, the framework proposes a different a different way of modelling requirements when compared to the use of Unified Modelling Language (UML)[7].

A different model, which also used goal based requirements elicitation to promote alignment of business and IT, takes into account the change of business goals and objectives (Azmat and Richard, 2011).

2.3.3 Business Goals-Driven Alignment

The authors of this framework developed a business goal-driven approach to elicit requirements, to align business and IT. It was proposed by (Azmat and Richard, 2011) and is divided in two stages. The first stage pertains to the modelling of the business environment (including strategy and infrastructure). The second stage deals with the modelling of the IT environment, using Business Process Model and Notation (BPMN)[8], the business goals analysis and extraction of systems requirements from business goals via UML.

The business environment modelling is based on the SAM. To model the infrastructure to link business goals and objectives, BPMN is used. Moreover, and to support the modelling of the IT infrastructure, goals are extracted from the business process and are analysed. A goal tree diagram is used for that effect, and system requirements are obtained. If tasks or goals are not able to be automated by the IT, they need to be marked for manual performance, and are subsequently removed from the goal tree diagram. After the diagram is finished, it is converted into UML state charts (Figure 7).

[7] http://www.uml.org/

[8] http://www.omg.org/spec/BPMN/2.0.2/

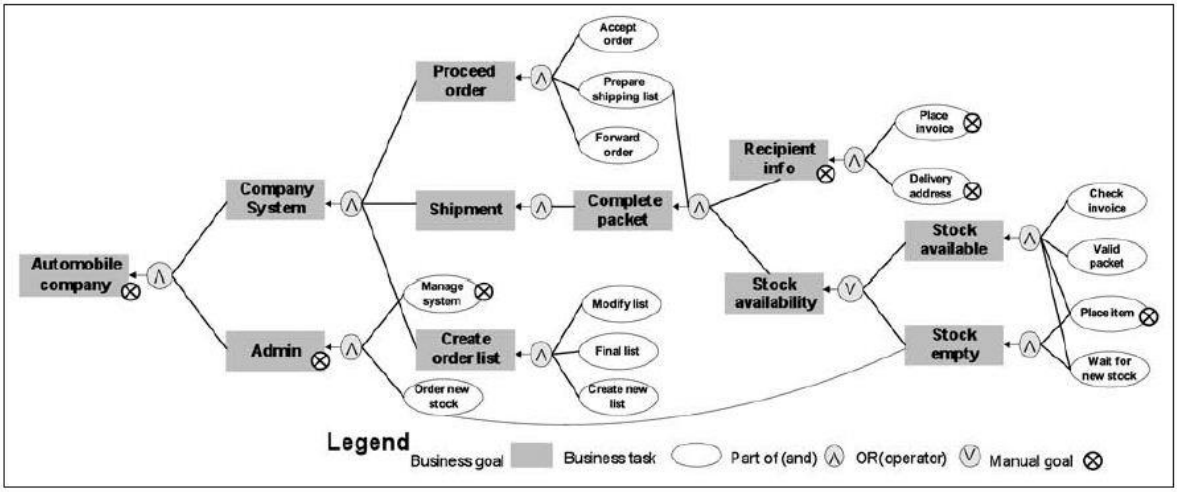

Figure 7: Finished Goal-Tree Diagram with manual tasks marked (source: (Azmat and Richard 2011))

The requirements generation phase is therefore accomplished by the use of UML. The use of UML allows the analyst to modify any requirement package at any stage if ambiguity exists. The state charts will depict business goals and the behaviour of the system, supporting the business and IT alignment (Azmat and Richard, 2011).

2.3.4 Goal and Business Modelling for Alignment

(Andersson *et al.,* 2009) proposed a method with the aim of ensuring that identified services are aligned with goals of an enterprise. Two domains of application were proposed, the identification of new innovative services and ensuring that the improvements are explored, and to be able to trace actions to top level goals (Andersson *et al.,* 2009). The method is comprised of four steps from which different models are constructed (Figure 8), as well as, three modelling concepts. The modelling concepts are (Andersson *et al.,* 2009): (1) actors – business roles that have goals; (2) goals – desired business state an actor wants to reach or maintain; (3) means – a task that can be used to reach the goal. The four steps are (Andersson *et al.,* 2009): (1) Strategic goal modelling – elicits information from the domain in order to arrive at goals and means for each actor, and thus deriving the goal model; (2) Goal-aligned business model – the business model is constructed based on the strategic goals, rules for goal to business model transformation and a chosen business model technique; (3) Top level service identification – by narrowing the business models to one actor and the resources transfer from and to it, services are identified for each transfer; (4) Low level service identification – the top level services are refined. Each service is associated with quality attributes and give rise to a goal; the goal is how the service should be performed according to the quality attribute. The goals are decomposed until means are identified and each mean becomes a service.

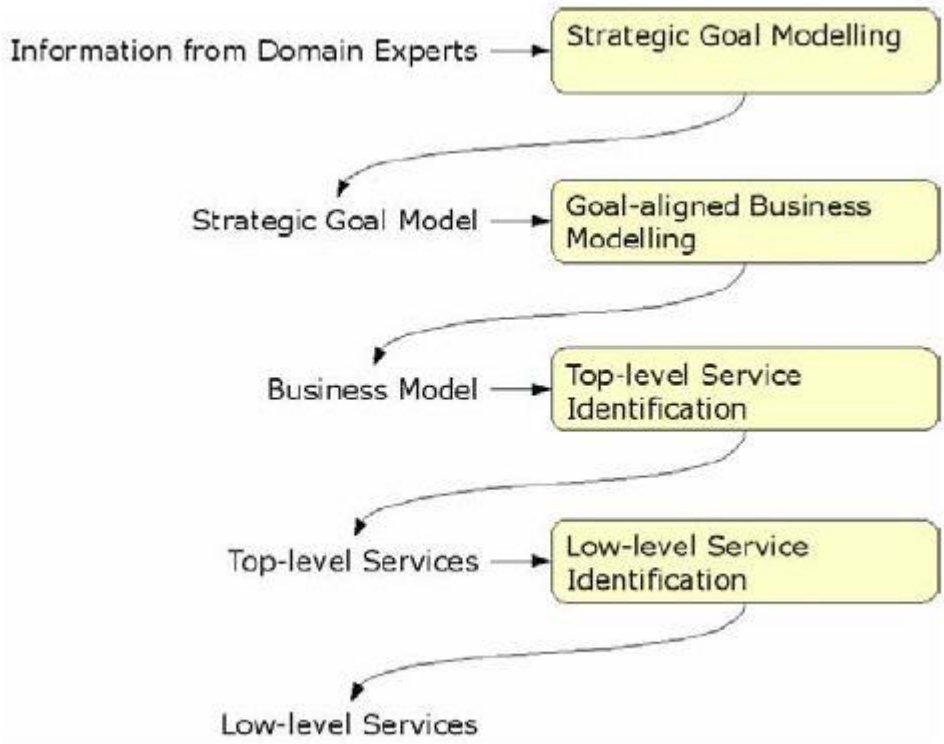

Figure 8: The 4 steps of the method (source: (Andersson *et al.,* 2009))

2.3.5 The PGR Approach

(Salgado *et al.,* 2014b) proposed a two-step (Figure 9) method to accomplish the alignment between business and IT, based on the combination of two different models and through the generation of a Business Canvas. Following guidance from the Rational Unified Process (RUP)[9] and the BMM the authors use three concepts to reach the alignment, namely Business Use Cases, Business Goals and Business Rules (Salgado *et al.,* 2014a). From BMM, the main idea is to define Means and Ends of a business plan in order to build a business model (Salgado *et al.,* 2014b). Through the use of BMM it is also possible to connect Rules directly to Processes, whereas the Goals are connected indirectly to Processes via an organization unit. Accordingly, the RUP guidelines state that from a Use Case scenario information, Goals and Rules can be obtained, where some heuristics apply, as for instance at least one Goal should exist for each Use Case (Salgado *et al.,* 2014a). Additionally, the importance of identifying business rules is to improve traceability and therefore to incorporate evolutions in software when business environment changes (Salgado *et al.,* 2014b). The refinement of Use Cases to include new goals, strategy and policies from the organization can be achieved by raising "How" and "Why" questions. Moreover, Mission and

[9] https://www.ibm.com/developerworks/rational/library/content/03July/1000/1251/1251_bestpractices_TP026B.pdf

Vision for an information system, can be inferred, by further abstracting goals and rules from the defined Use Case. Therefore the PGR (Process, Goals and Rules) from a business organization plan can be elicited (Salgado *et al.,* 2014b). On the other hand, the Balanced Scorecard (BSC)[10] technique can also be used to classify corporate goals and identify business rules, as it supports their classification when considering financial, customer, internal process and lean/growth perspectives (Salgado *et al.,* 2014b). A second step of the model pertains the generation of a BMC by performing a mapping from the BSC perspectives to the different canvas sections. Each elicitation done previously is now attempted to map into, at least, one of nine sections of the canvas. The method was named the PGR Approach, derived from the relation of Process-level Use Case, Business Goals and Rules.

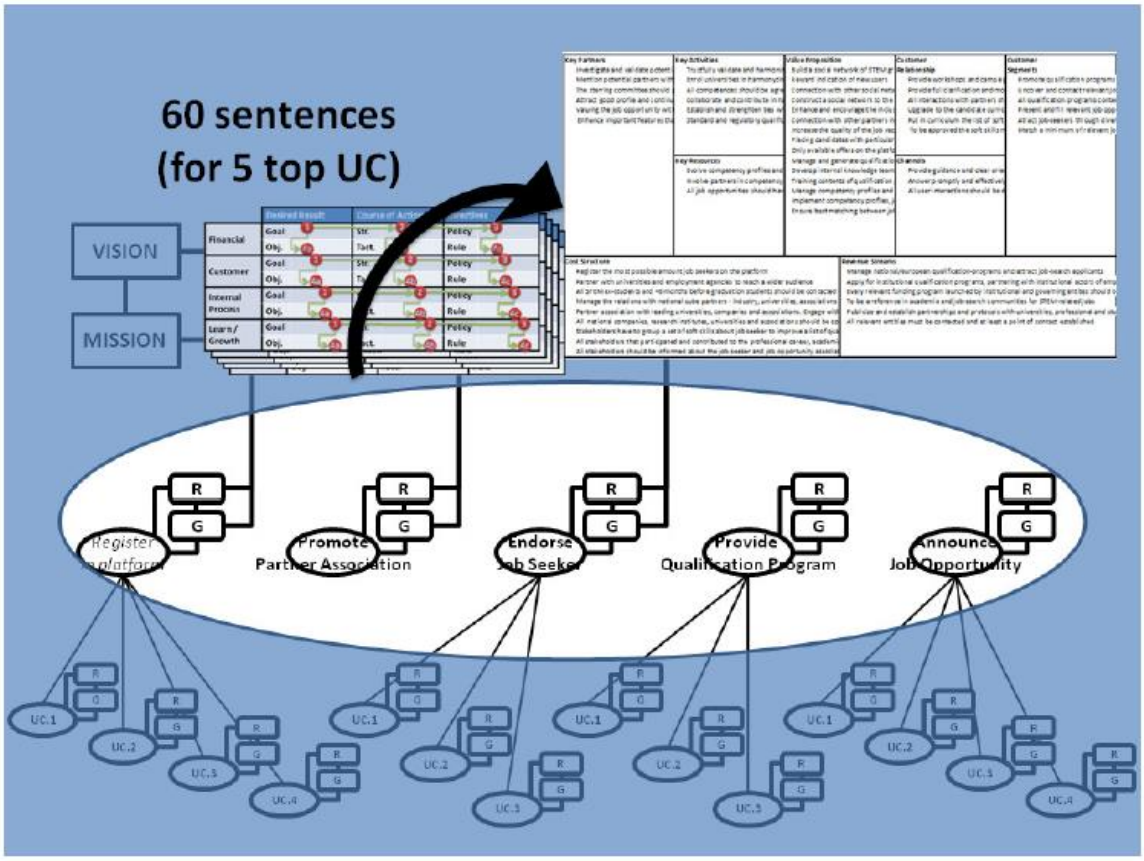

Figure 9: Overview of the process to align Business and IT through a business canvas (source: (Salgado *et al.,* 2014b))

2.4 Requirements Engineering for Business Modelling

Requirements in the engineering domain, and more specifically in IT domain, are the properties that a system should possess when built, which will satisfy the users necessities (Fernandes and Machado,

[10] http://balancedscorecard.org/Resources/About-the-Balanced-Scorecard

2016). The term requirements in the IT field was used for the first time in the in the seminal work by (Ross and Schoman, 1977) related to the use of an approach to manufacture a system. The authors have expressed the need for the requirements to answer the questions of *why* a system is needed, *what* features will it have and *how* should it be constructed. The *why* expresses the context analysis, *what* the functional specifications and the *how* the system constrains (Ross and Schoman, 1977).

The need to create an approach and systematic techniques, a process, to handle requirements and support system development, led to the coining of requirements engineering (RE). It is comprised of a set of distinct and well-defined activities, leading the analyst and software developer through the identification and capture of needs, to their transformation on system features and finally into a product, able to support the objectives for which it was conceived, having therefore a goal.

2.4.1 Requirements Engineering Activities

According to (Pressman 2014) there are seven main activities that constitutes the RE process: (1) inception; (2) elicitation; (3) elaboration; (4) negotiation; (5) documentation; (6) validation and finally (7) management. From those, three are seen as crucial to the requirements engineering (Fernandes and Machado, 2016), which will be subject to a summary analysis below.

- Elicitation – deals with the discovery, identification, capture, acquisition of requirements. Together with stakeholders, analysts should be able to comprehend necessities and expectations in respect of a system (Fernandes and Machado, 2016). It is the first step to understand a problem, identify stakeholders and goals of the system, therefore encompassing the tasks of apprehending the knowledge of a domain.
- Negotiation – this activity main objective is to deal with different and often contradicting views from stakeholders towards what requirements are important, and how should prioritization be made. The negotiation will help an analyst solve the conflicts that arise throughout the elicitation activity. The output of this activity can be considered a prioritization of requirements to be implemented taking into account its relative importance taking into account constrains such as budget, time, user satisfaction (Fernandes and Machado, 2016).
- Documentation – this activity pertains to the registry of information collected in the previous activities in documents to be referenced to during future phases of the development. There are two main calls of outputs expected for a system development (Fernandes and Machado, 2016): (1) user requirements – describe necessities of users, their likes and dislikes, plus functions that

a system should have; (2) system requirements – define what is to be implemented, set the functions and constrains of the system in detail, being an agreement between the stakeholders and development team. Taking into account the expected outputs, different techniques exist to conduct this activity. While for user requirements writing in natural language is possible and recommended to foster collaboration between different parties, it should follow a set of requisites to assure simplicity of sentences and avoid ambiguity. However for system requirements modelling techniques should be used, allowing for more precision and accuracy when building a representation of a reality. Different models can be used depending on its objective (Fernandes and Machado 2016): Structural models focus on the representation of components of a system; behavioural models address the behaviour of a system; prescriptive models define how the system to be built is supposed to be.

The requirements that result from following the RE activities should have a set of characteristics which support the development of a system with quality, and fulfils its intended purpose. The requirements should therefore be clear and unambiguous (Fernandes and Machado, 2016), should be complete (Lamsweerde, 2001) (Yu and Mylopoulos, 1998) and able to be validated (Fernandes and Machado, 2016), verified in their implementation and the costs estimated (Fernandes and Machado, 2016). They should allow for traceability (Fernandes and Machado, 2016) (Lamsweerde, 2001) (Lapouchnian, 2005) and be pertinent (Lamsweerde, 2001) (Lapouchnian, 2005).

