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Big Data in Smart Cities

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ABSTRACT

In today's rapidly evolving world, the emergence of smart cities has revolutionized the way urban areas are managed and developed. One of the key drivers behind the success of smart cities is the utilization of big data to enhance urban infrastructure and services.

Big data refers not only to the size of these datasets but also to their speed, variety, and potential to reveal useful patterns through advanced analysis. It has become a central component of smart-city development because it allows urban systems to be observed, analyzed, coordinated, and improved at unprecedented speed and scale. In a smart city, these capabilities allow leaders to understand urban conditions more accurately and respond more effectively. When supported by responsible governance, big data can improve decision-making, increase the efficiency of public services, strengthen sustainability, stimulate innovation, and make cities safer and more responsive to citizens' needs. This paper examines the transformative role of big data in shaping the future of smart cities.

KEYWORDS: *smart cities, urban areas, big data, urban big-data.*

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INTRODUCTION

Since the earliest days of civilization, humans have tried to improve their lives by developing various solutions to satisfy their demands and continuously adapt to the evolving world. The accelerated population growth that humanity has experienced in recent decades has led large cities to need to implement solutions that will contribute to an efficient management of urban resources and infrastructure. At the same time, sensors, smartphones, connected vehicles, public records, satellite systems, and digital services generate enormous quantities of information about urban life. Big data refers not merely to the size of these datasets, but also to their speed, variety, and complexity. When cities combine this information with cloud computing, artificial intelligence, geographic information systems, and predictive analytics, they can understand urban conditions more accurately and respond more effectively. The resulting model is often described as the smart city: a city that uses technology and data to improve public services, sustainability, economic opportunity, and quality of life [1].

In the last years an increasing number of innovative services and applications, exploiting urban data analysis, have been implemented in our urban environment to build smart cities. Big data is a foundational resource for smart cities because it enables urban authorities to understand complex systems, coordinate services, predict emerging needs, and allocate resources more effectively; nevertheless, its public value depends on responsible governance and the inclusion of human judgement [2]. It leverages key technologies like AI, IoT, and advanced analytics that enable urban environments to become more efficient, sustainable, and responsive to residents' needs.

WHAT IS A SMART CITY?

Cities around the world are being wrecked by the ever-increasing burden of traffic. Smart cities are a recent innovation perceived as a winning strategy to cope with some severe urban problems such as traffic, pollution, energy consumption, waste treatment. Governments can streamline the way cities are run, saving money and making them more efficient as a result. The notion of the smart city captured most people attention during the last decade as a blend of beliefs on how technology in general could be used to transform how cities around the world work, while improving their competitiveness, offering new ways of solving problems linked to poverty, social deprivation, pollution and poor environmental issues [3].

The concept of smart city emerges as a major response to the increasing global urbanization, global warming, sustainable growth, scarcity of resources, and socio-economic challenges faced by cities worldwide. IBM's Smarter Cities work began in late 2008 as part of the Smarter Planet initiative. The idea of "smart city" first appeared in the 1990s, with focus on the impact of ICT on modern infrastructures within cities. It is the merge of some other more familiar urban policies such as digital city, green city, knowledge city.

The word "smart" can be used to describe any device that can process information and can communicate with something. The term "smart cities" is a fuzzy concept and there is not a one-size-fits-all definition of the concept. The term has gained traction across sectors and has pervaded the fields of sustainability, urban planning, architecture, engineering, and computer science.

As typically shown in Figure 1 [4], a smart city is a high-tech urban area that connects people, information and technologies in order to increase life quality. It integrates ICT in a secure manner so as to manage the city's assets, increase operational efficiency, share information with the public, and improve citizen welfare. ICT is the key technology that weaves digital intelligence into cities' fabric. The main motivation for using ICT is the desire to eradicate human error. Smart cities are those communities that pursue sustainable economic development through investments in human and social capital and manage natural resources through participatory policies.

