Chapter 16

Smart Connected City for Holistic Services

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Additional information is available at the end of the chapter

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Abstract

The construction of a smart city is based on broadband networks and high-tech under consideration of city infrastructure with holistic city service systems. Digital city was started to connect computing devices using network-based technologies in 1990s. In the beginning of 2000s, many cities were interested in the construction of city infrastructure based on the broadband networks. With the developing high-tech like wireless network, the ubiquitous city was introduced as a new type of an urban city infrastructure to satisfy citizens' needs. These days it would become more important for citizens to provide holistic city services using the transferred data as generated resulting traffics from massive number of end-devices through broadband networks. Smart city has been constructed with multifaceted sectors like high-tech device-based physical and service-based social sector. The integrated sectors are creating new tremendous values based on embedding intelligence in the hyperconnected city. Finally, the smart city should be evolved by centering on people and the creative market is growing up rapidly.

Keywords: smart city, broadband networks, holistic services, embedding intelligence, digital city, ubiquitous city

1. Introduction

The concept of smart connected city has been developed through the era of digital city and ubiquitous city as a new type of city infrastructure. The construction of smart city for providing city services is grounded on high-tech using generated data from smart devices and Internet of Things, which are transferred through broadband networks and processed by information and communication technology. In addition, intelligent and smart systems support to provide holistic civil services for citizens.

According to the development of network-based technologies in 1990s, the digital city based on wired network was introduced and implemented as a kind of a sustainable eco-city, like Amsterdam

and Kyoto. At that time, the online commercial environment was also popularized. In addition, the electronic government was started to provide online civil administration services to citizens, such as e-government. In the digital city, unlike in the past, the concept of the city was expanded from the physical to the cyber world. As an instance of services in the digital city, e-government was popularized to provide more comfortable and reliable civil administration services for citizens.

In 2000s, according to the innovative development of mobile technologies, citizens' needs for civil services were more specified, customized, and refined in a variety of fields for their more comfortable urban life using network-based mobile services. Many cities started to build the ubiquitous city based on mobile and using information technologies. In the ubiquitous city, citizens can be connected to networked things using city broadband networks by mobile technology, which allows citizens to access the given and required services whenever and wherever. In the USA and Europe, the ubiquitous city was integrated with the concept of open innovation and expanded to the concept of a "living lab" because it was used to experiment and evaluate the newly introduced concept in the city infrastructure. A project related to the ubiquitous city was introduced as "Smarter Planet" by IBM in 2008. In 2009, IBM announced again the expanded concept of the city as a kind of smarter city to helping cities to efficiently use city resources, to provide comfortable civil services and to improve the quality of life for citizens. The evolving progress of city development is illustrated in **Figure 1**.

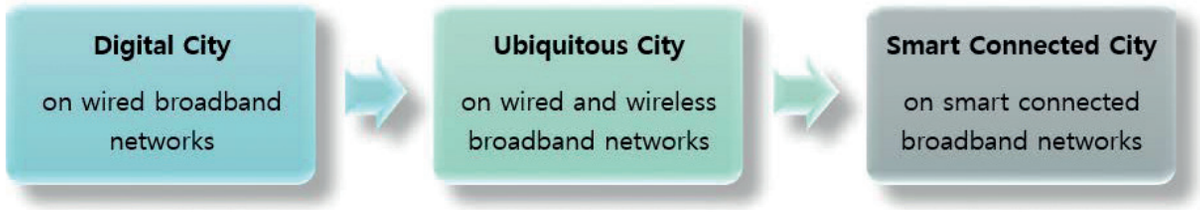

Figure 1. The evolution of cities based on broadband networks.

During the step of the evolution of a city, the digital city was a test bed to apply innovative technologies like online services to the city. The ubiquitous city was a living lab as an infrastructure to support urban services using interconnected high-tech. Finally, the smart city has been developed as a platform of the provision of high-tech, the city infrastructure, and an ecosystem to provide holistic services for citizens as in **Figure 2**.

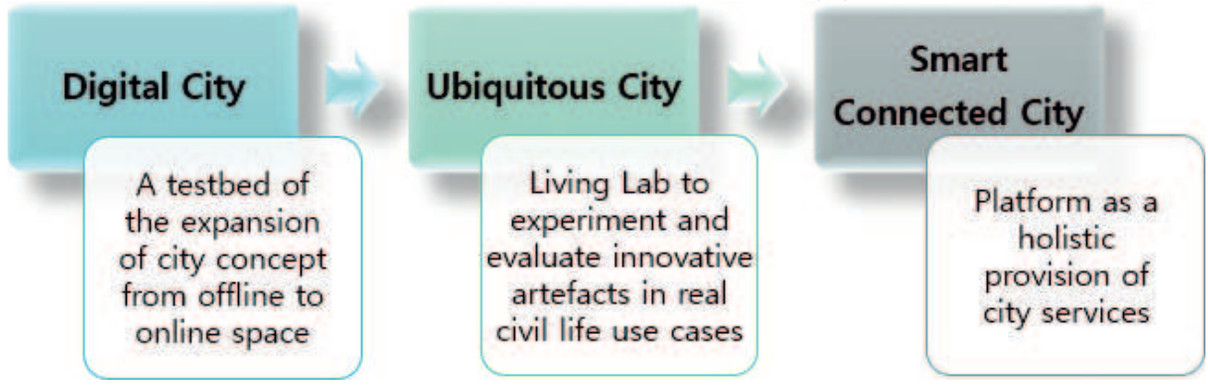

Figure 2. The transitions of city concepts.

Depending on the evolvement of a city, many countries are naturally focusing on the construction and development of smart connected cities that can provide holistic services to citizens using all developed high-tech and city infrastructure. Sometimes, a smart city can be a good test bed to implement innovative technologies and a living lab to interoperate and apply the developed high-tech to the city infrastructure to develop and provide useful services for citizens. It is important to implement and apply the developed technologies to citizens' real lives in the city. To achieve this, it is necessary to connect the high-tech infrastructure and to develop and apply appropriate services for the citizens. Finally, the smart city pursues a kind of ecosystem as a platform that brings together a variety of things with hyperconnectivity.

