A DIGITAL TWIN-ENABLED SYSTEM FOR SMART CITY

Abstract

Many nations and governments view smart cities as a solution to resource depletion, population growth, and global warming. The process of building a smart city is fraught with difficulties. Digital twins hold great promise for the conversion of the current urban governance paradigm toward smart cities, along with the Internet of Things, fifth-generation wireless systems, smart contracts, collaborative computing, simulation, and artificial intelligence technologies. The idea of a digital twin city (DTC) is put forth in this essay. A DTC's characteristics, core technologies, and use cases are de- scribed in detail. Additionally, we go over the theories, future directions for research, and framework for DTCs.

Keywords: digital twin city, smart cities, directions, research, and framework

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I. INTRODUCTION

The term ”digital twin” refers to a digital representation of a physical system or object. A distinct physical object, procedure, group, individual, or other abstrac- tion might have its own digital twin, which is an implementation of a software object or model that is encased within the software itself. It is possible to compile a comprehensive picture of a number of real-world things, such as a city or a power plant, and the processes that are associated with them by combining the data from several different digital twins.

A digital twin is a virtual or digital reproduction (copy) of real-world objects, people, systems, processes, devices, and locations. Vehicles, aircraft engines, and even people are all examples of objects that may potentially be duplicated with the use of digital twin technology.

When a car manufacturer creates a digital representation or copy of one of their vehicle models, we refer that digital copy as the ”digital twin” of the actual vehicle. In the same vein, the virtual production process that a manufacturing company would create will be a digital twin of the real production process.

A current and historical electronic profile of a procedure or physical object status is another way to think of a digital twin. This profile is stored in digital form. This virtual representation gives the dynamics and components that make up the living and working environment of an Internet of Things device.

The capability of the digital twin to provide the current location, state, and/or status of a physical assets is made possible by continuous learning and updates. Because the actual world and the digital world are brought together in this way, businesses are able to monitor their systems, formulate plans, and foresee potential issues before they arise.
The technology known as digital twining is used to create digital twins. Soft- ware capabilities, artificial intelligence, this same Internet - Of - things (IoT), and different network graphs are all components that are included into this technology, which can imitate physical assets or processes (physical twins).

The concept of the digital twin has been receiving an increasing amount of attention and popularity in both research and application. Both the amount of aca- demic papers published on digital twins and the range of real-world applications of these models have seen significant increases over the course of the past three years. This chapter presents a classification scheme for Digital Twin applications for the purpose of assisting researchers and practitioners in better comprehending, describing, and developing Digital Twin applications. The chapter offers a current summary of Digital Twin applications based on the numerous new findings that have been uncovered. Gartner has included digital twins on its list of the ”Top 10 Strategic Technology Trends” for each of the years 2017, 2018, and 2019 (Burke et al., 2019), and Market Research Future projects that the digital twin market will be worth 35 billion USD by the year 2025 (Enders & Hoßbach, 2019). Digital Twins are, to put it succinctly, digital analogues of real-world objects. According to (Grieves & Vickers, 2017), there is a possibility of a relationship between the product and its twin. This connection enables a reflection of the physical prod- uct’s current status in its corresponding digital representation (Hu et al., 2018). It is possible, for instance, to predict future behavior (Sivalingam, Sepulveda,

Spring, & Davies, 2018), run simulations (Ayani, Ganebäck, & Ng, 2018), and control the product (Dröder, Bobka, Germann, Gabriel, & Dietrich, 2018) based on the current and historical data of the Digital Twin (Sivalingam et al., 2018). This opens up prospects for new types of business models (Klostermeier, Haag, & Benlian, 2019), services (?, ?), and intelligent product designs (Abramovici, Göbel, & Savarino, 2017).

Researchers make contributions to the field by providing conceptual methods, such as Digital Twin implementation frameworks (Biermann et al., 2018; Zheng et al., 2018), as well as by conducting research on Digital Twin use cases (Dröder et al., 2018; Kurniadi, Lee, & Ryu, 2018; Sivalingam et al., 2018). At the moment, there is not a great deal of accumulated study in the canon of work pertaining to digital twins. In addition, the manufacturing sector or the aerospace industry is given a significant amount of attention in the reviews of the current literature. Ta- ble ?? summarizes the fundamental knowledge about digital twins in the scientific literature.

Efforts to make cities smarter have been started in cities as a direct response to significant concerns urbanization and increasing greenhouse gas emissions, for example (Pierce & Andersson, 2017).Due to the fact that buildings account for the majority of the total energy consumption in urban areas, they have become the main focus of smart city initiatives as well as the high potential that they have for energy conservation as a result of retrofits or operational improvements (Baxter et al. 2011). Actuality promise at the intersection of energy-efficient buildings and smart cities is intelligent planning. (Hastak and Koo 2016). A recent effort has been made to develop a digital representation of city infrastructure connected to live city data. The goal of this endeavor is to create smart city digital twins, through graphic designing and communication with city data, which are intended to enhance city supervision, control, and decision-making (Mohammadi and Tay- lor 2017). Given the increasing provision of building performance information at urban scales, the objective of smart city digital twins would be to encapsulate and incorporate urban complexity across time and space (BuildSmart DC 2017), Ur- ban energy management and constructing portfolio performance assessment could both benefit from the use of smart city digital twins as a platform (i.e., digital twin– enabled energy management).

II. PILLARS OF A SMART CITY

Last year, the Ministry of Urban Development (MoUD)1 created a ”Draft Con- cept Note on Smart City Scheme” to address the need for expanding urban space. Smart Cities, as defined by the document, are those with sophisticated institu- tional, social, physical, and economic infrastructure. A common person’s options for pursuing their livelihood and interests should increase as a result of the creation of such a smart city as shown in Figure 1. Considering this:

- Competitiveness includes ability of a city to generate employment oppor- tunities, draw in investments, and draw in residents is referred to as com- petitiveness. Its competitiveness is based on how simple it is to conduct business there and how high of a standard of living it provides.

- Sustainability includes a commitment to social, environmental, and finan- cial sustainability.

- Quality of Life includes possibilities for involvement in governance, op- portunities for convenience in discovering and obtaining public services, safety, inclusivity, entertainment, accessibility to elevated healthcare, and safety and security.

- As shown in Figure 2 there are four types of infrastructure that make up a ”smart city”: social, physical, institutional (including governance), and economic. Each of these pillars revolves around the citizen as its focal point. In other words, a Smart City works to secure the highest for all its citizens, regardless of status, maturity level, income level, race and sex, etc.

- Social Infrastructure Connect with those who support the development of social and human capital, such as the systems that support healthcare, entertainment, education, and other sectors.

- Physical Infrastructure refers to the city’s physical infrastructure, which includes the waste management program, drainage system, energy system, water supply system, sanitation facilities, urban mobility system, housing stock, and water supply system, all of which are technologically connected. This includes the stock of the city’s buildings. 1https://www.esri.in/ /media/esri-india/files/pdfs/news/arcindianews/Vol9/smart-cities- envisioned-by-MoUD.pdf

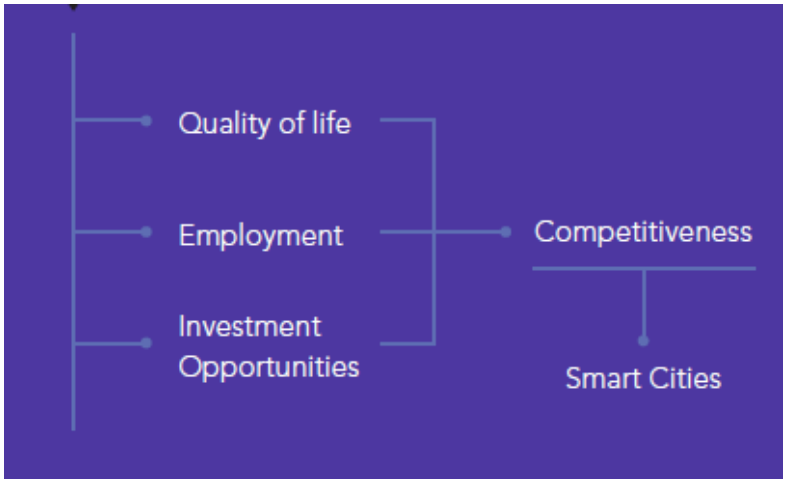

Figure 1: Environment & Social Sustainability

- Institutional Infrastructure refers to the actions that are carried out in con- nection with the planning and management structures present in a city. It is essential for Smart Cities to have exemplary governance with a significant local influence on decision-making. The maxim that should be followed in the majority of circumstances is ”Governance by Incentives rather than Governance by Enforcement.”

- Economic Infrastructure A smart city must first identify its core compe- tencies, comparative advantages, and prospects for trying to generate eco- nomic activities in order to attract investments and build the necessary in- frastructure and economy for employment opportunities. Only then will it be able to successfully compete for investments and create an environ- ment that is conducive to the creation of

employment opportunities. Af- ter that has been accomplished, it will be possible to identify the gaps in the necessary economic infrastructure. Business incubators, skill develop- ment hubs, industrial parks, export processing, information technology (IT) as well as biotechnology (BT) parks, commercial centres, service stations, specialized financial institutions and services, logistic support hubs, stor- age of goods and freight connectors, as well as mentorship and counseling services, would all fall under this category.

