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# THE ROLE OF INFORMATION AND COMMUNICATION TECHNOLOGY FOR SMART CITY DEVELOPMENT IN CHINA

Master's thesis

Supervisor: Ingrid Pappel PhD

Tallinn 2017

TALLINNA TEHNIKAÜLIKOOL
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# INFORMATSIOONI- JA KOMMUNIKATSIOONITEHNOLOOGIA ROLL TARGA LINNA ARENGUS HIINA NÄITEL

Magistritöö

Juhendaja: Ingrid Pappel PhD

Tallinn 2017

# Author’s declaration of originality

I hereby certify that I am the sole author of this thesis. All the used materials, references to the literature and the work of others have been referred to. This thesis has not been presented for examination anywhere else.

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Date: 10.05.2017

# Abstract

With the growth and evolution of information technology (IT) in the last century, the term of information communication technology (ICT) has been dominating over the 21st century in all aspect of our lives worldwide. The transition from traditional social structure towards a digital and smart society has begun already, particularly in the smart city project sector, where a variety of pilot projects and agendas have been implemented both in developed and developing countries.

From this study, it is obvious that ICT-based services and initials are becoming critically important in smart city development and sustainability, which raises the questions in which role the ICT plays in smart city construction and how it contributes to the aims. The purpose of this research is to analyze how the ICT components evolve towards sustainable and smart city design or redesign in China, clarifying the roles and relationship of other factors (such as the government, environment, and society).

A case study approach was used in order to explore and figure out how the ICT contributes to Chinese smart city development from an ICT entrepreneur's perspective. The findings reveal the positive outcomes and the benefits of the research will give a brief overview of smart city evolution within China and a clear understanding of the contribution of ICT to smart city development in China, which could be valuable and beneficial experience in E-services' sector for other respective nation.

This thesis is written in English and is 57 pages long, including 7 chapters, 7 figures and 1 table.

# Annotatsioon

Viimase sajandi infotehnoloogia (IT) arengu ja evolutsiooni tulemusel on info- ja kommunikatsioonitehnoloogia (IKT) mõistega seonduv domineerinud ülemaailmselt 21. sajandit kõikides meie elu aspektides. Üleminek traditsioonilistelt sotsiaalsetelt struktuuridelt digitaalsetele ja targale ühiskonnale on juba alanud, iseäranis ka sektoris, mis seotud targa linnaga projektidega, kus hulk varieeruvaid pilootprojekte ja päevakorralisi teemasid rakendatakse nii arenenud kui ka arengumaades.

Käesoleva uuringu tulemusel muutub ilmselgeks, et IKT baasil arendatud teenused ja algatused on omandamas kriitilist tähtsust targa linna arengus ja jätkusuutlikkuse tagamisel. See omakorda tekitab küsimusi, millist rolli omab IKT targa linna arendamisel ja kuidas aitab kaasa selle eesmärkidele. Selle uuringu eesmärgiks on analüüsida, kuidas IKT komponendid arenevad targa linna jätkusuutlikul disainimisel Hiinas, selgitades teiste oluliste faktorite rolle või omavahelisi suhteid (nagu näiteks valitsuse, keskkonna ja ühiskonna).

Uuringus kasutati juhtumiuuringu lähenemist selleks, et uurida, kuidas IKT panustab Hiina targa linna arengusse IKT ettevõtjate tasandil. Uuringu leiud toovad esile positiivsed tulemused, mis omakorda annavad põgusa ülevaate targa linna evolutsioonist Hiinas. Lisaks selgub Hiina näitel IKT panus targa linna arengu osas, mis võib osutuda kasutoovaks ka e-teenuste sektoris ning teistes teemaatikaga seotud riikides.

Lõputöö on kirjutatud inglise keeles ja sisaldab 57 lehekülge, 7 peatükki, 7 joonist ja 1tabelit.

# List of abbreviations and terms

| | |
|---|---|
| BCO | Build-Control-Operate |
| GPS | Global Positioning System |
| ICT | Information and Communication Technology |
| IoT | Internet of Things |
| IT | Information Technology |
| ITS | Intelligent Transportation System |
| ITU | International Telecommunication Union |
| MOHURD | Ministry of Housing and Urban-Rural Development |
| NITRD | Networking and Information Technology R&D Program |
| OECD | Organization for Economic Co-operation and Development |
| QR | Quick Response |
| RFID | Radio Frequency Identification |
| SC | Smart City |
| SOE | State-Owned Enterprises |
| SSC | Sustainable Smart City |
| U-I-G | University-Industry-Government |
| U-I-R | University-Industry-Research |

# Table of Contents

# List of figures

# List of tables

# 1 Introduction

## 1.1 Research Background

With the significant development of globalization and urbanization worldwide, a huge amount of population migrates into the city. According to the United Nation report launched in 2014, over half of the world's population lives in urban cities, which is likely to increase to 64 percent by 2050, with the notification that the largest growth will take place in China, India, and Nigeria. As the massive expansion of urban population, it is evident that the development of urban cities will be restrained by the shortage of regional public resources for example land space, energy, water supply and environmental pollutions etc (Ji et al. 2011). In this case, a new innovative solution should be figured out to cope with urban these issues rather than the traditional techniques and management methods, which means modern cities face various challenges and opportunities.

As the increasing awareness of making cities "smart", it seems that it has grown out the digital solution to meet these challenges and opportunities above. That is to say with the usage of ICT in urban city planning and construction, the traditional regional city will transit into the smart city, which enables the sustainable development of the city in the future and ensure a more smart and intelligent living areas for its all citizens. It is commonly accepted that Information Technology is changing our daily life year on year and meanwhile the ICT is changing the traditional urban city into smart and sustainable to make the economy, environment, quality of living life, control and expressiveness of a city more efficient and effective.

Based on the fact of evolution of ICT and relevant activities in smart city project development recently, a number of developed nations have already embarked its own smart city approaches and initiatives, related policy and strategy at national and regional level, which gradually forms its smart city standardization for each nation respectively, such as European Union, United Kingdom, Unite States of America, Korea and Singapore etc.

The concept of "smart city" widely accepted in China is a bit late than other developed countries, but various kinds of efforts and planning are conducted by the Chinese government at the beginning period. As the launch of Smart City Pilot Agenda in 2012 by the Ministry of Housing and Urban-Rural Development (MOHURD), there are

nearly 193 approved pilot projects of smart cities in China, which significantly accelerate the informatization, industrialization, urbanization and agricultural modernization (National Development and Reform Commission 2014).

This research will focus on the development and sustainability of smart city in China and highlight the important role of ICT as a key and fundamental component to make city "smarter". Furthermore, it identifies at a high level that the ICT infrastructure will enable smart city strategies. The next chapter will guide the reader through the objective and research questions of this study and outline the brief structure of this dissertation.

## 1.2 Motivation

Nowadays, the term of "smart city" is relatively novel as a potential research steam in China. The extensive literature has written about the general development of smart cities in Chinese mainland (Li, Lin & Geertman 2015) and the performance of sustainable urbanization during recent years, but not much focus on the particular perspective of Information and Communication Technology (ICT).

As the rapid evolution of ICT throughout the global, a variety of positive outcomes and mutual benefits can be witnessed along with diverse changes in social evolution, such as the successful E-government implementation in many countries and ICT-based e-services as well. In this level, this research would go further to investigate and study the contribution of ICT and associated factors that have been active all over China.

Studies have demonstrated that with global urbanization widespread, both advantages and challenges arise together. Massive city resources base face the pressure in energy, water, environment, and education etc. Apparently, when it comes to China, the challenges grow bigger as China has the largest population in the world; hence, it will be quite interesting for Chinese government how to solve these emerging issues to achieve urbanization with rapid space.

With the effective usage of ICT as a potential tool, smart and advanced solutions could be carried out to cope with these challenges in local, regional and global scale for cities.

## 1.3 Research Objectives and Questions

This research will mainly focus on a brief overview smart city evolution and the role of ICT play in smart city development in China. The central research question of this master thesis is the following:

How Information and Communication Technology (ICT) contribute to smart city development in China?

In order to answer the primary research question as above, several secondary research questions will be employed as follows:

1. How Smart Cities is an important concept for regional development?

2. How Smart Cities is going to solve the problems of urbanization?

3. How the stakeholders involved in smart city development?

The case study will be used in this research as to achieve a better understanding the nature of best practices for smart city development in China and gain experience which is contiguous authenticity. Academic literature, articles, and relevant references will help to accomplish the aim of the thesis and conclude findings from empirical data analysis. Quantitative research method will be used to get extensive and additional various ideas and arguments in this field to achieve the goal.

## 1.4 Overview of Development of ICT

As generally accepted ICT stands for Information and Communication Technology, which is an extended term for information technology (IT), highlighting the integration of telecommunications, computers and necessary relevant system that enable to access, share, transmit and store information etc. Since the 1980s, the term information and communication technology has been used in the academic research while the abbreviation of ICT spread worldwide after it was used by Dennis Stevenson in a governmental report in the UK (Jim Kelly 2000). Studies demonstrate that ICT is one of the most powerful driving forces of social development and will quickly become an important role for sustainable growth in the 21st century.

The definitions of ICT (information and communication technology) vary from different fields and research areas. ICT are broadly defined as a technological method to convey, manipulate and store data and information in electronic means, which carried

out an extensive range of communication and information function (Brian, 2010). The British Computer Society (BCS) defines ICT as:" the scientific, technological and engineering disciplines and the management techniques used in information handling, processing and disseminating; their applications; computers, networking and communication and their integration with human and machines; and linked social, economic and cultural matter." This definition provides a comprehensive and concrete explanation from social-cultural-economic level.

Even though there is no universal definition of ICT currently, it is no doubt that ICT is the mainly influential technology of human society since the second half of the 20th century, especially since the 1990s. During this period, development of ICT and implementation and services have increased rapidly, and the application of ICT has become more and more extensive. In general scale, ICT has penetrated into all areas of human life, promoting economic and social development and the improvement of people's living standards. At the same time, the positive outcomes from ICT in return create more demand for ICT, which further promote the development of ICT.

With the increasing accessibility of network and IT infrastructure, ICT contributes to many industry sectors and improve the production and revenue (Basu and Ferald, 2008). Many studies indicate as the usage of ICT embedded in the social and economic field, the outcomes tend to be positive and fruitful. For example, the United Nations (2006) regards ICT as a tool for reducing world poverty and other social and economic problems. Rangan and Sengul (2009) demonstrate in the economic business sector, costs can be reduced with the implementation of ICT in the international and transnational area.

Margaret Rouse (2017) shows the examples of the components of ICT sector listed as below, which indicates the gentle evolution of ICT actors by far. The list of ICT components is exhaustive and continues to grow to depend on the revolution of ICT implemented in different areas. In the early development stage of ICT, hardware, software and transaction are regarded as the basic elements, other elements are counted with the recently new concept, such as cloud computing, big data etc.