This chapter is organized as follows. In Section 2, we review the smart city trends and market size. In addition, we overlooked the broadband network trends and business impacts with the IoT in Section 3. In Section 4, we introduce the concepts of a smart city, and in Section 5, the smart city types are illustrated. In Section 6, regarding the smart city, there are discussions on smart infrastructure with data and services and the social sectors and values that are created and managed in the city are mentioned. In Section 7, smart city is discussed as a test bed and a smart platform. In Section 8, we illustrate smart city cases in several countries. Finally, we present conclusions.

2. Smart city trends and market size

Many cities are currently concentrating on constructing a smart and connected city with holistic services on broadband networks using high-tech. Over time, high-techs have been rapidly and progressively developed, especially in network-based technologies such as the Internet of Things (IoT), cloud computing, big data, artificial intelligence (AI), and information and communication technology (ICT). According to the customized and specified citizens' needs, the technologies help to serve more comfortable and reliable city services to the citizens in all areas of their lives. The requested and needed services are related to smart city infrastructures such as smarter building, government, work, transportations, information and communications, distribution, and so on that are constructed using high-tech. For instances, as artifacts of the constructed smart city, there are smarter street lighting, trash cans, parking lot services, climate and water services, waterways, smart grid and energy systems, and so on. They generate creative values for citizens using the generated tremendous data through the networked Internet of Things in the city. As in **Figure 3**, McKinsey expected that, until 2025, the allocation level of the Internet of Things will be in a minimum 3.9 trillion and a maximum 11.1 trillion dollars for a year [1]. The Internet of Things will be used to collect data from applied smarter services to the city infrastructure. As major components to construct smart city infrastructure, the illustrations of smarter artifacts in smart city are smart factory, smart health, smart retail, smart worksites, logistics, transportations, home, and so on [1].

These kinds of services need to be integrated, collaborated, and coordinated to provide appropriate services to customers using high-tech. The required services should be interconnected and intertwined to provide holistic services to citizens. The holistic services in the smart city are based on high-tech like the embedded intelligence.

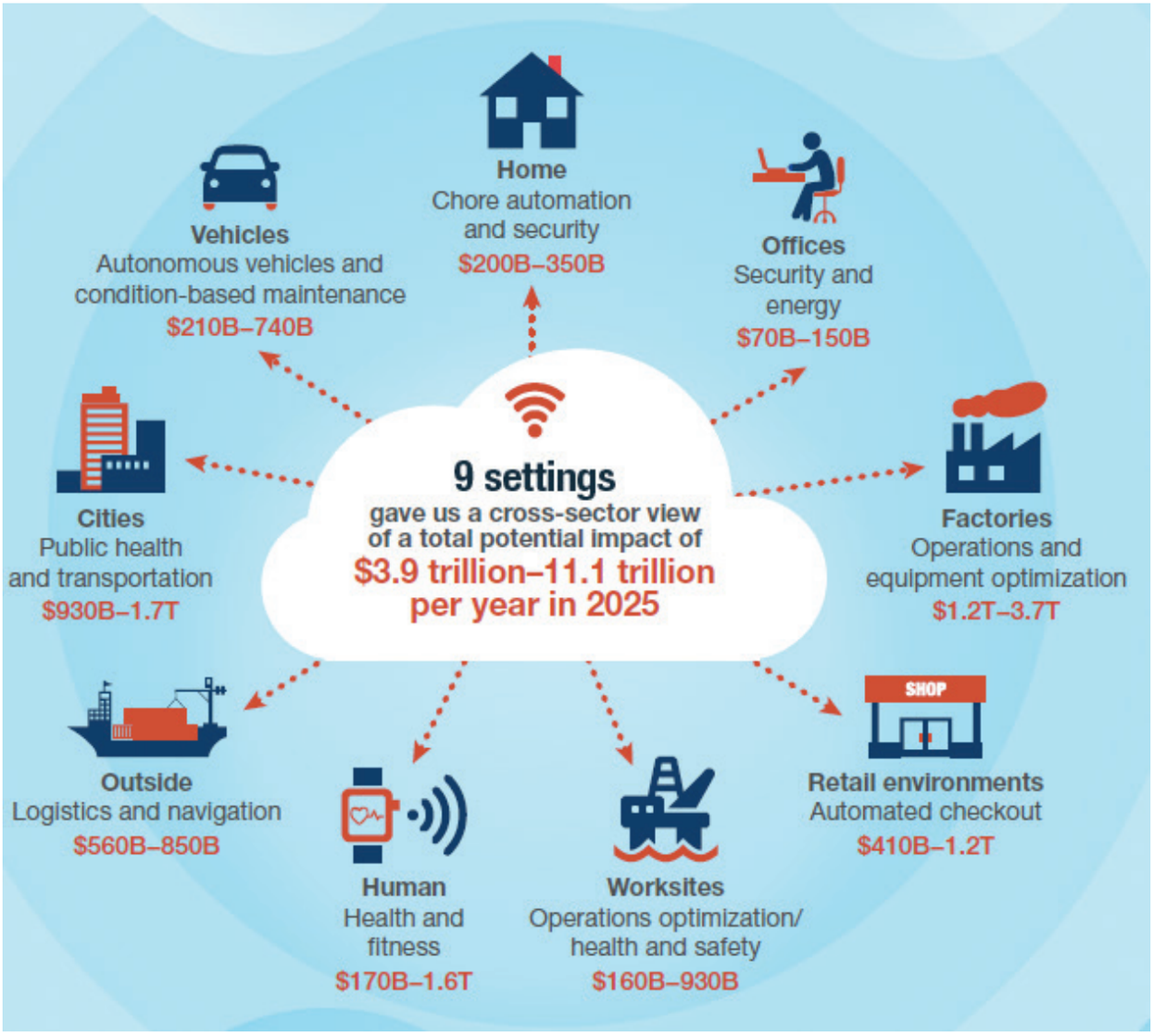

Figure 3. The Internet of Things: the value beyond the hype, McKinsey Global Institute (2015).

