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Redefining the Smart City for Sustainable Development

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Breakthroughs in Smart Cities

Fifty years ago, Jane Jacobs placed economic growth in cities at the center of national economic growth. She explained: "If my observation and reasoning are correct . . . rural economies, including agricultural work, are directly built upon city economies and city works."[1] She spearheaded urban development as a self-standing discipline for academics and policymakers.

By 2030, 60 percent of the world's population is projected to live in urban areas, double the share in 1950. Urbanization is fastest in developing countries in Africa and Asia.[2] With more than 80 percent of global GDP generated in cities, a well-managed urbanization is central to sustainable growth. Urbanization can lead to increased productivity, innovation, and the emergence of new ideas,[3] but it can also lead to slums and deteriorating security. Historically, the influx of population into urban areas has also caused environmental problems such as traffic congestion and air pollution.

Managing urbanization in a way that contributes to sustainable growth has given rise to the concept of "smart cities," an effort to comprehensively plan and control city development using science and technology. Starting around 2000, smart cities spread rapidly across the world, largely as demonstration test sites for

1. Jacobs, pp. 3–4.
2. UN-DESA.
3. See World Bank website "Urban Development," www.worldbank.org/en/topic/urbandevelopment/overview.

new technologies. Like any experimental movement, smart cities had failures as well as successes, and have evolved away from their technological origins. Today, smart cities are conceived of as "data-driven societies" that collect and analyze information via networked complex elemental technologies to solve social issues. In other words, the modern smart city model stores large amounts of data collected by sensors and cameras in a data center via a high-speed broadband communication network and examines ways to solve problems in human life through analysis by artificial intelligence (AI).

Currently, few smart cities have deep insights into the issues to be solved, public opinion regarding those issues, or the technological means of implementing solutions. Yet they are expanding fast. The global smart city market was valued at US$83.9 billion in 2019 and is expected to grow by almost 25 percent between 2020 and 2027.[4] By that time, the market size created from the relationship between cities and ICT will reach 600 billion U.S. dollars.

This chapter describes the breakthrough in smart city development that is now on the horizon. It is a breakthrough that can be implemented in developing countries as well as in advanced economies. It can help solve many of the pressing issues of the day. One study suggests that 70 percent of the Sustainable Development Goals (SDGs) can be achieved simply by converting to smart cities using technologies that exist today, but with new applications and processes. The breakthrough can be brought about by combining visionary technology with good governance and citizen-level collaboration.[5]

At the outset, it is worth emphasizing that the socioeconomic problems smart cities set out to solve will surely change over time. A clear example is the change in mindset occasioned by the global COVID-19 pandemic. With an estimated 90 percent of all reported COVID-19 cases, urban areas have become the epicenter of the pandemic. In the near term, for many cities, the COVID-19 health crisis has triggered multiple secondary urban crises: in access, equity, finance, safety, joblessness, public services, infrastructure, and transport, all of which disproportionally affect the most vulnerable in society.[6] Cities may have created economic growth through agglomeration, but it is now clear they also created vulnerability to the new enemy of invisible infectious diseases. Regardless of the country or region, none of the existing smart cities, which were proof-of-concept experimental sites for advanced technology, have demonstrated the "smartness" that could suppress COVID-19.

COVID-19 has highlighted the need to redefine smart cities to include the

4. Grand View Research.
5. Diamandis and Kotler, pp. 3–12.
6. United Nations.

concept of resilience. Cities must actively reduce downside risks and truly solve social issues rather than remain as demonstration test sites for new technologies that can accelerate economic growth. They must become genuinely sustainable, human-centered, transformable, and tolerant.

It is useful to compare smart cities to a smartphone. A smart city needs an "urban OS" upon which various stakeholders, including citizens, can flexibly develop and implement applications that contribute to problem-solving, with opt-in and opt-out features. What COVID-19 has illustrated is that excellence in technology and vision of the urban OS is not enough. It must also be flexible enough to address unknown issues of vulnerability that may arise in the future.