2.4.2 Goal Oriented Requirements Engineering

A system when envisioned to be developed, it has a goal. The stakeholders have goals that want to be fulfilled, the function of a system have goals and the elicitation activity of the RE intends to capture goals. Therefore the RE needs to understand why a software development is needed, the goals it has to fulfil (Lapouchnian, 2005). The Goal Orient Requirements Engineering (GORE) views RE through the lenses of goals. Goals are functional and non-functional, meaning that they are concerned with services a system will provide, and are also concerned to the quality of the system (Lamsweerde, 2001). In a GORE literature review (Lamsweerde, 2001) summarised the reason for a goal approach in RE:

- Goals provide precise criterion for the completeness of RE;
- Goals provide precise criterion for the requirements pertinence;
- Goal refinement trees provide the needed traceability for requirements elicitation;
- Goals provide structure for complex requirements;

- Alternative goals refinement allows exploration of alternatives routes;
- Goals drive the identification of requirements.

The goal oriented approach is active in different areas of the RE. The second of the seven proposed activities, elicitation, which deals with gathering knowledge of the domain and identifying requirements, is one of the areas where goals can be of use. By analysing an organization, goals can be elicited. Those goals can be refined and made simpler by asking *how* questions and *why* do certain goals exist (Lapouchnian, 2005), thus identifying further requirements. Moreover goals also facilitate the relationship between requirements and the business context (Yu and Mylopoulos, 1998). A number of techniques support the refinement of goals, such as the KAOS framework or the i* approach.

The negotiation activity also benefits from GORE, since disagreements between stakeholders can have their roots in different goals. By iteratively compare different goals, taking into account utility, feasibility, importance, risks or uncertainties, new sets of goals are unanimously achieved (Lapouchnian, 2005).

2.4.3 Business and Requirements Modelling

To better transmit the objectives, requirements, goals or even processes from a certain service, system to a client, user or even a reader, a model can be a very useful and powerful tool. A model is a representation of a reality, being person, structure or system, or on a smaller scale, or in any way that diminishes the complexity of reality. When deal with ICT developments, a model serves to represent the views of the analyst one mean to reach consensus over the final result. In this particular case, the model will support the design of the service, taking into account its business process and main objectives. Different tools or frameworks can be used to model ICT services, of which UML, BMPN and SoaML are the mostly used examples.

SoaML

The Service Oriented Architecture Modelling Language is a metamodel together with a UML profile to allow the specification and the design of services within service oriented architectures. It is managed by the Object Management Group (OMG), and the current and latest version is 1.0.1 from 2012[11]. SoaML supports enterprise mission by enabling a collaboration between the business oriented and systems oriented service architecture.

[11] http://www.omg.org/spec/SoaML/

SOA is an architectural paradigm that is centred on needs of an organisation, being business-driven and non-dependent of specific suppliers. SOA should be used by any service, technology of standards to satisfy business needs and driven by technology. Follows the object oriented paradigm, where each service implements a certain functionality.

SoaML provides one standardised way to architect and to model any SOA solutions. The UML is used to support the modelling activities to identify services and its dependencies to the service requirements. To better support a service and business driven development, SoaML also supports integration with BMM to better capture business requirements, through the desired ends and the means to achieve it. Through the BMM, SoaML also supports the linkage of business vision, goals and strategies or rules.

BPMN

Business Process Model and Notation is one standard, also managed by the OMG, which allows the specification of business process through a graphical representation, currently in its 2.0.2 version, from December 2013. It depicts the end to end flow of any business process, bridging a gap between the business process design and business process implementation. Its primary goal is the provision of a standard notation, using similar flows to activity diagrams in UML, to be understood by any business stakeholder. Moreover, another goal BMPN is to ensure that XML languages can be visualised in business-oriented notation. These capabilities allow BPMN to provide a common understanding and analysis of a business process by anyone within an organisation, from the technical developer and business analyst, to the business users and managers (Aguilar-Savén, 2004).

Nevertheless the BPMN is not flawless, and critics have been pointed, as to why it fails as a standard. For one that the standard does not guarantee a platform independent interoperability, which can cause communication problems between stakeholders. Also there are ambiguities and underspecifications, which lead to the same construct being understand differently by different stakeholders, or the same construct be compiled by different compilers to result in different behaviours, leading to BPMN being compiler dependant (Börger, 2012).

UML

The Unified Modelling Language as the name indicates, is a modelling language in the field of software development. It has appeared part of the object oriented paradigm and provides several techniques, its 2.4.1 version being an ISO standard, 19505-2:2012[12], with flexible notations to support analysis, design

[12] http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=52854

and implementation of software based systems. However, UML can also support modelling of business and similar processes. UML is currently in its 2.5 version, from 2015 and it is managed by the OMG.

Models defined through UML have three categories, while not containing objects, occurrences or executions. (1) Classifiers, describing a set of objects with state and relationship with other objects. (2) Events, describing a set of possible occurrences with associated consequences. (3) Behaviours, performance of actions, or executions, that can change the state of objects and generate or respond to events.

UML is also divided in two different semantics or diagrams, the structural and behavioural. The structure diagrams represent things that must be present in the system being modelled. The behaviour diagrams define what should happen to the system being modelled, how it changes over time.

Use-case diagrams are part of the behaviour diagrams, and has the goal of representing the user interaction with the system. Use-case as simple, universal and standardised diagrams are good communication tools between business and technical stakeholders. They mimic the real world and support the understanding of how a system works, and its functionalities. The elicitation of functional requirements can be easily achieved, with collaboration from the business and technical users through the use of use-case diagrams.

The retrofitting auction service will be defined and modelled using UML use case diagrams, to support an easy communication of the service functions and processes. From each use-case diagram the goals and rules of the service will also be retrieved, part of the worked performed in forthcoming Chapter 3 IT-Based Services for Cities.

2.4.4 Business Models

The Business Model (BM) concept and strategy definition have gained relevance in the fields of IS and IT (Al-Debei *et al.,* 2008). Its importance derives from the characteristics of the digital business, which greatly differs from the traditional business. Whereas in the latter, business is usually conducted in a stable environment and certainty is not a problem, the digital world is however very dynamic (Al-Debei *et al.,* 2008), the level of competition is high and the product life cycles are shorter (Osterwalder and Pigneur, 2004). This creates the need for a change in the way that businesses are conducted. Therefore, this lead to the creation of a gap between the definition of business processes and the business strategy. The translation of a business strategy to a business process became a challenge due to the different pace of conducting business (Al-Debei *et al.,* 2008).

The workings of some authors provide an answer to that missing link or gap between strategy and business processes, which is the case of the BM developed by (Osterwalder and Pigneur, 2010).

Business Model Definition

Throughout the years, different definitions of business models gave origin to different understandings of the goals, components or purposes of a BM. A comprehensive definition has been reached throughout several iterations of the work developed by (Pateli and Giaglis, 2003). These workings describe the creation of value to the customers, the logic behind the way that businesses are conducted, or the utilization of the models as conceptual tools and blueprints of the business itself (Osterwalder *et al.,* 2005). Before going further into clearly define what a business model is, it is important to understand both concepts.

On the one hand a model can be considered a simplified description and representation of entities or processes that can be considered complex (Osterwalder *et al.,* 2005), a representation of a reality that can communicated through words or pictures, with possibly different levels of detail (Jensen 2014). On the other hand business can be defined as the performance of activities towards the exchange of valuables by organizations or individuals, or also, can be seen as based on activities and opportunities across organizational entities (Jensen, 2014).

Regardless of the different definitions, conceptualizations or writings about BM, (Osterwalder *et al.,* 2005) arrived at the conclusion that business models were divided in three levels, linked together, and each with a different purpose:

- The business model concept – definition of what business models are and meta-models that conceptualize them. In this level a BM is seen as an abstract concept that describes what it does;
- Taxonomies – several types of business models, or meta-models, which are generic, but containing common characteristics;
- Instance level – consisting of descriptions and representation of real world business models, or more concrete models depicting real business.

The figure below provides a clear understanding of the levels differentiation and meanings:

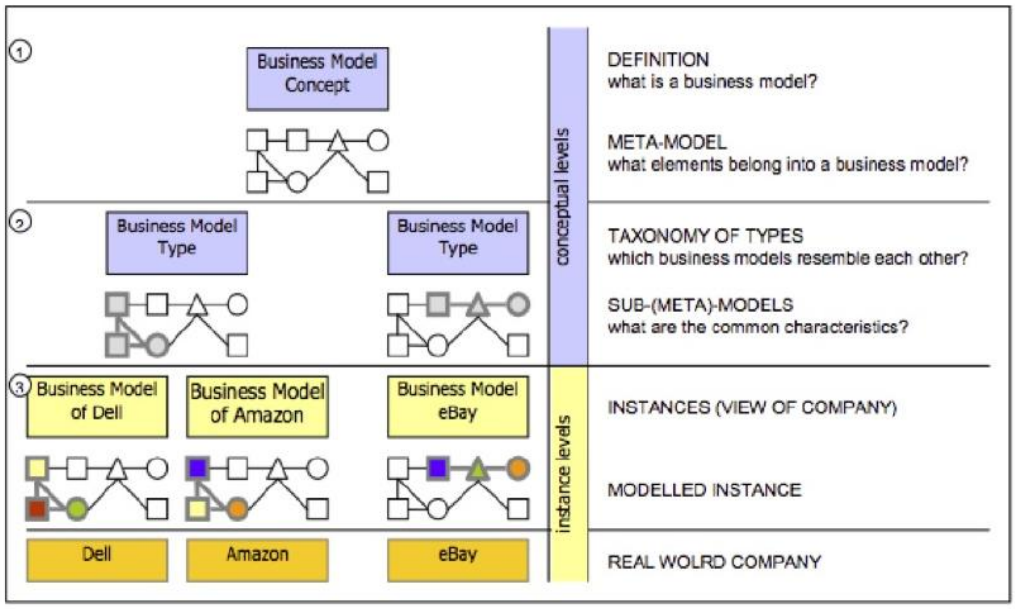

Figure 10: Different business model levels (source: (Osterwalder *et al.,* 2005))

The same authors also proposed that a business model should be supported by four pillars: product; customer interface; infrastructure management and financial aspects, together with nine building blocks: value proposition; target customer; distribution channel; relationship; value configuration; core competency; partner network; cost structure and revenue model (Osterwalder *et al.,* 2005).

The conducted work by (Osterwalder *et al.,* 2005) resulted in a definition, which is still valid nowadays, and will ground the work to be performed from here onwards:

"*A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams.*"

The continuous work performed within the field on BM led to the development of the BMC.

The Business Model Canvas

The BMC has been developed taking into account the nine building blocks mentioned above. It has been initially presented in a comprehensive book, published to support business leaders and entrepreneurs in defining business strategies and value creation (Osterwalder and Pigneur, 2010). The BMC proposes a set of questions that the model answers for each building block, in order to define a model that can be adapted to any organization. Therefore it proposes the analysis of the most important customer to the business, and how to tackle their needs by creating value to them. The different distribution channels

available to a business and which to choose to best reach a customer, while working also on the relationship aspects between business and costs. It does not leave the financial aspects aside. It focuses on the generation of revenue and the cost structure, in order to assess business validity. To address efficiency and effectiveness in the conduction of business, the canvas maps key resources and activities of an organization, as well as key partnerships as a means to create focus (Osterwalder and Pigneur, 2010).

The BMC design is based on the nine blocks, keeping it simple and contained. The model should be able to fit within a standard A4 sheet, thus addressing only the most relevant features and constrains of value creation of a business. The figure below provides an illustration of the BMC as initially presented by its authors.

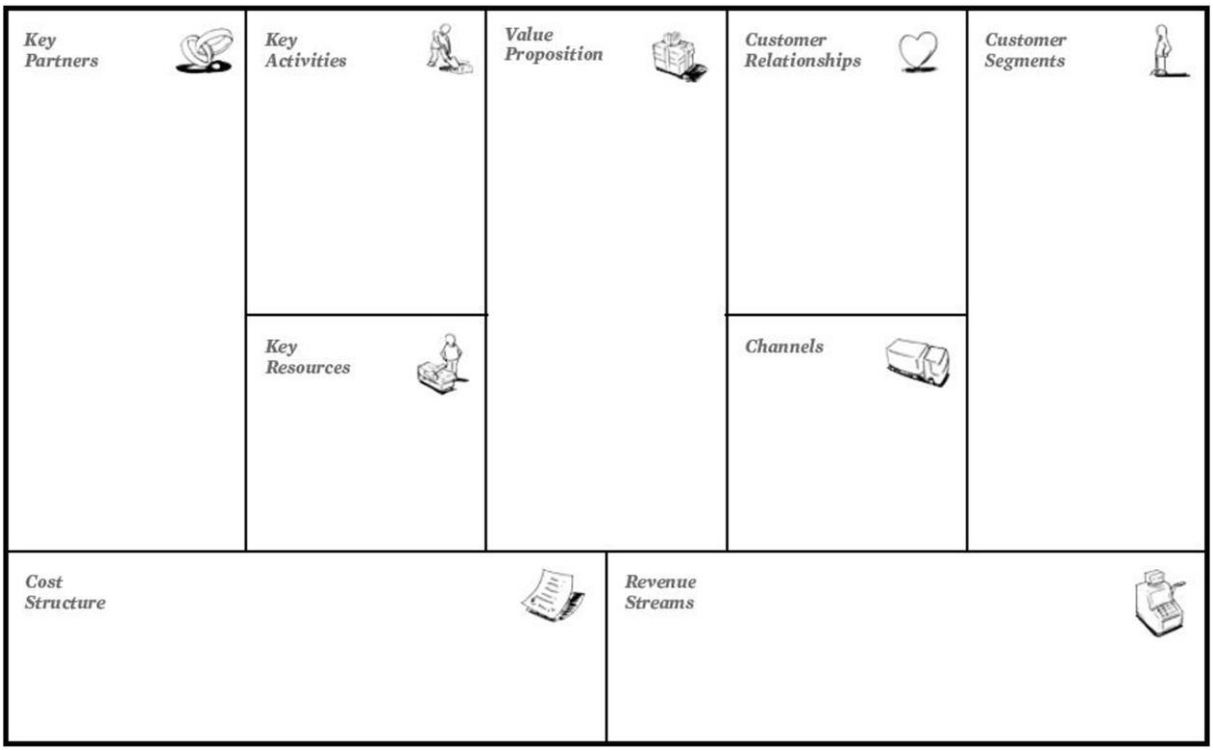

Figure 11: The Business Model Canvas (source: (Osterwalder and Pigneur, 2010))

Adaptations have been made from the BMC, while maintaining the structure, as well as some of the focus blocks, thus giving origin to the LC.

Lean Canvas

The LC is a business model canvas based on BMC and proposed by Ash Maurya that mainly focus on the problems that customers have, and the solution the business needs to provide (Maurya, 2012). The author addresses the need of a BM that can be used by both successful companies and start-up business, thus adding a risk factor. Moreover the LC is also seen as product from the author's perspective, which will be built into a solution based on well know-techniques from product development. Another main

difference from the BMC is the acceptance that risk exists and needs to be mitigated to allow the success of a marketed product (Maurya, 2012).