By Hewlett Packard (2016), as progress has been made in the high-tech sector, public institutions to provide city smarter services are already linking building security systems (57%), street lighting (32%), and automobiles (20%) to create an interoperable technological environment that will support the smart city of the future. For instance, the most widely deployed IoT applications in this sector are remote monitoring and the control of urban devices (27% responded that this is the main application) [2]. The major issues with the IoT are build costs (50%), maintenance (44%), and integration with legacy systems (43%). Within the city, the limitations of legacy technology are becoming the biggest challenge. Nearly half (49%) of IT departments in the public sector are having difficulty integrating existing technologies into the system. Smart cities that are implementing effective the IoT strategies, however, actually demonstrate why the IoT initiative is worthwhile. Seven out of 10 public-sector IoT adopters (71%) said they are saving money, and 70% said that the IoT has improved visibility across the smart city. This is an essential step toward realizing the smart city's integrated infrastructure [2].

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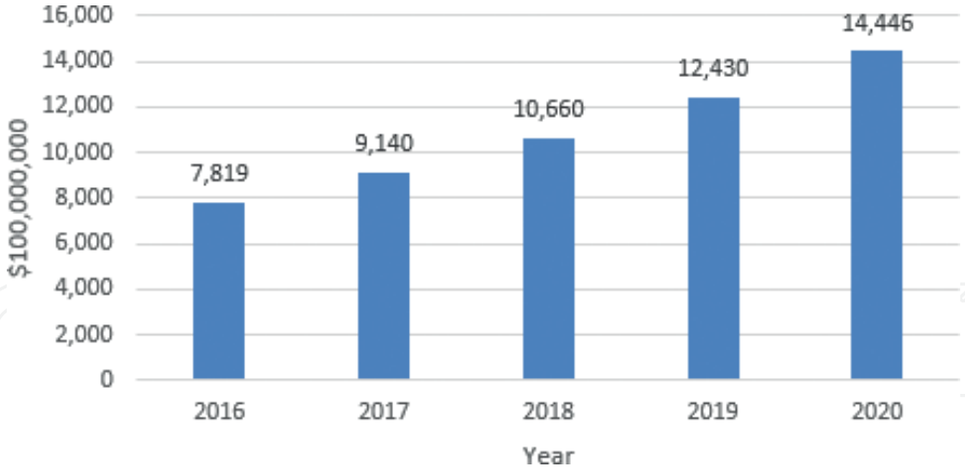

Figure 4. The forecast of smart city market size (source: Research and Markets, 2017).

The global market for the smart city is growing rapidly. As in **Figure 4**, by Research and Market, the market size of smart city was $781.9 billion in 2016. It forecasted that it will be $1.4 trillion in 2020 with an annual growth rate of 16.6% [3]. By Frost and Sullivan [4], the estimated smart city market is likely to be worth a cumulative $1.565 trillion by 2020. Grand View Research [5], a US-based market research and consulting company, estimates this will be $1.423 trillion by 2020. MarketandMarkets [6], a B2B research company, estimates this will be $1202 trillion by 2022.

Regarding the view of high-tech, according to Gartner [7], as the market size of the smart city is growing, the utilization of the IoT is also increasing significantly. Gartner predicted that 1.6 billion IoT devices will be used in a smart city in 2016, up to 39% from 2015. Smart commercial buildings were expected to be the top usage application of IoT devices in 2017, while smart homes were expected to rise to first place (more than 1 billion IoT devices) in 2018.

According to the United Nations (UN) [8], in 2016, 1.7 billion people (23% of the world's population) lived in a city with at least 1 million inhabitants. By 2030, a projected 27% of people worldwide (2.3 billion people) will be concentrated in cities with at least 1 million inhabitants.

3. Broadband networks

In technical view point, smart connected city is based on broadband networking. In advance, the real-time networks are used to transfer and communicate the generated and created data. The data are usually collected from the IoT devices equipped with sensors. Now, new 5G cellular standard is introduced to enable the IoT. In addition, the cutting edge technology like the IoT in **Figure 5** is tremendously emerging and they are applied to develop embedded intelligent systems for providing efficient services as optimal solutions to solve urban problems in city life with processing and transmission of big data through the broadband networking.