Smart Cities before COVID-19

The Evolution of the Concept of the Smart City

What is a smart city? There are no straightforward answers. "Smart" is a generic word that can mean many things. Similarly to other general terms, such as "sustainability" and "globalization," "smart" is now commonly used in the global development discourse but without precise meaning or definition.[7] It was not until the 2000s that the term "smart city" became popular, and since then it has been used in a variety of ways. In the most common early usage, "smart cities" referred to places that conserved resources, especially energy, and that put in place more efficient transport systems. They did this by using cutting-edge information and communication technologies (ICT); environmental technologies; smart grids and storage batteries that enable efficient use of renewable energy; extensive electrification of transportation systems, including electric automobile charging systems; and by promoting energy-saving home appliances and building codes and standards. Most early smart cities targeted energy and environmental issues, but few found a way to monetize the benefits. As a result, the number of smart city demonstration projects increased around the world, but without a sustainable financial model.

In the 2010s, smart cities began attracting attention again not only for environmental and energy benefits but also for the potential of autonomous driving and industrial technology represented by robots. Against the backdrop of the spread of high-speed internet, cloud computing, and the Internet of Things (IoT), there was renewed interest in data-based solutions to social issues. According to a McKinsey report, smart city solutions such as air quality monitoring; energy use optimization; and electricity, water, and waste tracking could produce

7. Townsend.

results such as 10 to 15 percent fewer GHG emissions, 30 to 130 fewer kilograms of solid waste per person per year, and 25 to 80 liters of water saved per person per day.[8]

In its new formulation, a "smart city system" can be described as a model that embodies a data-driven society with structural features embedded in four layers. The first layer is "perceptual," consisting of sensors, smartphones, cameras, and signal lamps that collect data. The second layer is the "network," which consists of the internet, IoT, and mobile communications network technologies that facilitate the real-time transfer and storage of information. The third layer, the "platform," continuously analyzes data using cloud computing. The fourth layer is the "action"—the decisions and management responses taken by policymakers and city managers.[9]

Examples of the World's Smart Cities

Smart cities are everywhere. Notable cases include Masdar City, the United Arab Emirates (UAE), a planned new city where almost all electricity can be supplied by renewable energy with zero carbon dioxide emissions; Amsterdam, the Netherlands, where smart meters will improve energy efficiency; Barcelona, Spain, which has an ecological approach that actively incorporates citizen participation; and Copenhagen, Denmark, where compact, highly convenient, and energy-efficient "human-centered smart cities" are being designed. In addition, countries such as Finland, which has a concept called "Aurora AI" with electronic administration that makes heavy use of AI, and Estonia, which advocates for a "Data Once Policy" and the digitization of administrative procedures across the country, are working on new solutions.

In China, there are more than a hundred smart cities of various sizes and forms, rooted in the Made in China 2025 national strategy. Xiong'an allows only self-driving cars on its streets. Shenzhen is now called the most innovative city globally.

Smart cities in South Korea and Taiwan have taken advantage of the fact that these countries have the highest ICT infrastructure development rate and high digital literacy. In both countries, digitization and technological innovation is advancing rapidly in public and private sectors. Singapore has already incorporated modern ICT into its city management practices.

Even in Southeast Asia, smart cities' efforts are being strategically promoted throughout the region. The ASEAN Smart City Network (ASCN) is a smart

8. McKinsey Global Institute.
9. Wu and others.

city promotion platform that was proposed at the ASEAN Summit Meeting in April 2018. It is a regional framework, through which twenty-six major cities nominated by ASEAN member countries will select priority social projects, formulate action plans, and check the projects' progress at regular ASCN meetings.[10] Among these twenty-six cities, the Bang Sue smart city in Bangkok is an advanced example in Asia of a master plan that calls for the city to deploy a fifth-generation mobile communication system (5G) and abundant sensors within the city, and analyze the collected data by making full use of AI.[11]

Within Africa, too, smart city plans are underway. They include Kigali Innovation City (Rwanda), Konza City (Kenya), Eko Atlantic City (Nigeria), the Village of ICT and Biotechnology (Côte d'Ivoire), and Hope City (Ghana). Kigali Innovation City (KIC) announced its plan at the World Economic Forum in Africa conference held in Kigali in 2016, and will cover residences, offices, universities, research institutes, and factories on a site of over sixty hectares. The total cost is over US$400 million for this flagship project aimed at environmental conservation and resource efficiency through big data management and full use of renewable energy and ICT.[12]

These examples all highlight the popularity of smart cities in Asia, Africa, and Europe, and point to the potential for rapid uptake of new models of smart city management as global experience accumulates.