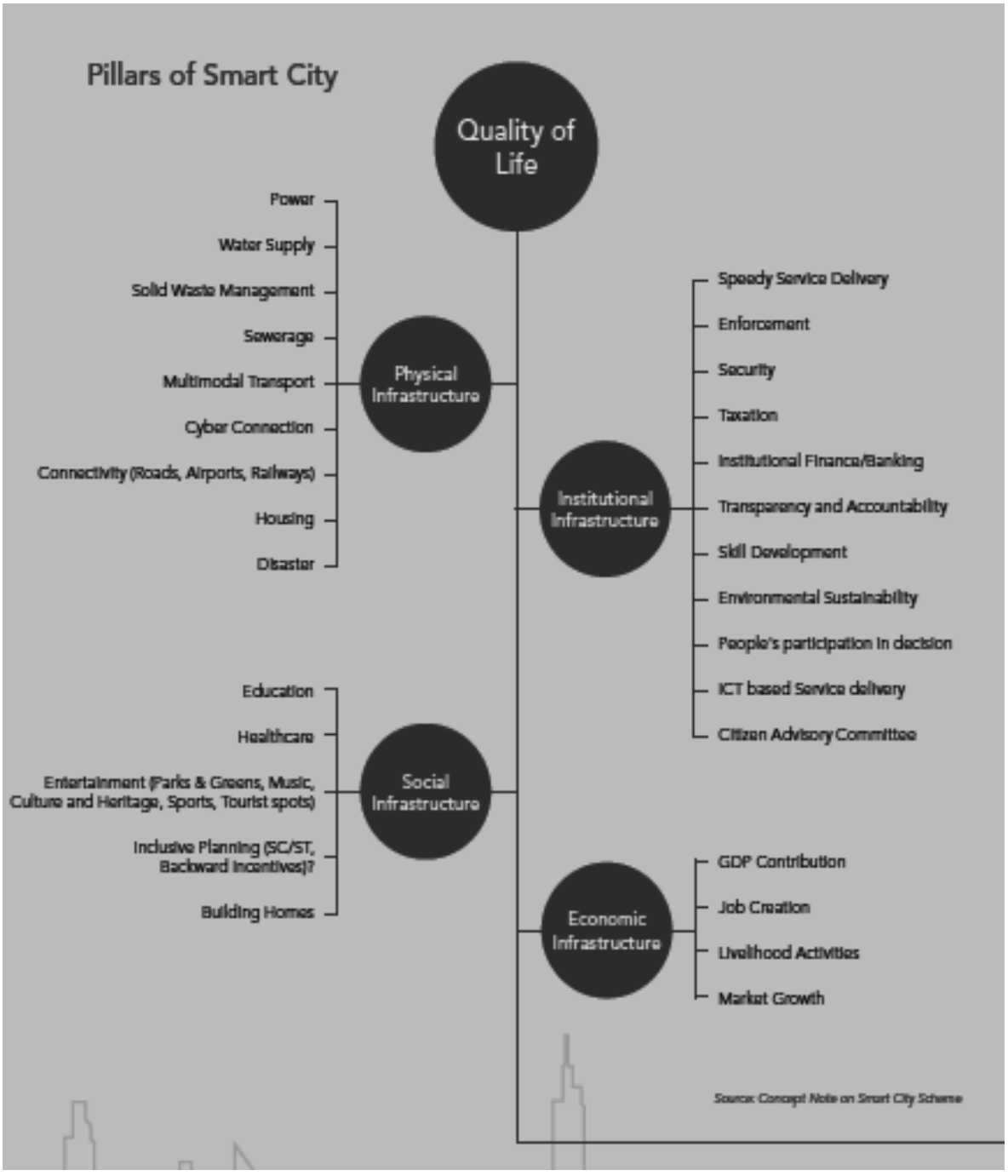

Figure 2: Pillars of Smart City

III. WHY ARE CITIES BECOMING SMART?

It has been determined that a number of different factors are acting as major motivating forces behind transition toward the smart cities. The alterations that are taking place on a global scale in the natural environment and the alterations that are taking place in the lifestyles of individuals are considered to be the two primary drivers behind this transformation. As of right now, an international consensus is forming on the topic of the establishment of a society that emits low levels of car- bon, and at the same time, the world is dealing with issues such as the depletion of resources and disparities among supply and demand as a direct result of the quick- ening pace of economic development. Cities all over the world are confronted with the task of attempting to address the emerging urban problems that are ex- pected to arise as a result of the anticipated huge influx of people. Alterations to people's ways of life are also happening at a rapid pace, in addition to the global environmental shifts described above. People now are placing a higher value on non-monetary terms as a result of the shift in consumption away from products and toward services. This can be seen as an increasing importance of intangibles, which can be seen as an increasing importance of intangibles. In a similar vein, the changes in demographics are contributing to an increase in the variety of new opportunities made attainable by the advancements in technology for information and communication.

Furthermore the major shifts that have been observed in today's urban society, one additional trend that is currently being observed is an increase in the involve- ment of the information technology sector in the activities associated with urban development. The urban environment is responsible for the production of a enor- mous amount of data every day, and the goal of the information technology sector is to improve the effectiveness of urban life by collecting and analyzing this data in order to achieve this goal. At the same time, a greater emphasis is placed on fusing the data related to the demand side and the supply side of urban infrastruc- ture throughout order to improve the effectiveness of infrastructure operations and achieve optimization.

In spite of all of the evidence presented above, a number of academics believe that the primary inspiration for smart cities is the aspiration of cities to realize economic development (Harrison & Donnelly, 2011). When it comes to achieving economic development, there is a lot of competition not only between the cities that are nearby but also in the context of the rest of the world. The cities are working hard to achieve perfection in the areas of investments and jobs, and they are also working difficult to attract the knowledge economy, which is the younger generation. These cities believe that the younger generation is the generation that will lead to the development of economic power. For this reason, it is believed that in order for cities to attract and keep members of the creative class — the new production, who are extremely mobile — it is necessary for cities to become heavily reliant on digital technology and to be smart in a number of different ways.

IV. FEATURES OF SMART CITIES

There is a lot of hype about making municipalities and cities "smarter" in town halls, corporate boardrooms, and the media in the midst of massive urban growth around the world. Despite this, it is difficult to define what a "smart city" is.2.
With technology as the main focus, many conversations about smart cities give a sense of complexity. Despite being the most crucial element in the creation of smart cities, technology

is not a goal in and of itself. Making the lives of both city residents and entrepreneurs better is the aim of trying to implement cutting-edge innovations and measuring organizational and operations on gathered information to build a ”smart city.”

In point of fact, the idea behind smart cities is quite straightforward and so- phisticated. In order to coordinate all of the necessary services, a smart city will use an integrated approach. In order to deliver city services which are more effi- cient, creative, fair and equitable, linked, safe, and durable as well as exciting, it updates the physical, digital, and social infrastructure. The transition to smarter towns and communities cannot be more urgent in an era where it is predicted that two-thirds of a worldwide people will move to urban centers within the space of just one generation.

In today’s world, urban areas are home to more over half of the total popula- tion. 80 percent of a global production as well as 70 percent of it’s own carbon emissions are generated in cities. Urban areas will confront greater difficulties in all facets of their operations if nothing is done, given the expected growth path for urban environments, including social inequalities, congested roads, pollution, and resource constraints. But if nothing is done, these difficulties may be somewhat lessened.
The mayors of cities all over the world are coming to the realization that in- corporating intelligent-integration of technology into planning and sustainable de- velopment strategies will make life better, entice investment, and promote urban
2https://www.smartcitiesdive.com/news/5-focal-points-needed-to-develop-a-smart-city/580023/ growth.

The idea of a ”smart city” can be conceived in many different ways, but any successful initiative will focus on the following five basic areas in a comprehen- sive and integrated way: the support infrastructure, city and leadership structures, sustainable service delivery, technological and innovative advancements, and so- cial infrastructure within the community.

- Smart development requires grid modernization. The expansion of con- nectivity will get a kickstart from the modernization of ”the grid,” which serves as the backbone networks of any smart community. The upgrading of the grid begins with the electrical system and is followed by the instal- lation of more advanced telecommunications, mobility systems, and intelli- gent buildings as essential foundations for the entire city. The grid will be- come the central nervous system that supports the internet of things (IoT), artificial intelligence (AI), electric vehicles (EVs), and other technologies in the future.

- All of these components can serve as hosts for sensor technologies, which will make it possible to collect data that can be used to support city or community-wide planning, management, and operations. Additionally, as the infrastructure is developed or deployed, protection and data strategies can be incorporated.

- A city or community that prioritizes the modernization of its grid, advanced telecommunications, and advanced transportation systems will have access to financing models that are both well-known and well-proven, which will allow it to make progress with its attempts. Other elements of a smart city plan will call for

creative problem-solving and collaboration between orga- nizations that have traditionally operated on their own.