The LC still maintains the same frame as the BMC, considering nine blocks from which a business model should be fractionated. However considers different parts and adds new blocks to the canvas, while removing others. The rationale besides the LC, in comparison to the BMC is as follows:

To develop a successful product the problem needs to be understood first, and only after can a solution be conceived. During the understanding of the problem the customer segment can also be determined, as the two concepts are closely related. The metrics to evaluate the different products are also considered, as well as what is the competitive advantage assisting that business, which should be difficult to replicate. A different box deals with what the author considers the most challenging "*and the hardest to get right*" block of the LC, the unique value proposition, which should in a few words attract the attention of potential customers. The distribution channels is one of the blocks that remains the same from the BMC, together with the cost and revenue streams, to address the business validity (and the customer segments already mentioned) (Maurya, 2012).

Figure 12 below depicts the canvas, very similar to the BMC, with the different block's naming:

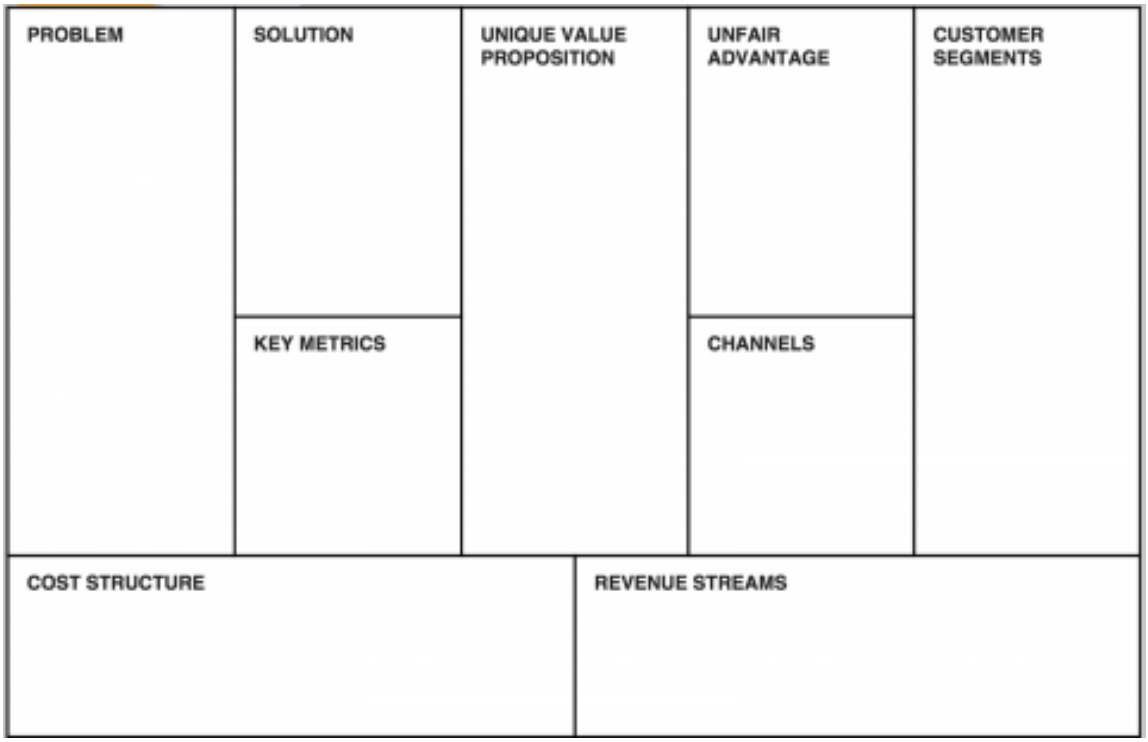

Figure 12: A blank Lean Canvas (Adapted from (Maurya, 2012))

The LC is grounded on three principles to guide the development of a model (Maurya, 2012): (1) documentation of the plan; (2) identification of the risks; (3) systematic testing of the plan. Another feature of

this model is the differentiation between product and market in the canvas. Whereas the left side regards the product, the right is related to the market. The unique value proposition is the middle ground.

2.5 Conclusions

This second chapter provided a few insights of what can a smart city be, based on different views from different organisations. Table 1 below provides an overview of the main concepts associated with a smart city from the analysed reports or frameworks. Without going into particular domains of city services and management, they provide an understanding of the main concerns of the smart city concept, the main challenges faced by decision makers and the opportunities that the information technologies and information systems bring.

Table 1: Overview of the main dimensions of a smart city

Analysed Reports	Society		Governance		Economy	Environment	ICT		
	Stakeholder	*Engagement*	*Governance*	*Vision*			*Infrastructure*	*Interoperability*	*Monitoring*
BSI	X	X	X	X			X		X
IEC	X	X		X	X	X	X	X	
CISCO		X	X		X	X	X		X
ITU	X	X	X	X	X	X	X	X	X

Therefore, it can be seen that a city evolves towards the smart concept when, while supported by ICT, is able to be governed in a way that guarantees environmental and economic sustainability, and is able to increase the life standards of its inhabitants throughout optimized decision making processes and consumption efficiency in the various city services. It is a multidisciplinary domain, therefore it needs a vision, understanding its needs to cater for evolution, and close monitoring of its initiatives to ensure that evolution goals are achieved.

Such an understanding allows grasping the need to assure that any initiative in the domain of a smart city should not be driven by ICT, but by the needs felt. Therefore, it is important to align business (needs) and IT, which this chapter also provided some insights concerning that domain.

The remainder of the document is related to the definition of an IT-based new service for smart cities – household retrofitting auctions. Initially an analysis of maturity models for smart cities is reported, since they provide the monitoring and evolution paths needed by the long term evolution of a city. Additionally, the retrofit auction service will be modelled in the next chapter with the support of UML, taking into account the previous work performed. Based on that model, six BSC will be filled which will serve as support to the mapping of a business canvas, both discussed in Chapter 4.

3. IT-Based Services for Cities

This chapter marks the beginning of the research contributions. It is the first part of the work that was developed and relates the concepts of smart cities with the ICT domain. Moreover reports the outcomes of the second proposed objectives – design of a retrofitting auction service.

Chapter Contents

Publications

Assessment of Maturity Models for Smart Cities supported by Maturity Model Design Principles **(ITAIS 2016)**

3.1 Introduction

The previous chapter provided a degree of characterisation of what can a smart city be comprised of, without pretending to have made the characterisation of a smart city. Additionally, knowing what some of the needs of a smart city are, and understanding that an IT solution should not be the sole driver for smart city initiatives, instead, the city needs, this chapter intends to propose a service for a smart city, considering the need for more energy efficiency. This problem has been raised at European level, with the Climate Action 20-20-20 targets[13]: 20% cut in greenhouse emissions; 20% of energy coming from renewables and 20% improvement of energy efficiency. Additionally, as previously stated, until 2020 the Portuguese government has also defined a target of reducing energy consumption in 25%, which counts as energy improvement.

Moreover, the motivation to initiate this work can also be pinned on a smart city project, the *SusCity*. The IT-based service here defined was part of the work program of an on-going smart city project, the *SusCity* Project. It is an IT-based service because it is online and it shall be integrated in the platform currently under development in the *SusCity* Project. The project targets the development and integration of new tools and services, to increase urban resilience and resource efficiency with minimum environmental impact, while also promoting economic development. The service here modelled contributes to the project in two distinct domains, the energy and environment and economic domains. The value of using the *SusCity* Project is the possibility to demonstrate the use of the service in a real context and to attest the validity of the extension of the PGR Approach that is here proposed

An analysis of maturity models for smart cities is also reported within this chapter. The pertinence of the analysis to this research work concerning smart cities, was the provision of insights to what is important to support a smart city evolution, as well as acknowledging the need for the monitoring of initiatives, which a maturity model supports. Additionally, a different objective was frame the *SusCity* Project, taking into account a maturity problematic.

The main objective and contribution of this chapter is presenting the Retrofitting Auction Services, which besides being a mean to increase energy efficiency, shall also prove the capacity of the *SusCity* Project to cater for innovative business models to devise optimal investment decisions, accruing economic value

[13] https://ec.europa.eu/clima/policies/strategies/2020_en

to the city. The service is modelled using the use case diagrams from the UML language, being additionally represented in BPMN.

Additionally this chapter also makes possible answering the research question of how to achieve an alignment between business and IT, due to information retrieved regarding smart city characteristics and the knowledge of the purpose of auctions and what they are.

3.2 Synopsis of the *Suscity* Project

The *SusCity* Project, under the MIT Portugal Program, is a Lisbon based project in the domain of smart cities. It is focused on developing and integrating new tools and services to increase urban resilience and resource efficiency with minimum environmental impacts, while contributing to promote economic development. It is a research and development project aiming at advancing science of systems modelling and data representation in urban environments and it is supported by "big data" collection and processing. It has a dual objective of enabling and demonstrating a suite of new services, while exploring economic opportunities associated with the transition to sustainable urban systems.

One of the foreseen impacts of the project is to advance emerging business models for energy and mobility solutions in a rich data and ICT driven context. The project shall not only service the economy, but also the society, since its smart solutions, will increasingly provide customized alternatives to the citizen, empowering him to an active role in urban design.

The project focus its interventions in Lisbon, in a test-bed located at "Parque das Nações", being an application-oriented research approach. The consortia that participates in the project is comprised of the Municipality, major utilities and energy network managers, a mobility solutions company, software houses, governmental labs and the national energy agency, which complement MIT and the Portuguese universities, of which Minho University, effort by providing their expertise.

SusCity, follows guidelines that should be common in any smart city project, which were also already identified in this document: (1) involving academia experts in the different fields to understand the city and urban systems in both time and space; (2) involving and engaging major utility companies to integrate individual solutions when designing new smart infrastructure for the city; (3) engages city government and national experts agencies; (4) takes into account multiple stakeholders and creating solutions to serve them, thus designing and adapting new urban services and business models to address citizen's needs.

Project Objectives

The major objective of the project is to advance the science of urban systems modelling as a unique strategy to uncover, develop and deploy a suite of new services that will engage the citizen and explore economic opportunities associated with the transition to sustainable urban systems.

It will deploy an Urban Systems Simulator and Dashboard (USD), allowing the ability to simulate urban physical models to envision and work on different scenarios, besides the essential features of visualisation and communication of data. Three long-term goals are envisioned for the project:

- To build a scientifically rigorous, media-enlivened tool, which constitutes a product with high economic value, with export potential intended to understand and propose new services and business models to sustainably manage urban resources. The communication and representation of information through the platform, both virtual and physical, is central to the work;
- To deploy the USD platform, which intends to contribute effective decision-making concerning urban technologies and services by using multi-dimensional simulations;
- To engage stakeholders through a series of workshops, with the aim of enhancing multi-level discourse on issues of the future of cities. The development of urban test-bed research potentially supports the development of entrepreneurs and current businesses.

Work Packages and Research Context

This research work is also contributing to the results of the *SusCity* Project. From the service here modelled a business model is defined, catering for the city needs. It is a result of the collaborations between work package (WP) WP2 and WP6. The project is constituted by six WP, as shown by the figure below.

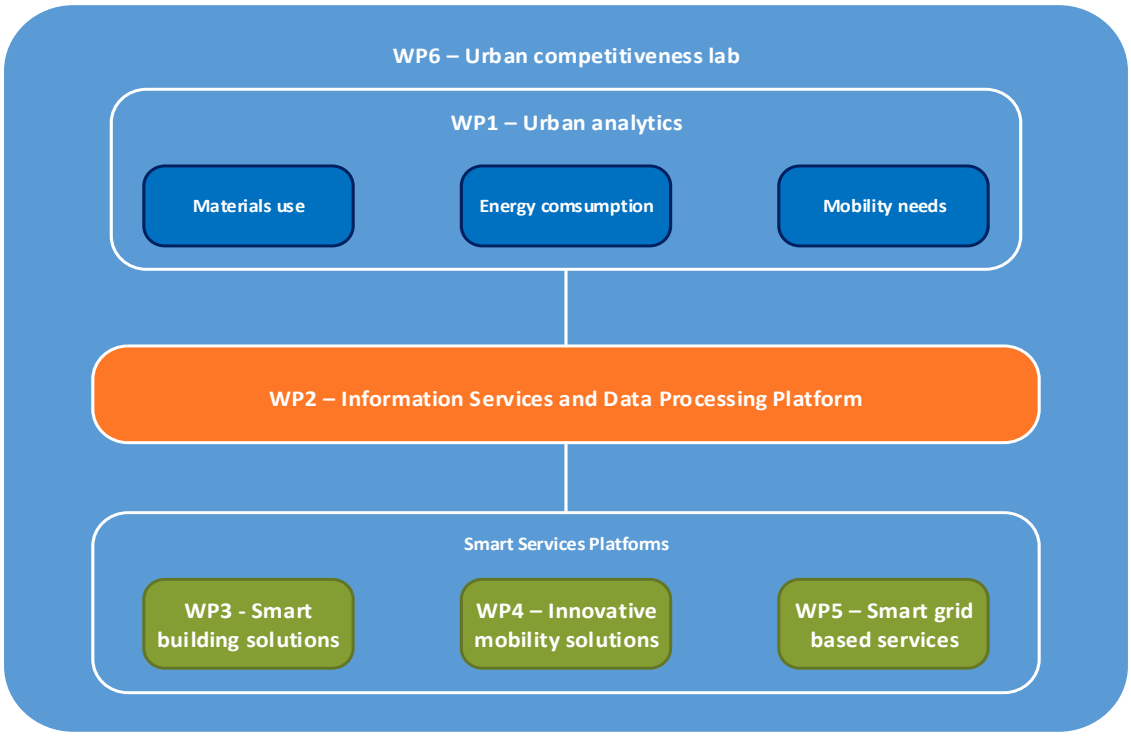

Figure 13: SusCity project structure

The *WP1 Urban Analytics* has the objective of providing perspectives on resource consumption, focusing on the use of energy and materials, in an urban context. The main output are models able to explore alternatives for more efficient use of those resources. Those models are to be validated by data collection and processing, through a platform being developed and deployed by *WP2 Information Systems and Data Processing Platform*. To explore evolution paths towards ensuring adoption of energy efficiency practices, the *WP3 Smart Building Solutions* will assess smart grid solutions related to the use of building integrated renewal energy and the installed electric power infrastructure. The *WP4 Innovative Mobility Solutions* focuses on understanding the urban mobility and accessibility, as drivers of city development, through data collection of diagnostics and vehicle positioning to validate mobility models. To improve energy generation and reach optimal balance by decentralise demand and supply of energy, *WP5 Smart Grid Based Services* is engaged in defining and validating new business models associated with energy aggregator. Last but not least, *WP6 Urban Competitiveness Lab*. The most relevant for the purpose of this work are WP2 and WP6, which are summarised:

WP2 Information Systems and Data Processing Platform

The objective of this work package is to develop an ICT platform to support the USD. It will collect, manage and process data from the city environment, transforming it into a standard format to enable the exchange in different layers and visualisation. It will use open architecture common standards and protocols, as well as well-defined interface.

The main deliverable of this WP is a big data platform as product, Big Data *SusCity*. Its architecture is constituted by the different state-of-the-art big data technologies, assuring the possibility of supplying new analytical services to the various stakeholders, not dependant on volume, variety and data velocity. This WP is collaborating with WP1 to integrate analytical services related to the characteristics and energetic consumption of the buildings in Lisbon. The platform being built intends to enable integration with other type of information and stakeholders for the provision of new services to the city.

One of the possible new services to be integrated and prototyped within the platform, is being modelled within this research work. It focus on the business processes to support further alignment to the IT, which will occur in the project. The service is being designed in collaboration with WP6, which has as main objective the transformation of smart solutions developed within the testbed in innovative business models, to devise optimal investment decisions, and accrue economic value to the city.