The main target for developing smart cities is to provide the following services [5]:

1. Convenience of the public services
2. Delicacy of city management
3. Liveable and sustainable living environment
4. Smartness of infrastructures
5. Effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens.
6. Adequate water supply and electricity supply
7. Sanitation, including solid waste management
8. Efficient urban mobility and public transport
9. Affordable housing, especially for the poor
10. Good governance, especially e-Governance and citizen participation,
11. Safety and security of citizens, particularly women, children and the elderly
12. Health and education.

Figure 2 displays the six major characteristics of a smart city [6], while Figure 3 shows different elements of a smart city [7].

OVERVIEW OF BIG DATA

Big data applies to data sets of extreme size (e.g. exabytes, zettabytes) which are beyond the capability of the commonly used software tools. It involves situation where very large data sets are big in volume, velocity, veracity, and variability. The data is too big, too fast, or does not fit the regular database architecture. It may require different strategies and tools for profiling, measurement, assessment, and processing. Different components of big data are shown in Figure 4 [8]. The cloud word for big data is shown in Figure 5 [9].

Big Data is essentially classified into three types [10]:

- *Structured Data:* This is highly organized and is the easiest to work with. Any data that can be stored, accessed, and processed in the form of fixed format is known as a structured data. It may be stored in tabular format. Due to their nature, it is easy for programs to sort through and collect data. Structured data has quantitative data such as age, contact, address, billing, expenses, credit card numbers, etc. Data that is stored in a relational database management system is an example of structured data.
- *Unstructured Data:* This refers to unorganized data such as video files, log files, audio files, and image files. Any data with unknown form or the structure is classified as unstructured data. Almost everything generated by a computer is unstructured data. It takes a lot of time and effort required to make unstructured data readable. Examples of unstructured data include Metadata, Twitter tweets, and other social media posts.
- *Semi-structured Data:* This falls somewhere between structured data and unstructured data, i.e., both forms of data are present. Semi-structured data can be inherited such as location, time, email address, or device ID stamp.

The different types of big data are depicted in Figure 6 [11].

The process of examining big data is often referred to big data analytics. It is an emerging field since massive computing capabilities have been made available by e-infrastructures [12]. Big data analytics is the application of advanced analytic techniques to large, heterogeneous data sets that comprise structured, semi-structured, and unstructured data from many sources with sizes ranging from terabytes to zettabytes.

It enables predictive analytics, which involves using historical data to forecast future outcomes. Analytics include statistical models and other methods that are aimed at creating empirical predictions. Data-driven organizations use analytics to guide decisions at all levels. Several techniques have been proposed for analyzing big data. These include the HACE theorem, cloud computing, Hadoop, and MapReduce [13]. Figure 7 shows big data analytics [14].

BIG DATA IN SMART CITIES

The twenty-first-century city is becoming a vast, interconnected system of sensors, platforms, institutions, and citizens. Rapid urbanization is increasing the pressure on transportation networks, energy systems, public utilities, healthcare services, and municipal institutions. At the same time, cities now generate enormous streams of digital information through traffic cameras, environmental sensors, mobile devices, smart meters, satellites, administrative records, online platforms, and connected infrastructure. Big data refers not simply to the size of these datasets, but also to their speed, variety, complexity, and potential to produce useful insights through advanced analytics. A smart city applies such information, together with digital technologies and institutional knowledge, to improve public services, resource efficiency, sustainability, and quality of life [1].

Just as data and data analytics can be leveraged to improve business performance, the same tools can also be used to improve livability, workability, and sustainability in cities around the globe. The use of big data in urban development has transformed the way cities are designed and managed. It allows urban planners to make decisions about infrastructure, transportation, housing, and public services based on the needs of the city. The importance of big data lies in its ability to convert continuous observations of urban life into evidence for action. Big data has the potential to transform cities by making services more responsive, infrastructure more efficient, planning more evidence-based, and emergency management more effective. It can help governments understand complex urban systems in near real time and anticipate problems before they escalate. A genuinely smart city is therefore not the city that collects the most information, but the city that uses information most wisely. Figure 8 shows different ways big data is creating smart cities [15].