- Leadership, policy, and regulation are drivers of investment and growth. To create a city that is truly ”smart,” it is necessary to have leadership that is bold and courageous, policies that look into the future, and regulatory frameworks that are flexible. Government representatives, lawmakers, as well as city and local organizers, need to develop a new paradigm in order to boost the size of the areas to meet the needs of the future in a manner that is safe, equitable, and cost-effective.

- Some of the bigger problems at the moment include a lack of centralised decision, difficulties obtaining sufficient funding, and divergent regulatory authority handling issues that need to be handled in a unified manner.

- Infrastructure integration must take into account institutional structures that control how the infrastructure is built, funded, and managed in addition to the innovations that are used to build it physically. It is the responsibility of city and community leaders, regulators, and planners to design initiatives that inspire companies of all sizes to put money in the adoption and imple- mentation of cutting-edge technologies while upholding residents' trust and ensuring their safety.

- Green services Improve life, reduce financial, health, and safety risks. According to the findings of research, there is a direct connection between a city's environmental performance and its level of prosperity. Local gov- ernments have a responsibility to implement strategies that promote sus- tainability and, in certain regions, strategies that make better to a changing climate.

- This requires a drive toward a growth of cities that are cleaner, nutritious, and more economically viable. Efficiency gains, investments in renewable technologies by funds, and financial regulation that fits each of these can all help achieve this. Additionally necessary is a greening of urban transporta- tion, property use, and development policies. In the event that this transition is not successful, the risks to our finances, the health of the public, and our safety will increase. Because the Innovation center partnerships ensure best technologies and practices.d angers of cyber intrusion are going to be mag- nified even though digital infrastructure continues to grow, another area that needs to receive attention is digital security and safety.

- Innovation center partnerships ensure best technologies and practices. The idea of ”interconnectedness” encompasses a much broader scope than just apps and sensors. Utilized effectively, technology has the potential to assist cities in enhancing the enjoyment of everything that communities cherish, including parks, neighborhoods, public areas, and business oppor- tunities.

- Utilizing cutting-edge innovations does not necessarily imply that every- thing being produced is brand new. The integration of existing systems and the improvement of those systems through the use of data that has already been gathered for other purposes is one way that advanced analytics can help increase efficiency and reduce costs associated with the delivery of services. This results in significant benefits for

both the city's residents and the city itself, which frequently must work within strict financial constraints.

- Smart community leadership can take advantage of connections to inno- vators who are working to solve problems that cities and towns are cur- rently facing as well as those that will arise in the future. These innovators include technologists, administration labs, academic institutions, and non- profit groups (NGOs). These organizations are already serving as proving grounds for new technologies, practices, cities are organized with a primary emphasis on the people who live there. The standard of living in cities ought to be the primary focus of smart city and initiatives if those initiatives are to be successful. Whether the digital and physical infrastructure that already exists is modernized or expanded, or a brand-new city is constructed where none previously existed with the intention of serving as a home, a place of employment, and a recreational area for the people who live there.

- Building widespread support from the community for just any smart cities or towns program is a challenging process that requires extensive outreach to and cooperation with society anchor institutions in addition to the individ- ual stake - holders. Only when the members of a smart community actively engage with and utilize the available resources and services can that com- munity be said to be successful.

- Cities and communities must "up their game" with greater urgency and focus in order to catch pace with the incredible rate at which modern tech is replac- ing social infrastructure. Given the scope of the necessary digital, physical, and social modernization as well as the exceptional rate at which modern tech is replacing existing social infrastructure. Comparatively speaking to how quickly urban migration is occurring, the large bulk are far behind. And most of them are lagging behind in terms of creating governmental frame- works that can deal with the industrialization of urban infrastructure inside a thorough and integrated way as well as creating the financial systems to pay for it all.

- Important projects need to go through a rigorous public selection process so as to be imagined and chosen. Establishing public-private partnerships and various other sources of funding is an urgent necessity. Establishing safeguards for personal information, data sharing, and other fundamentals of a functional social infrastructure must take place early on in the process. In addition, the planning structure needs to be adaptable in order to account for the high likelihood of sudden shifts in any and all aspects of the endeavor as well as the rapid pace of technological advancement and ideas, which can then be disseminated for the advantage of everyone, community leaders, companies, and residents.

- Social infrastructure is essential. Cities are organized with a primary em- phasis on the people who live there. The standard of living in cities ought to be primary focus of smart city and initiatives if those initiatives are to be successful. The goal of the city remains the same whether existing physical and digital infrastructure is updated or upgraded or whether a new city is constructed where none previously existed is to serve as a dwelling, a place of employment, and a recreational area for the people who live there.

- A complicated process, any networks in real or communities program that aims to build broad community support must engage community anchor in- stitutions and work closely with them as well as other stakeholders. Only when its members are actively interacting with the available resources and services and utilizing them will a smart community be able to thrive.

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V. CHALLENGES EVERY SMART CITY FACES

Using data analysis and information and communications technology (ICT), as well as other forms of cutting-edge technology, smart cities are tasked with the re- sponsibility of maximizing operational efficiencies across a wide range of sectors, including government, trucking, commerce, energy, and healthcare. It is unavoid- able for there to be problems in smart cities given the scale of the operations that they perform due to their complexity3.

1. **Inadequate smart city infrastructure:** The support of both physical and information technology infrastructure4 is required for smart city initiatives. It is necessary to implement intelligent technologies in as many different fields as is humanly possible, including public transportation, energy pro- duction, and power generation. If that isn’t the case, then these technologies won’t be able to ”smarten” a city to the extent that they could.

   The term ”physical infrastructure” can refer to a variety of different things, including poles, cameras, and terminals that are used by the general public. In a similar vein, the infrastructure of information technology needs to be efficient and efficient in order to process and analyze the data collected from the aforementioned industries.

   Both the physical and digital infrastructures of a smart city need to be able to scale in order to catch pace with the ever-increasing volume of data and population that smart

cities generate. Additionally, the infrastructure should be adaptable and able to work with a wide variety of software and techno- logical platforms.

The technologies underlying intelligent initiatives and those initiatives themselves need to be able to be maintained for the long term. Changing facil- ities every few years in order to accommodate emerging technologies and expanding demands is not going to be a practical solution.

The price as well as ends up costing of smart city projects may increase as a result of the construction of a reliable and efficient infrastructure. As a result, a lack of funding could also become an issue for initiatives related to smart cities.

2. **Data privacy, transparency:** Data collection and analysis from a wide va- riety of sources are essential to the functioning of smart cities. The problem is that unless appropriate precautions are taken, a significant portion of that information can compromise individuals' privacy. You have to inquire as to the location of the information's storage. What kinds of safety precautions have been taken, and what kinds of precautions still need to be taken, so that this information is not misused or given out to the general public?

   To better provide medical care, for instance, it is necessary to record and store patients' personal information as well as their medical histories. The application of facial recognition technology can be helpful in tracking down individuals and assisting law enforcement, particularly in nations where the rule of law is not as strong as it should be.

   Residents and citizens of smart cities get the right to be educated about how their information is being used. Additionally, they have the right to the pri- vacy of their data. Thankfully, there are already efforts being made by some countries to address these problems.

   For instance, the European Union (EU) passed the General Data Protection Regulation (GDPR), which governs the use of facial recognition software. In a similar vein, the state of California has enacted the California Consumer Privacy Act, which restricts the ways in which the data of consumers can be used by parties other than the consumers themselves.

   Fear of hacker attacks, information leakage, scrutiny of data gathering by the private and government entities, insufficient transparency, and a lack of pub- lic confidence can significantly impede the progress of smart city projects and initiatives.

3. **Public-private coordination:** The public sector as well as the private sec- tor are both used to gather data. Figuring out which pieces of information should be kept private and which ones should be shared can be a difficult task. The sharing of data is absolutely necessary in order to ensure the proper functioning of various operational processes, services, and data checks. On the other hand, maintaining an efficient flow of data between the public sec- tor and the private sector can be challenging.

   To start, the pair don't always see eye to eye. There is reluctance between the private sector and the public sector when it comes to sharing infrastructure and

standardising networks and tools. There is a propensity to place one's own interests ahead of those of the community as a whole.

Finding ways to persuade each sector that they will benefit from collabo- ration instead of keeping definite information to themselves is the best ap- proach to achieving data sharing. This should be your primary focus when looking for ways to achieve data sharing. After all, smart cities are depen- dent on strong partnerships and coordination between the public and private sectors in order to develop programmes that are both effective and sustain- able.

4. **Unable to implement smart city projects:** It is one thing to have the desire to incorporate smart city initiatives, but it is an entirely different thing to actually have the capacity to do so. Problems with capacity can be caused by any combination of the following factors: energy, financial resources, the capacity of the data processing system, and its efficiency.

- **Financial:-** The upkeep of smart cities necessitates a significant amount of resources. To be more specific, they call for the installation, oper- ation, and upkeep of intelligent technologies; the provision of physi- cal and information technology (IT) infrastructure for the above said technologies; the provision of labour from trained professionals who possess experience and expertise; and, of course, the provision of a spending plan to cover the costs associated with the aforementioned necessities.