Figure 1: Components of ICT (Margaret Rouse, 2017)

Even though the explanations of ICT vary in different sectors, it is acceptable generally that ICT leverages for the economic, social and interpersonal transaction and interaction (Margaret Rouse, 2017). International Telecommunication Union (ITU, 2014) has clarified the massive benefits of ICT as follow:

- "enhance our capability to measure progress toward all the sustainable development goals, evaluate the methods used to achieve them, learn what is working and not working, and improve the timeliness and quality of decision making
- provide opportunities to streamline and enhance the efficiency and effectiveness of the activities we undertake across the development landscape
- access to a whole new range of digitally-enabled products and services which strengthen local economies, local innovation and local communities"

When it comes to the development of urbanization, ICT is changing the evolution of cities, with the innovative concept to make a city "smart" (Escher Group). As Bakici, Almirall, & Wareham (2013) define smart cities as " cities that utilize information and communication technologies with the aim to increase the life quality of their inhabitants while providing sustainable development" (Bakici, Almirall, & Wareham, 2013, p. 137),

we can conclude that ICT plays a crucial role in sustainable urbanization development to ensure the best quality of living environment of its citizens.

## 1.5 Thesis Structure

This thesis is organized into seven chapters.

Chapter 1, the ‘Introduction,' presents the thesis research outlining the motivation and objective of the study, the scope and contribution.

Chapter 2, the ‘Theoretical Concepts,' reviews the related theoretical concepts of the research.

Chapter 3, the ‘Literature Review,' examines the pertinent academic research papers previously conducted in this space by which, the generated lessons learned is used to construct the initial guidelines to conduct the research.

Chapter 4, the ‘Methodology,' details the research approach of empirically analyzing the case study data.

Chapter 5, the ‘HUAWEI – Case Study,' discuss and study the case of smart city projects in China from ICT perspective.

Chapter 6, the ‘Discussion and Analysis, ' describes the reviewed ICT actors in the smart city and their key attributes.

Chapter 7, the ‘Conclusion,' reviews the research results in comparison to established theory. Identify the limitations of the research, opportunities for future research and closing thoughts.

# 2 Theoretical Background

## 2.1 Digital City Versus Smart City

During the past years of this century, urbanization and informatization have been emerging rapidly (e.g. ICT) in the global levels, such as technological advancement and economic growth, which contribute to improving the quality and comfort of people's living, especially in the urban development. On the other hand, a great variety of challenge emerges in the territorial development scale, namely, environmental pollution, lack of city resources, traffic jam, living standards of citizens etc. Based on this scenario, it requires the cities able to solve these urban issues (Cocchia, 2014). In result, a lot of conceptual city development planning have been studied by researchers, where the concept of digital city and the smart city come into reality.

Decades ago, the cities started to develop and evolute with the use of ICT to provide better service, and many concepts of cities have been emerged from "wired city", "visual city", to "intelligent city", "information city", "digital city", "sustainable green city" to "smart city" (Abdelfatten, Sanea, Abdelhak and Asmaa, 2016). This research highlights the digital city and smart city since there are relative connections and influence. In a global context, digital city and the smart city have somehow overlapping meanings and features from the original date till now. Ishida (2000) defined the concept of the digital city as a social information infrastructure including business, transportation, education, social wealth care and so on for urban everyday life, which specialize the physical interaction of ICT infrastructure-based representation and reproduction within the cities. Amsterdam (Netherland) is the example of digital city construction in Europe, one of the EU countries in the early emphasis on this area. The initiative of making Amsterdam a digital city originated from the De DigitaleStad project in 1994, which aims to enhance the level of communication and interaction between the government and public. As a public exchange platform for the public, the project provides a digital space for discussion and information exchange, including free public domain, free E-Mail, digital rooms etc, outlining the research of information communication infrastructure and its popularization.

The concept of smart city firstly originated from IBM's "Smart Planet" project in 2008. In response to the global economic crisis of 2008, IBM proposed the approach to build a

smarter planet and implement new strategic agenda for progresses and growth, as Sam Palmisano (IBM CEO and chairman, 2009) promised "let's seize this opportunity to create more and better jobs, cultivate valuable skills, and not simply repair but prepare our economy for the 21st century. "

Nowadays, there is no unique and general definition of smart city worldwide. But it is generally accepted that smart city is the new concept of city approach supported by the new generation of ICT innovation in a knowledge-based society. In this scenario, a smart city is of people-centered sustainable innovation, which is featured by user innovation, open innovation, massive innovation and collaborative innovation (Song and Wu, 2012). From this definition, we can argue that smart city is the evolution of the digital city, as the concept of the digital city is mainly ICT infrastructure-based and a concrete solution for a specific sector. Furthermore, it is necessary to take into the concept of sustainability when defining what is a smart city. The research institute, Forrester, studied that with the implementation of intelligent information technologies, the key smart city infrastructure components and services including urban management, education, social healthcare, transportation and public administration and security are more interconnected, efficient and intelligent (Washburn and Sindhu, 2010). From the perspective of technological advancement, Li (2011) argued that smart city is the combination of digital city and IoT (Internet of Things), which contribute a fundamental framework of sensing technology, information system and network technology to achieve socially sustainable development in the long-term perspective.

## 2.2 ICT Essentials in Smart City

The development a smart city differentiate depend on the approaches to urban planning and various local conditions (Chourabi, et al., 2012). Many types of research show, regardless of whether ICT takes center rold in the smart city development or not, ICT plays a vital role in urbanization and how to make a city smart and intelligent. Escher Group in a white paper pointed out five essentials in making a city more adapted to its citizens' need. The factors are listed as follow:

1) "Development of broadband networks

2) Usage of smart devices and agents

3) Developing smart urban spaces

4) Developing web-based application and e-services

5) Opening up government data" (Escher Group, 2012)

Broadband network, as part of ICT infrastructure, is the basis for smart city planning, which enables the connection and access for all users and ensures the high-speed internet activities. With the installation of the high-speed network in the city, such as governments, business sectors, educational institutes and end-users, it leads to the development of the smart city and innovative approach for new opportunities as well (Komninos, Pallot, & Schaffers, 2013). Smart devices penetration in city level is also considered as a fundamental element in ICT sector, which enables the access to public services through a wireless connection and in turn encourage the city management. Hernández-Muñoz et al. (2011) argue that ICT is becoming the core role in urbanization development, based on the intelligent technology and ICT-intensive solutions, empowering the public services for health, education, security, and governance. Smart urban spaces can be seen as a combination of spatial intelligence with ICT-based infrastructure, a place where services and applications can be delivered more efficient within the specific area. At the same time, design or redesign the web-based application enables the quality of e-services, which triggers the interaction between public sector and citizens.

The creation of new technologies in recent years, such as cloud computing, Internet of Things (IoT), big data and sensing system etc, promote the development of innovation of solutions, services and standardization of applications and decrease the costs for cities functioning effectively (Schaffers, Komninos, Pallot, Trousse, Nilsson, & Oliveira, 2011). In this scenario, adoption of new and innovative technologies accelerate the integration within a city development, hence these can be included in the ICT essentials. Cloud computing is an internet-based computing approach whereby shared hardware and software resources and information can be provided to various terminals and other devices (Wikipedia) while IoT refers to Internet of Things, as Liu (2010) states that IoT is the carrier of Internet and traditional telecommunications network realizing the interoperability of all functional objects. The wide range of emerging technologies promotes the process of smart city construction.

## 2.3 Conceptual Framework of Smart City

The notion of smart city refers to using pervasive communication technologies and smart devices to accomplish the urban environments and development (Kitchin 2013), thus in this scenario, the smart city can be divided into four layers according to Xu (2012) as listed below in Figure 2.

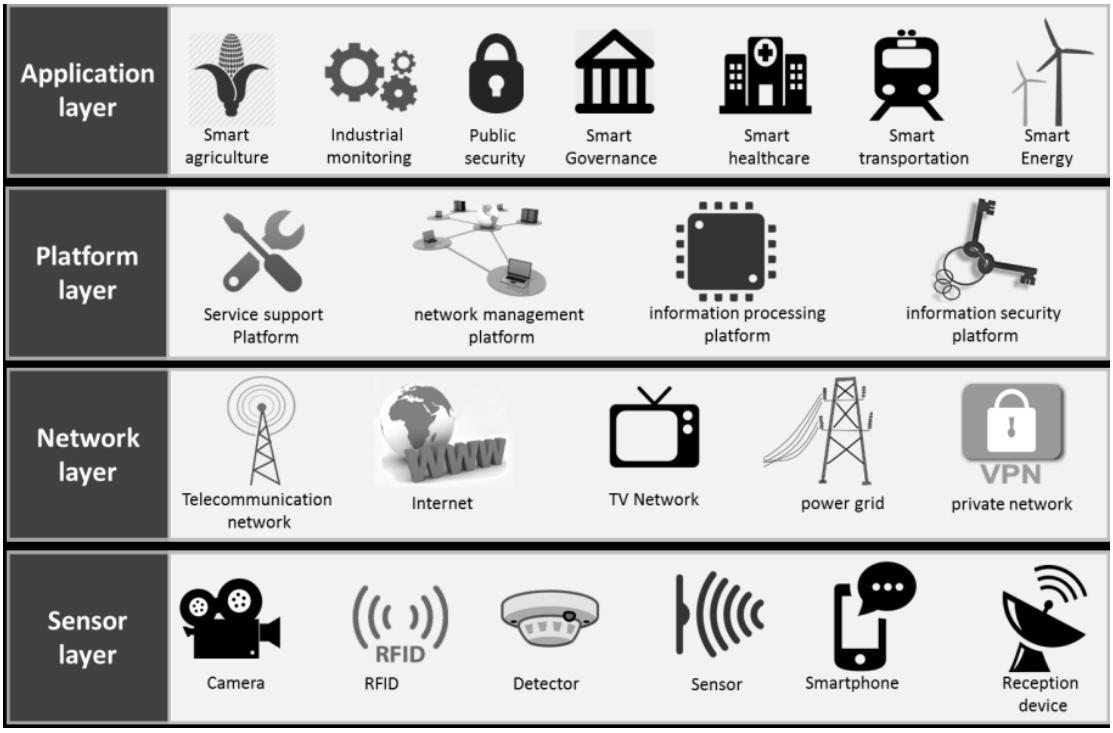


Figure 2: Four layers of smart city (Xu, 2012)

Xu argued that these four layers interact with each other in this framework. Sensor layer is the one that collecting and gathering information and data in real time which enable basic needs for managing these data into next step. RFID (radio frequency identification), cameras, GPS and QR code are widely used in sensor layer while network layer is one layer where information and data are exchanged and transferred. Platform layer is responsible for information processing and management through various platforms such as business support platform, network platform and cloud computing platform (Chen 2013). Application platform can be regarded as a solution platform to deliver smart services and the way how users can response to specific circumstance based on the collected information in different sectors within the smart city.