APPLICATIONS OF BIG DATA IN SMART CITIES

Smart cities have played a key role in transforming different areas of human life, touching sectors such as transportation, health, energy, and education. The applications of urban big-data include traffic management, public transport, energy forecasting, infrastructure maintenance, environmental protection, emergency coordination, disease modelling, water conservation, waste management, urban planning, and transparent governance. Common applications of smart-city big-data include the following [1,2,16,17]:

- *Smart Healthcare:* In smart cities, big data enhances healthcare services by tracking disease outbreaks, monitoring public health, and optimizing resource allocation in healthcare facilities. Several solutions to be adopted in the healthcare domain, leveraging on data analysis to improve hospitalized patient's lives, have been proposed. For example, real-time monitoring systems can collect real-time data (sleeping patterns, cholesterol, blood pressure) through smart devices, and they directly communicate with hospital ICT systems to integrate a comprehensive patient history and to allow timely responses to possible health issues. The integration of big data with telemedicine platforms provides remote access to healthcare. By analyzing patient data, doctors can offer accurate diagnoses and treatment plans without requiring in-person visits.

- *Smart Grids*: Energy consumption in cities is skyrocketing, necessitating the adoption of smart grids. These grids use big data to monitor energy demand and supply in real time. Data analysis is also exploited to deal with energy consumption issues, which are becoming more and more important due to the rapid urbanization phenomenon. In fact, big cities are demanding for increasing requests of energy, and scientists and engineers are continuously working to design technological solutions for energy-efficient infrastructures, with the aim of decreasing city-scale energy costs and reducing energy consumptions. For example, in Denmark, the integration of smart grids has enabled the country to manage its extensive wind power infrastructure. By analyzing weather and consumption data, Denmark ensures that renewable energy contributes over 40% of its electricity needs.

- *Smart Environment:* The collection and analysis of environmental data are very important to understand how natural phenomena (i.e., global warming, drought, torrential rains) are influenced by other factors, such as urban air quality, pollution, land uses, etc. Moreover, a more efficient management of energy utilization can improve agriculture effectiveness and crops efficiency.
- *Smart Transportation:* Transportation is one of the most visible applications of big data in smart cities. Smart transport, or mobility, includes urban transportation elements such as public transit, smart parking, shared mobility services (like carpooling and bike rentals), congestion management, and traffic information systems. Big data can make transportation systems more efficient. Conventional traffic management often depends on fixed schedules and periodic surveys, whereas connected urban systems continuously observe road speeds, vehicle locations, passenger demand, parking occupancy, and public-transit performance. By analyzing these streams, authorities can adjust traffic signals, identify incidents, recommend alternative routes, improve bus and rail schedules, and position shared vehicles where demand is expected.
- *Environmental Monitoring*: Urban big-data also strengthens environmental governance. Networks of low-cost sensors can measure particulate pollution, temperature, humidity, noise, water quality, and other local conditions at a much finer spatial and temporal scale than occasional manual surveys. When combined with satellite imagery, meteorological information, land-use records, and health data, these measurements can reveal pollution hotspots, urban heat islands, flood exposure, and unequal environmental burdens. Real-time monitoring allows authorities to issue warnings and target inspections, while long-term analysis supports policy evaluation.
- *Environmental Sustainability:* Big data can support environmental sustainability. Detailed information about air quality, building energy use, traffic emissions, waste collection, and local weather allows officials to identify where environmental harm is concentrated and which interventions are effective. For example, waste-collection routes can be optimized using information from container sensors, reducing unnecessary journeys. Recent research on urban big-data applications has examined its growing role in sustainable infrastructure and resource management.
- *Urban Intelligence:* A smart-city data system typically begins by collecting information from diverse sources. Internet of things sensors may measure traffic flow, electricity use, water pressure, air quality, temperature, noise, or the condition of physical assets. These observations are combined with geospatial information, public-service records, emergency reports, commercial transactions, and citizen-generated data. Cloud and edge-computing systems then store and process the information, while statistical analysis, machine learning, geographic information systems, and visual dashboards help identify patterns or anomalies. The resulting intelligence can support decisions at many levels.
- *Public Safety:* The integration of big data analytics in smart city operations has driven advancements in public safety. In the USA, Chicago's "ShotSpotter" system uses acoustic sensors to detect gunshots and triangulate their location, allowing for quicker police response times and reducing gun violence by 30% in monitored areas. Similarly, New York City has implemented a predictive policing system that uses data analytics to identify crime hotspots and allocate police resources more effectively, resulting in a 15% decrease in overall crime rates.
- *Emergency Services*: During emergencies, such as natural disasters, big data helps cities coordinate response efforts efficiently. Data from sensors and communication networks provides real-time updates, enabling faster decision-making and resource deployment. Emergency services must make rapid decisions under uncertain conditions. Big data can integrate emergency calls, traffic conditions, weather information, hospital capacity, video feeds, and reports from field personnel into a common operational picture. This supports faster dispatch, coordinated communication, evacuation planning, and the allocation of scarce resources during fires, floods, storms, or major public events. Historical incident data can also reveal when and where particular risks are concentrated.
- *Water Services:* Water networks and waste systems are essential but often largely invisible to residents until they fail. Smart water meters and pressure sensors can identify abnormal consumption, detect leaks, estimate demand, and reveal where infrastructure requires attention. For example, Singapore's official program notes that smart water meters allow households and