  Not every city has the resources to implement smart city programmes. It is a difficult undertaking to locate several partners and a supply of both public and private finance. Authorities and city planners must demonstrate to prospective investors and stakeholders that the advan- tages of a smart city initiative—both short- and long-term—far surpass the high costs associated with them.

- **Data processing efficiency:-** Smart cities require a reliable and effec- tive method to process and analyse enormous amounts of data in ad- dition to financial resources. These will originate from a variety of devices, including cameras and other real-time information-measuring sensors.

  A city would require the information, for instance, to identify and keep track of high-traffic locations for peak traffic hours, transporta- tion flow, modifications in traffic routes, etc. There will be hundreds, even thousands, of sensors encircling a city's extensive transportation system. For just traffic and transportation, that's a significant amount of information.

  A smart city offers a huge variety of operations and services. These will all need their sensors, systems, data collection, processing, and analysis.

- **Energy:-** A smart city will use more technology than just sensors and cameras. Power5 is required for smart technology to work. It's crucial to take into account issues like:

- Can all of these be supported by the city's power supply?
- Exist any backup energy sources that could power these gadgets in the event of a power outage?
- Will solar, wind, or hydropower be used to power the smart city?
- Or will all of it be powered by diesel generators?
- Which systems and technologies can function without alternate energy sources, and which ones are most likely to employ them?

5. **Politics and lack of will:** It might be challenging to find money for smart city initiatives. These projects and programmes frequently depend on po- litical will. Politicians may have contrasting views on smart city efforts. If they choose to provide their own money for these projects, it can run out before the end of its term in office.

   Smart cities require support from numerous local, state, and federal part- ners as well as commercial organisations, in addition to money from the government. When you take the mechanics of the many political players into account, this gets tricky.

   For instance, at the conclusion of each electoral cycle, political capital may lapse in the heart of smart city programmes. Smart city programmes come under scrutiny during the transition to the new group of government lead- ers. This additional testing may cause operations to be delayed or even end completely for some projects.

   Political figures, governmental organisations, interested parties, private or- ganisations, and urban planners must work together. To develop long-term initiatives that can be sustained across different administrations, they must collaborate. 5https://social-innovation.hitachi/en-sg/

6. **Smart city residents think short-term:** It takes a lot of time, money, and resources to complete projects including building support infrastructure, raising money, collaborating with public and commercial organisations, and installing and keeping smart city technologies. These alone, though, won't be sufficient to support smart city ambitions.

   The demands of perhaps the most crucial sector—the citizens of smart cities—must be taken into account by those leading projects in this area. When public funds is being used to finance the smart city initiative, few people are prepared to wait very long to see results. Additionally, the preparations, installation, and upkeep of the aforementioned projects could disrupt the life of the locals. For instance, constructing infrastructure can create congestion, and any sys- tem changes or installations might impede the delivery of public services and business by the government. These interruptions have the potential to irritate residents and discourage them from supporting smart city initiatives.

   Planners must consider and execute strategies in stages while creating smart city projects. This is completed in order to satisfy stakeholders and residents while still achieving short- and long-term goals.

7. **Missing smart city info:** The administration must make an attempt to in- form locals about smart city programmes when they are implemented. Good initiatives are useless if the individuals who stand to gain most from them are unaware of them, after all.

   It's not necessary to achieve this only through physical advertisements, bul- letins, and gatherings in person. Social media and the internet as a whole should be used by the government to inform its residents and those who stand to gain from new and ongoing efforts.

   People need to be fully aware of these initiatives' specifics and how they can benefit from them. Additionally, information on these can be made public by urban planners and officials prior to their release. The residents of the city should be able to easily and quickly access information on new, existing, and prospective smart city initiatives.

   Once more, social networks and the web can be used to evaluate how initia- tives are performing and identify any changes or enhancements that might be necessary. They are also able to learn more about what the general public thinks about potential future projects.

8. **Residents' lack of tech skills:** Next up for smart urban planners is deter- mining the general level of technical proficiency among residents. Do they have the skills necessary to use these initiatives well and benefit from them? Happily, the implementation of educational programs can resolve this prob- lem.

   With the right education provided through face-to-face meetings with gov- ernment representatives, tangible printouts, and easily accessible learning through the rise of social media, the transition to new operating procedures can be facilitated.

   - Inclusion in smart city initiatives: Initiatives for smart cities shouldn't be planned in a vacuum. All facets of society must be taken into consideration, including those that are most likely to be left out when smart city initiatives are put into practise. Smart city initiatives has to be advantageous to all citizens, not just the wealthy few.

   - Comfort with Technology:- It's simple to believe that smart cities and much more advanced technology are only appropriate for people of a certain age and academic background. In fact, as was noted in the earlier section, extensive training may be needed to ensure that most (if not all) residents of smart cities are familiar with technology.

   - In fact, when dealing with smart technology, the average person may come across a medley of scientific jargon that can quickly confuse them, if not put them off trying to deal with technology altogether.

   - As a result, it's important that these initiatives have access to infor- mation and education. Accessibility goes beyond simple distribution via a number of channels. Additionally, they involve ensuring that the majority of people can understand the information. A sustained programme and incentive system should be put in place to

gradually accustom the majority of citizens to smart technologies until they are pretty nearly a part of daily life.

- Socioeconomic Divisions:- There is no guarantee that a smart city will close socioeconomic gaps caused by things like class, racial group, gender, etc. It will most likely draw attention to them. For instance, if a city already has implemented encompassing initiatives (such as providing bathrooms for people who fall across the QUILTBAG spec- trum), this must continue to do so when implementing similar initia- tives in the future.

  Similar to this, wealthy and influential citizens may be using their in- fluence to drive undesirables out of their idealised version of a smart city utopia. Any smart urban initiative should therefore consider care- fully how the disadvantaged can thrive—rather than just survive—in a culture that has historically shunned or rejected them.

VI. DIGITAL TWINS- A KEY TO CREATING SMARTER CITIES

Digital Twins are becoming more important. Virtual models of vehicles, aero- planes, structures, industrial plants, cargo ships, wind turbines, and power plants are revolutionising asset creation, monitoring, and maintenance. Digital twins span a project's lifecycle in construction. This includes planning and building efficiencies, operation and improvement initiatives, and reprocessing and disas- sembling an asset sustainably and cost-effectively6.
Smart cities are using digital twins. Creating a digital twin ecosystem can improve municipal operations like roads, public transit, buildings, streetlamps, waste disposal, and energy. When a city's aspects are linked to a digital model in the cloud, performance and failures are easier to monitor.

Digital twins could benefit city planners and managers. ABI Research7 found digital twins can save cities $280 billion by 2030. There are many sources of these savings. Las Vegas and New York City city planners are already using digital twins to create net-zero carbon emission buildings to increase sustainability and reduce energy costs.

Regular data exchange between virtual and physical twins could help smart cities learn from the digital twin eco - system and develop over time. This would allow the city to respond more quickly and effectively to pandemics, blizzards, and even traffic jams.

A digital twin eco - system may seem scifi, but there are real-world ideas and implementations. The Finnish city of Helsinki utilizes a digital twin of the its Cli- mate and Energy Atlas to reduce climate change and boost energy efficiency. The digital twin provides data on electricity consumption, constructing central heat- ing, renovations, and moisture, which city planners use to determine solar energy potential of buildings.
6https://www.automation.com/en-us/articles/april-2022/digital-twins-key-creating-smarter-Cities 7https://www.abiresearch.com/press/use-digital-twins-urban-planning-yield-us280-billion- cost-savings-2030

Oracle Industry Lab's Virtual Command Center coordinates BIM models and digital twins as shown in Figure 3. The lab allows organisations to explore new techniques and

products as part of digital transformation. It's another instance of clients and customers emerging together to speed up innovative ideas from AI to robotic systems and digital twins.

Figure 3: Digital Twins a Key to Creating Smarter Cities

Cities considering a digital twin eco - system should consider several factors. First, digital twins require an early implementation of a sophisticated technology framework. Cities need to have an elastic cloud to build new apps. A common data environment (CDE) can help companies, landowners, and subcontractors design, build, and operate building projects agilely and collaboratively. Cities will need to install hundreds of sensors to gather data for meaningful insights and building information modelling and validation solutions. Digital twin ecosystems may seem like something that will only become a reality in the distant future, but in fact, they are already beginning to make smart cities even smarter. The way cities run could be completely transformed with the right technological investments.

VII. THE IMPORTANCE OF DIGITAL TWIN FOR SMART CITIES

Organizations like NASA and urban planners was using the use of geospatially analytics powered smart maps and computer-aided design (CAD) before the term "digital twin" was even coined.

Due to their affordability and usability, digital twins have become increasingly common in other industries as the Internet of Things (IoT) has grown. Through digital twins, is amply illustrated how the smart city concept works. It has the ability to efficiently govern the city via everything from urban planning to prop- erty optimization. With the help of digital twins, plans can be tested before being put into action, revealing issues before they arise. Digital tools could be used to plan and analyse architectural elements related to housing, solar panels, wireless network antennas, and public transportation.