The Focus Group on Sustainable Smart City from ITU (International Telecommunication Union) studied the attributes and pillars which characterize a smart city. Economy, governance, environment and society are reflecting a city through three dimensions, namely, environment and sustainability, city level services and quality of life (ITU, 2014). As the infrastructure is a fundamental sector in a smart city, it can be divided into three main types: physical infrastructure, digital infrastructure, and service infrastructure. In detail, common physical and service infrastructure include: (1) smart energy, (2) smart buildings, (3) smart transportation (4) smart water, (5) smart waste, (6) smart physical safety and security, (7) smart health care and (8) smart education. A clear understanding of these concepts is shown in Figure 3.

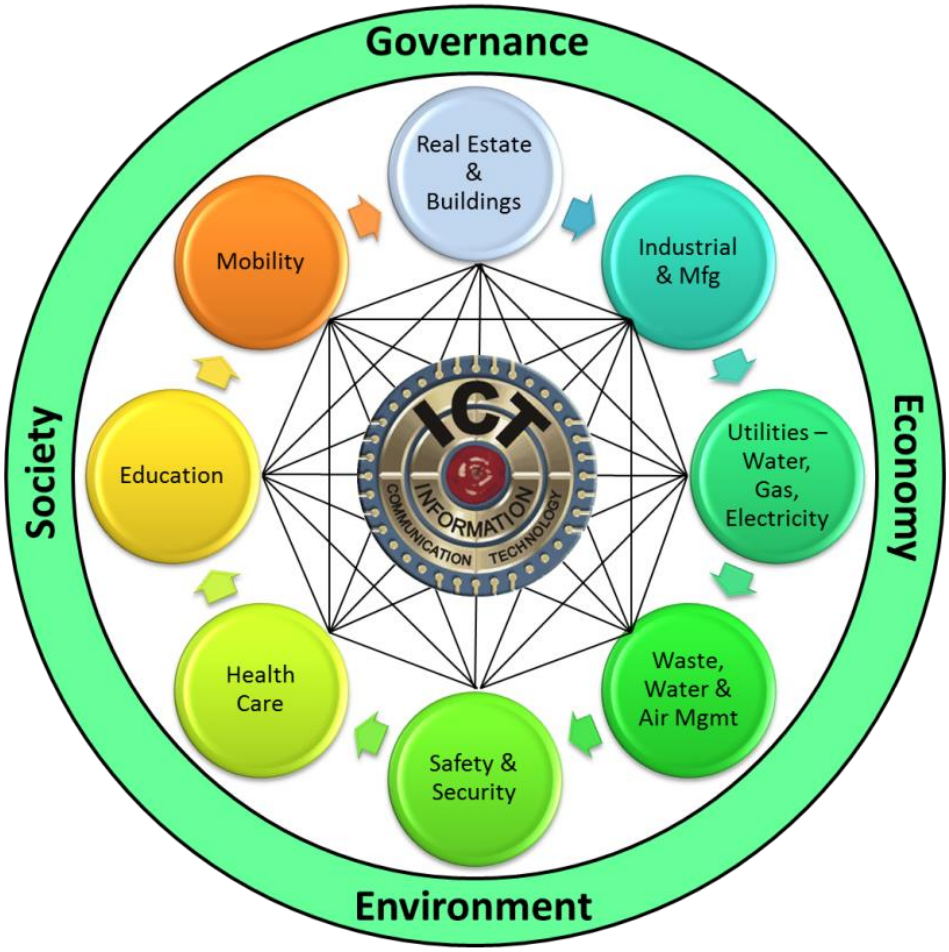


Figure 3: Core components of smart city and ICT (ITU, 2014)

ICT has a critical function in Sustainable Smart City (SSC) in view of the fact that it acts as the platform to collect and cumulative information and data from the field to help to enable an improved understanding on how the city is functioning in terms of resources consumption, services, and lifestyles (ITU, 2014). ICT also enable the

following functions, which are keys to achieving the goals and maximizing the performance of smart city:

- "ICT - enabled information and knowledge sharing: Traditionally, due to inefficiency on information sharing, a city may not be ready to solve a problem even if it is well equipped to respond. With immediate and accurate information, cities can gain an insight on the problem and take actions before it escalates.
- ICT - enabled forecasts: Preparing for stressors like natural disasters requires a considerable amount of data dedicated to studying patterns, identify trends, recognize risk areas, and predict potential problems. ICT provides and manages this information more efficiently so that the city can improve its preparedness and response capability.
- ICT - enabled integration: Access to timely and relevant information (e.g., ICT - based early warning systems) need to be ensured in order to better understand the city's vulnerabilities and strengths"

(ITU, 2014)

Different smart city designing approaches have been explored and vary dramatically according to different countries and local environment. The aims are concluded to create a smart and sustainable living environment for its all citizens and convenience of quality life, by ICT solutions and other relevant elements.

# 3 Literature Review

## 3.1 Introduction

In this chapter, I will examine the smart city research. Anthopoulos and Fitsilis 2013 describes smart city can be defined with alternative approaches, which range from attributes of ICT in the city level which describes different IT-enabled solutions in urban context to information flows and to large scale living labs (Marsh, 2008). The smart city approach can be viewed as an interdisciplinary case such as urban planning, ICT, living labs and creative industries in a specific city (Anthopoulos and Fitsilis 2013).

Primary sources for this chapter comes from the publication channels were selected: first, those from journals that publish corresponding works; second, those from major conferences that publish articles relative to the smart city in their proceedings; reports from research projects.

The smart city can be introduced from different contexts and focus such as user involvement or social participation and narrow down the digital divide with the availability of information and public services.

During the last several decades, there are two emerging phenomena can be identified which are: urbanization and information and communication technology. This technological growth and advancement contributed to increasing of wellbeing in the urban areas and attracted the population to urban centers (Cocchia, 2014). In the present era, cities are considered to be key areas for coping with some social challenges, and new interest has been given to mobilizing experimental practices in urban planning. Urbanization opens up new opportunities in the areas of education, social life, employment and so on (Cocchia, 2014). This is an era where urbanization is not just a challenge to control the population of cities due to the migration of people from rural to find employment or other benefits the city has to offer. At the present time, cities can be considered as effective playing ground to test and implement innovative initiatives such as co-creation, exploration, experimentation, and evaluation of concepts (Smas, et al., 2016) like urban living labs.

It is also valuable to mention that Urbanization helps the appearance of urban agglomeration not only the transformation of rurality to urbanity, which is also a driving force of entrepreneurial development and mobility opportunities. Over the period there

is a considerable enhance in the regular size of the urban areas and population. This enabled a shift in the urban technological limits upward where it also helps to address of accommodating more inhabitants. It is evident that not only the ICT development of infrastructure affect the definition of the smart city but also the improvement of human wealth and education involved.

The recent study reveals conducted by the Centre of Regional Science at the Vienna University of Technology, there are six main dimensions middles size cities can be made at the European level (Meijer and Bolı´var, 2016)

smart economy;

smart mobility;

a smart environment;

smart people;

smart living; and,

finally, smart governance.

One good example (Meijer and Bolı´var, 2016) where a city can be made smarter on the emphasis in urban governance is Amsterdam Smart City project. This is also an example where PPP (Public Private Partnership) model apply in the smart city approach. The main objective of the project is to develop the Amsterdam Metropolitan Area into a smart city (Meijer and Bolı´var, 2016).

Furthermore, this city is an 'Urban Living Lab' which is a research concept usually operate in territorial contexts linking the public research and innovation process (Marsh, 2008). The concept is based on a systematic user co-authoring approach that integrates research and innovation processes.

This facilitates knowledge exchange between all the stakeholders and actors in the particular region or city. This partnership leads to project focus on sustainability, innovation, the well-being of the citizens, citizen participation and so on (Meijer and Bolı´var, 2016).

Batty et al., 2012 states that the cities become smart not only in regard to ICT-enabled automated functions and services to the public and infrastructure but also to engage them in every level of the process. This gives them the opportunity to understand, plan

and monitor in a way to improve the city in the area of efficiency, equity and well-being of the citizens. Nowadays cities can be considered as good playing grounds to implement innovative initiatives like co-creation, exploration, experimentation, and evaluation of concepts (Smas, et al., 2016)

**City Size**

There is a relationship between the size of the city and development patterns of smart city approach (Neirotti et al, 2014). This relevance can identify in various aspects. Larger cities attract more human wealth which also has larger users of ICT services. Which means large cities rely on greater resources such as telecommunication, electricity and water infrastructure (Neirotti et al, 2014). Nevertheless, city size has a relationship to the barrier of the development of smarter cities. Neirotti et al, 2014 further discusses that the small cities or towns idyllic environment for pilot projects. This setting easily attracts stakeholders from different areas where they are willing to experiment new technologies.

**Technology development**

According to Beniger, 1986 organizations and systems that invest earlier in a new technology are in more advantageous circumstances to further development of technology in the same trajectory. This is also a true case where cities adopt new technologies in the smart city initiative (Neirotti et al, 2014). The distribution of internet access and use of ICT services represents the population signify the element of the development of information society (Neirotti et al, 2014). In contrast to this, limited distribution of said variables obstructs the success of a critical mass of users. This could be named as digital divide which is also "jeopardize the development of a variety of smart city initiatives and restrain their economic and societal value" (Neirotti et al, 2014).

Moreover, the smartness level of city increases depending on specific variables belongs to specific country or city. This variable can be listed as:

political leadership

types of strategic guidelines in the current political agenda

cultural variables etc. (Neirotti et al, 2014)

According to (Neirotti et al, 2014) level of corruption, decision making power and other political conditions influences smart city projects. This also influences the private-public partnerships (PPP).

When it comes to development approaches there is different in European and Asian countries. European countries focus more on a social dimension where Asian countries have a technological focus (Shichiyakh, et al., 2016). One example describes this differentiation is the smart city project in the city of Vienna, it was more concentrated on a diverse population. It has been centered around the reliability, adaptability, and flexibility of urban systems for reacting impacts from internal and external influences (Shichiyakh, et al., 2016). The strategy adopted by Vienna is based on integrated approach. Involvement of new policy mechanisms and management coordination fuel the said approach. On the other hand, Asian countries are more technology oriented, one good example is the city of Singapore (Shichiyakh, et al., 2016). They were focusing on implementing large scale infrastructure with the use of innovation aiming businesses and citizens, which they called 'intelligent island' (Shichiyakh, et al., 2016). Comparing these two initiatives, one can identify the Vienna and Singapore use different strategies. It is evident that two continents have different approaches and different priority when it comes to developing smart cities.