businesses to track consumption while helping authorities manage overall demand. At a system level, combining meter readings with weather, land use, and maintenance records can improve conservation and capital planning.

- *Waste Management:* Waste management can be improved through fill-level sensors, collection histories, traffic information, and route optimization. Instead of collecting every container on a fixed schedule, vehicles can be directed according to actual need. This can reduce fuel use, overflow, and operating costs. Service-request data can also reveal recurring problems with sanitation, lighting, potholes, or drainage, allowing agencies to distinguish isolated complaints from broader infrastructure patterns.
- *Autonomous Vehicles*: Big data is the driving force behind the development of autonomous vehicles. By processing data from cameras, LiDAR, and radar, these vehicles can navigate safely through urban landscapes. Big data helps city planners prepare for the integration of autonomous vehicles by redesigning road networks and parking systems. For example, Tesla's fleet of vehicles continuously collects data to improve its self-driving algorithms. Similarly, cities like Phoenix are testing autonomous taxis, powered by big data, to reduce traffic and emissions.

BENEFITS

Data can help cities move from delayed and fragmented responses toward timely, predictive, and integrated action. A related advantage is the more efficient management of energy, water, and other resources. Big data also supports public health and quality of life. Its greatest benefit is not the accumulation of information itself, but the ability to use that information to understand problems earlier and respond more intelligently. Other benefits of smart-city big-data include the following [1,18]:

