Chapter 1 Introduction

Today, 55% of the world's population lives in urban areas, and this share is expected to grow to 68% by 2050. Most of the world's economic activity, energy consumption and greenhouse gas emissions are carried out in cities. Therefore, in order to significantly reduce greenhouse gas emissions, it is necessary to streamline activities in urban areas and reduce energy consumption. "Smart cities" play a vital role in achieving these goals. Smart cities cover all urban activities, but are particularly concentrated in development in areas such as energy, mobility, environment, resource recycling, and living. In these fields, activities can be visualized based on ICT, AI, Big Data analysis, Digital twin, etc., and at the same time, digital transformation can be promoted to improve the efficiency of urban activities dramatically.

In particular, this handbook covers efforts in the field of mobility are important elements for realizing smart cities. People's movements are essential for all activities in the city, and newer transportation systems are needed to achieve efficient urban activities. Transportation of goods is also a basic function of urban activities. Realizing an efficient logistics system is one of the efforts in the transportation field. In the field of mobility, many efforts are already underway that are expected to lead to the realization of smart cities. The most obvious example is MaaS, or Mobility as a Service, which is an organic combination of various transportation services. By combining information from multiple transportation services and visualizing services through big data analysis, we can promote the multimodal and further digital transformation to significantly transform the service itself and make it energy efficient transportation system.

What kind of concept is a smart city?

A smart city was defined by the Ministry of Land, Infrastructure, Transport and Tourism in Japan as "sustainable cities or districts where overall optimization is achieved for various problems faced by cities, management (planning, maintenance, management, operation) is carried out while utilizing new technologies such as ICT".

By gathering various residents and companies in the city, economic activity becomes active, and an attractive space is formed, but on the other hand, It causes many urban problems such as the occurrence of traffic congestion, deterioration of public security, environmental pollution, waste generation, increase in energy consumption, etc. In smart cities, by utilizing ICT, the activities of each inhabitant and the activities of each company / organization

are aligned, creating and nurturing effective and efficient industries, using energy, maintaining public order, children and the elderly. We will be able to watch over people activities, eliminate traffic congestion, and take measures against natural disasters.

What is the difference from the conventional city planning?

Conventional city planning has been centered on making hardware such as designation of land use, installation of roads and lifelines, construction of buildings, etc. For this reason, it was difficult for urban functions to change significantly in response to a change in society. Thus, the residents and businesses living there have to be working in accordance with the city. In the future, as society changes drastically due to many technological innovations, such inflexible cities cannot accept this change.

On the other hand, in smart cities, we will change the city functions according to various social conditions that change with the times and the values and needs of society, and perform optimal city management. ICT is the basis of a system that flexibly responds to a change in a society.

Recently, there are signs of change in the concentration of population in large cities, such as the spread of telework triggered by the corona disaster. Smart cities that utilize ICT can change urban functions flexibly responding to such rapid social changes.

Smart city from the perspective of transportation system

As mentioned above, the realization of smart cities will be achieved through efforts in many fields related to urban activities, but especially achivements in the transportation field is an important key to the realization of smart cities.

This is because the movement of people and goods is indispensable for urban activities, and unless transportation is made smarter, the overall urban activities will not be made smarter. Many technological innovations have been made to improve the sophistication of transportation systems by utilizing information and communication technology. These technological innovations will be incorporated into the realization of smart cities.

1: What is smart transportation?

The transportation system in the city is not limited to automobiles and vehicles and roads and railroads, but is a system that includes overall movement including control and operation management of these.

Therefore, the traffic system consists of elements such as traffic condition monitoring, traffic information collection, traffic condition analysis, traffic information provision to drivers, traffic control, and public transportation operation management, all of which must be connected by utilizing ICT so that the transportation system becomes smarter.