Therefore we consider that the results of this research work will support two work packages of the *SusCity* Project. On the one hand it will provide the project with one service to be integrated within the platform, attesting for its interoperability features. On the other hand, it will support the WP6 in the creation of business models to valorise the results of the project.

WP6 Urban Competitiveness Lab

The main objective of this WP is to promote the competitiveness of the city by assessing and tailor new services that are created towards its needs and specificities. The achievement of that objective is intended through the creation of an Urban Competitiveness Lab. In that lab the multiple city stakeholders are organised in an Advisory Committee Medium to assess long-term competitiveness of the city and supports promoters to improve their business models in uncertainty contexts. Therefore, the solutions created within the project test-bed are intended to be transformed through innovative business models to facilitate and enable investment decisions taking into account future needs and city trends.

This WP involves all partners and aims at building up from the knowledge created and developed in the different WP, as well as inputs collected from different organisations in the city. The main contribution of this WP is to propose different scenarios and policies as an enabler to the transformation of the testbed neighbourhood. The business models that this WP aims at creating will not only be focused on the creation of value to the business suppliers, but additionally to support the sustainability and urban resilience of the city.

The work performed contributes to the results of those two work packages. Therefore it can be considered that while the *SusCity* is seen as demonstration case, motivating this research work, this research work also provides an added value to the project.

3.3 Analysis of Smart City Maturity Models

As previously stated, action plans are needed for smart cities. The evolution of a city is a long term process, therefore needing careful planning, as well as tools or mechanism to monitor the plan execution. Moreover, the monitoring activities can also be one way of communicating advances to the citizens, to correct decision making, and to effectively measure the current status of the city, expected outcomes and benefits, and additionally benchmark it towards other cities, or even the proposed evolution scheme.

A maturity model can be one tool to monitor that evolution, and to measure city status. This subchapter presents an assessment of smart city maturity models, which consider a smart city in a holistic way. Since maturity models need to be theoretically sound to be useful to decision makers, this assessment was based on an approach devised by (Pöppelbuß and Röglinger, 2011), and considers the design principles for the development of maturity models. It summarizes the presence of design principles in each analysed model and compares them. Moreover, it also aims to assess if the analysed models fulfil their intended purpose.

3.3.1 Maturity Model Design Principles

The main objective of maturity models is to assist organizations in improving the quality of their processes, its efficiency, and cost reduction, by comparing with the best practices of the relevant industry. To allow fulfilment of such objective, a maturity model development based on some principles, can maximize its usage purpose.

Maturity models fulfil different purposes such as comparison, identification of gaps, or the assessment of the “as-is” state of an organization. De Bruin (De Bruin *et al.,* 2005) has identified three different purposes for a maturity model: descriptive, prescriptive and comparative. Moreover, (Pöppelbuß and Röglinger, 2011) based on extensive literature review have considered design principles (DP) for maturity models and divided them between three groups of principles. The same approach is here followed and considers the principles categorized as: (1) basic design principles, (2) design principles for descriptive purpose of use and (3) design principles for prescriptive purpose of use.

Basic Design Principles

This first group of DP should guide the development of model, regardless of its purpose, stating the model basic information such as its audience, domain, or maturity stages (De Bruin *et al.,* 2005).

Table 2 describes the basic design principles, based on the literature, which any maturity model defined for smart city should contain:

Table 2: Maturity Models Basic Design Principles

DP	Name	Description
DP1.1.1	Application Domain	Defines the specificity of the model and distinguishes it from other models (De Bruin *et al.,* 2005)
DP1.1.2	Pre-requisites of Applicability	The application conditions and the intended benefits (Becker *et al.,* 2009)
DP1.1.3	Purpose of use	The outcome of the maturity assessment, whether is comparison, description, prescription (De Bruin *et al.,* 2005)
DP1.1.4	Target Groups	The requirements of the intended audience, who needs the model, why its application, how to be applied (De Bruin *et al.,* 2005)
DP1.1.5	Differentiation Factors from Similar MM	Understand the needs for a new model; support the development of a new model or improving an existing one (De Bruin *et al.,* 2005) (Becker *et al.,* 2009)
DP1.1.6	Validation of the Model	Support appropriate model development by understanding domain through literature review and validation through experts interviews or case studies (De Bruin *et al.,* 2005)
DP1.2.1	Descriptor of the Maturity and its Dimensions	Clear and concise identification of the levels and the model dimensions (De Bruin *et al.,* 2005) (Fraser *et al.,* 2002)
DP1.2.2	Definition of Maturity Levels	Descriptions of the characteristics of each level (Fraser *et al.,* 2002)
DP1.2.3	Definition of Maturity Paths	Define the paths between the stages and the description activities to be performed at each level (Becker *et al.,* 2009) (Fraser *et al.,* 2002)
DP1.3.1	Model Documentation	The design process should be documented, which methods were applied (Becker *et al.,* 2009)

Descriptive Purpose of Use Design Principles

A maturity model can have a specific purpose detailing the current state of a specific case (Maier *et al.,* 2012), that is, for each dimension (or PA) an understanding of what the current state according to a set of criteria is (De Bruin *et al.,* 2005). Therefore, different sets of design principles should be taken into account, besides the basic ones. The table below provides an identification and description of such principles.

Table 3: Principles for a Descriptive Purpose of Use

DP	Name	Description
DP2.1.1	Verifiable Assessment Criteria for each Maturity Level	The used criteria should be verifiable, so the maturity assessment can be compared and replicated (Pöppelbuß and Röglinger, 2011)
DP2.2.1	Procedure Model	To support user guidance on how to conduct the maturity assessment (Pöppelbuß and Röglinger, 2011)
DP2.2.2	Advice on the Application of Assessment Criteria	To support the understanding of what needs to be measured, as well as how it can be measured (De Bruin *et al.,* 2005)

DP	Name	Description
DP2.2.3	Guidance on Adaptation and Configuration of the Criteria	Maturity Models should be tailored to particular situations (Beecham *et al.,* 2005a), accommodate changes to meet particular needs (Paulk *et al.,* 1993), assessment criteria should also be configured to specific characteristics
DP2.2.4	Verifiability of the model	A model needs to be tested to verify measurement validity, ensure the results are accurate (De Bruin *et al.,* 2005) and that it fits its objectives, to support improvements if needed (Beecham *et al.*, 2005a)

Prescriptive Purpose of Use Design Principles

A maturity model can also be of a prescriptive purpose of use (De Bruin *et al.,* 2005), where detailed actions for each process area are proposed at each maturity level. The purpose of use concentrates on the *how* actions should be implemented (Beecham *et al.,* 2005b). The table below details the principles, which are part of prescriptive maturity models.

Table 4: Principles for a Prescriptive Purpose of Use

DP	Name	Description
DP3.1.1	Improvement measures for each maturity level	Recommendation of actions that lead to an improvement from the "as-is" situation, to a higher maturity level (Becker *et al.,* 2009)
DP3.1.2	Prioritization of actions	A model containing process or dimension prioritization is able to support reaching the defined goals (Beecham *et al.,* 2005b)
DP3.2.1	Procedure model	Similar to DP2.2.1 an user should be guided during the improvement process (Pöppelbuß and Röglinger, 2011)
DP3.2.2	Advice on the Application of Assessment Criteria	The same reasoning from a model fit for a descriptive use, can be applied to a prescriptive use
DP3.2.3	Guidance on Adaptation and Configuration of the Criteria	The same reasoning from a model fit for a descriptive use, can be applied to a prescriptive use
DP3.2.4	Verifiability of the model	A prescriptive model should be verifiable to ensure the prescriptions are able to improve the maturity level. This is also valid from the standpoint of the model validity in domain, as well as its relevance (Maier *et al.,* 2012)

3.3.2 Synopsis of Existing Maturity Models

Maturity models for smart cities have been defined to help city leaders assess the city' current state and provide guidance towards its evolution.

This section aims at presenting identified models that can be applied in a holistic way to a city (Pereira and Machado, 2014). Therefore, among different existing maturity models in the domain of smart cities, only three models were identified: (1) IDC Smart City Maturity Model (IDC MM) (Clarke, 2013), (2) Maturity Model to Measure and Compare Inequality in Brazilian Cities (Br-SCMM) (Afonso *et al.,* 2015) and (3) Smart City Maturity Model developed by Sustainability Outlook (SO SCMM) (Sustainable Business Leadership Forum, 2014).

IDC Maturity Model

The purpose of this model developed by the International Data Corporation (IDC) in 2013 is to provide a method for assessing city' current situation, serving also as a planning tool to adopt smart city practices. It is comprised of five domains, strategy, culture, processes, technology and data. It has also five maturity levels. The model is mostly concerned with the governance processes of a city and the how can they be improved.

Brazilian Maturity Model

The main purpose of this model is proposing mechanisms to assist city leaders and managers to improve social and economic conditions of a city. Additionally it aims to compare the different maturity levels cities can reach.

The model focus of ten domains: water; education; energy; governance; housing; environment; health; security; technology and transport, also having five maturity levels. The model was defined taking into account the reality of Brazilian cities and is focused on the basic infrastructure of a city and the social conditions.

Sustainability Outlook Maturity Model

The model proposed by the Sustainability Outlook organisation aimed at gauging the preparedness of a city against a battery of indicators. As the BR-SCMM is composed of ten domains, transport; spatial planning; water supply; sewerage & sanitation; solid waste; storm water drainage; energy & electricity; ICT & systems intelligence; economy & finance and environment. However, contrary to the previous models only has four maturity levels.

This model was defined taking into account the Indian cities reality, and therefore the application of the model was scoped to key areas proposed by the Indian Government. The model is also focused on the city infrastructure and urban resilience.

3.3.3 Analysis of the Maturity Models

This section compares the abovementioned models against the design principles previously analysed. The initial comparison involves the matrices below, which make an analysis on whether a principle is present (X) or not present (blank cell) in the three models.

Table 5: Comparison of Smart City Maturity Models based on Basic Design Principles

	Basic Design Principle									
	1.1.1	**1.1.2**	**1.1.3**	**1.1.4**	**1.1.5**	**1.1.6**	**1.2.1**	**1.2.2**	**1.2.3**	**1.3.1**
IDC SCMM	X	X	X	X			X	X		
Br-SCMM	X	X	X	X	X	X	X	X		X
SO SCMM	X	X	X	X			X	X		

Table 6: Comparison based on Descriptive and Prescriptive Use Design Principles

	Design Principles for Descriptive Use					Design Principles for Prescriptive Use					
	2.1.1	**2.2.1**	**2.2.2**	**2.2.3**	**2.2.4**	**3.1.1**	**3.1.2**	**3.2.1**	**3.2.2**	**3.2.3**	**3.2.4**
IDC SCMM		X				X		X			
Br-SCMM	X	X	X		X						
SO SCMM	X	X	X								

Most of the basic design principles are present in the different maturity models. However, the models do not seem to consider the majority of the DP for descriptive and prescriptive use. That stands true especially for the principles related to a prescriptive purpose of use. A deeper analysis of each principle in the models follows below.

Basic Design Principles

An analysis of the models shows description of both the specificity of the model (**DP1.1.1**) and the prerequisites of applicability (**DP1.1.2**). The models also define the major benefits of using them. The IDC SCMM refers that the application of the model will uncover maturity gaps, enable prioritization of investments and allow the definition of long and short term goals (Clarke, 2013). The Br-SCMM offers a tool to identify areas and goals to be planned strategically towards a smart city paradigm (Afonso *et al.,* 2015). The SO SCMM states that by identifying gaps in the city infrastructure and acting upon them, will allow better investment decisions towards the achievement of a long term urban resilience (Sustainable Business Leadership Forum, 2014). Moreover, the models state its application in a city, by local leaders or institutions, satisfying the **DP1.1.4**, target groups.

The purpose of the models (**DP1.1.3**) is always present. While the IDC SCMM is a model that intends to be an assessment of current state and a planning tool, the Br-SCMM besides measuring the "as-is" state wants to be a means of comparison be-tween cities progression assessment. This is also the purpose of the SO SCMM, gauging the preparedness of cities against a set of measures.

There is no evidence that any of the analysed models considered the others when being developed, thus skipping **DP1.1.5**. Nevertheless, the Br-SCMM does consider existing non-maturity models in the smart

city domain, pinpointing reasons for the development of a new model. The Br-SCMM is also the only model that documents having been validated (**DP1.1.6**). It was applied to different Brazilian cities, where comparisons were made between the positioning of the cities in the first two maturity levels.

All models define each of the maturity levels and provide the descriptors for each dimension (process area or measure), thus fulfilling **DP1.2.1**. Moreover, within each model, the maturity levels are defined. The IDC SCMM and Br-SCMM, however, go a step further and define the dimensions. Considering the **DP1.2.3** and **DP1.3.1** there is a lack of information on the majority of the models. The SO SCMM does not provide any information concerning those two DP. On the one hand, whereas the IDC SCMM provides glimpses of possible paths, through some ideas for improvement towards increasing the maturity level, the model does not propose any concrete actions, or any kind of measurement; on the other hand, it does not provide information on the design of the model. The Br-SCMM clearly states that the maturity levels are not cumulative and that any city can choose the most pertinent action to close gaps. The Br-SCMM also documents the model design process.

Descriptive Purpose of Use Principles

A descriptive purpose of use is the ability that a model has to measure the current state of the applicable domain.

Two of the three analysed models have, or refer to, indicators or key metrics enabling the assessment of a city, considering **DP2.1.1**. The IDC SCMM does not provide any measurement, however, states in the document that they are working on performance measures (no other related document was found). Nonetheless, a report produced to support and engage Scottish cities in a smart city assessment (Urban Tide 2015) integrates the IDC SCMM with the indicators identified in a report published by the BSI (PAS181:2014, 2014). Therefore, we conclude that in spite of the lack of indicators in the model, integration is possible with the BSI report indicators, or possibly other existing frameworks.

The Br-SCMM identifies ten basic indicators, one for each dimension. These indicators are used as a benchmark and enable comparison between cities, by allowing scoring from 1 to 5. However for higher maturity levels the criteria is not applicable. The model also describes how the indicators can be measured, covering **DP2.2.2**.

The SO SCMM provides a comprehensive set of indicators to be measured (also explaining how they can be measured), enabling the assessment of a city. The indicators identified are also compared with the indicators produced and introduced in ISO 37120 (ISO 37120:2014(E), 2014). Nevertheless, the same

issue found in the Br-SCMM is also present in SO SCMM, after the first level there is an absence of indicators, thus creating a void in the promotion of progression towards sustainability and urban resilience.

All of the models provide a description of how the maturity assessment should be conducted, thus fulfilling **DP2.2.1**. Nevertheless neither of the analysed models considers the possibility of tailoring the model to different situations, nor describes the possibility to accommodate changes; the **DP2.2.3** is not verifiable. The **DP2.2.4** is fulfilled by the Br-SCMM only, since the model is applied to different Brazilian cities.

Prescriptive Use Design Principles

The IDC SCMM provides information on **DP3.1.1** and **DP3.2.1**, stating actions and guidelines that city leaders can adopt to improve the "as-is" state. Nevertheless, the actions are not sufficiently detailed to allow for a clear progression towards further levels.

No other principle has been considered during the development phase of any of the models. One exception however, can be noted regarding to **DP3.2.2** in SO SCMM. The model clearly defines indicators that enable the understanding of the goals to be achieved, and which actions to take to progress further to reach the first level, such as, "High quality and high frequency mass transport within 800m (10-15 minute walking distance) in residences for 175persons / ha built area" (Sustainable Business Leadership Forum 2014). However, since higher levels of maturity lack defined measures, there is apparently no progression throughout the remaining levels, thus it is considered that it does not fulfil the principle.