- *Better Decision-making:* One of the most important benefits of big data is better urban decision-making. Traditional city planning often depends on periodic surveys, historical reports, and limited observations. Although these sources remain valuable, they may not reflect rapidly changing conditions. Real-time and frequently updated data can give officials a detailed picture of how people, vehicles, resources, and services move through a city. By combining information from different departments, decision-makers can identify patterns that would otherwise remain hidden, assess policy outcomes, and direct resources toward areas of greatest need.
- *Democratic Participation*: Big data can improve governance and strengthen democratic participation. Open-data portals allow researchers, journalists, businesses, and community groups to examine public information and develop new services. Digital platforms can help residents report hazards, comment on projects, or track government performance. These practices may increase transparency, but participation must be meaningful rather than symbolic. Participation should mean more than asking residents to supply data. Communities should be able to influence which problems are measured, how success is defined, and what safeguards are required
- *Transparency*: Big data can improve government transparency and citizen participation. Open-data portals allow residents, researchers, journalists, and businesses to examine public information, evaluate government performance, and propose new solutions. Public dashboards can display progress on road repairs, air pollution, housing, and service requests, while digital platforms can enable residents to report local problems and contribute knowledge about their neighborhoods. UN-Habitat stresses that smart-city governance should be effective, inclusive, and sustainable rather than driven by technology alone.
- *Energy Efficiency*: Cities consume substantial energy through homes, offices, transport systems, street lighting, data centers, and public facilities. Smart meters and building-management systems create detailed records of demand, while weather and occupancy data help explain changes in consumption. Big-data models can forecast peak loads, detect unusual usage, balance supply and demand, and support the integration of variable renewable energy. They can also identify inefficient buildings or equipment without waiting for a visible failure.
- *Predictive Maintenance*: Predictive maintenance is especially valuable for urban infrastructure. Roads, bridges, and public transit systems require constant maintenance. Big data analytics can predict wear and tear by analyzing data from sensors embedded in infrastructure. This proactive approach not only saves costs but also ensures public safety. Sensor readings, inspection images, and maintenance histories can be analyzed to identify early warning signs and prioritize repairs according to risk. Instead of following a rigid maintenance calendar, cities can intervene when evidence indicates that an asset is likely to fail. This reduces disruption and may extend the life of expensive infrastructure.

Figure 9 shows some of the benefits of big data is smart cities [18].

CHALLENGES

Cities face several challenges such as inadequate financial resources, shortages of data-management skills, weak business models, private-sector compliance problems, cybersecurity threats, and fragmented data stored in organizational silos. Other challenges of smart-city big-data include the following [1,16,19]:

- *High Initial Costs:* Implementing big data solutions requires significant investment in sensors, communication networks, and data storage systems. For many cities, especially in developing countries, these costs can be prohibitive. Public-private partnerships, like those in India's smart city initiatives, can help overcome financial barriers.
- *Data Quality*: A major challenge is the reliability and compatibility of data. Urban datasets may contain missing values, duplicate records, inaccurate sensor readings, outdated entries, or inconsistent geographic and temporal units. A faulty air-quality sensor, for example, can distort pollution estimates, while incomplete mobility data can produce misleading forecasts. Because algorithmic outputs inherit weaknesses in their inputs, poor-quality data can lead to poor decisions even when the analytical model itself is advanced.
- *Data Governance*: The central issue is not simply how much data a city possesses, but how that data is governed. Governance will be especially challenging because much urban data is produced or controlled by private companies. Data governance includes rules about ownership, quality, access, interoperability, security, retention, procurement, accountability, and acceptable use. Research on smart-city governance argues that urban data must be reliable, accessible, secure, interoperable, and aligned with public value. Effective governance should clearly identify who may collect information, who may use it, for what purposes, for how long, and under what oversight. Governance must therefore be built into the entire data lifecycle. Good governance requires more than compliance with data-protection law. It requires clear institutional roles, audit rights, public reporting, procurement transparency, and accessible mechanisms for challenge and redress.
- *Data Integration:* Smart cities often use various data sources, each with different formats and protocols. Ensuring data integration and interoperability between these systems is a complex challenge. City planners must create unified platforms capable of consolidating data from disparate sources, allowing for seamless data exchange and collaboration across departments.
- *Privacy Concerns*: Privacy is among the most serious challenges because smart-city data are often generated through routine activities rather than deliberate disclosure. It will become a decisive test of legitimacy. The same systems that make cities more responsive can also make residents more observable. Location traces, facial images, travel records, utility use, and online interactions may reveal sensitive details about an individual's behavior. Even when names are removed, combining several datasets can sometimes make people identifiable. Research on smart-city privacy highlights the significant implications of large-scale data collection by both public and private actors. As a result, privacy cannot be treated as a technical adjustment added after deployment. Cities should apply privacy by design, collecting only the data that is genuinely necessary, limiting retention, controlling access, and assessing privacy risks before a project begins.
- *Bias:* Algorithmic bias is another concern. Predictive systems learn from historical data, but historical records may reflect unequal enforcement, underinvestment, or inconsistent reporting. An apparently neutral model can reproduce these patterns by directing greater scrutiny toward already disadvantaged communities or by overlooking residents who are poorly represented in digital datasets. A city that digitizes services without preserving accessible alternatives risks excluding older adults, low-income residents, people with disabilities, and other vulnerable groups.
- *Digital Divide*: The digital divide is a challenge in smart cities because unequal access to services can increase social inequality. The digital divide affects both participation and outcomes. A recent review finds continuing disparities in digital access, literacy, and skills, with older adults, people with disabilities, low-paid workers, migrants, and other groups at risk of exclusion from digital urban services and decision-making. Smartphone-based reporting systems, cashless transit, automated benefit portals, or online-only consultations may improve convenience for some residents while making access harder for others.