2: Efforts to make transportation smarter

Since the 1970s, when the increase in automobile traffic caused the problem of traffic congestion in cities, mechanisms have been introduced in many cities to monitor traffic conditions, provide traffic information, and provide appropriate traffic control. Until now, ultrasonic and loop coil vehicle detectors have been installed in various parts of the city to monitor traffic conditions and control signals, which have been put into practical use in many cities. SCAT, SCOOT, MODERATE, etc. are widely introduced in cities around the world as typical signal control methods.

Recently, these systems themselves are also becoming smarter by utilizing ITC. Infrared detectors and image detectors and mobile communications such as Bluetooth and WiFi with GPS are being used to monitor traffic conditions. In addition to utirize detected traffic infomation to control traffic signals, the method of providing it to the driver as traffic information has become widespread. Today, many cars are equipped with car navigation systems, and it is common to provide guidance on the optimal route based on traffic information.

With the spread of digital maps, such information provision has become more sophisticated, and route searches and the like are generally performed on mobile terminals and the like based on traffic conditions. Such route search using mobile terminals is becoming widely used when using public transportation such as taxis, buses, and trains other than private cars. The location information of taxis, buses, and trains is also being used for operation management, which is important for achieving efficient operation and redusing traffic congestion. Furthermore, even in emergency vehicles and freight transport vehicles, these traffic information are utilized and used for optimal route selection, etc., contributing to the realization of efficient transportation.

3: ITS development

Many technologies have been developed that enable safer and more efficient road transportation systems by using such ITCs for information collection and operation of transportation systems. That is the intelligent Transportation system or ITS. It is expected that the use of ICT will reduce external diseconomies such as automobile congestion, air pollution, and traffic accidents, and some applications have begun.

ITS targets mainly traffic on roads, including pedestrians, which is not sufficient from the perspective of making the city smarter.

4: Expectations for CASE

Currently, it is said that automobile society is entering a period of change once every 100 years. The four keywords that symbolize this are connectivity (C), autonomous driving (A), sharing economy (S), and electric vehicle (E). Connectivity means that all vehicles are connected to the Internet, information is exchanged as a whole, and each vehicle can be controlled as a system. Underlying this technology is the development of ICT and IoT technologies. Autonomous driving is the control of vehicles by machines, and this technology is also supported by sensing technology and control technology. The sharing economy, as typified by car sharing, is the idea of sharing with society without owning a vehicle. For the operation of car sharing, technology using conventional ICT such as vehicle management and reservation system is indispensable. An electric vehicle is a vehicle that is driven by a motor rather than an engine. Naturally, it will greatly contribute to the reduction of greenhouse gases, but the electrification of vehicles will make it easier to connect to Internet pictures and control by ITC. The technology developed as the above-mentioned ITS is an elemental technology that supports this CASE. The lean and energy-efficient automotive society brought about by these CASEs is essential to the realization of smart cities.

5: Promotion of multimodal by MaaS

At the same time as automobiles, other transportation modes will also be connected to the Internet, so the entire transportation system can be operated and used as a single system, and the selection of transportation modes becomes more efficient. MaaS makes it possible to use all of these transportation modes as a single transportation system using ICT. It is expected that MaaS will enable users to select the most suitable combination of transportation modes according to the situation and pay as a single system, and will reduce unnecessary travel and realize more efficient transportation. This really means realizing multimodal using ICT.

In order to realize MaaS, in addition to general traffic information, big data analysis that centrally collects and analyzes all traffic information such as operation information such as public transportation and information provision that enables multimodal selection Various technologies that have been utilized are required. Technology development in this area is exactly one of the main themes of this handbook.

Achievement of SDGs Targets by Smart City

Sustainable Development Goals (SDGs) are set forth in the 2030 Agenda for Sustainable Development, which was unanimously adopted by member countries at the UN Summit in September 2015, until 2030. It is an international goal to aim for a sustainable and better world. It consists of 17 goals and 169 targets for achieving socio-economic and environmental ambitions. Multiple goals below are involved in better cities, transportation, water and sewage, realization of energy systems, and solving global warming problems.