**China: Becoming an urban nation**

When it comes to evaluation of the progress of smart city and sustainability, one must understand and analyze consistent administrative units in a specific environment. Furthermore, it is worth to understand definitions of a city, mainly cities are identified and defined by political boundaries. The United Nation's World Urbanization Prospects define the city as

"according to legal/political boundaries and an administratively recognized urban status that is usually characterized by some form of local government" (UN, 2012).

The other conditions where the city can define are based on land area, population, and so on. (Zhou and Williams, 2013). Which also means that when defining a city there are several criteria's (Zhou and Williams, 2013). In the case of China size is an important criterion. Chinese populations approximately one-tenth of the total world population (Zhou and Williams, 2013). According to population statistics, China had 858 cities in the year 2005 with a population over 500,000 (Zhou and Williams, 2013).

In China cities defined based on political and administrative jurisdictions. Mainly here are three official urban administrative types in China:

1) provincial-level municipalities;

2) prefecture-level cities (PLCs); and

3) county-level cities (CLCs).

There are four provincial-level municipalities: Beijing, Shanghai, Chongqing, and Tianjin. These cities are given a grade and administrative powers practically equal to those of provinces (Zhou and Williams, 2013).

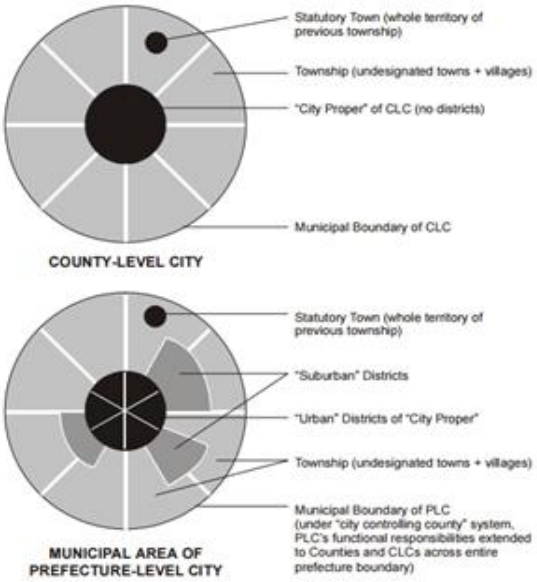


Figure 4: Statuary urban areas in China (OECD, 2009)

## 3.2 ICT Effect on Smart City Development

The Smart City as a concept intended to boost the quality of life of citizens' has been gaining increasing impact in the policy making at a different level. However, there is no common definition of the smart city available and it is difficult to identify common universal trends.

With the immense numbers of interconnected citizens, businesses, and different means of transport, communication networks, services, and utilities, the cities are becoming more complex than ever before. This leads to growth in population with urbanization, which also raises a diversity of problems such as technical, social, economic and

organizational problems (Neirotti P., De Marco, 2014). The need for the more sustainable city is increasing (Neirotti P., De Marco, 2014).

The rapid development in cities raised traffic, pollution, and growing social inequality. In this perspective, a discussion has begun on the means to new technology-based solutions and to use of ICT, as well as innovative methodologies for urban planning, where assure future feasibility and sustainability in the urban area. In this debate, the concept of Smart City has been one of the main the subject of growing awareness and it now appears as a new paradigm of urban planning and development and sustainable socio-economic growth (Neirotti P., De Marco, 2014). Even though the rise in the smart city in the urban planners' debate on the planning future of cities, the dispersion of smart city initiatives in countries with different requirements and economical levels makes it challenging to identify shared current trends in a global context and scale (Paskaleva, K.A., 2009). As discussed earlier there is still, no general definition of the term smart city.

In spite of the rapidly evolving information technologies and the passed legislation promoting paperless office, a great number of governments, businesses and citizens still prefer paper records, manuscript signatures and traditional public services instead of their electronic alternatives. On the other hand, there are states known as "digital societies" which conduct almost all public sector transactions digitally (Batty, M., Axhausen, K.W., Giannotti, 2012).

Nevertheless, the common agreement about the smart city is the fact that it characterized by a great use of Information and Communication Technologies. In different urban settings, ICT enables to make the best use of their scarce resources. However, ICT-based solutions can be introduced as only one of the many ways how resources planning and initiatives to urban planning and development with the goal of civilizing the sustainability of the economy, society and environment in a city. This indicates that even though a city has greater use and rich ICT infrastructure, it does not necessarily mean a better city, but in fact, it increases and reflect transition towards more smarter ways and enhance future possibilities.

The smart city literature emphasizes the need for urban planning and regulation and the central goal of the ICT system as a city digital and intelligent nervous system that manages data and information from different sources. Thus, many intelligent cities are

complex systems of "sense and act", that is, a large number of real-time information and data are analyzed and combined with multiple systems, organizations and value chains to optimize operations and inform the authorities of initial issues (Chourabi, H., Nam, 2012). The role that ICT plays in cities is equivalent to the ICT technologies which have in organizations. It has been described in Information Systems literature and organization studies as a way of improving productivity through automatic routine processes while supporting decision-making, planning, and management activities. In urban and city development, ICT is expected to contribute to solving the emerging urban problems of citizens in order to achieve city sustainable development.

Nevertheless, it has been proven that benefits of e-Governance include enhancement of governance efficiency and transparency, elimination of corruption factors, improvement in the quality of public services, provision of better access to public services. All of this leads to democracy by transforming traditional relationships between public agencies, citizens, and businesses. The introduction of different ICT solutions by the governments might erupt controversial reactions within the respective societies. As a matter of fact, it is always important to characterize the society by its nature, cultural and social differences. Religious and political heritages also play a crucial role in this regard, as in traditional communities, whose history is shaped according to these features, general acceptance of innovation and globalization is always law (Kramers, A., Höjer, 2014). When we are talking about such societies, it is important to review how they anticipate the relationships between the governmental structures and the church, as the religion is very sensitive to them, the opinion of different religious leaders might be decisive in almost every aspect of their daily routine. In this regard, the general opinion of the church about ICT and the means of new technologies which facilitate citizen-to-government interactions is always not supportive. Many factors enhance such perception: digital divide and general lack of knowledge, the absence of proper marketing from the government side, lack of possibility of self-education (inaccessible/insufficient materials in the native language, poor educational systems, lack of interest from the government side to invest in research and development in such areas).

According to above insight on the smart city, the distribution of ICT infrastructure should not be recognized with the standardization of a smart city. Smart city approach does not only reflect technology changes, but also development in human capital and

changes in urban living practices. ICT is assisted as a general purpose technology, where it helps to improve the quality of human and organizational capital. In other words, depending on political decisions and urban ecosystem (citizens, tech vendors, and local authorities) the ICT helps to shape future of a city (Neirotti P., De Marco, 2014). This gives directions towards researching various dimensions of smart city initiatives around the world (Neirotti P., De Marco, 2014).

As information and communication technology cannot transform the city without human capital, another focus is on the role of human capital in improving urban housing capacity. Therefore, the SC program can also include human capital investment designed to promote urban learning and innovation, support and encourage the role of local residents in education, and improve their own lives, attract and retain other valuable external inputs : talented and highly educated people, innovative companies, investors and entrepreneurs to invest capital and human capital, start a new business.

Finally, in previous studies, The adjective "smart" also mentions the ability of a city government, as well as the ability to provide services and communication to local residents (Albino, V., Berardi, U. and Dangelico, R.M., 2015).

The opportunity for a city to improve the level of wisdom also depends on a number of country-specific variables that go beyond its economic, technological and environmental development levels. In particular, country-specific factors can capture a range of complex institutional variables (the type of political leadership, the type of strategic policy in the current political agenda etc), cultural variables, forms and climatic conditions such as identifying the needs and methods of SC policy development.

In terms of the political environment, political decision-making power is concentrated, political risk and corruption will affect the city's ability to implement intelligent city projects. For example, in countries with moderately high political risk, transnational ICT companies may be more reluctant to enter public-private partnerships due to higher economic and political uncertainty. These factors must have played a role in explaining the considerable number of smart city initiatives adopted in the some of the large cities in Asia (e.g.: Singapore, Seoul and Hong Kong), which have reported a unique combination of favorable conditions for the current smart city condition of the past decade: a centralized governance that helps to shorten the decision-making process of

public investment and implement faster development time; a Rapid economic development, low political risk, and the unique weather conditions that determine specific needs, with special influence on social systems (Neirotti P., De Marco, 2014).

State factors can also indicate differences in the political agenda that may affect intelligent urban policy design and planning. For example, the focus on a knowledge society in the European Union's Lisbon political agenda could lead European cities to put more focus on policies that promote human capital, education and entrepreneurship. If citizens cannot use services or interact with political processes in a meaningful way, the use of complex information technology (IT) in the government is of no social value. This means that no matter how high the government's expectations or political will, if their respective societies are not prepared for technological changes, any attempt to build an e-society will lead to failure, which again raises the citizens' proper marketing of public electronic services And they also understand how to use certain services to adequately respond to the challenges of everyday and business life. Stakeholders are important roles because e-government resource allocation and political decision-making may not always be consistent with the state, so it is interesting to understand how the main actors at the national level affect or promote national e-government development (Lee, J.H., Phaal, R. and Lee, S.H., 2013). Many governments are trying to change to an e-government through an implementation strategy that has been or has been successfully implemented in developed countries, but the concept of "best practices" may not apply to differences in democracy, freedom of speech and so on and express a technical readiness (the digital divide ), social/cultural contrast may require different approaches.

## 3.3 Co-operation and Innovation

The rapid proliferation of the Internet, mobile phones and broadband networks has revealed how common information and communication technologies (ICTs) become a reality. ICT has been the core of economic volatility for more than a decade. It is beneficial to improve the competitiveness of all sectors and meet the needs of the socio-economy. The advancement of this technology and the forefront of novelty has always been the government's goal. The EU Member States have allocated a total of €9.1 billion for backing ICT over the period of the EU's Seventh Framework Program (FP7) to develop the effectiveness of European industry. The United States has financed over $3 billion to master and shape the future growth of these technologies under the Federal

Networking and Information Technology R&D Program (NITRD) (IT Strategy Research Group 2009).