Fairness cannot be achieved solely by adjusting an algorithm; it requires attention to the wider social and institutional context.

- *Cybersecurity:* Cybersecurity presents a serious challenge. Smart-city networks connect physical infrastructure to software, which means a digital breach can disrupt real-world services. A compromised transport, water, energy, or emergency-management system may threaten public safety as well as confidentiality. Municipalities therefore need layered security, encryption, continuous monitoring, tested recovery plans, careful vendor management, and regular staff training.
- *Public Trust:* All these challenges converge in the issue of public trust. Building public trust in the use of big data is vital for the success of smart city initiatives. Residents may resist smart-city initiatives if they believe data are collected secretly, shared without justification, inadequately protected, or used to automate unfair decisions. A technically efficient system can still lack legitimacy if citizens cannot understand it or contest its outcomes. Conversely, transparency alone is insufficient when individuals have no meaningful influence over policy. Trustworthy urban data governance must combine openness with enforceable rights, competent institutions, security, and continuing public participation.
- *Interoperability:* Interoperability is equally important. Urban data is often divided among separate agencies, vendors, and incompatible systems. The OECD identifies data silos as a major barrier and recommends shared platforms, common standards, and policies that make appropriate data exchange easier across departments and levels of government. The future smart city will therefore require an ecosystem rather than a collection of isolated projects. Open standards can reduce dependence on a single vendor, make public procurement more competitive, and allow successful tools to be adapted across jurisdictions.
- *Scalability:* The sheer volume and velocity of data generated in smart cities necessitate scalable infrastructure to effectively store, process, and analyze this information. Many cities may not have the existing infrastructure to handle this influx of data, presenting challenges in adopting big data analytics. Collaborative efforts with technology partners can help create the necessary technological backbone for smart city applications.

FUTURE OF BIG DATA IN SMART CITIES

In the future, big data and smart cities will move toward a more predictive and sustainable model focused on citizens. Future smart cities will increasingly combine artificial intelligence, edge computing, digital twins, connected vehicles, advanced remote sensing, and privacy-enhancing technologies. Edge computing can analyze information near the point of collection, reducing latency and limiting the transfer of raw data. Digital twins can allow planners to simulate changes before making expensive physical interventions. Artificial intelligence can detect complex patterns across many systems, but it also increases the need for transparency and accountability when automated recommendations affect rights, safety, or access to services. For example, Dubai's Smart City initiative offers a forward-looking example by leveraging blockchain, AI, and big data to redefine urban living.