The Impact of COVID-19 on Smart Cities

COVID-19 showed that although cities have an advantage of creating value through agglomeration, they also have a weakness of more rapid contact-based transmission, given high population densities. As a result of COVID-19, large--scale urban lockdowns have been happening around the world. These were adopted as a precautionary measure to slow the spread of infection worldwide, but at significant economic cost of lower output and reduced employment.

COVID-19 underlined the potential and the limitations of new technology in smart cities. In some cities in China, Taiwan, Singapore, and South Korea, contact tracing applications on mobile phones linked to citywide ICT recognition systems proved effective. The best-known and extensively applied example is China's "Health Code." However, in many other instances, including in Japan and the United States, democratic values of data privacy meant that tracing apps could not be widely implemented. Even in Barcelona, Spain, regarded by many

10. ASCN.
11. JICA and others.
12. Rwanda Development Board.

as one of the most advanced smart cities, the spread of COVID-19 had not been halted as of January 2021, and citizens are being encouraged to use old technology means of social distancing and handwashing.[13] Most smart cities have not functioned smartly against infectious diseases.

COVID-19 has also reduced budgetary allocations for smart city development. Public funds have been reallocated to public health; private foreign investment has collapsed. Thus, smart city plans in many developing countries have been delayed. In Indonesia, the plan to relocate the capital by 2024 from Jakarta to an environmentally friendly, data-driven, smart city on Kalimantan Island has been put on hold, despite its prominence as a central policy of President Joko Widodo's second term. Egypt had also planned to open a new administrative capital about fifty kilometers east of Cairo by the end of 2020, but this has been delayed to 2021. In Saudi Arabia, the plans for construction of the futuristic city "NEOM" on the Red Sea coast, in which the country had planned to invest US$500 billion—more than 70 percent of GDP—are being reviewed, as a result of the stagnation of global crude oil demand.[14] Even in Thailand, the installation of network equipment to introduce 5G into several smart cities, including Bang Sue, which began in the first half of 2020, has been delayed due to the economic slowdown caused by the pandemic.[15]

These postponements and revisions are largely due to the difficulty in raising funds for smart city projects, given economic stagnation or recession accompanying COVID-19. However, funding is not the only issue. The pandemic has also raised questions about how future smart city plans will ensure resistance to various VUCA (volatility, uncertainty, complexity, ambiguity) that can occur in the future. Policymakers everywhere are being forced to rethink their strategies as they become aware of this new challenge.

COVID-19 may yet prove to be a long-term boon for smart cities. It has created a "new normal" for remote work, distance education, and telemedicine, and underlined the necessity of adopting digital technologies as rapidly as possible.

The implications of the impact of a transition to digital life on city infrastructure and buildings is still unclear. Demand for office space could decline. Urban segregation and even out-migration could occur as people at higher income levels look for new ways of living and working outside the city in response to the pandemic. Some analysts worry about an increase in urban sprawl and inequalities across income, race, and gender.[16]

13. Info Barcelona.
14. *Nikkei Newspaper* (2020a).
15. Quoted in Leesa-Nguansuk.
16. United Nations.

However, the majority opinion is that a world where VUCA is expected to increase will be a world where smart cities will become more important. Smart city plans simply have to evolve to allow people to conduct their daily social and economic lives while managing whatever uncertainties the future may bring, be it serious infectious diseases such as COVID-19 or something else.

Infectious Disease Management in China: New Value of Smart Cities

Before the COVID-19 pandemic, EMS (energy management system) and MaaS (mobility as a service) were central to the idea of smart cities. These systems and services showcased how a data-driven society could employ high-speed internet and cloud computing, sensor technology, and smartphones to collect a large amount of citywide data. AI, equipped with algorithms in ultra-high-speed computers on the cloud, could then be used to analyze big data through machine learning to solve pressing social issues. Proponents argued that the model would create new business opportunities, attract investments, generate employment, and create a broader ecosystem of stakeholders that would increase the value of the city.

In the new vision of the future, it has become a requirement for smart cities to go beyond considerations of energy and mobility, to visualize and manage "invisible enemies" using digital technology. From this point of view, China's approach to infectious disease management offers one model for using digital technology. The "Health Code" is a database of citizens' behavior and health status collected through various channels and stored on a data platform specifically constructed by the Chinese government as part of their national strategy. By collating data with national ID numbers, China is able to see how its broad societal rules and norms are reflected in the behavior of individuals.