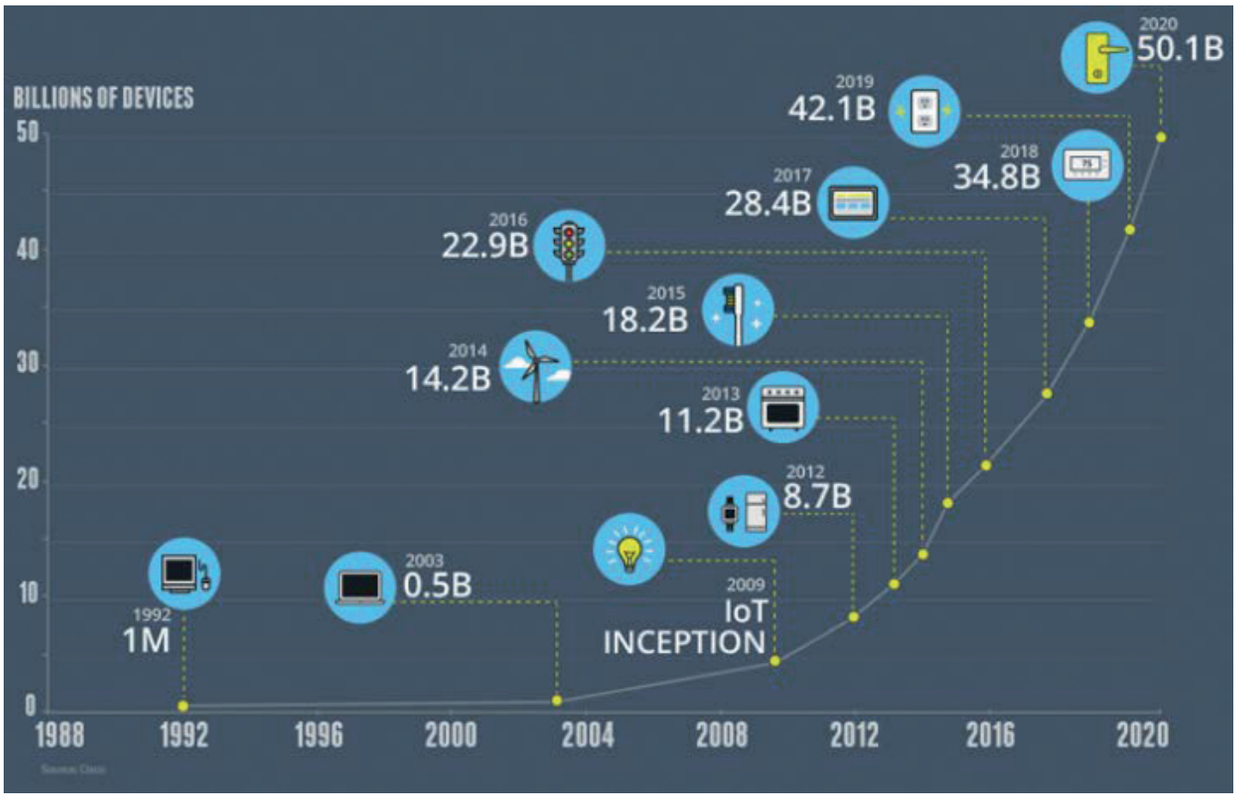

Figure 5. Growth in the Internet of Things (the number of connected devices will exceed 50 billion by 2020), source: WEF (assets.weforum.org).

By experts, by 2022, more than 1 trillion sensors will be embedded in networked devices and there are the embedded 45 trillion sensors in the world within 20 years [9]. By 2020, the estimated IoT market size, the number of connected devices will be around 50 billion by Cisco, 32 billion by IDC, 30 billion by McKinsey, and 26 billion by Gartner [10].

In the smart city, physical things embedding computing systems can be hyperconnected by IoT technology. The IoT was developed for the purposes of connecting various things to exchange information and realizing value-added information services. If the IoT is effectively applied to cities' facilities, management and surveillance for city functions could be performed faster and more efficient than before. In addition, it is possible to provide a variety of services that are required by citizens for their smart living and lives.

According to the development of the IoT, by 2020, the estimated economic effect is $19 trillion by Cisco, $7.1 trillion by IDC, and 1.9 trillion by Gartner. By 2025, the economic impact depending on the IoT-based created business is estimated between $2.7 and $6.2 trillion [10]. Machina Research forecasted the extreme growth of the IoT-based business market, especially in platform and services as given in **Figure 6** [11]. By Machina Research (2015) [12], the global IoT market opportunity will reach $4.3 trillion by 2024.

In **Figure 7**, by ETRI, the world market size of 5G mobile communications is estimated from $52 billion in 2020 to $1.2 trillion in 2026 at a CAGR of 148%. In 2026, the market size of "communication services" is forecasted for $731.9 billion, accounting for 60.6% of the total, while

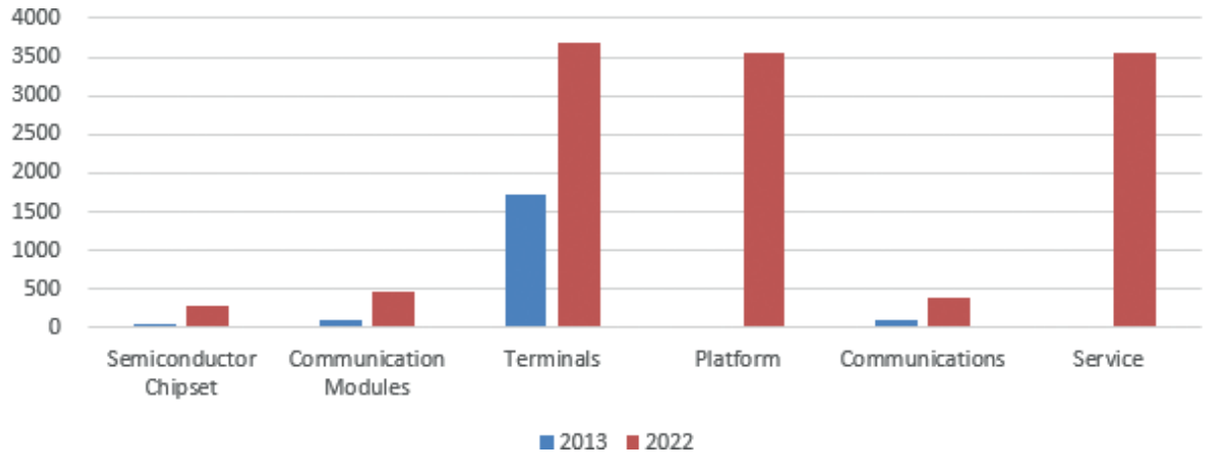

Figure 6. The estimated market size by the Internet of Things in the world (millions), source: Machina Research (2013).

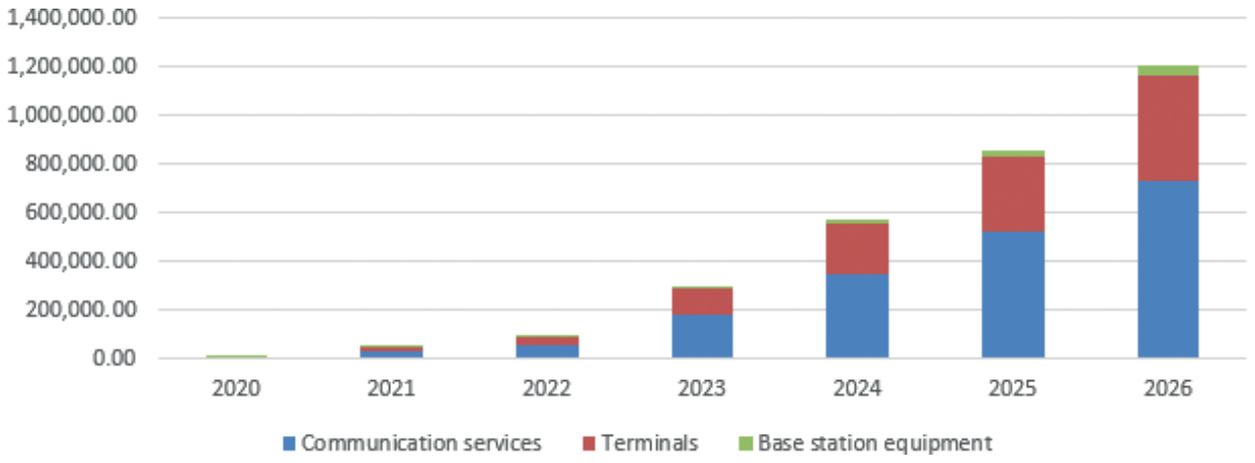

Figure 7. 5G mobile market size in the world (millions).