Goal 6: Ensure availability and sustainable management of water and sanitation for all

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Figure 1-1 The four aspects of the Sustainable Development Goal [1]

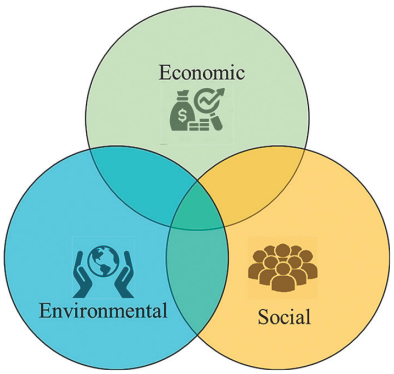
Goal 12: Ensure sustainable consumption and production patterns

Goal 13: Take urgent action to combat climate change and its impacts

The original purpose of SDG is to create an inclusive, safe, resilient, sustainable city where people can live properly, and to create prosperity and social welfare without harming the environment (Figure 1-1) [1]. Goal 11 directly contributes to the promotion of the smart city targeted by this book and is designed to address the challenges of most cities.

To enjoy a convenient modern life in cities with reduced impact on the environment, products and services should be delivered considering multitude of perspectives. In particular, policies and plans should target a balance between economic growth, social equity and environmental preservation within a city over the long term in connection to the Triple Bottom Line (Figure 1-2) [1]. Accordingly, the governing agencies require a strategy that covers the design, implementation, evaluation and enhancement of urban systems. In this connection, Information and Communication Technologies (ICT) represent a great opportunity to rethink a new urban configuration [2] through eliminating redundancy in urban operations and services, and integrating urban domains, facilities and networks [3].

Figure 1-2 The Triple Bottom Line [1]



The success of achieving SDG depends especially on the local government. They should look to transportation, city planning, mitigating and reducing disaster risk, and protecting the environment to configure urban measures by the next 15 years.

1: Sustainable smart city

While the cities around the world are trying to achieve the smart city tag, those especially of developed countries are aiming to obtain the tag without prioritizing sustainability aspect [4]. Conversely, smart city should produce sustainable and livable places for all instead of overemphasizing providing sophisticated digital technology services to the citizens [5]. Such lack of integration of environmental, economic and social aspects in achieving a smart city lead to the term “Smart Sustainable City” to strengthen this linkage.
Not surprisingly, cities of developed countries have been more successful in becoming smart than those of emerging economies. In this connection, the there are no sophisticated tools that bring all types of cities in all kinds of contexts into a comparable framework.
In fact, a mechanism to evaluate in terms of their contribution to sustainability is still very scarce.

Given the scale, complexity and mutuality of sustainability challenges, cities need integrated strategies to deliver sustainable, effective services and engage citizens to make better choices in their daily lives.
To achieve this, suitable platforms are necessitated to gather and assimilate huge data from multiple sources; this would allow a real-time access of the demand and availability of services, both for governing agencies and citizens.

2: Inclusivity

In developing countries, the population growth rates are high where local agencies lack enough resources to handle the integration of these new settlers who are especially near poor and marginalized [6]. Most often, the slums represent a territorial exclusion due to the lack of equipped spaces. Social sustainability is achievable only when there is suitable environment for human interaction, communication and access to facilities [7]. Appropriate use of ICT can enhance interaction with citizens, increase public service efficiency and thus facilitate transparent governance [8]. In fact, involving the people in decision-making is one of the desirable features of a sustainable society. Digital participation enables residents to comment and enquire proposals within administration and politics.
In addition, it also gives the citizens an opportunity to make their own suggestions and enable t making efficient plans and strategic goals that incorporate citizen experience. Accordingly, the products and services should balance the technical advancement of infrastructure with social engagement and empowerment.

3: Urban safety

Urban safety encompasses activities such as managing traffic, quick response to emergencies or having safe infrastructure, and protection from crime. The smart technologies accessible to law enforcement are also advancing in various fronts [5]. Digitalization is revolutionizing policing and assisting authorities do more with data gathered.
Many cities around the world now have command centers that have provision real-time information assimilation and sharing across agencies.