As an evolving country, China is by far the major exporter of ICT products, and it is now the largest importer (OECD 2010). One of the major challenges facing the Chinese government is how to derive greater revenue from information and communication technologies to promote economic growth and expansion. In fact, the ICT industry is recognized as one of the high-tech industries in the National High-Tech R&D Program of China (863 Program) launched by the Chinese government as far back as 1986. From 1986 to 2005, the central government allocated 86 billion yuan to 33 billion yuan. During the 11th Five-Year Plan period, the share of information and communication technology in several key areas has increased, including network and mobile technology, information acquisition and processing technologies, and information security technology. In 2009, China believes that the ICT industry has become a national strategic emerging industry, this industry has become an important force to stimulate economic recovery. The goal of the National Medium- and Long-Term Science and Technology Development Program (2006-2020) is to transform China into an important role in the ICT sector by 2020. As the importance of the ICT industry to the economy and its society policymakers are gradually demanding indicators to measure the consequences of government ICT policies.

With the advancement of the Chinese government's investment, the level of independent modernization of the information and communication technology industry has been improved and the output of innovation has increased rapidly. Over the past decade, China's number of ICT patents has increased significantly. China (4.2%) is the top five, and in 2000 there are more than 2,000 ICT-related patents (OECD 2008). Compared with all republics, China's information and communication technology-related copyright concentration is very high, as well as its display of technical improvement indicators as the representative. In the report, China's technological progress shows 1.43 which is a bit lower than Finland and Singapore (OECD, 2008), between the year of 2003-2005 China ranked third. However, China's information and communication technology industry is lagging behind many other developed countries. For decades, significant technological innovations have emerged in this area, such as the Internet, Web Explorer and Linux, but are not designed by Chinese researchers. The top journals are few in ICT sector, and the global reflection of Chinese publications is still being cut. As the

government planned, China will become a leading executive in the ICT industry by 2020. China needs to increase efforts in its research and development and endorse the partnership between the University-Industry Research Institute (U-I-R) and achieve technological progress. Therefore, it is important to analyze the technical practices of China's information and communication technology industry, as reflected in its patent activities, in order to investigate the nature of U-I-R cooperation.

In recent years, modern research and related fields have made a major breakthrough in the systematic view. Companies are often considered to be leading the way in innovation, and universities are considered to be inventive support organizations, providing training staff, research results and the necessary competencies to the industry, and the role of government is not just control and standardization, but also support the collaboration between universities and industry (Lei et al. 2012; Liang et al. 2012). In general, the diverse of the combination university-industry-government (U-I-G) interactions in the commercialization of new information has been described by the "Triple Helix Model" (Etzkowitz and Leydesdorff 1995, 2000). This model has been used to test the links between universities, industry and government in countries such as Sweden, Korea, the Netherlands, the United States and Canada (Danell and Persson 2003; Park et al. 2005; Park and Leydesdorff 2010; Leydesdorff and Meyer 2010; Belkhodja and Landry 2007).

However, China's national innovation system has undergone intense economic and organizational reforms from the central resource allocation planning system to the free market. China's U-I-G relationship is different from that of the western countries. For example, in the United States, the academia plays a key role in U-I-G collaboration. A total of 80 % of basic research jobs and 28 % of applied research jobs in the United States have been taken by colleges and universities (Etzkowitz and Leydesdorff 1995, 2000). University and the government are closely linked, the relationship between universities and industry is very active. Government and industry are the main sources of subsidies for universities. Government cadres in the relationship between the university and the industry is relatively weak. China's situation is different. In China, universities and research institutions have long played a prominent role in innovation, in recent years due to technological and technological reform, the company is becoming the main source of technological innovation. The Chinese government plays a major role through policy, timing and financing. In fact, China's science and technology policy

are more emphasized on the cooperation between industrial research institutions, in order to improve the national innovation capacity of the importance. Over the past two decades, the Chinese government has continuously strengthened the cooperation of enterprises, universities and research institutions. China's State Council in the central government has already determined the 332 laws and governmental regulations to strengthen the enterprise, universities and research cooperation from 1992 to 2007 (Liang et al. 2012). It is more meaningful to investigate the relationship between U-I-R and U-I-G in China.

The benefits of the government to the university-industrial-government triple helix is always a challenging calculation, so there is little research on the U-I-G relationship in China. The inventions were observed based on the triple helix model and the interaction between U-I-G was considered in China. In their work, state-owned enterprises (SOE) are symbolizing the government with the U-I-G relationship (Lei et al. (2012). The Chinese government is a supervisory stakeholder of state-owned enterprises, but the state-owned enterprises operate in the same way as the private sector, following the market rules. Thus, state-owned enterprises should be considered an industry, not a government in the U-I-G relationship. In addition, so far, the attribution of U-I-R has not been studied (Chen and Guan 2011). Academic scholars only study the cooperation between universities and industry in China's innovation system (Liang et al. 2012). In these studies, public research institutions were jointly analyzed with universities, or omitted from the analysis. Public research institutions play an equally important role in university innovation. For example, in the field of biotechnology in China, patent innovation is mainly carried out by public research institutions (Chen and Guan 2011). Chinese Academy of Sciences scientific research institutes are major innovators, which focus on major scientific and technological projects. Thus, in the U-I-R analysis, the division between universities and research institutions will be more pronounced than the two combinations.

Bibliometric testing is widely used to estimate the development of science and technology (Guan and Gao 2008; Rojo and Gómez 2006), while little researches regard for the ICT sector as a whole. Some studies use bibliometric tools to observe a specific area: Computer Science (Guan and Ma 2004), Semiconductors (Tsay and Ma 2003), and Telecommunications or Consumer Electronics (Gao and Guan 2009). There are other extensive studies on copyright-based advanced activities, including ICT (Hicks et

al. 2001). One recent study on the ICT sector as a whole is the work of Rojo and Gómez (2006), who Based on paper and patent data, the use of bibliometric surveys to analyze the wide range of scientific and technological achievements in the Spanish ICT industry. In the case of China, there are two ICT-based relevance studies based on international patent classification (Lei and Chen 2011; Liu et al. 2010). However, China's ICT industry's comprehensive, long-term research is rarely carried out.

# 4 Methodology

This chapter provides information on the research methods of this thesis. The previous section describes the methods used to construct and produce the deliverables of this research.

## 4.1 Case Study Research Methodology

Qualitative research was carried out to satisfy the objectives of this thesis. While the outcomes of qualitative research are no measurable and quantifiable, it has the advantage of which it offers complete description and analysis of a research subject (Bhattacherjee, 2012). It is recognized that qualitative research is used to discover facts and not verifying existing truth (Baxter, 2008). The methodology of this paper consists of case study research and literature-based research.

Case study method can provide a detailed understanding of a particular situation to create better theories then in this case how ICT factors and essentials can foster smart city development. Hence case study approach is applicable when researching 'how' question over which the researcher has little or no control ( Johnson, 2008).

## 4.2 Data Collection Method and Tools

The method of analyzing available literature and case study used in this research, these methods were having been chosen due to the efficiency of data collection and based on the objectives and research questions of this study. As mentioned above a gathering of data in this study is divided into two main parts. Available supporting literature was gathered from various sources (Journal articles, Google book, Google Scholar, ENoLL, etc.), this helped to identify main concepts discussed in this research. Next empirical data were collected through investigating the case study.

## 4.3 Approach

Case study research and literature analysis were carried out in this study due to the lack of knowledge on the topic of the situation. As stated by (Yin, 2004), the case study research approach is best when the boundaries between of the study and context are unclear. This approach will help to understand this phenomenon through qualitative data. This study has the nature of explorative approach where it uses a process in discovering the primary variables and will help develop the theory (Yin, 2004).

Eisenhardt (1989) stated that to develop the theory by combining observations from previous literature with common sense is not uncommon for researchers. Nonetheless, it is preferred to pool resources from various qualitative data from several sources (Baxter, 2008). Combining several sources allows for a reasonable analysis to understand the context and would significantly improve the validity of the conclusion (Kenneth K. Boyer, 2008).

As this thesis use the case study research, the primary problem question is formulated and identified the key variables using the literature. It is important at this stage not to construct the specific relationship between identified variables which possibly limit the outcomes. To address this point, preliminary problem question is defined a way that it allows the research process to expose the true specific findings.

The findings from the different research parts will together help to understand what measures should be used to improve current self-service and how Estonia should do it. Possible solutions for Estonia together with the opinion about the feasibility of them is offered.

### 4.3.1 Analyzing Data

Data collected through desk research (literature based) from various sources such as Journal Articles, academic literature were analyzed. Then lessons from the case studies help shape the objectives of the thesis which were collected through documented studies and unstructured interviews ( Yin, 2004). Baxtar (2008) explains analysis of data "should continue to develop and be completed as the study progresses." They further state that over analyzing of data will lead to a stage called "Analysis Paralysis" which means never ending data collection. In this research, both literature review and case study methods were adopted. The data collected through document studies help enrich and appropriate to the data from the interviews as in this study it only provides limited information about the territorial development of the living labs. Even though data is collected from various sources, the primary source for analysis was data collected through desk research due to the limitations faced with in-depth interviews. Nonetheless, data collected through interviews provides this study an imperative contribution.

Data derived from documents studied used as major part of the analysis and data from interviews used to expand and elaborate on the outcome of previous empirical data. One

advantage of this approach is that there is data already representing ready to be analyzed while on the other hand interviews do not.

### 4.3.2 Limitations

Due to time constraints, criteria was set to limit to one case study. Moreover, there were a limited number of interviews. Multiple case study approach would have enabled to cover more organizations and therefore, the possibility to generalize the finding of this study would have been greater ( Yin, 2004). Another limitation of this study is the limited journals on the topic as. One more limitation is that the interpretation of the qualitative data was dependent on the researcher's current understanding of the subject ( Yin, 2004).

# 5 HUAWEI- Case Study

In this research, the case study about Huawei will be discussed from the perspective of ICT services provider, to analyze the contribution of ICT in smart city development in China and highlight the successful smart city model in a specific area.

Since the Open Form policy launched for more than 30 years, China's urbanization has achieved remarkable achievements. China has more than half of the population living in the city since 2012, and the city is a center of society, where the development of economic, political, cultural and other aspects of the activities of the center and people's lives are closely related (Su, K., Li, J., & Fu, H. 2011).At the same time, with China's extraordinary development in urbanization, the "urban disease" problem is more prominent. Environmental pollution, traffic congestion, security risks and other issues are highlighted, thus urban development faces many challenges. The development of modern information technology, especially cloud computing and big data, Internet of Things, mobile Internet and other new generation of information and communication technology innovation and application, are contributing to provide information infrastructure and technical support and meanwhile creating more opportunities for public and enterprises to participate in the construction of the smart city. Enterprises and citizens are the main bodies of the city, and government, citizens and enterprises and relevant stakeholders are directly involved in the construction of urban governance system to ensure the sustainable development of smart City. Along with the scientific usage of a new generation of information technology, this will be able to accurately grasp the pulse of urban development, which can effectively alleviate the "urban disease" to enhance the level of social management and improve the quality of people's livelihood.