The future of data-driven urbanism should be people-centered, transparent, secure, and inclusive. Municipal governments need strong data-governance frameworks, interoperable infrastructure, privacy protections, cybersecurity capabilities, and continuous public participation. They must also ensure that technical innovation remains subordinate to democratic values and human needs. When these conditions are met, big data can become more than a tool for operational efficiency; it can support cities that are more sustainable, resilient, equitable, and accountable.

Ultimately, the future of big data in smart cities will be determined by institutional choices. Cities that treat data primarily as a tool of surveillance, commercial extraction, or automated control may become more efficient in narrow terms while losing public trust. Cities that combine analytics with transparency, privacy, cybersecurity, interoperability, professional capacity, and citizen participation can use the same technologies to create safer, healthier, more resilient, and more equitable communities [1].

CONCLUSION

The promise of a smart city leads to an exponential increase in data by several orders of magnitude. Consequently, such enormous volumes of data or big data are at the core of the services rendered by the IoT. Big data offers smart cities a powerful means of turning everyday urban information into practical public value. It can help governments make evidence-based decisions, improve transportation, conserve resources, maintain infrastructure, prepare for emergencies, promote public health, and engage citizens. Smart-city systems must manage massive and heterogeneous information while overcoming poor data quality, incompatible platforms, privacy risks, cyber threats, opaque governance, algorithmic bias, unequal access, financial pressure, and shortages of expertise.

The successful application of big data requires more than sensors and algorithms. It requires capable institutions, interoperable systems, strong cybersecurity, ethical safeguards, public participation, and continual evaluation. When these conditions are met, big data can serve not as an end in itself but as a carefully governed instrument for building cities that are more efficient, sustainable, resilient, inclusive, and responsive to the people who live in them. Big data is undoubtedly a game-changer for the future of smart cities. Its ability to provide actionable insights and facilitate real-time decision-making makes it an indispensable tool for urban planning and management. By enhancing urban infrastructure and services through data analytics, technology, and innovation, cities can achieve unprecedented levels of efficiency, sustainability, and quality of life for their residents. More information on big data in smart cities can be found in the book in [20-28] and the following related journals:

- Cities
- Urban Governance

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Figure 1 A typical smart city [4].

Figure 2 The six major characteristics of a smart city [6].