Even though Singapore is one of the technologically advanced countries around the world, Thomas Pramotedham, CEO of Esri Singapore, thinks that any city starting its digital transformation journey must first create a digital twin8. Gov- ernment agencies can only analyze data effectively to determine what can be done to enhance citizen livelihood, foster economic opportunity, and revitalize a sense of community with such a digital twin in place, according to Pramotedham. Al- though the idea is still novel in many nations, it is expected to catch on within the next five to ten years.

Challenge Advisory is exerting significant effort to reduce this timeframe. The one that is the 2019 event for digital twin smart city planning9. The goal of this seminar is to raise awareness of the simulation-based optimization of cities and towns as well as the concept itself. Unimaginable advantages could be gained from data-rich digital city models that recreate its physical characteristics and record its procedures in real time. Digital twin implementation can improve a variety of areas, including infrastructure management, waste disposal, security monitoring, and mobility enhancements.

8https://www.challenge.org/insights/digital-twins-and-smart-cities/
9https://www.challenge.org/insights/digital-twin-conference/

VIII. WHAT GOALS WILL BE ACHIEVED BY CREATING SMART CITIES WITH DIGITAL TWINS?

Without the need for a doubt, the people who live in the cities that can use this inno- vation and take advantage of the benefits will prosper. They will advance techno- logically while also improving their social, economic, and environmental sustain- ability. However, some analysts have questioned how this technology would out- perform conventional strategies. According to experts on digital twins, the digital twin would offer the same services as computer-aided design does today—creating designs and providing insights into to the design process—but it would also offer a finding also shows that users could interact with. The designers would be able to anticipate any potential issues if they had a counterpart. Another excellent il- lustration of how this innovation improves current procedures is the comparison of technology with smart maps that are powered by geospatial analytics. These maps are designed to aid users in the visualisation, processing, and analysis of nu- merous, large, and complex georeferenced data. Again, the digital twin provides the same provider, but it also simulates a functioning physical object that changes dynamically and almost instantly as the condition of the real object does.

Users can create simulations using this tool to inform their future plans. That extra function is not available in smart maps. In conclusion, it is still too soon to say that digital twins will be the answer to the complicated problems that cities face. It will undoubtedly be essential to any city's long-term resilience plan. Like any advancement, there might be some potential drawbacks, but overall, the ad- vantages outweigh them. It would be wise to integrate digital twins with current systems in the beginning because a total restructuring of them could be disastrous. By combining the use of this technology with current procedures, the government would also be able to recover money that was previously spent on ineffective sys- tems. The additional savings could then be used to make other investments in the city.

1. **Digitizing City Security:** Digital simulations will help companies develop, improve, and enhance technol- ogy 100x faster than before. Until recently, manufacturing companies relied solely on human labour. They've greatly increased production with automated machin- ery. This was the first major shift in fulfilment and development processes. Could we go further? Instead of hiring people to run software, machines, and devices, we could rely on simulations to project the future, handling automation, performance, and production of end-user products or services. Digital Twin technology could do this. In addition to the enormous number of business benefits that Digital Twin tech- nology can offer, there are many advantages to using it to make the future of hu- mans safer. In London, we will be holding a seminar on digital twinning, during which we will discuss

the advantages of the technology in terms of safety. The en- tire procedure would be built around averting risks and issues that could endanger life by simulating them in the future. This will be accomplished through the use of a digital twin-based simulation that will accurately predict how it will behave in the future by continuously incorporating data from its physical twin.

2. **Twining Reduces Traffic:** Let's envision how digital twin technology will make commercial aerospace safer in the future. In a specific context that they can influence, shift, and create, devel- opers will be able to replicate future events. Consider an impending takeoff for an aeroplane to better understand what this means. To test how each plane engine will behave during the course of the flight and how resilient it will be under constant wind pressure, the pilots of the aircraft will be able to simulate the future 3+ days later. The organisation in charge of the aircraft will be able to take the necessary actions to ensure the safety of their customers if a potential risk is predicted by the simulation.

3. **Better Infrastructure:** Transport systems that are safe and secure both in the air and on ground will be part of the simulation world of the future. The development of a transport net- work that is more effective in big cities than it is right now is currently one of the biggest challenges facing the transportation sector. Traffic congestion is a con- stant problem in large cities, particularly after work. Engineers and programmers could devote all of their attention and focus to designing cities with structures that could solve the issue of slow transportation by building an intricate digital twin of any city that exists. The ability to replicate almost anything is the most signif- icant feature of digital twin platforms that the majority of people are unaware of. Additionally, elements, conditions, and structures may be included in the virtual simulation in addition to the replicated digital twin to complete it. This will make it possible to present fresh solutions that will be evaluated in order to find workable ones.

4. **Smart City Operation Brain:** On the basis of the digital twin city, a "Smart City Operation Brain" (SCOB) can be created, and the local government will take the initiative to create a "Smart City Operation Center" (SCOC) and designate a Chief Operating Officer (COO) to manage operations. Figure refArchitecture shows the full organizational struc- ture of the SCOB based on digital twin city. Management and coordination are the responsibilities of the Chief Information Officer (CIO) Joint Conference Commit- tee, which the COO and SCOC jointly chair. The four primary areas of the urban data that SCOC oversees are the Big Computer System, Urban Procedure Moni- toring and Command Center, Smart Repair Facility (including online information systems, data marts, and other businesses), and Urban IT Operation and Mainte- nance Center. The following are some of SCOB's main duties:
   - Examining the general layout of the city and taking part in it;
   - Starting to plan and reviewing the broad goals, structures, activities, and governance frameworks of the data innovation across various industries;
   - Creating appropriate standards, regulations, and policies;
   - In charge of sharing and integrating urban information resources;
   - Observing city operations, multi-departmental coordination, and command;
   - Fostering the development of a network of open big data applications, ser- vices, and transactions

The infrastructure component of the SCOB is the Public Info Cloud Service Platform. The office of SCOB can start operating once the Public Information Cloud Service Platform is set up, and the officials can simply use the platform's "appli- cations" to take over management of the smart city. A Public Info Cloud Service Platform's organizational chart is depicted in Figure 5. The platform is made up of an infrastructure layer, an application layer, and a platform for software devel- opment and operation. In order to collect data, the platform that makes use of sys- tems, servers, and sensor hardware. It then uses cloud platform, data, platforms, and applications as services to implement cloud service platforms across a vari- ety of industries, including smart urban planning, smart national safety, and smart tourism. The platform can set up a feedback loop for data collection, handling, storing, cleaning, mining, and application. The operation center constructed just on digital twin city serves as the brain of the city of the future. It functions as the hub of the urban Internet of Things and a resource hub for big data in urban centers. It commands, monitors, and collects thorough data on the procedure of the city in order to achieve the efficient coordination and disaster response functionality of cross-departmental and bridge systems.

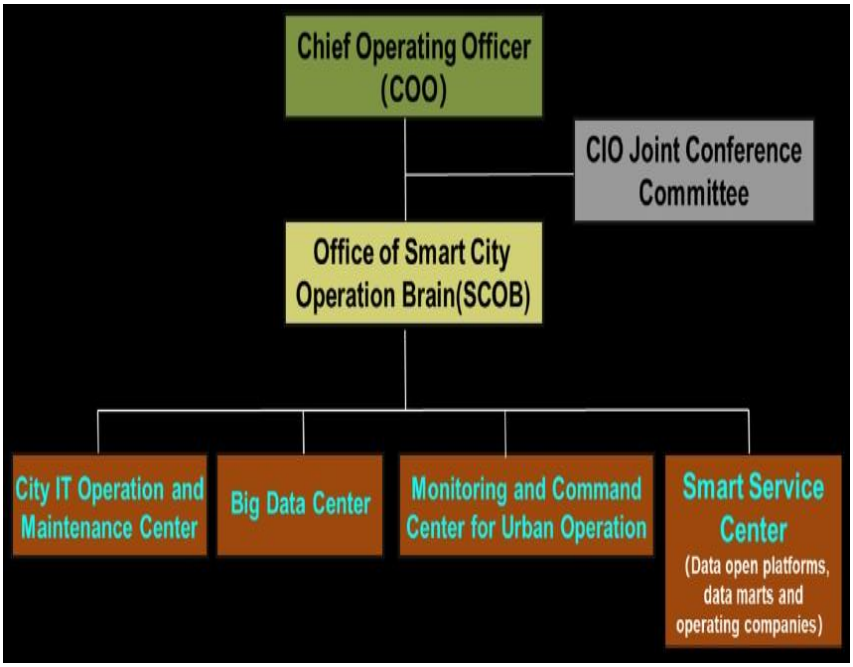

Figure 4: Smart City Management Architecture based on Digital Twin

The framework of a smart urban procedure brain modeled after a digital twin city is shown schematically in Figure 6. A multi-portal integrated city control and emergency center based on smart city procedure brain can be built by integrating data from cloud data center and the electronic subsystems of various departments. The center also makes use of fundamental data analysis tools like data mining and multidimensional analysis, as well as analysis software like IoT perception as well as real-time operation monitoring. This center can lower the cost of urban information technology projects and their upkeep, lower the cost of government operations, and boost urban productivity.