Traffic accidents can be significantly reduced using smart technologies. Video surveillance technologies are also coming up with accident detections and predictions thus enabling the riders to avoid accidents. Improving infrastructure for pedestrian and cyclist can promote greener commute along with safety [4]. Improving traffic flow with intelligent signals can reduce risky driving at intersections. Advancement in technology of autonomous vehicles can also decrease traffic accidents.

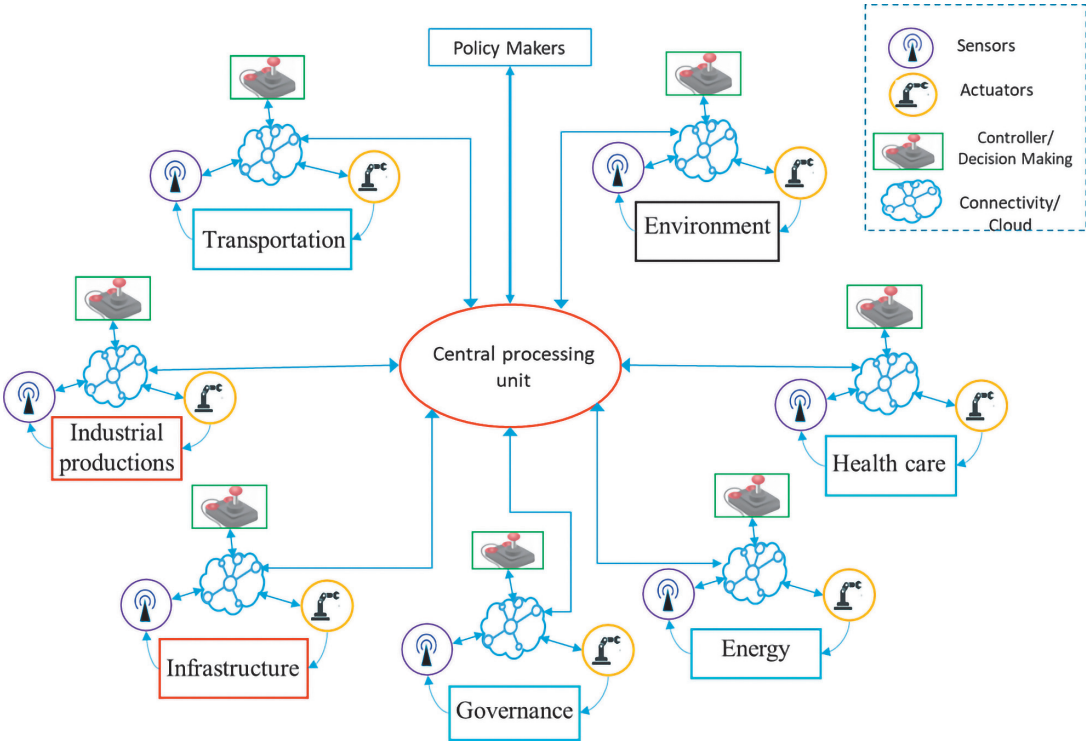
The health of buildings and bridges can be continuously monitored with sensors. Similarly, the covers of man holes when interfaced with sensors can avoid accidents during rainy seasons. Encrypting, stamping, and safeguarding footage taken from body-worn cameras in a certified cloud environment could protect it from being altered or hacked.

4: Environmental sustainability

ICT can bring down GHG emissions, lower water consumption and reduce the volume of solid waste in cities. GHG emissions come from three major sources in cities: transportation, buildings and waste. In general, the most effective ways that smart city technologies can help decrease emissions involve reducing electricity usage and thus generators.

Several measures developed to improve urban transportation have secondary effects on reducing the vehicular emissions. Those with the potentially significant effect involve reducing private vehicle usage and shifting to a greener mode of transport. This can be achieved by using advanced digital technology

Figure 1-3 Smart cities through cyber-physical systems



to provide better services in public transportation. Intelligent traffic lights, which are designed to smooth the flow of traffic, have the additional benefit of minimizing the time that vehicles spend idling.