"terminals" and "base station equipment" are estimated by $438 billion at 36.3% and $38.4 billion at 3.1%, respectively [13]. It is assumed that the market transition will be started from 3G and 4G to 5G networks from 2020. The terminals are including the market size of sales of feature and smart phones except for the wearable devices [13].

According to ETRI, the world 5G mobile communication market is predicted to grow at a CAGR of 148% from US $5.2 billion in 2020 to US $1.2 trillion in 2026 [13].

4. Smart city concepts

According to research by the International Telecommunication Union (ITU) in 2014 [14], there are 116 definitions of the smart city. Keywords used in definitions vary from "environment" and "sustainable growth" to "information and communication technology" (ICT) and "intelligence." According to this research, 26% of 116 definitions of the smart city are related to keywords such as ICT, communication, intelligence, and information. This means that ICT is

a core concept of the smart city. The United Nations Conference on Trade and Development (UNCTAD) [15] defines the smart city as smart mobility, smart economy, smart living, smart governance, smart people, and smart environment.

In **Figure 8**, there are three components like physical services, holistic services, and broadband networks. Recently, the definition of the smart city has been extended from the physical aspects, such as city infrastructure and technologies, to the social aspects to serve holistic services including social services and impacts, as results of the interoperated processing of smart financing and capital, government, health care, welfare, and environment.

In the initial stage of the digital city, the implementation of the cities was based on fixed broadband networking technologies to connect among physical devices with computing and connectivity functions. In the city, the implemented digital services were online commerce, information service providers, electronic governments, and so on.

With the entrance of mobile computing devices, the developed ubiquitous city was spotlighted. It focused on the building of dynamic connections among mobile devices as well as physical things as components of infrastructure of the city. Ubiquitous city began to serve city public and private services using mobile devices in mobile broadband networking environment. For instance, pedestrians with mobile devices can easily access electronic services such as e-government and e-markets whenever and wherever they want even if they are walking down the street. In the ubiquitous city, it was focused on the transferring and deliberating data among

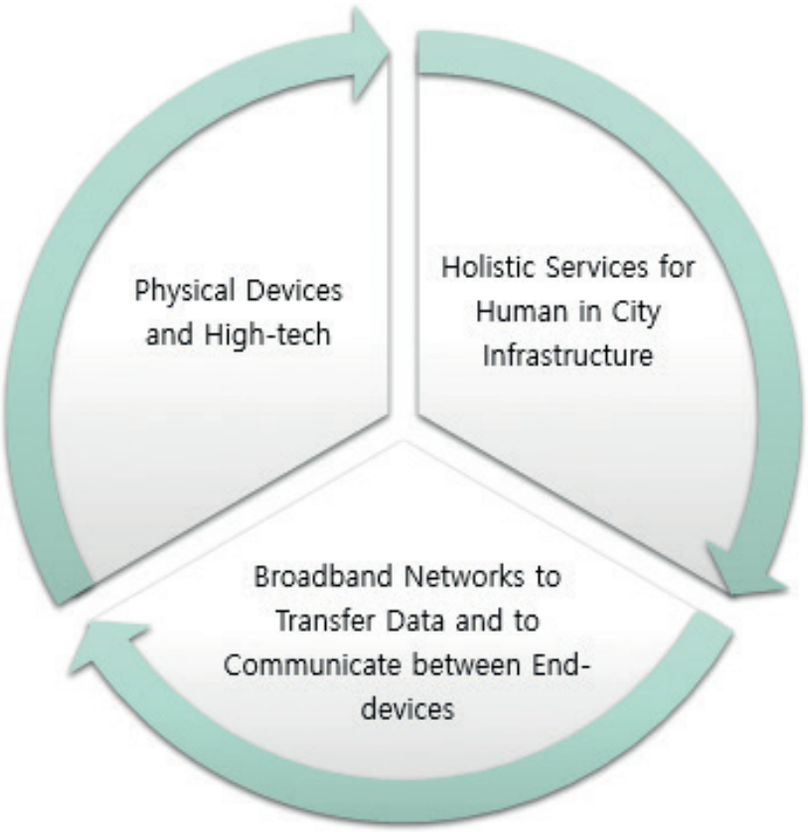

Figure 8. The components of smart city.

discrete objects through broadband dynamic networking. It started to build dynamic connections among the physical computing devices such as products, devices, sensors, vehicles, and drones as components of city infrastructure. However, the developed services were centered on city service providers like e-government services and construction of city infrastructure.

In smart connected city, it is important to provide citizen-centric services which are based on smarter connected networking according to the appearance of the fourth industrial revolution. The developments of these kinds of services depend on the embedded intelligent technologies and created customer centric services based on dynamic connecting network systems. The smart connected city is constructed by integration of the intelligent techs, dynamic and interactive connections, and city infrastructure. It orchestrates the physical techs, social services, and broadband services to provide city holistic services. It connects and internetworks among the physical devices such as products, drones, devices, sensors, and vehicles that are components of city infrastructure to serve smarter administration, smarter energy, smarter home, smarter office, smarter security, smarter vehicles, smart factories, and so on as in **Figure 9**. So smart connected city becomes a kind of a platform to create and provide the holistic city services to citizens, and it is possible to provide a variety of services that are required by citizens for their smart living and lives. As a platform, in smart connected city, services for social aspects are implemented depending on citizens' desires to solve a variety of urban problems, such as housing, health care, capital, energy, transportation, and public services. Finally, in the smart city, the concept of space is expanded from physical space to connect physical things to social space to provide citizen centric services, social impacts and effects, and so on. The construction of the smart city is based on the holistic orchestration of physical and social states for social efficiency.