China locked down several cities in response to the COVID-19 pandemic and has succeeded in suppressing the spread of infection since the middle of 2020. Part of the strategy was to publicly monitor people's movements and economic activities according to the Health Code. The Health Code is a dynamic code for mobile phone apps and consists of three colors: green, red, and yellow. It is automatically checked and generated by the municipal system using information received from users' self-reports and from disease management big data. The green Health Code acts as a digital pass that allows people to travel to places where others congregate, such as public transport, communities, offices, supermarkets, and pharmacies. When a user contacts an infected person, the Health Code may turn red or yellow, and the user can be notified to quarantine immediately. The Health Code is not easy to forge, and the application screen must be presented whenever entering or using public places or transport systems.

The benefit is that it is possible to create a "safe zone" that gathers only those who have proved, by showing the green color on their screens, that they are very unlikely to be infected. These people can then continue to carry out the same social and economic activities as before.[17] The disadvantage, of course, is that citizens who are indicated as being in the yellow or red risk categories are subject to significant restrictions, leading to inconvenience and discrimination.

CCTV cameras also provide data input into the Health Code. These cameras, which have been placed in many cities in China for crime prevention, are networked by high-speed communication. They can collect personal data and collate it with other data sources by using biometric authentication technology. In addition to the heat-sensing function (thermography) on the camera side, China has introduced a technology that detects and instantly identifies individuals with a fever. In addition to the fixed CCTV cameras, drones are used to fly over an urban area and similarly detect feverish citizens. Drones are also used for unmanned spraying of disinfectants in urban areas.

The Health Code relies on noncontact detection and collating of data through new technologies, including face recognition, that are being enthusiastically supported by the Chinese government. The high-tech companies SenseTime and Megby, known for their face recognition technology, have developed and deployed noncontact temperature measuring software using AI. SenseTime is also developing and deploying a "smart AI epidemic prevention solution." It combines AI algorithms and infrared thermal technology to detect heat with an error of fewer than 0.3 degrees and can identify unmasked people with over 99 percent accuracy. Based on its experience with the Health Code, China is now aiming to standardize the concept and method of monitoring cities to prevent infectious diseases, by proposing it to technical committees in international standards bodies such as the International Standardization Organization (ISO) and the International Electrotechnical Commission (IEC). Since the related agreements of the World Trade Organization (WTO) require member countries to create domestic standards based on international standards, if ISO, IEC, and others accept China's proposals, it is more likely that future smart city development in the world will adopt the Chinese method as a standard technology for pandemic surveillance.[18] With other countries scaling back their smart city investments, China's determination to press ahead with using digital technologies for pandemic management could strengthen its competitive advantages in this sector.

17. Quoted in Xiheng.
18. *Nikkei Newspaper* (2020b).

A Human-Centered Smart City to Enhance Sustainability

The limited take-up of the Chinese-style Health Code shows it cannot be a model for smart city development in the rest of the world. We argue that the following three conditions must be met to advance a human-centered, sustainable smart city:

1. Criteria and commitment to introduce critical technologies in the public and private sectors
2. Construction and operation of a robust digital infrastructure through a public-private partnership
3. Consideration for privacy protection and seamless data sharing between the public and private sectors

The first condition requires a commitment to the use of critical technology. If technology adoption remains only a recommendation, subject to individual choice, it may not be effective unless a minimum threshold number of installations are secured. It is due to this democratic dilemma that tracking apps similar to Health Code are not widespread in Japan or the United States.

The second and third conditions call for stronger public-private cooperation. For example, democratic nations typically oppose the seamless sharing of data between the public and private sectors. In South Korea, nevertheless, there is a growing willingness to restrict personal rights and to share the whereabouts and behavior history of COVID-19-infected persons, once these are confirmed to have contracted the disease through a positive PCR test. Similarly, in Japan, the "Amendment of the Act on Prevention of Infectious Diseases and Medical Care for Patients with Infectious Diseases" and the "Act on Special Measures for Countermeasures against New Infectious Diseases" were approved by the Cabinet on January 22, 2021. The Japan Federation of Bar Associations is strongly opposed, noting that legal possibilities contained in the new acts, to impose penalties for noncompliance, display a lack of consideration for fundamental human rights.[19]

This is not the first time that conflict has arisen between surveillance-based solutions that make full use of digital technology and forcible sharing of personal information without obtaining sufficient agreement from citizens. In a data-driven society, accelerating personal data visualization and strengthening social monitoring and management are inseparable from protecting personal information.