Cities can use technology in using water efficiently. Water wastage can be restricted by keeping a limit of usage-per-household. This approach could be made more effective if digital tools are used in making the consumption more transparent. Water consumption tracking, which uses advanced metering combined with feedback messages to the consumer, can increase awareness and nudge people toward responsible consumption. In fact water leakages can also be avoided by deploying appropriate sensors. Smart irrigation technology can tune the water use in public spaces by considering weather, soil conditions, and sunlight patterns.

Similarly, some cities have reduced the volume of solid waste by implementing effective recycling programs based on the said ICT technology. For instance, charging households according the weight and type of the waste disposal enables better waste management. In addition, illegal dumping should also be monitored. More importantly, using ICT, one can create more awareness about appropriate waste disposal by displaying on billboards.

5: Urban resilience

UN-Habitat defines resilience as "the ability to resist, absorb and accommodate to the effects of a hazard, in a timely and efficient manner" [9]. Thus, cities with resilience can withstand, adapt, and recover in a from any kind of challenges they face, either planned or unplanned. The agencies anticipate hazards and adopt strategies unemployment The cities can adopt ICT to handle shocks such as natural disasters and terrorist attacks. For instance, sensors deployed around cities can be used to maintain detect the said calamities and develop warning and management systems. Cybersecurity is also another vital aspect underpinning resilience, due to the increasing digitalization of critical infrastructures. Cities that effectively use new technologies, and successfully imbed them into urban planning and design will be more resilient to future challenges.

In summary, to make the cities smart and sustainable, sensors should be deployed in all necessary domains (physical systems). Next data should be collected and analyzed. Subsequently, agencies to intervene and improve the physical systems. Generally, the physical systems together with said components are together are considered as cyber-physical systems (CPS). Smart city can infact be visualized as multi-level CPS (Figure 1-3).

What are challenges in this Handbook?

As mentioned above, promoting multimodal using ICT is a very important initiative for realizing smart

cities. Efficient movement not only achieves efficient use of limited urban space, but also minimizes the energy required for movement in cities and significantly reduces greenhouse gases and roadside air pollutants emitted. In addition, the spread of EVs, which is expected in the future, will further promote the computerization of automobiles, so it is expected that the efficiency of movement will be further improved by connecting to the Internet.

However, since many of these technologies such as ICT, digitization, AI, big data analysis and Digital ware currently being developed individually, even if these technologies evolve, an efficient transportation system will not be realized. Therefore, the next challenge is how to combine these technologies to build a more efficient transportation system. And how to connect this to the realization of smart cities.

The M2Smart project is a research project under SATREPS, which was launched in collaboration with Indian Institute of Technology Hyderabad, Nagoya Electric, and Nihon University with such an awareness of the problem.
The purpose of this handbook is to realize a multi-modal transportation system, promote smart cities by it, and further greenhouse effect by sharing the results of research members discussing and developing technology in the M2Smart project widely with society. It is to contribute to the reduction of gas.

In the handbook, Part 1 will first present the basic concept of smart cities, the realization of multimodal transportation systems that support smart cities, and the effects of reducing greenhouse gas emissions in the situation in India. Next, in Part 2, we will introduce various technologies that are the basis for realizing a multi-modal transportation system that will lead to the realization of smart cities. Many of the technologies and their applications introduced here are the technologies and application methods developed by the M2Smart project, but at the same time, we will also introduce general technology development trends.

At the end of this handbook, we will introduce our efforts with the test bed installed on the campus of Indian Institute of Technology Hyderabad. The purpose of this testbed is to operate the technology developed in the project in a space that imitates the real space and verify the technology. It is dangerous to put new technology directly into the traffic that is moving violently every day. The approach of verification using such a test bed is very effective, and we will introduce its contents.

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