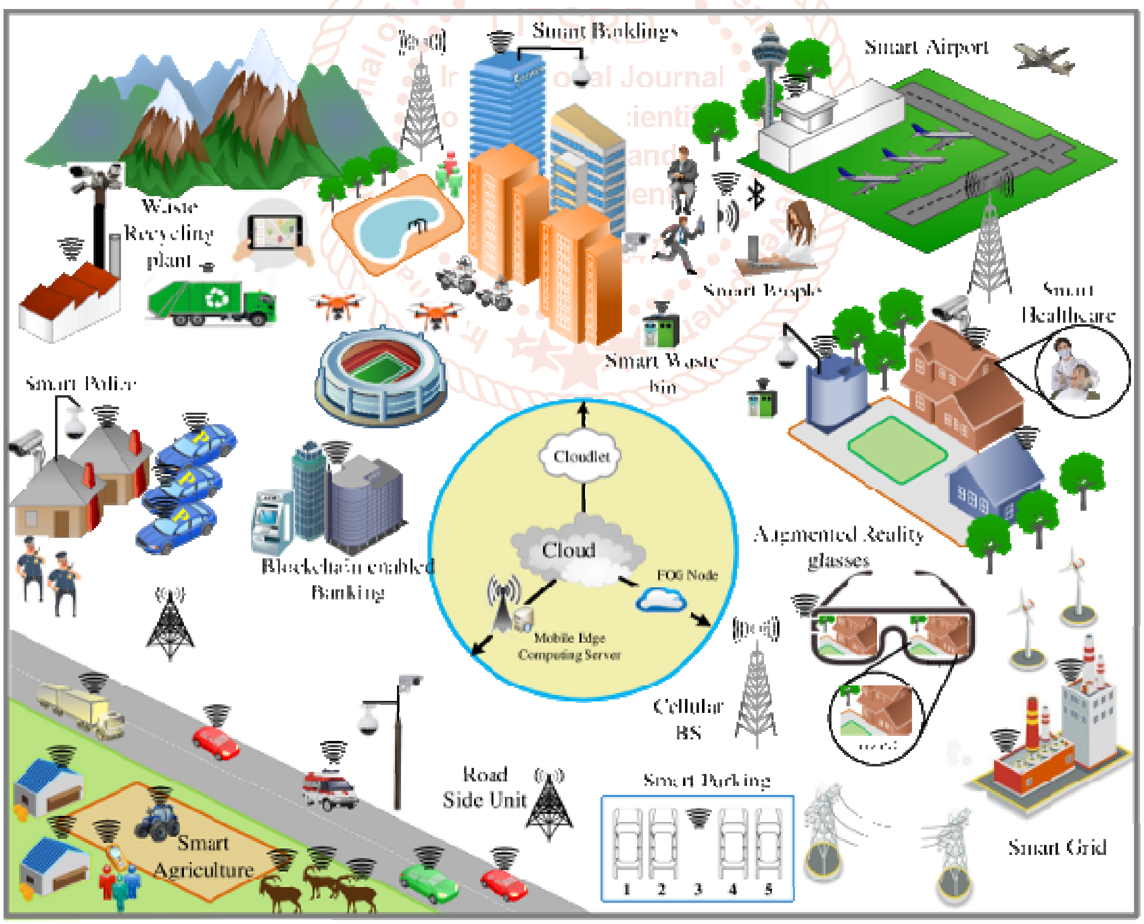

Figure 3 Different elements of a smart city [7].

Figure 4 Different components of big data [8].

Figure 5 The cloud word for big data [9].

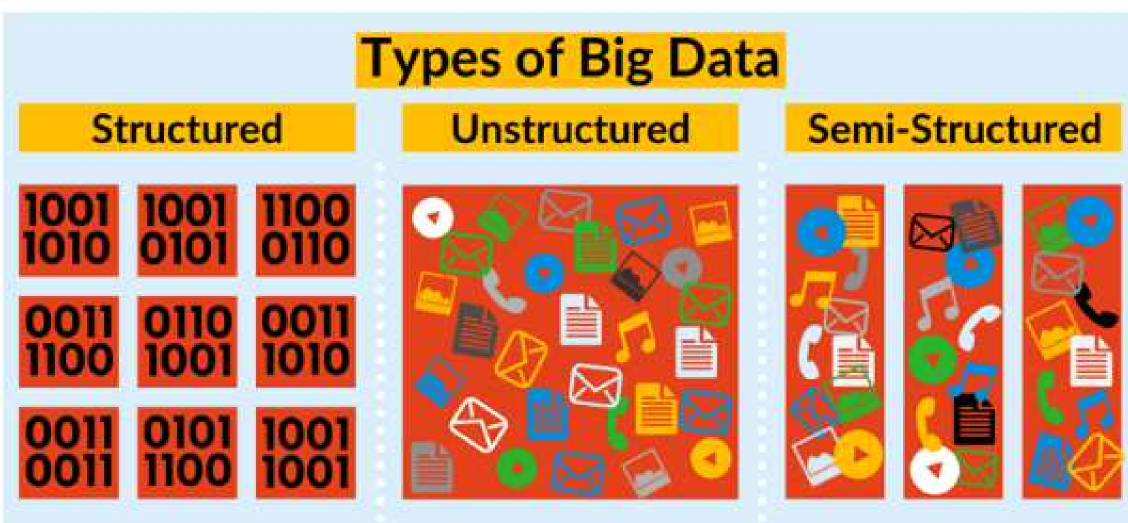

Figure 6 Types of big data [11].

Figure 7 Big data analytics [14].

Figure 8 Different ways big data is creating smart cities [15].

Figure 9 Some benefits of big data is smart cities [18].