This analysis of the different maturity models provides an important insight on the preoccupation of institutions in serving a city, its leaders and citizens. Their major contribution is the provision of expertise to achieve development and sustainability through projects, action roadmaps and measures to support that evolution. In particular, these analysed maturity models, state important dimensions, or areas of focus that city leaders should work on. One of the analysed models is more focused on the governance processes, and the technology maturity of a city. It considers that a city has already a degree of development that allows disregarding concerns for basic city infrastructure. Other two models, on the other hand, are specified with the objective of providing supportive actions towards promoting urban resilience, and development of basic city infrastructure.

By analysing a city and providing metrics to measure current state and propose actions, leaders are able to pinpoint needs and work towards the future.

The *SusCity* is a project that took the needs of a city and made it a problem to solve. From the knowledge imparted by the study of the different maturity models and different frameworks for smart city, it can be deducted that a successful implementation of the project, should it deliver the expected results, will position the city in a higher maturity, even if at this point that affirmation is only possible empirically. The project intends to deliver a platform to manage big data generated in the city to support more accurate decision making, being focused on contributing to higher levels of energy sustainability, both from buildings in the city and the mobility. Additionally shall position itself as an instigator of economic development by providing an incubator for the validation of new businesses and services to be integrated in the platform increasing its economic sustainability. While not focusing on all dimensions that a city could have, the SusCity focus on its citizens and how to serve them better, aims at creating more environmental sustainable neighbours, and be a vehicle to drive the creation of new business, by deploying a platform supporting new business to create value to the city. Therefore, it can be concluded that when the project is finished it will have impacted the city its economic, social and environmental dimensions.

3.4 The IT-Based Retrofitting Auction Service

This sub-chapter reports the auction service, for households retrofitting services that is being designed within the *SusCity* Project. The service is presented in use case diagrams, which also serves an input for the mapping of the BSC in Section 4.

3.4.1 Auctions

Auctions have been used for a very long time, from government agencies, to banks, extraction industries or nowadays, even citizens, posing as auctioneers or seller in digital platforms. However, only recently has been the subject of studies, brought by the field of economics, especially to allow the understanding of value perception, and game-theory aspects (Klemperer, 1999). The use of auctions can be seen as a trade-off between the advantage of price discovery and the disadvantage of having high transaction costs. Therefore, it is easy to see one of the advantages of running auctions, cut in costs when dealing with transaction costs, due to the gathering of several interested people in one place and a certain point in time. Moreover, nowadays, with the digital technologies, participants can interact, in real-time, without needing to be present. Online auction have indeed widespread around the world and the service boomed, especially due to the further decrease in transaction costs and higher potential of gains (Ockenfels *et al.,* 2006). It is possible to see a shift from retailers to online auction sellers, and that is explained due to

lower transaction costs, entry costs and a substantially higher and large customer base (Bajari and Hortaçsu, 2004).

However, there are several factors affecting sellers will to participate in online auctions. From the explicit costs, which are the listing fees that online auction platforms charge, eBay is example, and the fees charged if an item receives a bid higher than the listing or reserve price. To the opportunity costs that exist if a seller raises the price, or includes a different options in the listing, such as setting a reserve price and receiving no bids (Walczak *et al.,* 2006).

Different platforms charge different fees, and that is much related to their user base, service experience, and marketing tactics are heavily used between the major players. Regardless of the company, different countries, much related to the specific culture, aversion to risk and other factors, require different techniques to gather users. Therefore, since the perceived pool of buyers and sellers by one potentially new user is a crucial factor, online auction platforms offer different listing or transaction fees to increase the pool, some even not charging listing or transaction fees. It is therefore important for online auction platform to understand where the satisfaction of users lie, of both buyers and sellers, to define the best strategy and promote platform visibility (Chiou *et al.,* 2009).

It is fairly easy to grasp that the major force behind an auction, and thus, online auctions, is to obtain a lower cost to the goods or service in question, whether because there is not enough interest and there are not enough bids, or because the supply of the good or service is higher, thus the different choices available drives the prices down. Typically prices in auctions seen a 10% to 20% reduction (BuyIT Best Practice Network, 2004). Additionally, different types of auctions can also accrue more savings. Reverse auctions can on average reduce prices in three to five times more of regular auctions, in United States an average of 15% is seen, while on United Kingdom 18% can occur. Moreover, savings can go up to 90% depending on products or services in place (Williams, 2010). However, studies also point to different conclusions: cost savings do not substantially differ across different type of auctions, but more on the conditions of the auctions and the kind of goods and services being auctioned (Jap, 2003). Nevertheless, it is common agreement that online auctions are able to decrease the final price of goods and services to buyers.

There are usually four types of auction, the most common, which can be used in either traditional auctions or online auctions: (1) Ascending-bid or English auctions, (2) descending-bid or Dutch auctions, (3) first-price sealed-bid auctions and (4) second-price sealed-bid auctions (Klemperer, 1999), (Bajari and Hortaçsu, 2004), (Ockenfels *et al.,* 2006), (Easley and Kleinberg, 2010).

(1) The bidder has the option, in real-time, to submit one bid, higher than the previous one, and seller automatically considers that bid as current high bid. When the time runs out, the highest bidder wins the good/service.

(2) This type of auction has the feature of the seller decreasing the current high initial price at defined intervals. The bidder who decides to bid, gets the good/service at that moment and that current price. In this auction type the buyer cannot learn anything regarding the price or interest in the good/service, since only one bid is accepted. So as soon as there is one bid, the good/service is sold.

(3) Bidders submit simultaneous bids, unknown to anyone else. In the end of the auction the bidder with the highest bid is able to obtain the good/service.

(4) It is the same process has the first-price type. However, the bidder who wins only pays the second highest bid, not the winning bid.

3.4.2 The Household Retrofitting Auction Service

The service here described is the product of several discussions and interactions between the *SusCity* Project participants. It has involved experts working within different work packages. The views underpinning this model are the views of the WP2 participants, responsible for these activities, which additionally take into account the contributions from the several meetings that were held throughout the project.

The modelling language being used, also to follow the PGR approach is UML, and the service is depicted in use case diagrams. Moreover, the auction service considers three types of the auctions referred above, with different features for the ascending-bid and descending-bid auctions, but adding a fourth auction type. The differences and new auction type are as follows:

(1) Ascending-bid auctions – In a normal ascending-bid auction, usually when the time runs out, the highest bidder wins the product. In the retrofitting auction service there is a possibility of one seller having several interventions, therefore, the final price can be presented to the highest bidder, and to other bidders, which did not want to bid higher, but are willing to buy the intervention at that winning price;

(2) Descending-bid auctions – In the retrofitting auction service the seller is given the opportunity to list several interventions, or list an intervention as one. Listing as one enables selling several interventions at the price that the interested buyer bade, subject of other buyers being interested

on that price. Having multiple listings can result in different interventions being sold for different prices;

(3) First-price auctions – we also call this auction as a blind auction. In the case of retrofitting auctions this type can have two modalities. The most usual, where buyers bid for a certain intervention, and in this case each seller can only perform one intervention, the highest bidder obtains the service. The second modality, is the auction being performed between the sellers, where they compete to provide the lowest value for buyers. After a lapse of time, predetermined by the auctioneer, the bids are opened and the lowest bid (minor price to provide the service) wins the auction. The seller with the lowest bid, obtains the right to get their intervention conditions (cost, materials, date, etc.) offered to all buyers interested. In the event that there are more buyers interested in interventions, and the first seller is incapable of performing it, the next lower price seller will be called to offer the service for the remaining interested buyers;

(4) Reverse Auctions – in this type the roles of the seller and the buyer (here represented by the auctioneer) are inverted with the primary objective to drive purchase prices downward. During the auction, each supplier can submit multiple offers, responding to the competition and successively bidding down the price. The lowest (winning) bid is always available to all participants. Just like in the blind auction, the seller that wins the auction, gains the right to get their intervention conditions proposed to all the subscribers (buyers). If the seller is unable to satisfy all the interested buyers, the other sellers are requested to match the price.

At this stage the Retrofitting Auction Service is composed of three actors and six root use cases describing the services main processes. The Platform Content Manager is the responsible for the *SusCity* platform and facilitator of the auctions. The Buyer are the group of users interested in the services that will enable energy efficiency; the Sellers are the suppliers of the solutions for the retrofitting services. The currently defined use cases processes, represented below, are: {U1} Show Service Interest, {U2} Propose Auction Service, {U3} Subscribe Auction Proposal, {U4} Advertise Auction, {U5} Run Auction and {U6} Manage Profile.

The main objectives of this service is to promote increased energy efficiency in residential households, as well as to create a marketplace for suppliers of retrofitting solutions. This supports the achievement of the Portuguese Government and European Commission goals of reduction of energy consumption, as well as it supports creation of new business, therefore adding value to a city and supporting its self-sustenance.

The actors represented in the service are:

Platform Content Manager: (Facilitator | Platform) The persons who run and are responsible for the auctions. Representatives of the *SusCity* data platform, facilitating the communication and promoting the establishment of contracts for energy-related services, between suppliers (ESCO) and buyers (residents).

Seller: (Supplier | ESCO) Commercial companies that provide a broad range of energy solutions including designs and implementation of energy savings projects, retrofitting, energy conservation, energy infrastructure outsourcing and power generation.

Buyer: (Subscriber) To whom it may interest the products and services that will be auctioned. Typically, a resident (home owners or tenants), willing to implement mechanisms to improve energy efficiency.

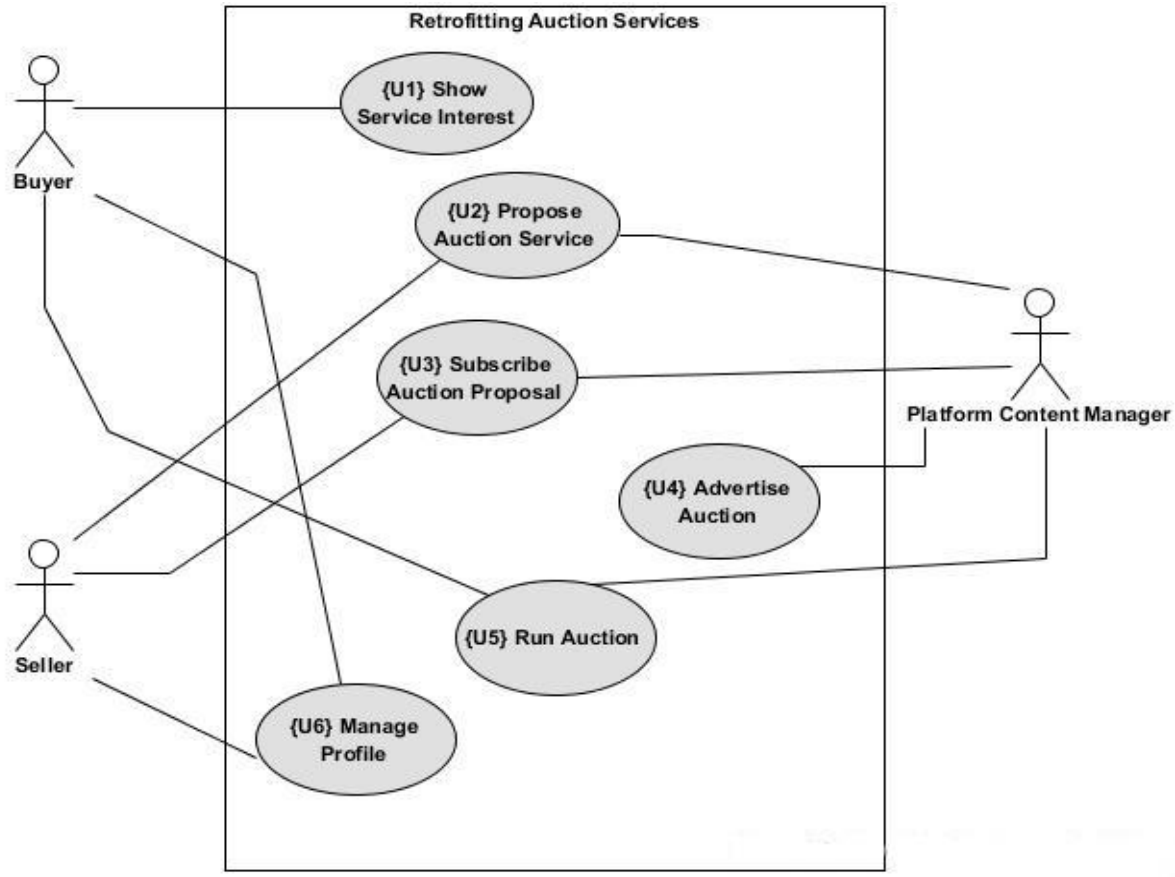

Figure 14: Representation of the *SusCity* Retrofitting Auction Services

{U1} Show Service Interest

This use case pertains showing interest for auctions, and the scheduling of auctions. A user registered as Buyer has the possibility of signalling his interest in auctions. He can also populate a wish-list with different interventions that he would like to make at his place, or request information on auction schedule. The Platform Content Manager receive those notifications to be able to manage upcoming

auctions. Moreover, the he has also the responsibility to provide and agenda with upcoming auctions, as well as provide the details of the next auction. That information is built from the interactions occurring in different use cases.

{U2} Propose Auction Service

The Platform Content Manager deals with one or more suppliers (Sellers) to evaluate possible products/services (also called interventions) to be subject of a subscription process, which is an auction. The auction service is proposed to Seller taking into account the {U1} Show Service Interest.

Following that call for interest, the seller needs to evaluate his capacity of providing a service, considering the data regarding the interested shown by Buyers. Both the Platform Content Manager and Seller define the general terms of the intervention subscription as well as the format for the auction and mandatory properties of the intervention. These will be subject of advertisement to potential buyers before the auctions start date.

{U3} Subscribe Auction Proposal

This use case aims at formalising the occurrence of an auction. Both Seller and Platform Content Manager agree on the auction format taking into account the preferences. The Seller that do not want to follow on with the auction based on the auction format are able to do so. The subscription process is formalised and presented to the Seller, namely the terms, the number of potential subscriptions, and the types of interventions that will be auctioned. Sellers willing to go forward need to formalise the subscription by fulfilling a request for proposal with data such as, type of service, number of interventions that can be achieved, the time needed to execute the projects and the specs of the service that will be performed. This is information is then presented to all Buyers upon the advertising and during the auction.

{U4} Advertise Auction

Upon defined the auction type, and formalised the proposal, the Platform Content Manager advertises the auction. Different possibilities are available. He can create sections in the platform to deal with the advertisement, include information in newsletters, request ad in newspapers, or use social networks. The minimum information that should be advertised are the type of interventions that will be subject of auction, as well as date and runtime of the auction. Additionally the type of auction or base price of interventions can also be provided.

The information should be viewable in the platform, whether or not the viewer is a registered user.

{U5} Run Auction

The Run Auction use case refers to the auction process whole life-cycle. From the beginning of the auction, until the end. It involves only the Buyer and Platform Content Manager. The list of services under auction is presented and the available actions are the same regardless of the auction type. Buyers can place bids taking into account the established minimum bid, and the highest bidder is automatically noted by the platform. Every valid bid increments or diminishes the value of intervention, and the name/number (if applicable) of the current highest bidder is shown. The process runs iteratively until the end of the time. Based on the terms of the auction anti-snipping rules can be in effect.

Anti-Snipping rule is a rule that disables last minute winning bids. The auction time is extended limited or unlimitedly until there is no bids within a defined time frame.