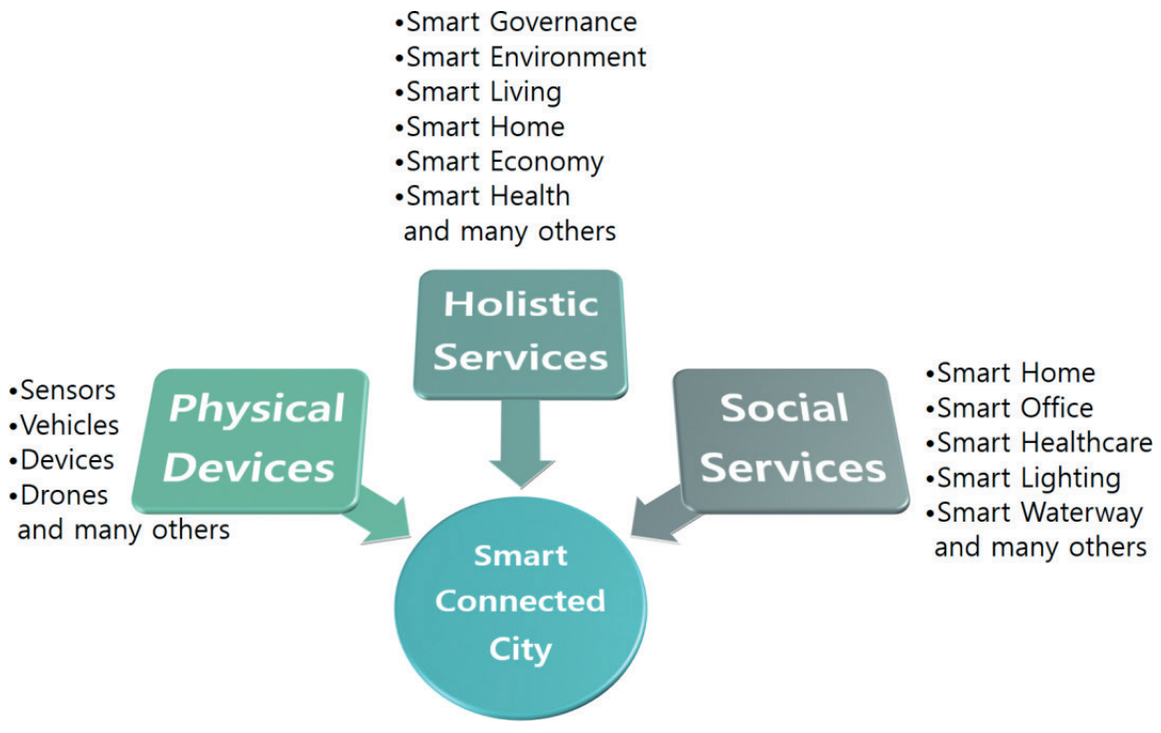

Figure 9. The holistic services in smart connected city as a platform.

5. Smart city types

The world is faced with several problems due to the increase in energy consumption and the urban population. The hyperconnected city could solve these problems. It is clear that the future city, with autonomous driving cars, the use of renewable energy, and the spread of the shared economy, will not be the same as the present metropolitan areas. The future smart city will be a new city that pursues sustainable development based on advanced citizen consciousness and overcomes the problems of industrialization based on digital technology. Smart city types can be clustered by several types of purposes, such as urban problem solving, environmental and ecological, and the ICT-based smart city.

5.1. Urban problem-solving smart city

The smart city is designed to systematically solve urban problems for the sustainability and resilience of the city. These problems are increasing according to urban population growth. Urban problems include a lack of infrastructure, traffic congestion, the carbon problem in transportation, parking problems, and air pollution, which are related to roads, waterworks, electricity, schools, etc., as parts of the public sector in the city. Thus, urban problem-solving is closely coupled to solving problems in the public sector for citizens in the city.

5.2. Environmental smart city

This is specifically focused on the environment in urban problems because it is directly related to improving the quality of citizens' lives and the sustainability of the city. From the environmental perspective, the environmental smart city can concentrate on a green-smart city, smart environment, climate-smart city, zero-energy city, smart grid city, carbon-free smart transportation, carbon capital creation and management, and so on.

5.3. Ecological smart city

If a hyperconnected society that connects things and cities is realized in the near future, we will be able to truly experience a smart city that can integrate the city management system that has been operated individually. For the improvement of the efficiency of the city, certain actions should be taken, such as avoiding wasting time and the reduction of energy and materials. In the ecological smart city, considerations include the enhancement of environmental quality, fostering system effectiveness, and the optimization of resource yields for resource circularity in the city. To construct a smart city, it is necessary to consider several sectors, such as the connected, data, public, social, business, and environment sectors.

5.4. ICT-based smart city

In the smart city, physical things are hyperconnected by smart and intelligent technologies, such as the IoT using sensors, big data analytics, cloud computing, and AI. The IoT generates a huge amount of data called big data. It is necessary for a city to create, manage, and control services using big data for citizens, because the data include a significant amount of

information on the city that are generated yearly, monthly, and daily. However, it was difficult to collect and manage such data before the appearance of high-tech. In the ICT-based smart city, by using the collected and generated data and information, it can be focused on types of cities, such as data-, knowledge-, and network-driven cities. The accumulated, classified, and processed data can be stored in knowledge management systems, which can be applied to create and improve citizens' services in the city.

5.5. Technology-driven smart city

In the technology-driven smart city, three major facts are considered. First, there is hardware, such as computing and mobile devices, sensors, equipment, controllers, and Wi-Fi. Second, there are data and software applications usually used to develop services for the citizens or for controlling and managing the resources of the city. There are big data analysis, cloud computing, the digital industry and capital, integrated operational and control centers, and so on. Finally, they are connected by a network that plays the role of connecting all things (e.g., machine to machine, machine to people, people to people, physical things to social value, and the public and private sectors) [16]. This is for the development of the sustainable city and to provide smart services for the citizens. Therefore, we can consider hardware-driven, data- and knowledge-driven, software-driven, and network-driven smart cities.

6. Smart infra with data, services, and social sectors

In the smart city, there is the coexistence and organization of infrastructure, data, and services based on digital and smart tech. The Korea Transport Institute (KOTI) defines the smart city as consisting of infrastructure, data, and services. Infrastructure refers to physical and technical implications, including cities and ICT technologies. Data originates from all infrastructure and things in the city based on IoT technology. Services are developed for utilization by citizens based on the collected data.