19. Japan Federation of Bar Association.

Consider the example of Google's affiliate Sidewalk Labs (SWL) project in Toronto, Canada. In 2017, a public corporation, Waterfront Toronto, initiated a redevelopment project for the waterfront area. SWL won the tender and, in the spring of 2019, it put forward a Master Innovation and Development Plan (MIDP). Its vision for the redevelopment project, called "Sidewalk Toronto," was expected to utilize the latest sustainable technologies such as modular wooden construction, automatic garbage collection, and data utilization in each field. It was billed as one of the world's most advanced data-driven city projects.[20] The plan attracted worldwide attention, with considerable speculation as to how Google's various data-driven social problem-solving applications could be advanced in Sidewalk Toronto. However, a group of activists criticized SWL's failure to prioritize consensus-building with the public, leading a representative of the Waterfront Toronto Digital Strategy Advisory Board (DSAP) to criticize the project for too much "technology for technology," and the project was finally canceled in May 2020.[21]

There may have been other reasons for the cancellation, including the response to COVID-19, but the example shows the importance of considering the relationship between humans and technology in smart city planning. If new technologies are introduced and promoted without obtaining citizens' buy-in and agreement, the project may fail. Conversely, if citizens agree in advance to share their data and adopt the necessary technology, a smart city can provide public goods, including controlling the spread of infectious diseases, by actively developing and operating digital infrastructure.

The breakthrough in smart cities will come about by improving the architecture of the model. Returning to the original four-layer construct of the ideal smart city, laid out at the beginning of this chapter, the "network layer" and "platform layer" should be developed as public goods and operated as effectively as possible rather than as a single vendor's monopoly infrastructure. The dialogue and consensus-building with citizens should be encouraged at the level of the "perceptual layer," of what kinds of data to collect and the "action layer" of the type of decisions that policymakers are empowered to take. In the presence of VUCA, the "perceptual layer" needs to be able to evolve flexibly according to the times, and the "action layer" must become human-centered.

Architectures that realize "human-centered decisionmaking" in this way have already been tried in Barcelona, Spain, and Aizuwakamatsu, Japan. For example, in common with many other cities in Japan, Aizuwakamatsu City, Fukushima Prefecture, is suffering from a decrease in the youth population and

20. Sidewalk Toronto.
21. CURBED.

from negative population growth due to a decline in the birth rate. To overcome this urban structural issue, Aizuwakamatsu City launched a smart city plan in 2012 to make the entire city smarter.[22] The architecture design incorporates the idea of FIWARE, the next-generation internet infrastructure software developed and proven in the European Union (EU). FIWARE has adopted an open international standard API called NGSI (Next Generation Service Interfaces). There are two features: (1) linkage and use of data beyond the local system, and (2) exclusion of vendor lock-in, which consists of a group of software components called Generic Enabler (GE). The data infrastructure is an open API with high interoperability, and partnerships among industry, government, and academia are building a "human-centered architecture" that can be used for solving social issues and urban development, with the option of an opt-in method. The overall architecture is collectively referred to as the "urban Operating System" (OS).[23] Demonstration projects utilizing open APIs with high interoperability are being carried out one after another, and citizen services such as regional digital currencies and remote medical care systems have begun to be implemented. It is hard to say whether the architecture has been useful in addressing an unknown shock, like COVID-19, but there is a sense that smart cities with urban OS and open APIs, with opt-in efforts to encourage citizens' prior consent and partnerships with diverse stakeholders, will create more resilient and sustainable urban agglomerations over the medium-to-long term.

The Long Journey to a Smart City Breakthrough

Historically, public health concerns have been a significant turning point in urban policy. The plague, which was intermittently prevalent from the sixth to the eighteenth centuries, disrupted the feudal social villa system and induced growth of commerce and industry centered on urban areas. In late-nineteenth-century Paris and London, which saw massive inflows of a large working population during the Industrial Revolution, cholera spread in unsanitary and inadequate living environments because urban infrastructure development did not keep up. Ultimately, this became an opportunity for roads and water and sewage systems to be improved. The 1918 influenza pandemic (1918–20), a global pandemic that infected more than 500 million people and killed 20 to 50 million people, was the catalyst for the introduction of social distancing as one of the urban policies as a public health measure.