Cloud - based data framework, analysis system, response system, and user terminals can be used to build a Smart City Public Pandemic Service System (Li, Shao, YU, Zhu, & Zhou, 2020). Figure 7. A communication operator's spatiotem- poral trajectory data and clinical records from major hospitals are combined in the patient's spatiotemporal database. The global epidemic big data analysis scheme and the spatiotemporal public cloud can both be connected to this database. To 26

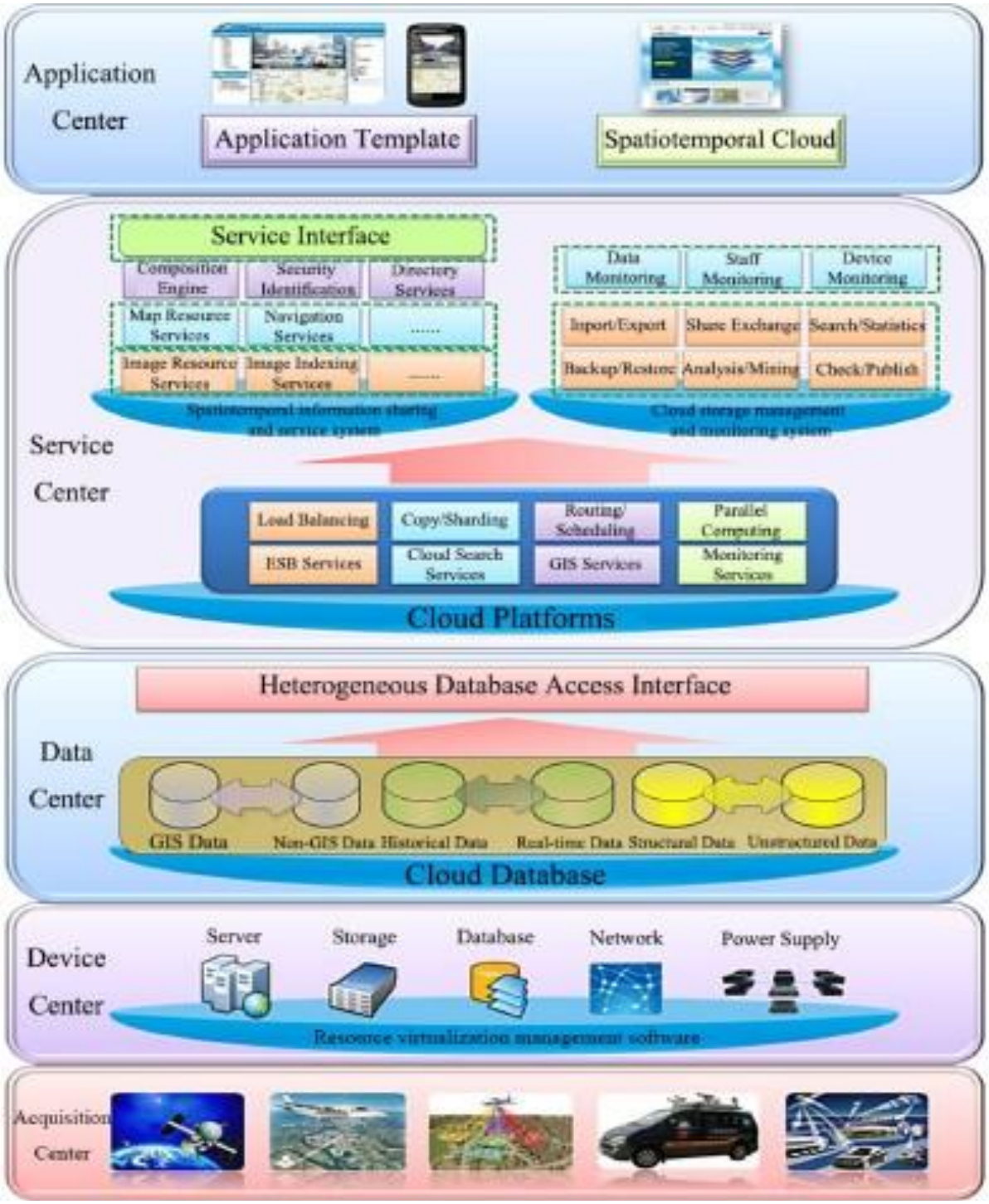

Figure 5: Schematic of a digital twin-based smart city public cloud service plat- form

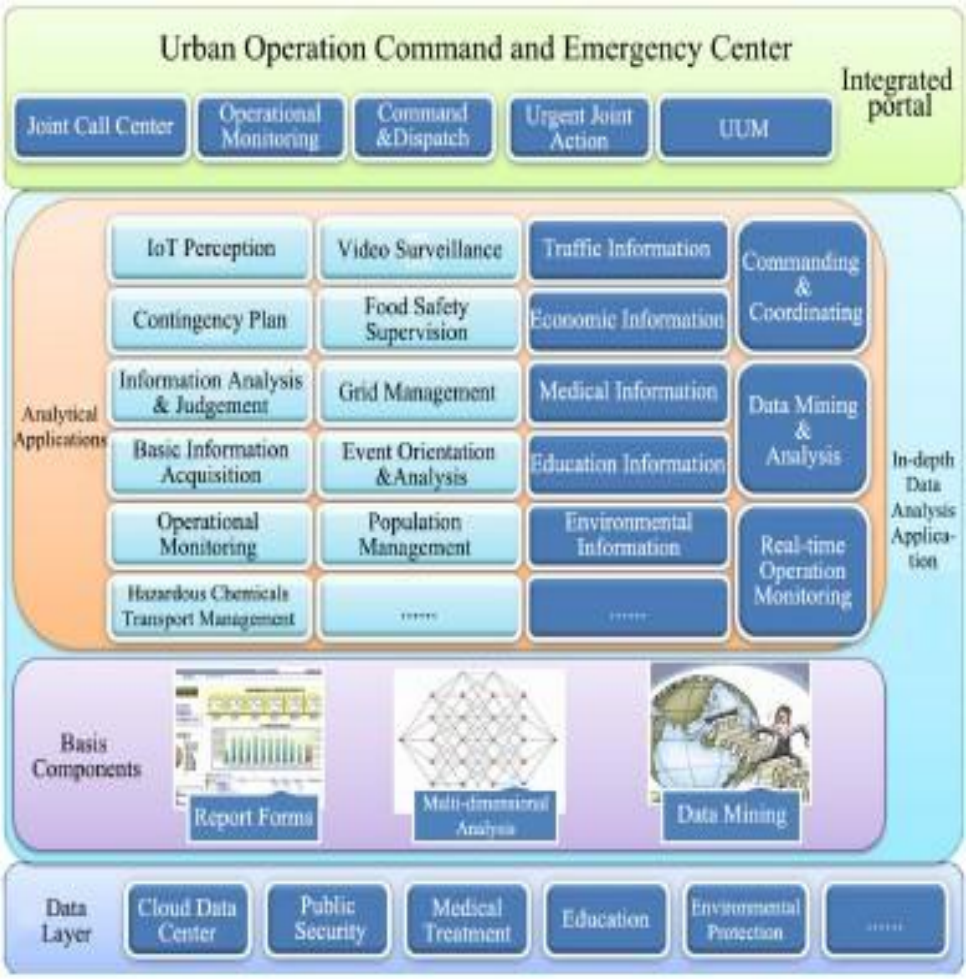

Figure 6: Digital twins power the smart city brain. Unified Users Management

Identify the spread of the pandemic and the people in close proximity, the analyze process makes use of technologies such as spatiotemporal closeness analysis, AI analysis, and others. The response system links government agencies, businesses, and individual users, giving the former a resource for pandemic prevention and control, the latter a resource for employee medical issue statements, and the for- mer a resource for information on self-isolation and protection.