According to the urban development stages, the digital city was based on data and network-related technologies and focused on the development of software applications. The ubiquitous city was based on mobile-based technologies and concentrated on the construction of the city infrastructure. As an advanced city model, the smart city is introduced, which is constructed from data, software applications, networking technologies, and citizens' services. It has been available for all of citizens using the developed digital technologies, hyperconnected network, and high-tech, including big data as citizens' data, cloud as the network, and AI for customized services, in the smart city. In addition, the smart city is a kind of holistic system with infrastructure, data, and services to efficiently integrate the city resources. It is constructed from smart infra, which is organized and controlled by smart operating, smart management, a smart trade system, and so on based on the collaboration and coordination of resources.

In the smart city, the data sector is related to collecting, storing, and analyzing data. From the big data collected by sensors, the smart city can construct the smart cloud as a network using the IoT. In the digital sector for the collection of data, there are sensors for the collection

of data, data storage, data platforms, and network devices. Data truly makes the smart city smart, and data visualization is needed to facilitate data access.

The service sector is related to solving citizens' problems and providing more convenience in citizens' lives. Factors related to the sustainability of the city include low-carbon systems, the reduction of pollution systems, and climate systems, and those related to improving citizens' convenience include street lighting, traffic congestion systems, welfare services, and so on. In addition, it is necessary to intertwine and integrate the individually developed services to provide services to citizens. The services are also specifically developed for the improvement and support of the citizens' community in the municipal government, advanced public sector provision, planning, permits, and operational entities. It is necessary to demonstrate the developed services and applications in the city. The city as a kind of platform contains good infra. Therefore, it is sometimes called smart infra for the integration and interoperation of urban sectors to build the smart city, such as the physical, public, private, business, economy, capital, social, environmental, and ecological sectors.

Ultimately, the smart infra pursues the creation and support of social sectors in urban areas with social goods, effects, and value in the fields of national health care, welfare, climate, low-carbon resources, economy, social community, funding for innovation, and so on. Social facts are closely related to the public sector, which is developed to solve urban problems. For the construction of the smart city, it is important to consider social facts to provide the society with social goods, effects, and value using innovative digital technologies. The use of digital and high technologies to generate positive social impacts as "social tech" has emerged in a number of fields, from the provision of health care to addressing financial exclusion. In the smart city, the purpose is the creation of social facts for citizens who need customized services. To achieve this, it is necessary to analyze big data and to customize services that can be implemented using AI.

Even if the social sector is related to the public sector to improve public services in the city, through the progress of the city and the development of innovative technologies, citizens' service needs have become very specified and customized. Therefore, public service support processes have also been individualized for the improvement of citizens' satisfaction and can be customized depending on an individual citizen's needs. To provide customized city services, it is necessary to dynamically interoperate social things under the collaboration and coordination of smart services. In addition, there are some significant sectors, such as the economy, capital, business, environmental, and sustainable sectors, for the ecological smart city. The business sector is related to financing and loan systems, the market and trade system, and so on. The environmental sector supports climate systems and the energy gird and so on. The sustainable sector is related to a low-carbon and green city. As an instance of the economy and capital sector, this is related to carbon capping and trading for dual benefits, such as the improvement of sustainability and enjoying the prosperity of the city.

7. The smart platform as a holistic ecosystem

In the smart city, there are many components of the physical and social sectors to be interconnected and integrated with interactions. To achieve this, there are two significant aspects. The

first is a test bed to implement the developed physical and high technologies. The other is for the completion of a holistic and ecological city using digital and social tech. To achieve this, it is necessary to have a test bed. It is called a variety of names, such as a Digital Living Laboratory [17], platform, big data hub, and ecosystem. This means that it is indispensable to pass through the test bed for the completion of the construction of the smart city as a kind of platform. In the platform, the components can be assembled and integrated as interoperable blocks to create social value for collaborative and coordinated services for citizens in the smart city.

It is important to serve and share optimized services with citizens. This is based on the optimization of the resources of the city and improvement of citizens' satisfaction. For instance, the energy grid system optimizes energy resources to improve citizens' satisfaction by trading energy among citizens. In smart trash can systems, cleaners collect the cans when the cans are full. This is also an instance of the optimized practical use of city resources. Using the collected data, it is possible to make a correct decision using the optimization systems. For instance, we can make a decision about how many trash cans are needed and collected in the city and how much idle energy exists and can be traded in the city. It is possible to rationally allocate the resources of the city as a kind of holistic system. Through this process, we can construct necessary optimized services to improve citizens' satisfaction for a sustainable, efficient, effective city.

To complete the holistic smart city, it is necessary to evolve thinking. When technologies are developed, it is necessary to employ system thinking to understand the new developed technologies and find application for the technologies. With ever-changing technological advances, thinking processes need to be evolved from system thinking based on technologies to digital thinking based on the design of services and the developed digital technologies. Digital thinking can positively determine applications using the developed digital technologies. This means that digital thinking can create new services. Finally, the created services using the developed technologies need to be integrated, collaborated, and coordinated to seamlessly provide services. This is called holistic thinking to optimize resources and reduce friction for citizens.

The smart city is a kind of ecosystem because it is not simply completed by only digital technology, smart components, and climate and environmental systems. It needs organic interaction among them and is based on the intertwined components. There are many connections, such as machine to machine, people to people, and people to machine. Thus, it is important to seamlessly operate the components and connections without disharmony.

The smart city is a kind of a platform to trade and share digital and smart technologies and a kind of ecosystem to provide holistic services.

8. Smart city global trends

Therefore, many countries around the world are promoting the smart city for various purposes. In this section, we will briefly look at the smart city trends in the US, EU, UK, Spain, Japan, China, and Korea.

8.1. The United States

In 2013, the US government implemented a project named "Smart America," which was boosted by the White House and confirmed that IoT technology could penetrate into society. Based on this, the White House has invested $1.6 billion into 25 kinds of new technology projects with the "smart city initiative" [18]. The White House is preparing for the future by organizing the skills needed for future cities. Local governments are also making efforts to build smart cities to help ease traffic jams and the fight against crime and for the stimulation of economic growth, response to climate change, and city administrative services.

In 2016, the US Department of Transportation (DOT) launched the smart city challenge. In March, seven finalists were announced, and Columbus, the state capital of Ohio, was chosen as the final winner in June. The smart city challenge was a pilot project to employ advanced technologies in mid-sized cities to create innovative solutions for future city transportation. Columbus received $40 million of funding from DOT along with $10 million of funding from Vulcan Inc. for electric car projects.