Given these precedents, the impact of COVID-19 is also likely to change

22. Ebihara and Nakamura.
23. Ministry of Internal Affairs and Communications.

urban policy significantly. Historians may view the year 2021 as the year when cities began to flexibly upgrade to VUCA using digital technology and human intelligence; that is, the year when breakthroughs in smart cities started to be achieved.

As Larasati points out, the development of smart cities does not rely solely on strengthening technology-driven automated procedures, but is a sophisticated model of negotiating process redesign, political and stakeholder support, and organizational and institutional changes.[24] Therefore, in any new smart city plan, it is essential to build on values and philosophies that match a region's actual conditions.

The world is learning from COVID-19 that expectations for smart cities must be raised to embrace inclusion and resilience. Smart cities are no longer limited to demonstration test sites for specific new technologies such as EMS and MaaS. Cities can have truly smart functional devices that guide people's lives in a genuinely sustainable direction. The new smart city is not just a showcase of new technology; it is a genuinely human-centered, transformable, tolerant, and resilient place to live, work, and play.

Both China's case and the case of Toronto ignored the consent of citizens in favor of the primacy of technology. The results differed; China has been successful in slowing the spread of the pandemic, but at a potential cost of discrimination and exclusion that cannot be assessed because of the absence of dialogue. The project in Toronto was canceled. By contrast, the urban OS and open API that enable citizen participation in Aizuwakamatsu City is a significant feature that gives citizens the right to opt-in; the architecture prioritizes the active will and choice of human beings over technology itself.

To create a genuinely human-centered, transformable, and resilient smart city, it is necessary to develop and strengthen the "network layer" and "platform layer" as public goods in cooperation with the public and private sectors.

The "network layer" requires a high speed, low latency, high security, large capacity communication infrastructure.[25] However, high speed communication infrastructure is often categorized as a private good, and pricing to recoup the considerable initial investment and maintenance costs can reduce citizens' access. One technology that alleviates this concern is Network Functions Virtualization (NFV). The advantages of NFV are that vendor lock-in can be avoided, investment and maintenance can be significantly reduced, and various functions can be added or changed simply by adding software. This innovative technology has been developed in India and can fundamentally change the conventional concept of communication infrastructure development, even in developing countries.

24. Larasati and others.
25. Oxford Business Group.

The "platform layer" needs to have an open API as its urban OS and to encourage a broad range of stakeholder participation, as in Aizuwakamatsu City. In addition, blockchain technology can be adopted to manage personal information while ensuring transparency and preventing falsification.

A bold metaphor for these concepts may make it easier to understand. President Zelensky of Ukraine has said, "We really want to create a country in a smartphone"—this is the idea that should be applied to future smart cities.[26] The smart city's urban OS is like Apple's iOS. The OS can be updated flexibly, various developers can create applications, and the collected data from users can be efficiently utilized. Organized like this, smart cities can provide a breakthrough in the achievement of SDG 11, "Sustainable Cities," as well as contributing to many other SDGs. Joia and Kuhl argue that smart city development in developing countries can only be considered successful if it can integrate the basic needs of all and actively contributes to several SDGs.[27] Tan and others point out that technology-enabled smart cities in developing countries can only be realized if socioeconomic, human, legal, and regulatory reforms are initiated simultaneously.

In this chapter, we have argued that to redefine smart cities in the future, it is essential to deepen the understanding of and attention to data governance and the necessary technical conditions. The international community has begun to foster dialogue through platforms such as the G20 and the World Economic Forum, based on the SDGs' perspective of "no one left behind." In 2020, the World Economic Forum selected thirty-six cities across twenty-two countries and six continents to pioneer a new global policy roadmap for smart cities. This Global Smart Cities Alliance, hosted at the forum, commits participating cities to adopt privacy protection policies, better broadband coverage, accountability for cybersecurity, increased city-data openness, and better accessibility to digital city services for disabled and elderly people.[28] There will surely be setbacks along the way, but a path toward smart cities is being created.

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