Finding close contacts, identifying high-risk areas, and studying virus trans- mitting dynamics models are all possible with the use of space-time big data ana- lytics and data location intelligence (Figure 8), specifically:

- Disease tracing analysis. Given the population data of visiting urban cen- ters was possible to realize the feature of trying to analyse epidemic exposure across different risk areas by using high-risk regions, distributed file maps, and crucial pandemic areas. The scheme can also analyze daily flow data to monitor this same status of populations in severe areas.
- ”Risk warning” alert. Using a model of disease transmission, the sys- tem can identify high-risk areas. People attempting to enter can receive in- stant mobile telephone

warnings to take measures or lane changes (exposure warning). The program can offer impact advance warning service offerings

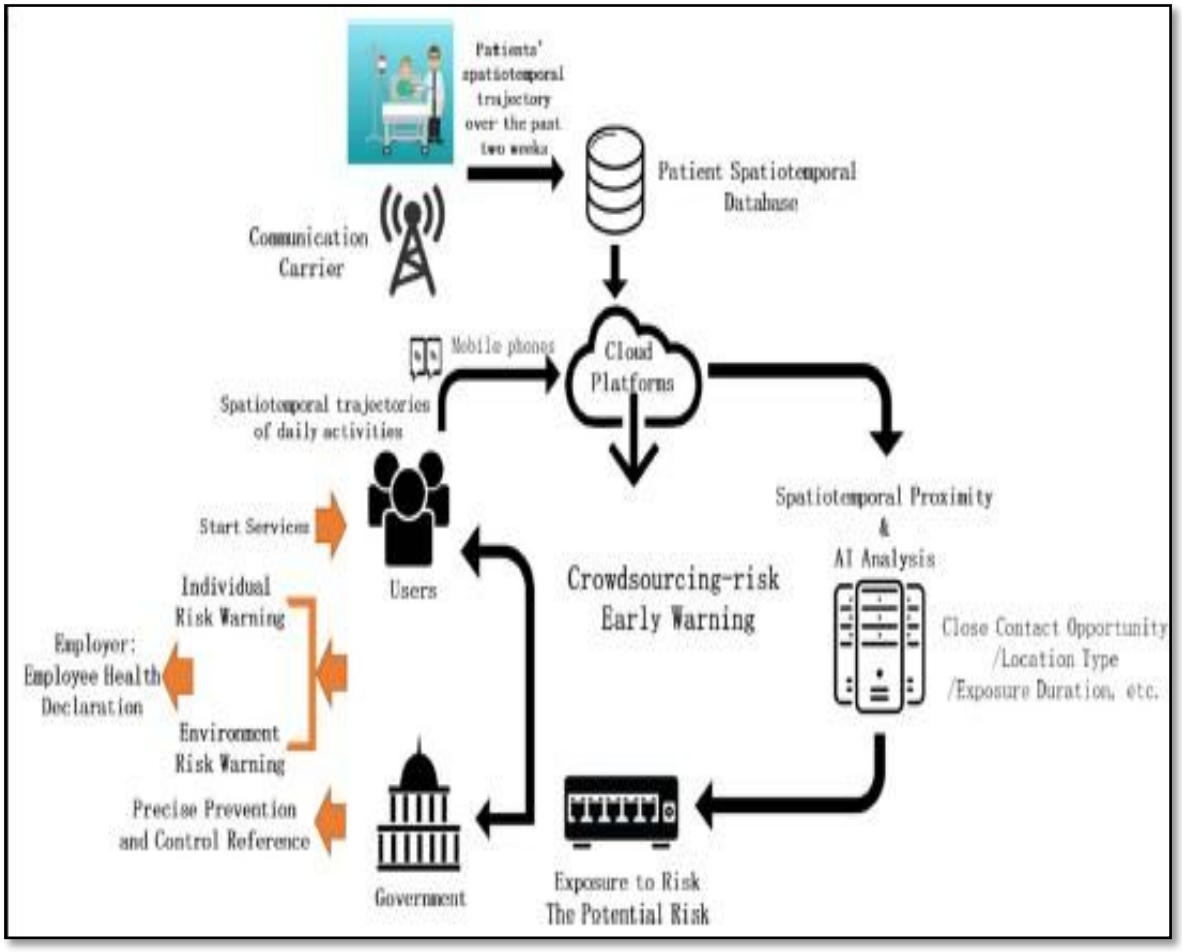

Figure 7: Public health epidemiological surveillance and response network dia- gram

on contact histories of confirmed cases, which aids the disease control man- agement department in precisely identifying the uncertainty and risks and enhancing disease control effectiveness (contact early warning).

- ”Grid Prevention and Control” global management. To illustrate the epidemic’s widespread distribution, the system shows a heat map of cases reported of the disease from the nation, provinces, cities, districts, streets, and communities. In order to track epidemics in real time, the system man- ually configures dynamic data in a flexible manner and uses multidimen- sional charts to analyze individual ’s socioeconomic flows in areas, cities, and districts.

- Work/production restart approval. The system fills in employee personal health information and oversees epidemic prevention measures in accor- dance with a company’s come right back to work pronouncement and re- view process. System can also analyze abnormal enterprise situations as well as provide true advance warning services to aid in work resumption and epidemic preventative measures management.

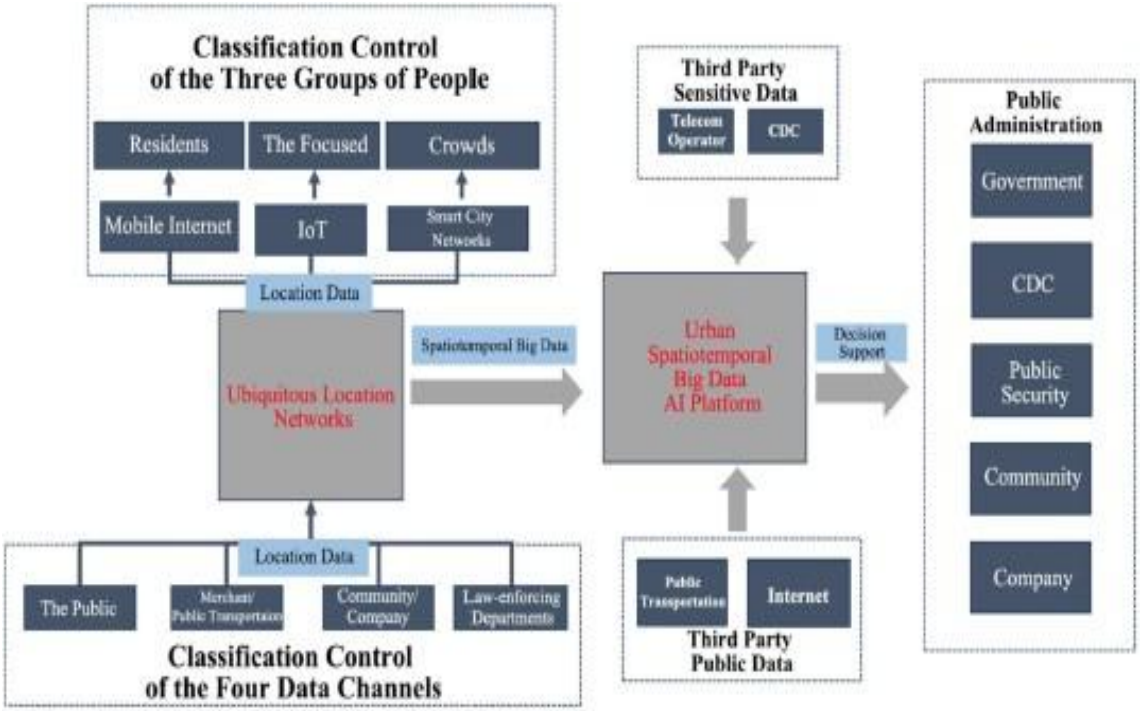

Figure 8: Smart city public health platform diagram

Flood monitoring and flood situation services

Digital twin technology could be used for real urban flood simulated world and research company research and conviction services, adding services to the devel- opment of smart cities, in the complete cycle of flash flood normalized tracking and predicting before really disasters, lively monitoring and analysis all through- out disasters, and assessment and rebuilding after disasters (Figure 9). The digi- tal twin-based smart city deluge tracking and service includes a flood knowledge map, a flood service application, and normalized and lively big data monitoring. Flood big data tracking is the real-time collection of big data from the IoT at ur- ban and watershed scales along with earth, air, and space monitoring technology. Ground sensors are used as monitoring and collection tools to gather data on the water quality of rivers and lakes, the amount of rain at urban weather data, and the dynamic paths of people and vehicles. Cloud and rainwater volume, lake wa- ter volume, river and water tank water level modifications in the upper and lower basins can all be monitored using satellite remote sensing technology. Gaofen-3 and Radarsat2 images were utilized to track Wangjiaba and the surrounding waters both before and after the gate opened, as shown in Figure 10. Prior to background flood storage, the water region of the Mengwa flood store room was 10.19% on July 13 (the blue area); The Mengwa flood storage water area in the district in- creased to 30.68% on July 20 around 6:30 pm (roughly 10 hours after the gate was opened), and the newly added body of water was an orange area; The sub- merged area increased to 59.19% at 5:30 pm on July 21 (33 hours after the door was opened), and the new water body turned red. Four days later, on July 24, the submerged area had increased to 80.31 percent and had turned a deep shade of red. The service also collects information on public opinion. The flood disaster as shown in Figure 11 illustrates sentimental tendencies. The public has a favor- able opinion of flood prevention, and warm feelings are more common than cool feelings.