When the auction reaches an end the Buyer with the winning bid is notified that he won. If an intervention has a reserve price that is not met, there are no winners. Sellers are notified whether interventions are won, or reserves are not met, and how many interventions they need to perform.

Buyers receive Seller contact details (within platform) and need to initiate contact to agree on procedures.

{U6} Manage Profile

This is a support use case that depicts the management of profiles of registered users in the platform. Among different options the most critic is the ability to register a profile, of Seller or Buyer. Any type of user is able to manage notifications and leave feedback for any completed intervention. The feedback score is visible by anyone accessing the platform, whether user or not. Additionally Buyer are able to define a wish-list of services and view the profile of Sellers. Sellers are able to create a profiling detailing their know-how and service portfolio, and are able to make the profile visible or invisible to registered users.

To better support an understanding of the service process, its representation in BPMN follows below. This allows a better understanding of the process, through the power of visual analysis. The visual analysis also makes possible the traceability, knowing causes and effects of the different activities. Moreover, it shows the main process, considering hidden sub-processes, all at one time, in a single flow.

An explanation of the process accompanies the representation.

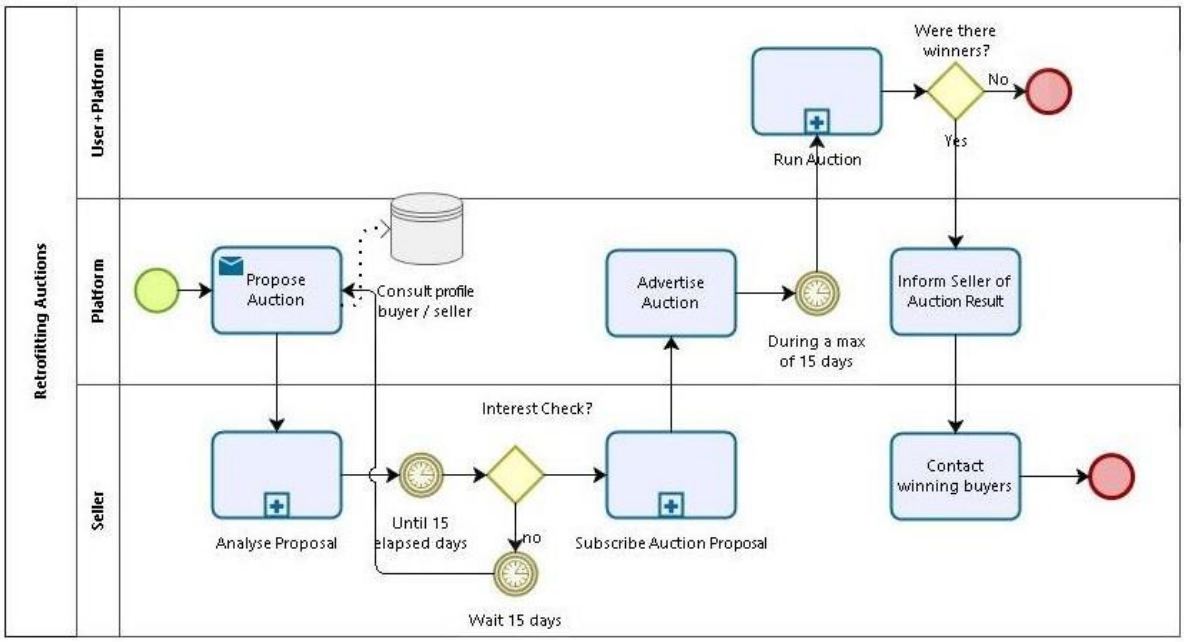

Figure 15: Representation of the Retrofitting Auction Service process using BPMN

The process is initiated by the Platform Content Manager, above represented as the Platform. After browsing through the public section of the profile of potential buyers, to see if there is demand for retrofitting services, a proposal for an auction is sent to Seller. The Seller should consider the auction proposal, which is comprised of the auction terms, a proposal for a type of auction, time and date, as well as other particularities that are deemed important. The Seller will have up to fifteen days to analyse it and add new terms or change proposal terms for the Platform to analyse. Additionally the analysis should consist of the Seller schedule and availability to supply a service, as well as the specific interest of buyers, which can be accessed in the public part of the platform user profile. Should the majority of contacted Sellers do not want to have an auction the Platform can request analysis for another auction after at least fifteen days. Should there be an interest in the proposal the Seller shall subscribe it. This subscription subprocess occurs within the "Subscribe Auction Proposal" task, and serves as a formalisation of the commitment of Seller to supply the service after the auction is over.

The Platform shall make the necessary arrangements for the auction to take place, and has up to fifteen days to advertise it. The advertisement shall serve not only to attract further potential buyers, but also to create awareness to the population concerning the need for efficient energy consumption, how to achieve it and the benefit of the auction service.

The auction runs on the date defined between Platform and Seller during the time allotted to the occurrence. The run auction process follows with buyers submitting bids subsequently (or Seller, depending on the auction type), until the time runs out and one winner (or several) are announced. If there were no

winners because no one bade, the main process is over. If there were bidders and winner the Platform Content Manager informs the winners as well as the Seller of the service. The Seller has the responsibility of contacting the different buyers and supply the service.

The time interval between the finished process and a new process can begin is defined by platform. However, to maintain the service active, should be interesting to have auctions occurring at least every odd month.

3.5 Conclusions

This chapter presented a smart city project, *SusCity*, and performed an analysis of smart city maturity models, which supported the definition of an IT-based service for retrofit auctions in a context of smart city.

The presentation of an on-going smart city project, *SusCity* Project acts as a demonstration case of this research work, and where the results will be applied and used. One of the impacts of *SusCity* is to advance emerging business models for energy and mobility solutions in a rich data and ICT driven context. The artefact that resulted from this research is one of the emerging business models, therefore contributing to the expected outputs of the project. It foresees impacting the project results in two domains. On the one hand, the environmental domain, enabling purchase of retrofitting solutions, to increase energy efficiency, through the use of auctions services. On the other hand wants to promote the boosting of a marketplace for those type of energy services, and the creation of new businesses.

The analysis of maturity models for smart cities is important because they are tools to assess current state and monitor initiatives concerning their evolution towards a defined paradigms. If a city knows its current state, it can more easily assesses which technology better serve its needs. From the three analysed models the main conclusions are that the IDC SCMM fulfils six out of ten basic design principles; one out of five principles for a descriptive purpose of use, and two out of six of the third group. The Br-SCMM seems to be the most complete model, having fulfilled nine basic principles out of ten; four out of five for the descriptive use group and none for the prescriptive use group. The SO SCMM fulfils six principles from the basic one, three of the second group, and, like the Br-SCMM, none of the third group. Additionally, the models were developed to be applied in different contexts. The IDC SCMM aims to be applied in a context where basic infrastructure exist and the main concerns are the governance and management of a city. Both the Br-SCMM and the SO SCMM apply within contexts where the urban resilience and basic infrastructure is still sought. While the objective was not to apply any of the models

to the *SusCity* Project, it can be considered that once the project is completed shall provide a higher maturity to the city.

The artefact presented in the next chapter, a business canvas, takes into account the modelling of the retrofitting auction service portrayed above. The choice of an online auction mechanism is due to the benefit for both buyers and sellers. Whereas sellers are able to incur in lower transaction costs and have a larger pool of buyers, buyers have the possibility to more easily find goods and services they need and have a reduction in price, usually 10-20%, when winning a bid. The retrofitting auction service is modelled using UML use case diagram, having resulted in six root use cases and three actors. Each use case diagram is explained in natural language and an activity diagram is also present to provide the reader with an experience of the mechanics of the service. This latter diagram is presented using BPMN.

These set of use case diagrams serves as input to fill a BSC, which subsequently will serve as input to map a business canvas. The next chapter explores the application of the PGR Approach, and proposes its extension.

4. Aligning IT with Smart City Needs

This chapter reports the second part of the contributions based on the research performed. Identifies the goals and rules of the auction service presented in the previous chapter and builds the business canvas, based on the Lean Canvas, an innovation to the PGR Approach.

Chapter Contents

Publication – Submission to Conference

Extending the PGR Approach for a Business Model Proposal for Auction Service within a Smart City Context **(IESS 2017)**

4.1 Introduction

The fourth chapter intends to present the main contributions of this research work. Whereas in the previous chapter new material has been presented, this chapter objective is to build the business canvas and propose the extension of the PGR Approach.

To be able to build a relevant canvas contextualising this research, and also fulfil the objectives of an auction, first the elicitation of the goals and rules associated to the service was needed. This is also the first step as suggested by the PGR Approach. Prior to the definition of the goals and rules, based on the use cases above defined, heuristics are identified. These pertain the domain of smart cities, taking into account the *SusCity* Project, as well as the objectives of an auction.

The BSC is filled following the heuristics. Six BSC were prepared, one for each use case diagram. Each of the four BSC perspectives is filled for a goal and objective, a strategy and associated tactic, and a policy and rule which enforces it, following the Business Model Motivation (BMM).

While the original form of the PGR Approach uses the BMC as the final output to reach the alignment of business and IT, here is proposed a modification. Instead of the BMC, a LC is used to portrait the business model. The LC is mapped considering all the BSC, thus refining all the business goals and rules.

The final section of the chapter discusses that alteration in the approach, mentioning difficulties and limitations of the resulting business model. Additionally, an empirical economic analysis is presented, intending to show the value of the proposed service.

4.2 Identification of the New Service Goals and Rules

This sub-section explains the BSC mapping process. Since there are no defined rules on how to map a BSC, only guidelines, it is important provide an understanding of the assumptions underlying each BSC perspective. Therefore, we identified a set of heuristics to follow while filling in the BSC. These focus on the objectives of an auction as well as on the concept of a smart city.

4.2.1 Heuristics

An organisation can have a multitude of business models, depending on the different engaged domains and on the different strategies, which accompanies them (Labes *et al.,* 2013). Therefore, to be able to

build a model that is completely focused on a business strategy, which might be different than the corporate global strategy, it is important to employ a BSC. The components of the BSC will give the strategic significance, which will be mapped into the business model. To support that specification, a set of heuristics is identified, to be used when filling in the BSC. These focus both on the particularities of auctions and the smart city domains that are relevant to the objective of the auction service.

With what concerns to the Smart City, management needs to consider decision making centred on citizens needs and well-being, as well as economic and environmental sustainability. A smart city beyond inclusive, is also sustainable and resilient, but also democratic with strong sense of welfare, and environmental friendly, focused on urban development (European Commission — Directorate General for Regional Policy, 2011). As an urban place, aggregating the majority of the population, cities need to achieve self-sustenance. Hence, a retrofitting auction service needs to serve the objective of sustainability and that can be achieved in two ways.

A smart city aims at being energy efficient, providing its citizens with the means to be able to maintain the standards of life with more affordable energy prices, more efficient consumption and less emissions of gases. A good and strong economy allows the creation of new business and wealth leading to full-employment and more resources to be spent on education, culture and health, leading thus to sustainability. Hence, the service will on the one hand engage and enable citizens the purchase of energy efficient solutions at affordable prices. On the other hand, suppliers have a larger pool of buyers and can possibly sell more of its services and solutions. Therefore, the service will champion energy sustainability through value and wealth creation. We consider therefore the relationship between the smart city and the BSC perspectives as follows:

- Financial – The financial perspective aims at maximising the economic value of smart city services, by involving existing and new industries and services, towards the creation of wealth. Moreover it is also related to decreases in expenditure for citizens and productivity rise, creating new businesses and efficient markets.
- Customer – Is the city itself, their citizens, institutions, both public and private, industry or academia, while related to the comfort of living and quality of life. This perspective addresses needs of a smart city, in this case the needs for the creation of wealth and be more energy sustainable.
- Internal Business Processes – Ensure the services created have a purpose, that any initiative follows a plan and is related to the global vision of the smart city. Ensure that involved stakeholders are being served and that transparency and accountability measures are in place. The internal business processes should facilitate the definition of services that create value to the city.

- Learn & Growth – This perspective is somewhat transversal to all perspectives. It ensures that support exists when carrying out the normal activity, both from the ICT point of view, as well as human capital. The satisfaction of citizens and stakeholders of the city services should be a priority as well as the service quality.

Additionally, the BSC should not be mapped taking into account only what a smart city is, but also the purposes of an auction. Therefore, we define also a relationship between the BSC perspectives and auctions:

- Financial – An auction service creates value overall. Or because the buyer will pay a price that is lower than his perceived value of the good/service, or because the seller is able to amass a great number of interested buyers in one place and saves in marketing and transaction costs, and has greater chances of selling good/service.
- Customer – Both buyers and sellers are the customer of an auction service. It is important to achieve a large pool of buyers and sellers, which is balanced, and where buyers and sellers feel that it is the best place for them to conduct business.
- Internal Business Processes – Ensure satisfaction and loyalty from customers, service quality from the auctions, transparent processes, design and ease of use of the auction service for all service stakeholders.
- Learn & Growth – Cater for the monitoring activities to ensure that service quality of auctions is always the best, that inefficiencies are detected and solved. Lessons learnt mechanisms to enable service upgrade and growth are also suitable to this perspective.

Based on this grouping of perspectives, taking into account that the service is both an auction service for retrofitting services, and those services need to support smartness of a city, the BSC is filled.

4.2.2 Building the Balanced Scorecard

Regardless of the framework used, the goals and rules pertaining to the auction service will be retrieved from the use case diagrams using the perspectives from the BSC. After the BSC is filled, the next step is the mapping of the canvas from data contained in it.

The BSC is being filled taking into account the different use case diagram presented above. Therefore, to ease the analysis, six BSC are shown, which will be compiled into one business canvas. This occurs because, according to the PGR Approach (Salgado *et al.,* 2014b) it is needed to elicit the goals and rules and associated policies for each root UC. Each UC will be associated with each BSC perspective. The

BSC mapping follows the reasoning: (1) identify the associated goal of the UC; (2) determination of the strategy and (3) the business policy governing the strategy. The goal shall refer to the desired result that needs to be achieved, the strategy the course of action to be followed, under which directive given by the policy.

The PGR Approach also suggests that further concreteness and specificity can be achieved for each goal and rules, by defining SMART objectives, determining tactics and establishing a business rule item, following the BMM.