Huawei Technologies Co. Ltd (Huawei), founded in 1987 in China, is known as a leading global provider of information and communication technology (ICT) solutions, focusing on ICT, maintaining the robust management, continuous innovation, open cooperation, and building end-to-end in telecommunication operators, enterprises, terminals and cloud computing. With competitive ICT solutions, products and services, Huawei is committed to enabling and creating the future information society and build a better all-in-one world (Huawei Official Portal). In the global digital and information economy evolution, Huawei is acting as a typical representative of Chinese enterprises

and driving force, who has made outstanding contributions to become a global leader in the field of information and communication enterprise. In the field of a smart city, Huawei focuses on ICT infrastructure and open capacity aggregation with partners, to promote the healthy development of the smart city in an ecological circle and smart city solutions.

## 5.1 Value Proposition of Smart City

Human beings have created a high level of urban civilization, which attracts more people to the city. Thus urban construction and development are facing unprecedented challenges, such as traffic, environmental problems, lack of energy and security issues etc. Under such circumstances, Huawei proposed the smart city solutions based on its technologies advantages and the idea of creating the "Information Superhighway" to provide various ICT solutions within the smart city, including smart governance, safe city, smart healthcare, smart education, smart transportation, smart grid, smart park and smart tourism. Huawei emphasizes the key role of Information Superhighway, which has the similar meaning of X-road in Estonia and Finland. The features could be described as 1)information sharing and integration, 2) high level of the widespread network, 3) convenient application and services available, 4) credible and green information (Huawei Smart City Solution, 2013).

As Huawei defines a smart city, it is a selection of ICT-enabled solutions for sensing, analyzing, and integrating the key information of a city's core operating systems. Smart City improves quality and intelligence of citizens' livelihood and enhances environmental protection, public safety, urban services, and business activities, which highlight the ICT blueprints for a smart city. Furthermore, the features of the smart city can be explored from this definition. ICT-enabled solutions for city challenges is the main aim for building a smart city, and time-efficient, cost-effective systems are integrated into the city architecture. Diversified services and widespread benefits should be shared by the advanced and intelligent technologies.

## 5.2 Smart City Architecture

In 2016 Huawei held a summit named “New ICT, make city smarter” in Suzhou, China, with near 500 customers, partners and experts in IT field to discuss smart city developing trend and share experiences in city designing. In this summit, Huawei launched the smart city solution architecture and the plan for the sustainable smart city.

A smart city is a complex giant system, which requires a lot of support from business application developers. For the majority of small and medium enterprises, fast and rapid response to market demand, incubation of innovative programs are heavily needed in this scenario (Huawei Smart City Solution, 2013). With the 20 years experience in ICT infrastructure, Huawei transforms their traditional technologies advantage into integrated smart city application. Huawei smart city architecture can be concluded as One Cloud, Two Network, and Three Platforms (see Figure 5).

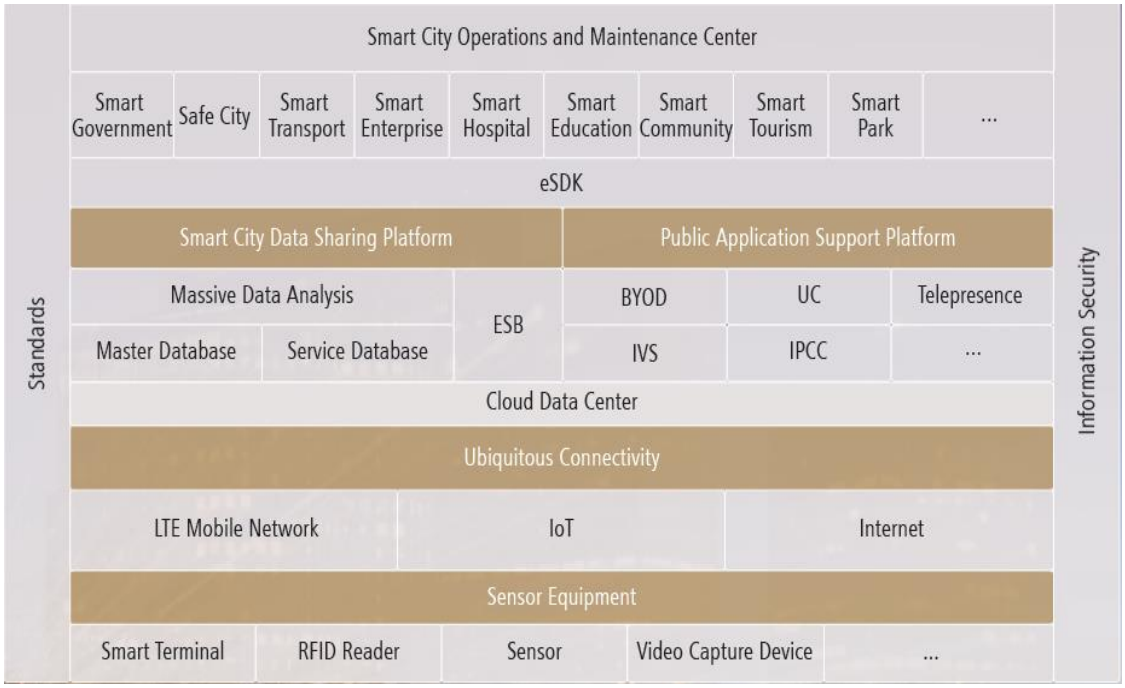


Figure 5: Huawei Smart City Architecture (Huawei Smart City Solution, 2013)

As it is shown in the figure, the entire smart city architecture is described.

1) One Cloud: Cloud Data Center

Based on the open architecture, various types of urban information resources are shared and used for the construction of urban integration and combination of open and secure

cloud data, which in turn enhancing government services and decision-making efficiency and rationality.

2) Two Networks: Communication and IoT Network

In this level, two networks enable to provide broadband network both wired and wireless for the city with ubiquitous broadband, so that the city public service at your fingertips anytime and anywhere. In the field of Internet of Things, Huawei provides the industry's most lightweight physical networking operating system LiteOS, a variety of types to access gateway, which is the main contributor to the IoT standard. In the IoT platform, data services can be implemented in smart city application via different sectors.

3) Three Platforms: Data sharing, Application support, and Operation Platforms

In this scenario, ICT capabilities will be integrated and packaged for business application developers to provide intelligent solutions for the smart city overall. And with a large data service support platform, business application enabled platform, urban intelligence applications can be accessed to automation in information resources, software development and operation and maintenance management services.

In addition, Huawei provides end-to-end information security solutions for smart city construction, including physical security, network security, host security, virtualization security, application security, data security and other aspects of products and solutions for the protection of smart city development.

Huawei Smart City Solution features omnipresent connectivity, information sharing and integration, and cross-sector association. The urban infrastructure network commonly connects users' equipment terminals; the urban information sharing platform carries various smart applications; the cloud-based urban data center stores, shares, and integrates the entire sector and subsystem data services, such as Smart Government, Safe City, Smart Transport, Smart Enterprise, Smart Education, and Smart Hospital.

## 5.3 Smart Solution in Urban Context

The rapid development of ICT is changing people's lives and the way the city runs and manages, which enables to sensitize, analyze and integrate key information about urban operations and management systems in response intelligently to the needs of urban governance, livelihood services, business activities, data-driven cities. In the urban context level, Huawei has proposed various smart solutions in different sectors based on ICT infrastructure. In the following, a list of smart solutions are described and discussed.

### 5.3.1 Smart Transportation

With the accelerated pace of urbanization, the number of motor vehicles grows rapidly. But the road network construction is lagging behind, and the level of traffic management is not high, which result in congestion problems and frequent traffic accidents. Urban road traffic management is facing major challenges and has become one of the most urgent problems in the city that need to be solved. In spite of rational planning and construction of roads and transport facilities, it is more necessary to speed up the traffic management in a scientific, informative and intelligent way, which result in reducing the pressure on government and improving the city road traffic conditions.

Huawei with its partners has launched smart transportation solution, providing traffic data center, agile network equipment, video surveillance platform etc. ICT infrastructure is used to build integrated traffic management platform, and integrate traffic signal control, electronic police, bayonet, traffic flow collection, traffic guidance system. The following features are highlighted as below:

1) Comprehensive traffic sensing system

Based on Huawei intelligent video surveillance platform as the core, building various systems throughout every street of the city, including traffic video surveillance system, traffic guidance, signal control system, flow volume acquisition, and other information systems.

2) Unified cloud traffic command platform

Huawei establishes the traffic cloud data center as the basis, in order to build traffic management platform, achieving a high degree of traffic data resources sharing. With full use of traffic data, it is possible to realize comprehensive utilization and enhance the

scientific and efficient management, so that multi-department can visualize coordination of operations and improve traffic management level.

3) E-police

Through the usage of electronic police system, it is more efficient to obtain traffic fiduciary evidence, and in further strengthen the driver's traffic awareness and ensure traffic safety. E-police system can also help to ensure the road unobstructed and effectively improve the urban traffic order.

4) Real-time traffic emergency command

The deployment of Huawei smart video conferencing systems can be regarded as a fundamental role in traffic control, and integrate intelligent traffic emergency command platform. In this case, a reasonable decision could be made in time, for example, if there is a traffic accident, the real-time command can dispatch police, inform the hospital timely and quick response to the situation.

**Case 1**: Best Practice in Langfang

In this part, it will highlight the successful case about smart transportation in Langfang conducted by Huawei.

1) Background

Langfang is a city in Hebei Province in China, located in the middle of Hebei province and 40 kilometers from Beijing. With a population of more than 4 million, Langfang was planned as a center of high-tech and sustainable city by the government in 2014. Many economic and technological park are launched in this area, which attracts many Chinese and foreign investment.

2) Challenges

With the swift economic development, Langfang faces various of traffic problems in recent years. As the traffic control infrastructure fails to keep up with the pace of urban development, inhabitants have to deal with traffic congestion and frequent accidents. Langfang needs to better handle the flow, and also need to evolute the city outdated dispatch police and patrol car system.

3) Solution

As an ICT solution provider, Huawei established a smart transportation solution, which is known as Intelligent Transportation System (ITS).