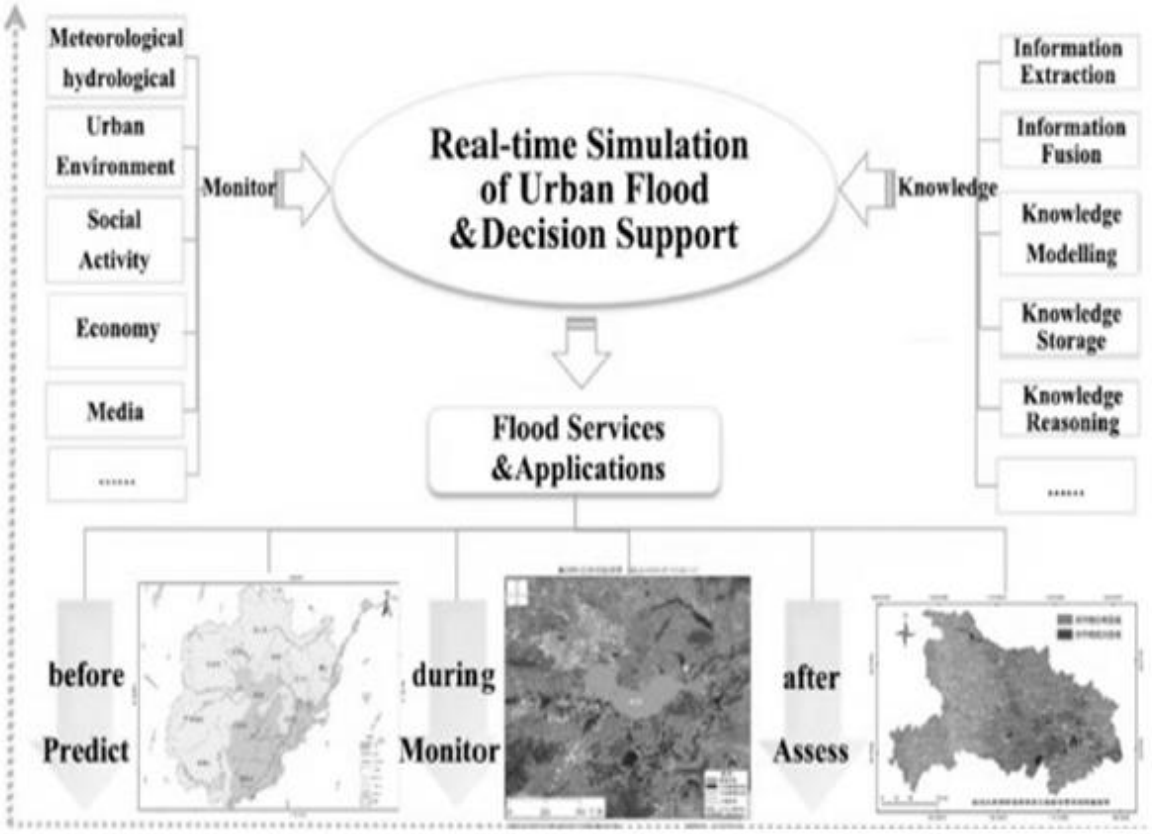

Figure 9: Flood monitoring and service platform architecture for a smart city

IX. DIGITAL TWIN EXAMPLES

Planners can build situations and interrogate impacts in sense and with necessar- ily justify using data from smarter, more accept and embrace than they can with conventional techniques like physical models, spreadsheets, and straightforward digital 3D models. For instance, IoT sensors on automobiles assist planners in comprehending where and how traffic flows. This information can be utilized to

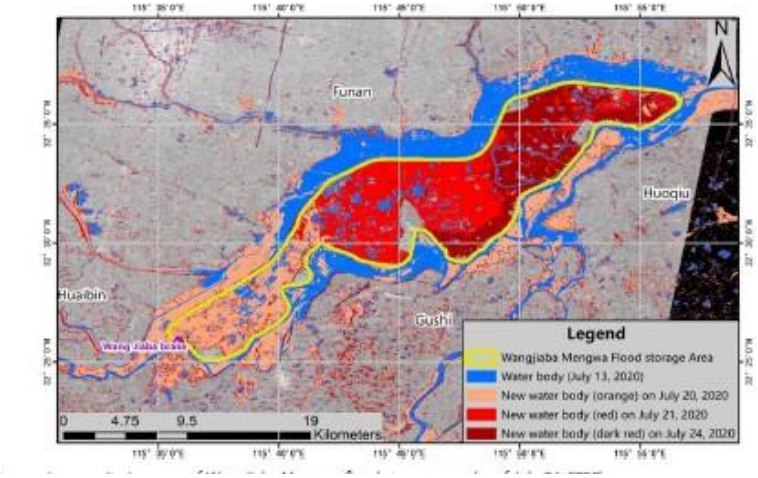

Figure 10: Wangjiaba Mengwa flood-reservoir satellite imagery for monitoring

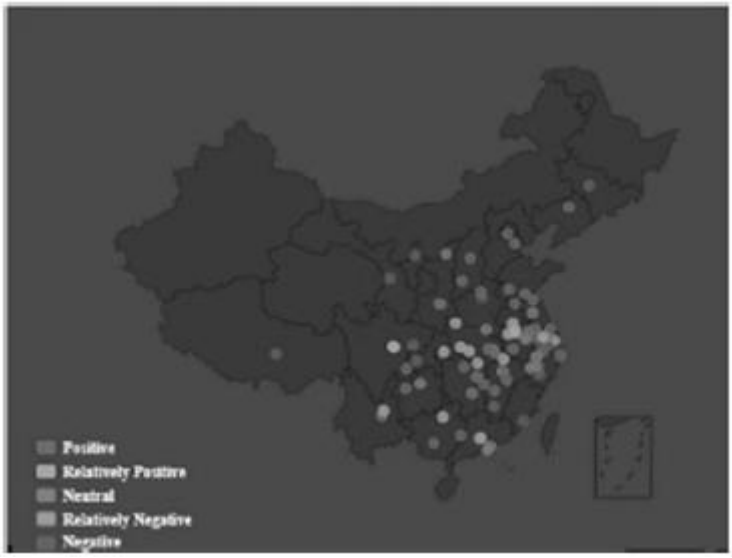

Figure 11: Weibo's distribution of public opinion following the flood disaster and its sentiment trends enhance pedestrian security along specific routes, improve traffic flow, and pro- mote alternate modes of transportation where they are most practical.

Planners can also use digital twins to examine what proposed developments relate to and affect the surrounding area using data from the real world. Planners can assess whether a proposed development is desirable by considering how it might affect the combination of residential and commercial properties in a neigh- bourhood. Additionally, in order to better serve the city's underserved residents, planners may employ a digital twin to investigate transit times between different parts of the city in conjunction with socioeconomic data.
In each of these scenarios, location offers a context that connects various data types, producing a comprehensive and accurate representation of reality. All of these data are combined by a GIS into a visual, analytical model that models both the present situation and a desired one. The examples of how actual communities are utilizing digital twins are explored below.

1. **Boston – Development impacts and scenarios:** In this web scene, Boston's proposed developments are depicted in relation to the shadows they cast on Boston Commons, a park in the city. Urban planners in Boston are using ArcGIS Urban10 to explore various scenarios, incorporate various pieces of data, such as building footprint, height, and location, and achieve their goals—in this case, reducing the amount of shadows cast on the park.

2. **New York City – Vision Zero:** This dashboard, created by New York City for its Vision Zero program11, displays important pedestrian safety metrics using data from sources and IoT sensors, in- cluding traffic sensors integrated into a geospatial context, intelligent cameras, and pedestrian traffic tracking. With the aid of predictive analytics and real-time traffic collision monitoring, public safety agencies can better manage traffic flow and increase pedestrian safety.

3. **Oshkosh, Wisconsin**: Securing economic and investment opportunities the city of Oshkosh, Wisconsin created a plan named Imagine Oshkosh12 to pro- mote economic activity and safe investment options in the wake of business owners leaving the city center. The Imagine Oshkosh plan was developed, assessed, and communicated using ArcGIS tools like Business Analyst and City Engine.

4. **Maracaibo, Venezuela – A digital twin from a bird's eye view down to specific buildings:** Maracaibo, Venezuela's second-largest city, has been transformed into a digital twin by Esri Venezuela and collaborators at the University of Zulia using ArcGIS Urban13 and related tools like CityEngine. The digital twin incorporates a wide range of variables and indicators, including information on particular properties and developments as well as zoning and regulations, mobility patterns, the nat- ural physical environment, and power usage. This comprehensive, place-based perspective makes it easier to assess how different scenarios will affect plans and how well they will comply with societal goals. As illustrated below, various as- pects, such as a location's accessibility to parks and medical facilities, influence whether a particular area is more suitable than another for development projects.

X. CONCLUSION

A metropolitan area's ability to perceive, manage, and offer intelligent services to the people and things relies on a lot of the physical world and the virtual age created by smart cities, the Internet of Things, and cloud computing. The creation of brand-new smart cities has a new starting point: the digital twin city. In order for man and nature to develop more in lockstep, cities to digital twins have such a wide range of opportunities for economic reform, urban smart managerial staff, and public smart services. For use in smart city applications to be effective and cost-effective, a more comprehensive spatial information infrastructure is needed. Big data in smart cities offers both opportunities and difficulties. Strong technical invention and research are required to expand the digital economy, actually realise the software solutions of the Internet + smart city, and develop the digital services sector. Building a smart city is the main project. A top-level layout, comprehen- sive planning, a smart city process center, and brain are required to create a city smart. Only by carefully designing, planning, and constructing the physical ur- ban centers' infrastructure and enacting corresponding policies can smart cities be built.

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