{U1} Show Service Interest

Table 7: BSC perspectives concerning process root case U1

	Goal	Strategy	Policy
Financial	- Having an active platform and engaged community - Run an auction at least every 60 days	- Partnering with the local government agencies to create awareness - Communications in local government webpages	- Benefits from using auction services easily grasped from the platform - Follow features, advantages and benefits (FAB) acronym
Customer	- Allow users to have both seller and buyer profile - Have the major supplier of retrofitting services registered	- Send personal invitations to supplier to register - Request support from local government agencies in identifying potential suppliers	- Provide type of services, or appliances as choice form to support show interest - Ensure the show interest section of profile has option to be visible/invisible
Internal Business Process	- Users able to use alert system when their interest/service supplied is targeted - A non-intrusive/non-spam alert system	- Platform having a set of services which are triggered for alerts - Users have option to turn off alert system	- Warn users of upcoming auctions based on interest shown statistics - The auction is not certain before approval from sellers
Learn & Growth	- Have a FAQ related to the Show Interest feature - FAQ must be comprehensive	- Request feedback from users to support comprehensive FAQ - Have a feedback section in the Show Interest feature	- Feedback is always addressed - Pertinent feedback and options added in FAQ

{U2} Propose Auction Service

Table 8: BSC perspectives concerning process root case U2

	Goal	Strategy	Policy
Financial	- Be the Marketplace for retrofitting services - Have a large pool of users: buyers and sellers	- Create awareness of energy efficiency benefits - Services without transaction fees to sellers	- Information on benefits of auctions and pricing system - Low service fee if service is sold
Customer	- Ensure that auctions occur every 60 days - Engage potential sellers and protect personal information of users	- Market the advantages of online auction - Provide E-S-Qual service	- Have sufficient public information of users to create interest - User public profiles need to be viewable at all time
Internal Business Process	- Have user friendly menus - Assure feedback is provided within 24h	- Metrics for quality of service - Provide a section with the results of assessments	- Formalisation is bidding - Non-compliance is met with expulsion from the 3 next auctions
Learn & Growth	- Have a section in the platform with the most sought services - Ranking by need and number of interests	- Have automatic updates to the ranking - The update occurs every day	- Propose auction types that favour the Seller based on interest - Propose at least two options of auction type

{U3} Subscribe Auction Proposal

Table 9: BSC perspectives concerning process root case U3

	Goal	Strategy	Policy
Financial	- Proposal to seller attractive enough not to be refused - At least 50 potential subscribers foreseen as participants	- Provide as much information as possible concerning the needs to the Seller - Inquire potential buyers about interest	- The type of auctions defined according to the best value for Seller - Simulate added value accrued from different type
Customer	- Seller have sufficient time to analyse the proposal - Give a 15 days period before subscription decision		- Auction is considered accept if majority of Seller subscribe - at least 60% of Seller agree to participate
Internal Business Process	- Seller have a pre-defined template to fill necessary info - User-friendly and non-time consuming	- Seller needs to formalise acceptance to be part of auction - Send reminders in the last 3 days of decision period	- Send reminder to Seller if feedback is not received in last 24h - No subscribed proposal accepted after deadline
Learn & Growth	- Have a section of the top Seller - Have new Seller subscribing each new auction proposals	- Each Seller that supplied service part of ranking - Set up a feedback system to trace supplies	- Seller considered in the ranking has positive feedback - After a transaction ensure feedback is left

{U4} Advertise Auction

Table 10: BSC perspectives concerning process root case U4

	Goal	Strategy	Policy
Financial	- Measure the ROI of advertisement - Have no more than 1% of supply return in ads	- Use the most effective type of ad - Request feedback from users concerning how they were became aware of auction	- Free advertisement is preferred - Advertisement budget must not be blown
Customer	- Reach a good audience - Have at least 50 new users registered in the platform until the auction	- Advertise in different media types - Use social networks, the platform and local government newsletters, local newspapers	- Reach relevant audience - Only advertise in local newspapers if there are sellers from there
Internal Business Process	- Advertise well in advance of auction - At least 15 days before the auction date	- Have ads ready within 5 days - Have ad template retrieving necessary info from subscription proposal	- At least one type of advertisement is used - All auctions are advertised
Learn & Growth	- All the relevant information should be advertised - Receive no request for information concerning advert	- Create ad template with mandatory fields to be filled - The fields are incorporated in the different ad format and types	- All inquiries related to the advertisement are answered - Feedback given within 48h

{U5} Run Auction

Table 11: BSC perspectives concerning process root case U5

	Goal	Strategy	Policy
Financial	- Keep the auction animated and advertise it throughout its duration - Exhaust Seller capacity to provide services every auction	- Promote auctions with a mix of bid increment - At least 3 levels of bids increments where at least are in place	- Offer prize to the highest bidder - if two bidders are in equal footing, both receive prize
Customer	- Protect personal information of users - Auctions are a secure and quality reliable service	- Create sense of trust to the participants of auction - Use secure protocols and employ security measures	- Ensure that an auction always runs smoothly - Provide compensation when faultiness is observed
Internal Business Process	- Ensure no downtimes - The system must have rapid response, low latency	- Auction capacity is enough to meet demand - Latency times must be checked before every auction	- Maintenance checks after every auction - All issues are always addressed within 24h
Learn & Growth	- Provide a dynamic user experience - Perform evolutive maintenances	- Run usability tests for every new functionality - Request feedback from users every year	- All buyers contacted within 72 hours - Implement good contact channels for users

The last use case, {U6} Manage Profile is not considered because it is a support use case, and does not provide any added value to the overall objective of the business.
The next section will use the different BSC to fill in a canvas. That process can be considered a sharper refinement of the goals, strategies and business policies of all the service processes, which enables a global overview of what is more important to the business taking into account a city context.

4.3 The Retrofitting Auction Service Business Model

While the BSC addresses a specific processes of the global service, the canvas synthetises the different BSC and its perspectives in a unique business model. The business model will try to solve the problem of increasing energy efficiency, while creating value to a city. The value created is not only due to the potential savings achieved by reducing the energy consumption, but also by the expected creation of a new marketplace for retrofitting service provision. We opted to use the LC (Maurya, 2012) for a business model proposal, because its approach focus on finding the best solution for a giving problem, so prioritizing the creation of value. Additionally, allowed also propose an extension of the PGR Approach, thus continuing the work of (Salgado *et al.,* 2015).

The LC is a business model canvas, based on the BMC, however, it is focused on the lean approach, that is, being more flexible and more adaptable to the fast pace of nowadays businesses. It is a canvas supporting start-ups and, more specifically, online-business needs, being focused on customer engagement and on solving problems. Those were also the reasons to have opted for this canvas. The service model here depicted is for online business and aims at resolving one current problem, increase energy efficiency for residential households, which in Portugal stands at a level C.

The LC is composed of nine blocks, which can be defined as:

- Problem – The main problems at hand;
- Solution – The main features of the solution;
- Key Metrics – Activities to measure;
- Unique Value Proposition – A message that states why is the business different and worthy;
- Unfair Advantage – What can't be easily copied or bought;
- Channels – How to link business to the customers;
- Customer Segment – Who the target customer is;
- Cost Structure – Which costs are needed to create the business;
- Revenue Streams – The pricing model and revenues to accrue.

The author of the LC defends that the first block to be filled is the problem, since it is because of a problem exists that a solution is needed. This is also what we stressed above, especially for smart cities. Any initiative should be taken if there is a real need. And that need should be satisfied by the results of the initiative. Therefore, at all times a city is being served by actions and initiatives and not the other way around.

The complete LC regarding the online auction service and smart city needs, according to the BSC filled following the defined heuristics, is represented below.

Table 12: Mapping of the Lean Canvas

<table>
<tr>
<td rowspan="2">Problem
● Inefficient energy consumption
● High Energy costs
● Increasing efficiency in energy consumption
● Value creation to the city</td>
<td>Solution
● The Creation of a market place for retrofitting services
● Ensure auctions as a secure and quality reliable service
● Have an active platform to engage citizens
● Have user friendly menus
● Ensure no downtimes
● The system must have rapid response and low latency</td>
<td rowspan="2">Unique Value Proposition
● Have in one place, the possibility to conduct business for retrofitting services in an affordable way to both buyers and sellers, regardless of their location, and the assurance that the business is conducted in a secure and reliable place.</td>
<td>Unfair Advantage
● Present the services without any fees to sellers
● Provide compensation when faultiness is observed
● Provide a quality of service according to the E-S-Qual standards
● Provide dynamic user experience
● Perform evolutive maintenances to have a system new and demanded functionalities
● Prizes available for the highest bidder in each auction</td>
<td rowspan="2">Customer Segments
● Sellers – suppliers of retrofitting auctions
● Buyers – household owners or household tenants</td>
</tr>
<tr>
<td>Key Metrics
● Metrics for the quality of service
● Latency times must be checked before every auction
● Auction capacity is enough to meet demand
● Run usability tests every time new functionalities are added
● Feedback from users every year
● Advertise at 15 days before auction date</td>
<td>Channels
● Auctions occur every 60 days
● Online auction service</td>
</tr>
<tr>
<td colspan="3">Cost Structure
● Cost to supply the service
● Service fee if retrofitting service is supplied
● Advertisement costs - Only advertise in local newspapers if there are sellers from there</td>
<td colspan="2">Revenue Streams
● Supply of retrofitting services
● Increased energy efficiency – saves on energy
● Services without transaction fees to sellers
● Prizes for the highest bidders</td>
</tr>
</table>

4.4 Discussion and analysis

This section provides an overview and summary of the steps taken to build the business canvas. Additionally points a few limitations faced when applying the PGR Approach, as well as limitations of the canvas itself in its current state. A different section proposes an empirical economic/value analysis on the benefits of using the retrofitting auction, based on the proposed business models. Since it is deemed an empirical analysis a set of assumptions are considered and referred below.

4.4.1 The Model Added Value and Limitations

The objective of using the PGR approach is to follow a methodology based on known frameworks to devise a business model for any business, especially if it is IT dependant. This approach is based on processes that are modelled using use case diagrams, complemented on goals and rules associated information, and intends to align business and IT. The extension of the PGR Approach supported the building of a business model that could be fit to our particular needs, hence its application in one ongoing smart city project. Furthermore, the author also considered its knowledge, based on life experience and the literature review in the explored domains, since mapping a canvas is highly dependent on the analyst knowledge and in the available heuristics. In this case it was deemed important to define those heuristics based on smart city definitions and indicators, as well as on auction service practices.

Adequate business goals and rules were elicited, enough to fill six BSC, for each modelled uses case of the target service. However, the “strategy” and “tactic” of the “customer” perspective of “U3 Subscribe Auction Proposal” was not filled, due to difficulties of in finding suitable strategies. Moreover, these goals and rules are as subjective as the reader understanding, and therefore resulted in BSCs that are valid and true to the views of the authors of what is a smart city and an online auction service, and how they fit in the BSC perspectives.

On a second step, the PGR Approach considers the generation of a BMC based on the previously mapped BSC. In this case, the BMC was replaced by the LC. The reason for using a LC instead of a BMC is twofold. On the one hand the LC is more focused on the problems that the business solution needs to focus, is therefore more able to be adapted to a rapid change in business conditions. Moreover, as the canvas author stated, it is more adequate to online businesses. On the other hand, since we are working on a service that needs to provide solutions to solve existing problems concerning energy efficiency, we felt that the LC could provide a more focused canvas.

The LC, as the BMC, is divided in nine sections, however, the mapping of the nine sections was not easily made after the BSC. Since the LC focus on solutions to solve problems, we had to first have a "Problem" to generate the canvas. Therefore, it was not possible to map that section directly from the BSC perspectives. Moreover, it was also difficult to map the "Unique Value Proposition" directly from the different BSCs. The block is supposed address the most important feature of the business being modelled. Therefore, this section is also highly subjective and relies on the author deductions and feelings.

The remaining sections were possible to be mapped from the BSC perspectives. While the "Solution" and "Key Metrics" were generally mapped directly from the "Internal Business Process" perspective, the "Unfair Advantage" and "Channels" were mostly mapped from the "Customer" perspective. The "Cost Structure" and "Revenue Streams" were related to the "Financial" perspective from the BSC. The "Customer Segments" were retrieved a bit from the whole BSC.

At the time of writing this dissertation, the *SusCity* Project was also underway and the different BSCs and the canvas were not able to be discussed and shown to the different stakeholders of the project. This hindered the validation of the different goals and rules. Nevertheless, based on the assumptions and considering that a company can have different business fields, and therefore, different business strategies, according to the Business Model Framework by (Labes *et al.,* 2013), the achieved result is valid and portraits a strategy that is fit to the needs at hand.

As the project progresses and the services are better defined, the BSCs and subsequently the business canvas will be reformulated and new rules and goals added. At that point a better assessment of the pertinence of the LC to the specific service will be made. Currently the author strongly believes that the canvas framework is solid and useful, interesting to apply and provides a unique view towards supporting definition of services to cater to a niche in the market or to supply solutions to an existing problem, always focusing on its unique features.

4.4.2 Value analysis

This analysis has the perspective of the potential gains a platform user can have if he buys and installs a retrofitting solution. The analysis is deemed empirical because it is based on energy certification reports of buildings that have been sold in Portugal. It does not take into account current service prices, nor in situ measures of energy consumption.

However, it provides some insights when considering efficiency rank improvements, which is the main objective of the proposed service, to increase efficiency in the consumption of energy.

As above mentioned, Portuguese households accounted for around 16% of all energy consumption in 2013. The graph below, measured in million tonnes of oil equivalent (MToe) provides an evolution of the different sectors throughout the years.

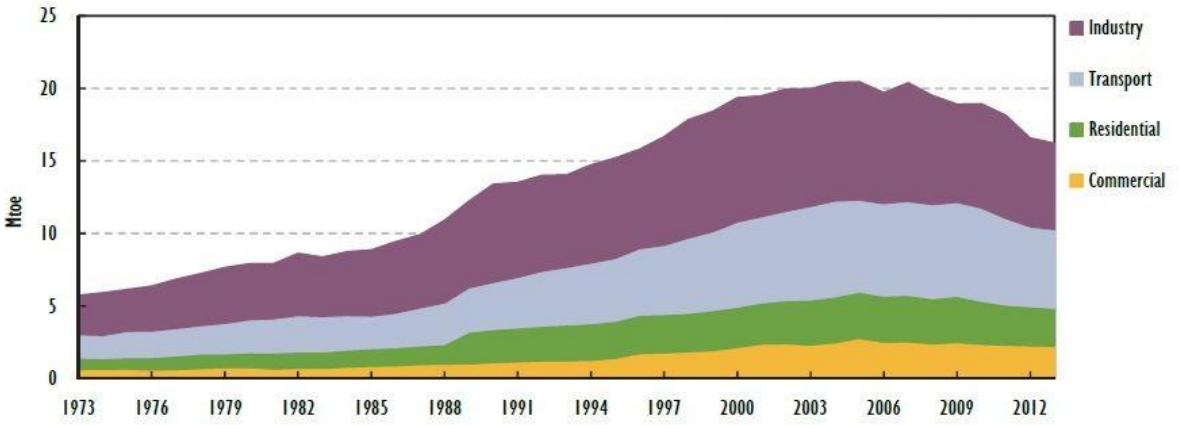

Figure 16: Total Final Consumption of energy per sector, 2015 (Source: (International Energy Agency, 2016a))

In a survey produced in 2010 it is possible to see the consumption distribution in Portuguese households:

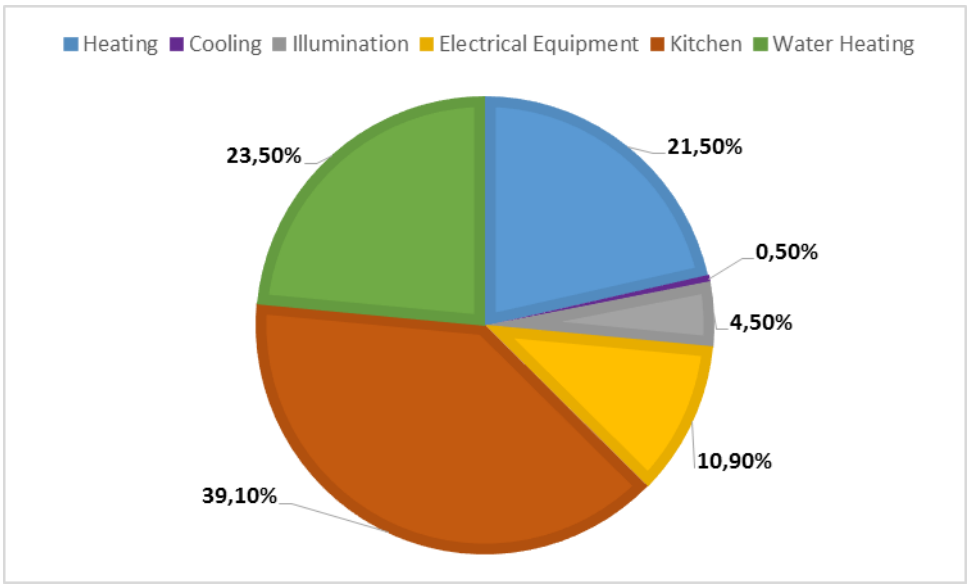

Figure 17: Distribution of household energy consumption in 2010 (Source: (INE and DGEG, 2011)

It can be concluded that the biggest spending is in space and water heating as well as kitchen.