In this, ITS system, central systems and a range of system components are included to recognize the local traffic management in a digital way. Thus Langfang could reduce traffic problems by monitoring traffic, controlling traffic lights and dispatching police and patrol cars. The system components are listed below in the table.

| **Subsystem** | **Equipment and software** |
|---|---|
| Traffic Signal Control System | Traffic signal controllers at 64 intersections, 186 units of video-based vehicle detection equipment, 209 sets of vehicle signal lights, and 60 sets of pedestrian signal lights |
| Traffic Flow Information Collection System | 43 solar-powered microwave traffic volume detectors |
| Traffic Guidance System | Eight 11.47m² traffic guidance screens and related equipment |
| Traffic Surveillance System | Surveillance equipment at six overview sites and HD surveillance equipment at 60 intersections |
| Red-light Camera System | 100 HD cameras and 100 SD cameras at 33 intersections |
| 122 Alarm Systems | Automatic Call Distributors (ACDs), Computer and Telephony Integration (CTI) servers, Call Control Servers (CCS), Interactive Voice Response (IVR) systems for voice guidance, recording system, data middleware servers, remote communications servers, web servers, database |

| | |
|---|---|
| | servers, and six alarm agent workstations |
| Police Car GPS | 82 sets of vehicle-mounted GPS devices and GPS servers, and database servers |
| Command Center Display System | 12 HD Digital Light Processing (DLP) displays, six LCD monitors, and two LED information displays |
| System Integration Platform | One system platform that integrates information about traffic flow, traffic signal control, traffic video surveillance, electronic police and other subsystems, as well as background servers and other hardware |

Table 1: ITS system components (Huawei City-wide Transportation System, 2014)

As we can see from the table, ITS has different systems that function in a specific area, with the collected data from real-time, output and decision could be made timely. In this case, Huawei smart transportation solution integrates diverse systems, such as traffic signal control system, traffic flow information collection system, traffic guidance system, traffic surveillance system, 122 alarm system, Global Positioning System (GPS) and command center display system. With the ICT-based infrastructure, the ITS system is integrated and actively interacted via each factor. A general overview of the ITS solution is provided below in Figure 6.

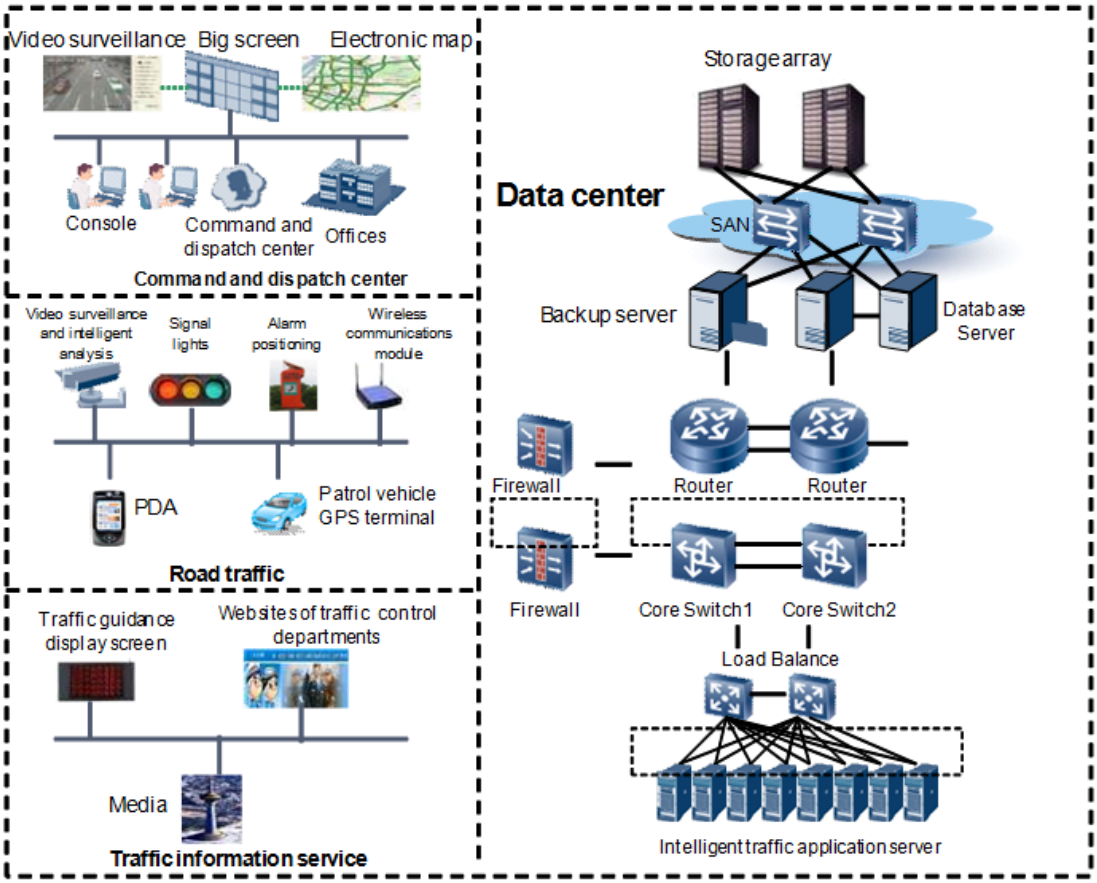


Figure 6: ITS solution system (Huawei City-wide Transportation System, 2014)

In the ITS system, there are four key sectors: road traffic, data center, command and dispatch center and traffic information service. From the beginning, the information and data of real-time traffic can be collected by traffic sensor system and video surveillance components, and then the traffic date can be transformed into the data center, where the traffic data can be analyzed and stored. The traffic data and other information will indicate the real-time traffic volume, traffic flow, and congestion. After gathering these data, the traffic command center can manage traffic in an efficient and safe way. The traffic information service will deliver to its citizens through the traffic guidance display screen and social media.

Information and data from traffic monitoring system will enable command and dispatch center to track the overall situation of the city and some specific situation. The police can use the automatic HD recording system to capture the driver who runs in red light. The system uses video recognition technology to detect violations and then generates images and provides vehicle information by reading license plates.

### 5.3.2 Smart Hospital

1) Challenges

Over the past two decades in China, the informatization of hospital has evaluated from administration-centred service to the diagnosis-centred service in the initial stage of development. Now it is developing a new stage of the service-centred digital hospital. However, these systems still face the challenges: 1) traditional telemedicine with standard-definition video services could not integrate with hospital ICT system. 2) low network stability and capability for mobile medicine. 3) difficult operation and management system and energy-consuming data centers with low scalabilities.

Based on this situation, Huawei and its partners have developed smart hospital solution that serving hospital management, digital clinic services, and advanced ICT infrastructure. The smart hospital is based on the ICT infrastructure development, to achieve hospital business informatization, telemedicine and mobile medical etc, which highlight the role of database and information network, providing smart hospital application to hospitals and patients. ICT plays a progressively significant role in the daily procedure of hospitals. It is evident that advanced ICT systems serve as a hospital's central nervous system and drastically improve medical service efficiently and effectively.

2) Smart Hospital Solution

Huawei smart hospital solution involves the rich harvest of medical ICT systems such as wired and wireless networks, data centers, medical systems and hospital management systems. According to service needs, Huawei has modified the cloud computing platform, providing telemedicine, mobile medicine, unified communications, hospital office collaboration, video surveillance and related medical information sharing. The overview of the smart hospital is listed below (see Figure 7).

When designing the solution for modern hospital informatization, three following aspects should be considered: the first level is medical business, aiming to achieve available network and paperless office. The second level the management of information resources and systems, achieving the integration of information, service application, and platform. In the third level is to activate the needs of medical

informatization and barriers, fully sharing information and continuous innovation in order to meet the continuous development of medical services.

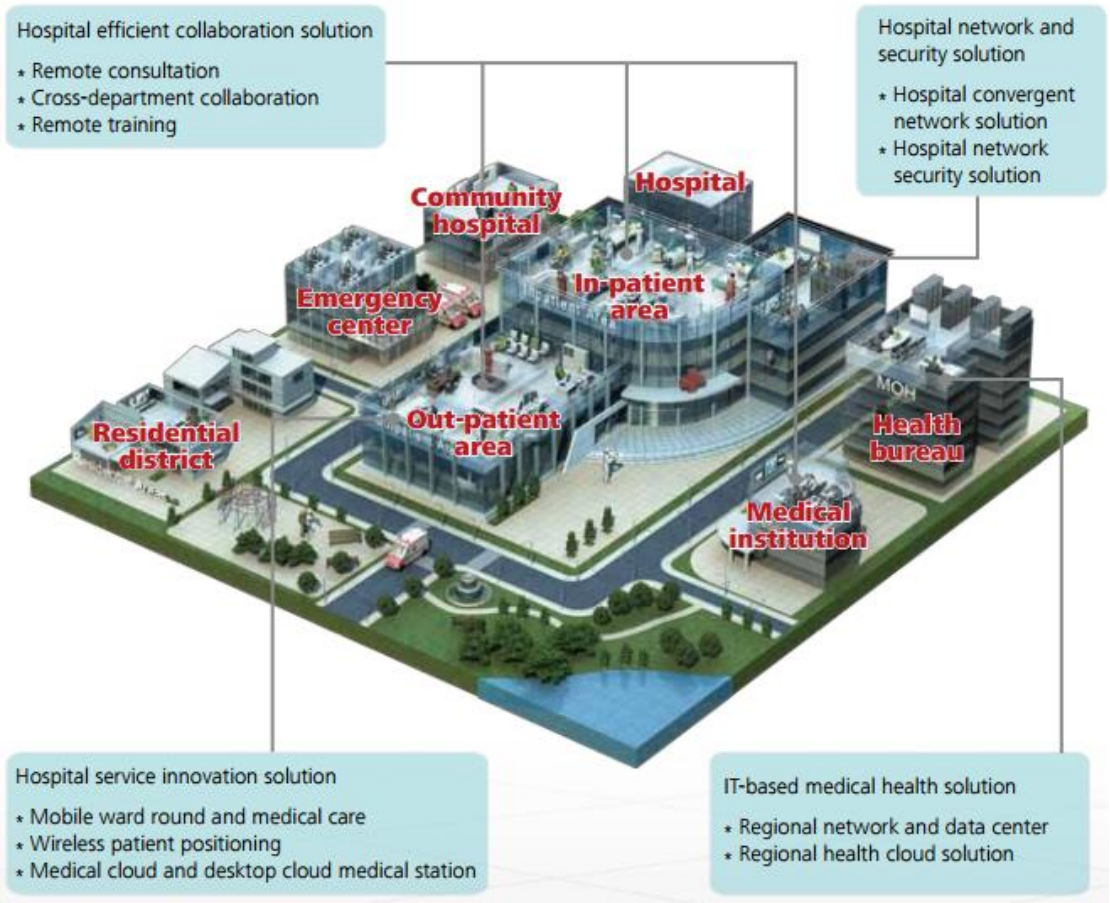


Figure 7: Smart Hospital Solution Overview (Huawei, 2013)

Huawei smart hospital solution has the following four features: 1) comprehensive hospital network that allows divers service application and operation. 2) intelligent management system and system integration with full use ICT advantages. 3) information sharing within hospital level and innovation encouraged through cloud-based hospital data center. These solutions allow hospitals to improve the user experience, quality of service and efficiency while reducing total hospital costs. The development of medical ICT systems requires the participation of all parties in the industrial chain.