8.2. The European Union

In response to changes in economics and technology triggered by globalization, European cities have faced challenges based on the need to enhance competitiveness and transform into sustainable cities. In particular, small- and medium-sized cities, unlike big cities, are gradually approaching a crisis with less competitiveness [4]. Therefore, the EU has established the smart city strategy focusing on small- and medium-sized cities with more than 100,000 people [19]. The characteristics of a smart city in the EU include a smart economy, smart people, smart governance, smart mobility, smart environment, and smart living [20].

The elements that need to be wiped out in the smart city are congestion, air pollution, crime, and high-cost energy. On the other hand, the elements that need to be boosted in the smart city are energy efficiency, a clean environment, and convenient transportation.

8.3. The United Kingdom

The UK is one of leading countries for building smart and digital cities in the world. They are operating the "HyperCatCity project" in Milton Keynes, Manchester, and London. Milton Keynes as a municipal government is focusing on economic growth and building transformative, open, and accessible services with connectivity using sharable data [21].

Manchester is a large-scale smart city demonstrator that shows how IoT technologies and services can improve the quality and efficiency of services in transport, energy, health, and culture. Manchester is focusing on supporting an open platform and opportunities in four key areas. Using technology can enrich the local community activities for residents. Collaboration is essential for open innovation [22]. After adopting the smart traffic system application, there were reductions of 25% of traffic time, 50% of traffic accidents, and 10% of air pollution [23]. Additionally, London, a tech city, has funded the development of innovative digital technologies. For instance, smart city "hackathons" have been run many times and increased the overall level of participation between citizens and business to address city-specific challenges.

8.4. Spain

Barcelona's smart city was planned from 2011 to 2015 and was awarded the European Capital of Innovation 2014–2016 title. The model is focused on the alignment of resources and development of a sustainable city for citizens' welfare. For instance, about 30% energy savings are made per year through free Wi-Fi routed via street lighting systems [23] and smart parking spaces have been adopted [24].

As a smart city, Valencia is focused on smart, sustainable, and inclusive growth. Smart growth is based on the knowledge and innovation economy. Sustainable growth is focused on the effective use of resources. Inclusive growth is related to a high level of employment, delivering social and territorial cohesion. In Valencia, the smart city has been implemented based on e-government, smart economy, quality of life, sustainability, and mobility and infrastructure. There is a Valencia smart city platform for smart service management based on intelligent management systems [25].

8.5. Japan

Japan is promoting a "Strategy for becoming an environment and energy power through green innovation" as part of the "The new growth strategy (basic policies) toward a radiant Japan" since 2010 [26]. The Ministry of Economy, Trade and Industry (METI) and New Energy and Industrial Technology Development Organization (NEDO) have been jointly promoting a "Smart Community" strategy since 2010. According to NEDO [27], the Smart Community is "a mechanism to use energy intelligently by sharing data in both directions between the supply and demand sides of the system using ICT. This enables the optimal use of renewable energy such as solar power, wind power, and biomass while limiting the impact on the environment and increasing energy efficiency."

8.6. China

The smart city has become a new urban development trend in China since IBM introduced the concept of a "Smarter planet" in 2009. The Central People's Government of China has been directly managing and promoting China's smart city policy since 2013, which was promoted at the local government level. According to research by Li et al. [28], there were 193 approved smart city pilot projects in China by 2013. The Chinese government has regarded the smart city as a key strategy to promote industrialization, informatization, and urbanization. Therefore, the rapid development of the smart city in China is largely attributed to the cooperation between IT companies and the government.

According to news from SmartCityWorld based on an Arup study [29], China has been recognized as a significant driver of global smart city growth as some RMB500 billion ($75 billion) has been earmarked for the smart city in the country during the 13th Five-Year Plan period (2016–2020).

8.7. Korea

Korea recently launched its Presidential Committee on the fourth industrial revolution in September 2017, and this committee set up a special subcommittee on the smart city that aims

to promote the smart city as the innovation engine of the fourth industrial revolution at the national strategic level. The Korean government is accelerating the creation of the smart city, which is the product of the ICT convergence industry [30].

The development of Goyang smart city is based on an open innovation platform to solve pending urban problems using the developed converged and intertwined services employing the IoT. In addition, Goyang smart city is building a citizen-based local community in the municipal government as a demonstration of IoT-based services. Goyang applied high-tech to a smart park service for a street lighting system, a smart welfare service for a children's day-care center, a smart climate-monitoring center, and a smart ecological service by monitoring biomass [31]. In June 2017, Goyang city built a smart garbage collection system based on the IoT along the city streets and in the residential areas. Specifically, the system consists of a load detection sensor, a solar compression garbage can, a garbage collection tracker, and a garbage collection system. The data measured in the smart trash can are transmitted to the Goyang City Demonstration Center server and the environment-friendly smartphone so that the garbage-loading information can be checked in real time. The smart parking enforcement system can perform monitoring and decision-making regarding if something is legal or illegal using the IoT sensors that are attached to garbage collection can in Goyang [32].

Busan smart city is focused on the collection of data as big data that are interconnected with networking. Busan smart city has been developed as a platform for machine-to-machine and city-to-city connections. Busan is focused on the development of urban services, such as safety, transportation, energy, converged services, and local community services, and the demonstration of big data-based services [32].

9. Conclusion

Many cities and countries are interested in building smart cities and have started to construct them. The smart city is an ecological system including many components, such as high-tech and digital sector-based and social and community-based components, and city sustainability related to environments and ecosystems, economy and business, and government. The smart city is a kind of platform to connect physical, social, governmental, public, business, and environmental systems as components of the city. The development of the smart city is closely coupled with newly developed technologies, such as the IoT, big data, cloud, and AI. In the smart city, there are interoperable services and social value for the citizens. Manwaring [33], cofounder of the IoT Living Lab in Amsterdam, mentioned that "We need to empower communities to solve their own problems, provide them with tools to accelerate social impact and make their lives better. Smart People make Smart Cities and technology is useless if it doesn't engage the public." The smart city built with IoT should ultimately serve as a people-centered and equitable space that increases people's quality of life [34].

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