The energy consumption is also divided in eight ranks, the most efficient A+ and the least efficient F. In between can be found A and B-. In Portugal the average from the last measurements has degraded to

level D, the six in a scale of eight. The graph below shows the comparison between 2013 and 2016. This values are known because in Portugal every house that is sold, being a new or used building, needs to be subject of an energy certificate. The authority responsible for such certificates is ADENE[14], the Portuguese agency for energy.

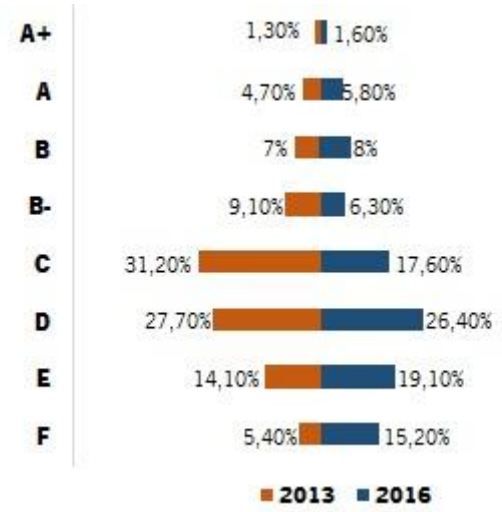

Figure 18: Energy Classes Distribution Portugal (based on ADENE energy certificates)

A quick analysis shows that Portuguese households are inefficient. Not even 10% reach the A class, and less than 15% reach class B. There are efficiency to be gained, and hence this service here proposed.

It is very difficult to make an economic analysis where most of the information available is qualitative. Available report state efficient gains in percentages without stressing monetary savings. Moreover, the different classes are not associated with an average consumption, just relative efficiency against a reference value, which is class B-, the minimum efficiency a new building needs to achieve. That class has an energy efficiency from 76% to 100%. Higher values means less efficient households, lower values means more efficiency.

Taking into account a potential buyer that wanted to increase its house energy efficiency, and considering the information comprised of a standard certification report, the following analysis could be made. Additionally the rationale present in the business canvas presented is also followed: A large pool of buyers and sellers is present and during the auction the goods and services are sold with a good value to customers.

[14] http://www.adene.pt

The efficiency classes are shown in Figure 19. To build the case it is considered a two room dwelling with an average energetic yearly spending between 650,00 € and 700,00€. Moreover, the energetic class of the flat is C.

According to information received from ADENE, to reach B- from a class C, an average spending of 5.000,00€ is needed in more efficient solutions. Considering acceptable an increase of 25%-30% in efficiency to reach class B-, it can be deducted that the building has become 25% more efficient, meaning it will consume less 25% of energy to provide the same output of services. That means that is expected to decrease the yearly invoice amount.

Assuming the auction mechanics, with a good affluence, the solutions to reach B- can be acquired with a 10% to 20% discount against market prices.

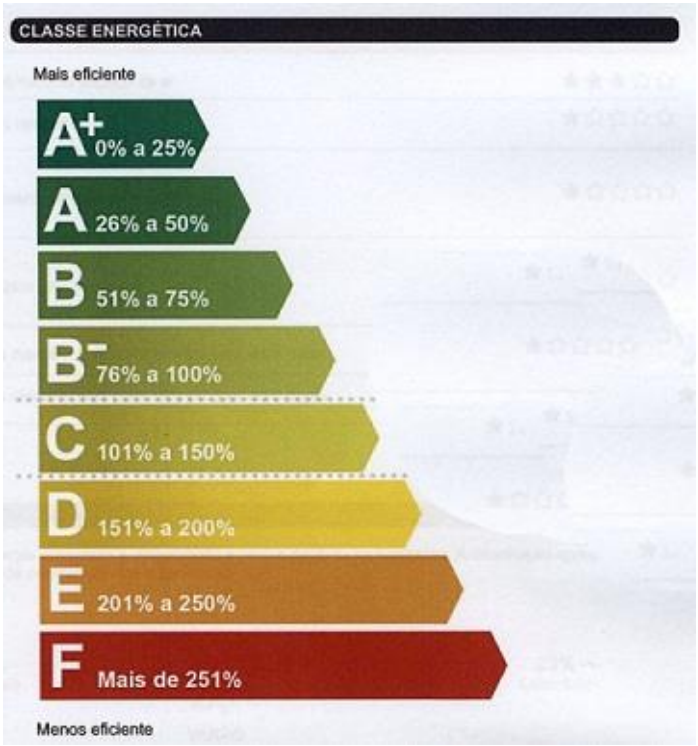

Figure 19: Energy Classes in Portugal (Source: ADENE)

By being B- efficient the buyer would save 25% of 700,00€ yearly, 175,00€., summing 1.750,00€ in a 10 year period. Considering a 10% price reduction in the solution, a buyer can potentially spend 4.500,00€ instead of the 5.000,00€, plus having a more comfortable home. In total in a period of 10 years 2.250,00€ could be saved in energy.

To further increase efficiency these average spending were collected: from class B to class A around 4.700,00€ are needed, and from class A to A+ around 5.700,00€. A maximum of 50% increase of

efficiency gains can be achieved with each rank. The discounts that are possible with the auction vary, but it is expected that they will support further savings when dealing with improvements.

4.5 Conclusions

The PGR Approach as initially defined proposes alignment of business and IT through the mapping of a BMC, using as inputs the four perspectives of the BSC, financial, customer, internal business process and learn & grow. For each perspective, and based on the previous chapter modelled auction service, goals, objectives, strategy and tactics, policies and rules were identified. This step was made to five of the six use cases modelled. However, there was one difficulty in filling the BSC "strategy" for the "customer perspective" of U3, therefore, has been left blank.

The first iteration of the PGR Approach has thus been performed. As for the second iteration, a mapping of the BMC from the BSC is proposed.

However, in this work instead of following the original designs of the PGR Approach, a mapping of a different canvas was attempted. A LC, one business model better suited to the fast pace of today's businesses and more focused on online services, was built. This difference allowed to better cater for the specificities of the service proposed, that is, the context of its proposal, the *SusCity* Project, the problems that it tries to solve, and moreover, to be available online. While the LC follows the same structure of the BMC, being composed of nine blocks, a direct mapping from the BSC is not entirely possible, as with the BMC. Nevertheless, the LC has been mapped taking into account the information contained in the six BSC. Some of the difficulties are discussed in the final section of the chapter, where an economic analysis is also performed.

Based on a set of assumptions, and empirically, as this was not an objective of the research work, it is possible to see that the acquisition of services through an auction entail a lower price, which further supports the decision of increase energy efficiency based on expected savings.

5. CONCLUSIONS

This chapter concludes this document. It documents the main conclusions taking into account the research questions and objectives that framed this dissertation. Additionally it synthetises the attempted contributions, referring to the achieved publications. Last, but not least proposes future work.

Chapter Contents

5.1 Conclusions

This dissertation arose from the evident need for more environmental sustainability. It aimed at creating and supporting behaviour and societal change with premise that IT should not be a driver of smart city initiatives, but should be a facilitator. Framed within a smart city project, the *SusCity*, which served as a demonstrator, had the overall and main objective the alignment of business and IT of smart city service, through the generation of a business model. Due to the project objectives, as well as the EU climate action targets, and the Portuguese Energy National Strategy, the work focused on the definition of a new online service tackling environmental changes, the retrofitting auction service. The service has two immediate goals: (1) be a means of increasing efficiency of energy consumption in residential households, (2) create value to the city, in this case through the creation of a marketplace for retrofitting services. The problematic of the alignment is therefore of utmost importance, since any initiative within the field of IT should not have as driver the IT, but the needs of an organisation, in this case the city. Therefore, can be concluded that the work follows the paradigmatic philosophy of the socio critical theory, by proposing a practical change, an online service, which has been aligned to meet the needs of a city, therefore, taking into account and supporting its processes. Since it was framed within a smart city project it was a collaborative work, sensitive to the needs of the project

To achieve that alignment the PGR Approach was chosen due to the following reasons: The PGR Approach builds on from root use cases, trying to elicit through them goals and rules, by filling BSC for each use case. That step brings an analyst closer to grasp the mission and objectives of an organisation, allow him a deep knowledge of it. Additionally, the BSC serves as input to map and define a business model in the form of a canvas. The canvas is a useful and flexible way of picturing one business, which depict its strengths, customer base, solutions or financial overview, thus representing in an abstract way an organisation. By having such a model for an IT solution, it is easy to understand that an alignment has been achieved between the business and IT, which is the main objective of the PGR Approach.

Furthermore, to be able to address the specificities of the context, a minor extension to the PGR Approach has been proposed. Since this service is framed within a project, also being an online service, and being created to tackle a known problem, or opportunity, a different canvas was seen as more suitable. Therefore, instead of applying the PGR and having as output the BMC, which could be

mapped directly from the BSC, a LC was chosen. While also having nine blocks, this canvas is focused more on the problem and uniqueness of the business, hence created some difficulties to be mapped.

Nevertheless, and also due to the identification of heuristics, which in any situation is a manner to support an analyst in understanding the specificities of the domain, filling the LC was also possible.

The main objective of this dissertation was thus achieved. An IT-based service was defined and a business model built to support the creation of value to the city.

Backtracking to the questions raised and the research questions and objectives, all of them were fulfilled. The first question, "*What can make a City Smart?"*, is answered within the first chapter, where the context is detailed. From that question, a second one arose, *"Which are the needs of a smart city?",* related to the first objective elicited, to identify characteristics of a smart city. The second chapter provided a synthesis of different models and frameworks characterising a smart city. That characterisations provided the needed knowledge to support an alignment between the IT and the business, the smart city needs. Based on those needs, framed by the *SusCity* Project an online retrofitting auction service was proposed. The main reason to propose an online auction service, was due to their popularity derived from the internet and the comfort to both buyers and sellers, the easiness to gather a relevant pool of buyers and the lower transaction costs to sellers and savings in final prices achieved by the buyers. The third chapter reports the definition of the service, and thus the accomplishment of the second objective of the dissertation. The fourth chapter comprises the second research question, the creation of value with the new service. To answer that question, an objective was identified and needed to be fulfilled: "Application and Extension of PGR Approach and the Generation of a Business Model".

The main contributions to the body of knowledge that this work gives are threefold.

Initially, while understanding the concept of smart cities, a systematisation of maturity models considering the smart city in a holistic way was presented. Based on principles that maturity models should follow, three smart city maturity models were analysis and a synopsis was made. Therefore, anyone wanting to further develop a maturity model for smart city, or to update any of the analysed models, has already a set of conclusions on what are the necessities of these models.

Moreover, and considering the needs of the *SusCity* Project, a service was proposed. It is a new IT-based service, with the main goal of allowing potential buyers to acquire retrofitting solutions at lower prices and thus support more efficient consumption of energy. The PGR Approach was applied to the

service to increase its value and to align it to the needs of the city, which brings us to the third contribution. An extension of the PGR Approach. The approach was used with the aim of producing a different output than what was originally conceived. The LC was mapped and the achieved was quite satisfactory, therefore attesting to the validity of the PGR Approach using a different canvas.

This contributions were also disseminated through two publications. In one publication, a paper was submitted to ITAIS 2016 and the work was presented in Italy in October 2016. That publication pertained the assessment of maturity models for smart cities. A second publication was attempted and waits feedback. The proposal of the new service and PGR extension was submitted to IESS 2017 in late December 2016.

Considering the proposed research approach, the Design Science Research, and taking everything that was told into account, especially the time frame, it can be concluded that the guidelines were followed and that the approach was correctly implemented. Therefore, the research is self-validated. The final output is an artefact, a business canvas, which can be used during the development of the service and its roll-out. Moreover, since the problematic was the alignment of business and IT, the canvas has built taken into account the needs evidenced by the city, throughout the *SusCity* project, which framed the context, hence attesting the second guideline. The evaluation of the research output were achieved empirically. There was not enough time to develop the service within the time frame of this research work. However, since a previously defined and validated approach was used to secure the alignment, and the results achieved were satisfactory, it is thus considered to have been validated. The fourth guideline suggests that contributions should be made to increase the body of knowledge. In this case, those have been referred above: a systematisation and analysis of smart city maturity models; proposal of a new IT-based service to solve an identified problem and last but not least the proposal to extend the PGR Approach to consider as output not only BMC, but also a different canvas. In this case, the LC was used. The defined canvas was based in heuristics, therefore valid in that situation, but with enough flexibility to be valid in different situations, should the heuristics be adapted. Therefore, the research rigor is achieved. Different research objectives were proposed, and the work advanced in an iterative way. Nevertheless it is possible to see some limitations, as the solution was not tested and validated against other solutions. Hence, it is difficult to ascertain if this is the best solution that could be achieved. Nevertheless, it is an effective solution, considering the research objectives, and the *SusCity* Project objectives. Last but not least, different outputs of this research were communicated through several means: (1) As outputs of the *SusCity* Project; (2) One paper

Submitted and presented in one conference in the Italian Chapter of the AIS; (3) Another paper submitted to the International Conference on Exploring Service Science 2017.

5.2 Future Work

The work reported here is far from over and several roads can be taken over from where this document ends. Following limitations identified, or continuing the research in the smart city domain, it is the author's firmly conviction that there is still much more to add the body of knowledge.

The exploratory work related to smart city maturity models will be pursued in future endeavours, towards the definition of a maturity model, adapted from the analysed models and taking into account the maturity model design principles enumerated above. The importance of having one tool that cities can use and be certain that will produce results is of utmost importance. Several smart city projects have started and ended in different cities, and it is difficult to ascertain if there was a clear evolution in the city landscape and paradigm, and mostly if the citizens feel that their quality of life has improved. Several frameworks exist directing the city, suggesting actions, and providing guidelines, but there is not clear and accepted model to monitor the initiatives and evaluate them. A complete and comprehensive model takes years to develop, and it is usually difficult for private companies to initiate such endeavours. Therefore, it is one future goal while in a position of researcher, to develop a maturity model for smart cities.

The proposed retrofitting online auction service, as well as its business model have not yet been validated by the stakeholders of the project. Upon that validation and updates are taken into account, if need be, the service can be deployed and replicated in different cities. Assessment of workings, gauging its performance and capacity to fulfil its objectives is also one possible future work. This will further validate the PGR Approach, as an approach to align business and IT, which is able to build sturdy and sound business models.

Further progress can also be made in the field of business models. New services or new ventures need business models, however stable businesses and existing companies can also benefit from business models. A few questions can thus be raised, following this work.

Should IT innovations bring about business change in companies? The work presented here shows that for a new IT-based service, a business model allows for a better answer to the identified needs of a city. If a company implements new IT systems, or changes its IT environment, will a new business

model help create more added value from that service? What should be the concerns to allow the creation of a multitude of business models aligned with the strategy of an organization? With regards to any of those questions, new avenues for research are thus opened. Any of those questions, especially the last one, supports adaptation of business and strategies to an everlasting need for radical changes in constant and ever evolving competing environments.

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