# 6 Discussion and Analysis

This chapter consists of an analysis of findings of the qualitative data gathered through case study and literature review. Further, this section discusses the background, operations, goals and how the project contributes to the territorial development and encourage innovation in the region of the chosen case study. In the previous chapter, the methodology of the research was explained.

The goal of new urbanization is to solve the social problems and the concept of the smart city is the technological way and solution in urban construction which will accelerate the development of cities. Regardless of the current situation of a smart city in China, on the whole, smart city construction process is still in a beginning stage. Whether in the urbanization or smart city development, it is stressed that every process should conduct as "people-oriented", that is the core of this two construction. The ultimate goal is to provide diverse serves to its citizens. At the same time, green and sustainable development is the theme of this stage both in China and the whole world, which is a harmonious and systematic environment. To achieve sustainable development is the goal for smart city and new urbanization, at this level, they have the same objectives. A smart city is an upgraded integration of information and communication technology, which highlights the collaboration of advanced information technology. This upgrade is based on the allocation of resources, emphasizing the supply and demand that enables the development of service quality, and the pace of development in quantity. Overall, the scientific allocation of existing resources enhances the development of social efficiency and cultivates the innovation for future potential development.

In recent years, the concept of the smart city is gradually emerging and developing, as many countries have launched a national strategy to implement different kinds of projects. In addition, smart city has become a new type of urbanization and an important means to achieve sustainable development. The smart city strengthens the usage of ICT-based network and services within cities and promotes the continuous exchange and development of regions and local conditions. The use of information and communication technology is intended to make urban life more intelligent and smart, such as efficient use of resources, energy savings, improvement of service and quality of life. The implement of smart city projects is more effective in improving the quality

of life in urban space and promoting cultural and economic development. Smart city, based on the ICT infrastructure, is providing more efficient services for the residents while bringing the promotion of social and economic innovation, as well as urban and regional space changes. At the same time, the smart city is a systematic understanding of the concept of urbanization and sustainable development. Therefore, the smart city plays a significant role in the development of new urbanization in order to improve the quality of urbanization and promote the sustainable development of urban socio-economic development. Smart city can be regarded as an important direction of urban city construction and smart service applications, such as smart transportation, smart education, smart governance, smart hospital, smart public security, are the main characteristics of urban functions, which in turn can be more intelligent and technological support for urbanization. A smart city is mainly based on technology applications while urbanization is a trend focusing on how to solve social problems. These smart solutions and technologies can not only bring convenience to human daily necessities and work efficiency but also can be used to alleviate social contradictions from the macroscopic level and solve the social problems in the process of urbanization. So the smart city can be seen as an integrated carrier for urbanization. A smart city is featured in the intelligent identification, technological innovation, smart management and other aspects, which promotes the incorporation of urban infrastructure. In result, the evolution of urban industrial development and transformation can be strengthened and urban interaction can be managed depending on the market demand and residents' needs. The combination of urban construction will achieve an intensive, green and smart urbanization development for all the citizens. The technological innovation of smart city has promoted the development of service capability in various fields such as urban transportation, environment, medical care, public safety, e-government, social networking and so on. The development of various intelligent applications to a certain extent will enhance the efficiency of energy and resources and optimize the city's management and services, which will promote the transformation of the urban economy in further. These improvements by smart city enhance the capacity of urbanization in sustainable development. The popular usage of smart applications guide innovation and knowledge accumulation, that has become the core driving force for urban development, which has a positive impact on urban environmental protection and optimization, high-tech industry development, urban culture, science, and technology.

The smart city is the outcome of deep integration of ICT innovation application and urban transformation and development, with the technological support of information technology such as Internet of Things, cloud computing, big data and mobile Internet, which promotes the capability of urban planning and redesign, urban construction, urban management and urban service. In specific, the development of the smart city is to promote the integration of physical infrastructure and ICT infrastructure, building a basic city intelligent infrastructure. Based on the new generation of information technology in urban economic society, the aim is to make full use ICT solutions in all areas of the city. The core goal for the smart city is to maximize the development, information sharing and use of various types of urban information resources, to offer and provide timely, efficient and intelligent information service for residents, businesses sector, and society. In this way, city planning management, intelligent infrastructure, the convenience of public service convenience and modernization of industrial development can be reached by smart means.

At present, China's economic development grows onto a new stage, and the construction of smart city is a strategic choice for the Chinese government to conduct actions and planning. Then smart city initiatives are matched with the new economic growth, and a variety of benefits could be seen. Smart city will not only enhance the city carrying capacity, promote economic quality and efficiency improve the quality of life for people, but also actively lead the new economy and the Chinese unique road for urbanization with new industrialization, information technology, agricultural modernization and sustainable development. A smart city is conducted to improve cities' comprehensive carrying capacity and promote the new urbanization. It is helpful to optimize the urban spatial structure and management pattern and promote the digitization and precision of urban planning, urban infrastructure network, landscaping, environmental protection and so on. In the urban context, the operation and management level will be improved in the energy, transportation, environment, disaster prevention, water supply and public safety and other aspects of the city through the smart solution. On the basis of this, it is necessary to enhance the facility of the urban economy, infrastructure, and public service and realize the urban space intensively and efficiently, making the living space reliable and comfortable for all citizens. This is of great significance in promoting the new urbanization process in China.

Currently, China's urban industrial development model is transforming the manufacturing industry to the modern service industry, emerging industry, intelligent industry. The construction of smart city will improve urban economic growth efficiently and accelerate the widespread usage of new ICT such as Internet of Things and mobile Internet in all areas of urban economic development with the support of the network sharing, intensive integration, collaborative development and efficient utilization of urban information resources. This will undoubtedly help to optimize the mode of social organization and regional productivity distribution and enhance the city's economic vitality and competitiveness. Nowadays, the smart city has become the main carrier of new ICT development, and with the large implementation of big data and internet, a lot of opportunities will emerge for China's smart city development and form a huge industrial scale. Smart city initials will trigger the innovation of social governance and public services and enhance people's living hood. Presently, China's urban governance is transitioning from urban governance mechanism with extensive, empirical and public participation to the urban governance mechanism of informationalization, intelligence, and pluralism. In the construction of the smart city, with the use of ICT technologies, it will increase data open and information sharing in various governmental departments, which will effectively enhance the accurate and efficient urban management. At the same time, building a smart city will promote the integration of resources and information sharing in the field of social aspects in urban management, social security, healthcare, culture and education, public safety, traffic promotion, community service and other important areas related to the citizens.

Smart city construction is a multidisciplinary and multi-sectoral work. From the government management level, the process of smart city construction really tests the government's decision-making and skills of management. During the construction process, several of efforts should be set up to participate in multi-sectoral discuss and study. The governmental administration is one of ICT applications and services, while government management can regard ICT as a tool and enabler to achieve its goal of "good governance". In the early stage of smart city construction, the government should lead the smart city project and decision-making including construction of large scale infrastructure and project planning and evaluate since high risk of a new project in the beginning. During the middle period, it is more beneficial to undertake BCO mode (Build-Control-Operate). In details, enterprise builds the operation platform oriented to

market and government will supervise the whole process. The enterprise is responsible for specific project construction and maintenance, and the government can monitor and coordinate throughout the project management process. Then certain concessions will be given in some case to ensure the success of smart city construction.

The benefits of the government to the university-industrial-government triple helix is always a challenging calculation, so there is little research on the U-I-G relationship in China. The inventions were observed based on the triple helix model and the interaction between U-I-G was considered in China. In their work, state-owned enterprises (SOE) are symbolizing the government with the U-I-G relationship (Lei et al. (2012). The Chinese government is a supervisory stakeholder of state-owned enterprises, but the state-owned enterprises operate in the same way as the private sector, following the market rules. Thus, state-owned enterprises should be considered an industry, not a government in the U-I-G relationship. In addition, so far, the attribution of U-I-R has not been studied (Chen and Guan 2011). Academic scholars only study the cooperation between universities and industry in China's innovation system (Liang et al. 2012). In these studies, public research institutions were jointly analyzed with universities or omitted from the analysis. Public research institutions play an equally important role in university innovation. For example, in the field of biotechnology in China, patent innovation is mainly carried out by public research institutions (Chen and Guan 2011). Chinese Academy of Sciences scientific research institutes are major innovators, which focus on major scientific and technological projects. Thus, in the U-I-R analysis, the division between universities and research institutions will be more pronounced than the two combinations.

# 7 Conclusion

The objective of this paper was to examine How Information and Communication Technology (ICT) contribute to smart city development in China. Case study research about Huawei has been carried out on the examples of Smart Transportation and Smart Hospital projects.

Main intention with this work was to add to the understanding of smart cities by exploring the perspective of territorial development and experience with smart cities. From the theoretical perspective, this study investigated how smart cities relate to urban context and governance theories. Then this study explored a case study from a practice perspective.

Furthermore this thesis investigated the importance of research engagements on the quality of governance in smart cities and how they inform or participate in policy and territorial development. Smart cities in China can be seen as an additional form of "experimental" governance because the rules of the game are often not defined to avoid limiting innovation and far-sighted thinking. However, there is a risk of becoming unequal expectations, power games and places of conflict in the governance perspective. Therefore, it is crucial for future research to investigate how these informal soft governance models relate to formal government models. However, the exploratory nature of the smart cities provides a promising way to balance power in the context of participatory urban development. The smart cities in China can be a creative environment for exploring new forms of intelligent urban governance, rather than merely proposing a new environment for applying established theories. This is closely related to the smart cities, which aims to promote creative insecurity by harnessing the innovative capacity of various actors in creating urban development. Therefore, the smart cities may serve as an empirical environment for the development of social planning theory and practice. However, this needs to be studied and explored in real life environment, especially in the balance of stakeholder influence.

An issue that discovered which needs attention is the continuous involvement of actors of the projects throughout the process. In smart cities planners play a vital role in this regard, they are the connectors and coordinators. Partnerships between stakeholders are crucial in the smart city scenario where it involved research-based innovation, the link between the government, research institutions (universities etc.), companies/firms and

more importantly among its citizens need to be strong, and they need to be motivated throughout process lifecycle to benefit and achieve objectives. Stakeholder relationship approaches it is beneficial and help to understand needs and coalitions among actors. In conclusion, this study provides more insight into smart cities in China. Stakeholders know the purpose of a smart city, their roles and how smart cities influence to develop innovation. Moreover, stakeholders can identify advantages of living labs in the territorial development and could focus their efforts on involving in the smart cities to harness benefits.

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