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Smart City

- Smart-cities are emerging paradigm made possible by the combination of new technologies, like the Internet of Things (IoT) and big-data. It is an integrated living solution that links many life aspects such as power, transportation, and buildings in a smart and efficient manner to improve the quality of life for the citizens.
- A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operations and services, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects.
- It is predicted that around 70% of the world population will live in urban areas by 2050. At present cities consume 75% of the world's resources and energy which leads to the generation of 80% of greenhouse gases. Thus, in the next few decades there can be severe negative impact on the environment. This makes the concept of smart cities a necessity.
- Smart cities, in spite of the costs associated, once implemented can reduce energy consumption, water consumption, carbon emissions, transportation requirements, waste.

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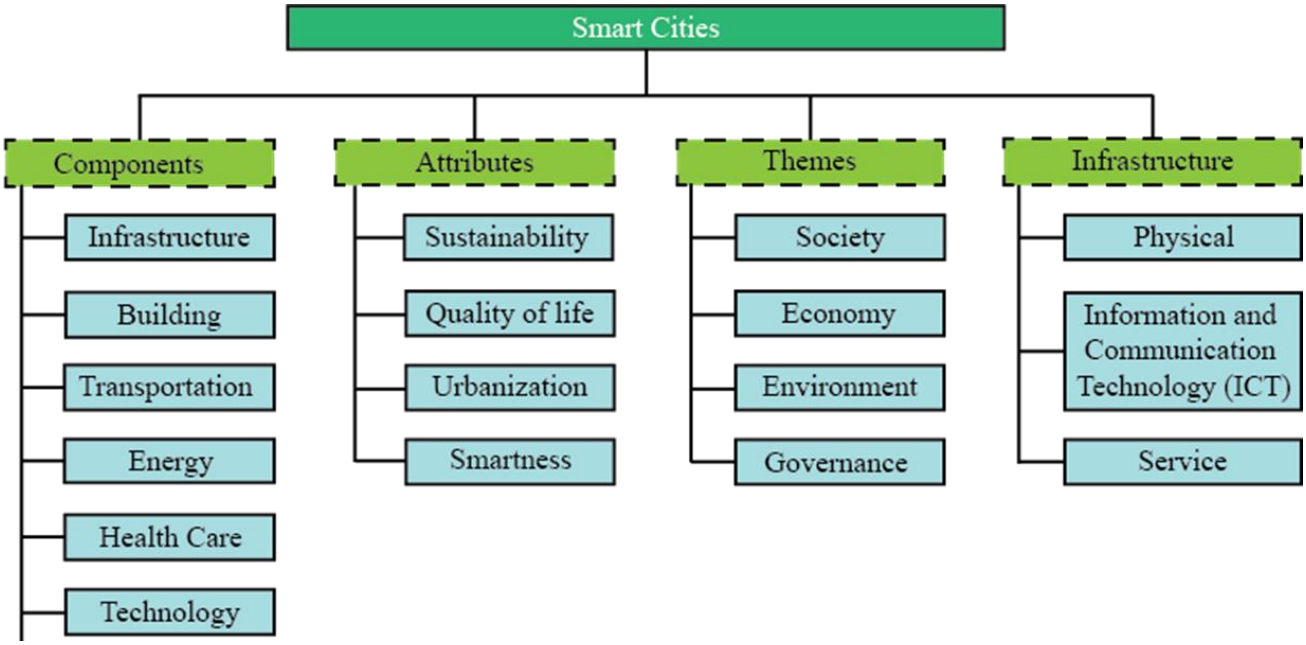
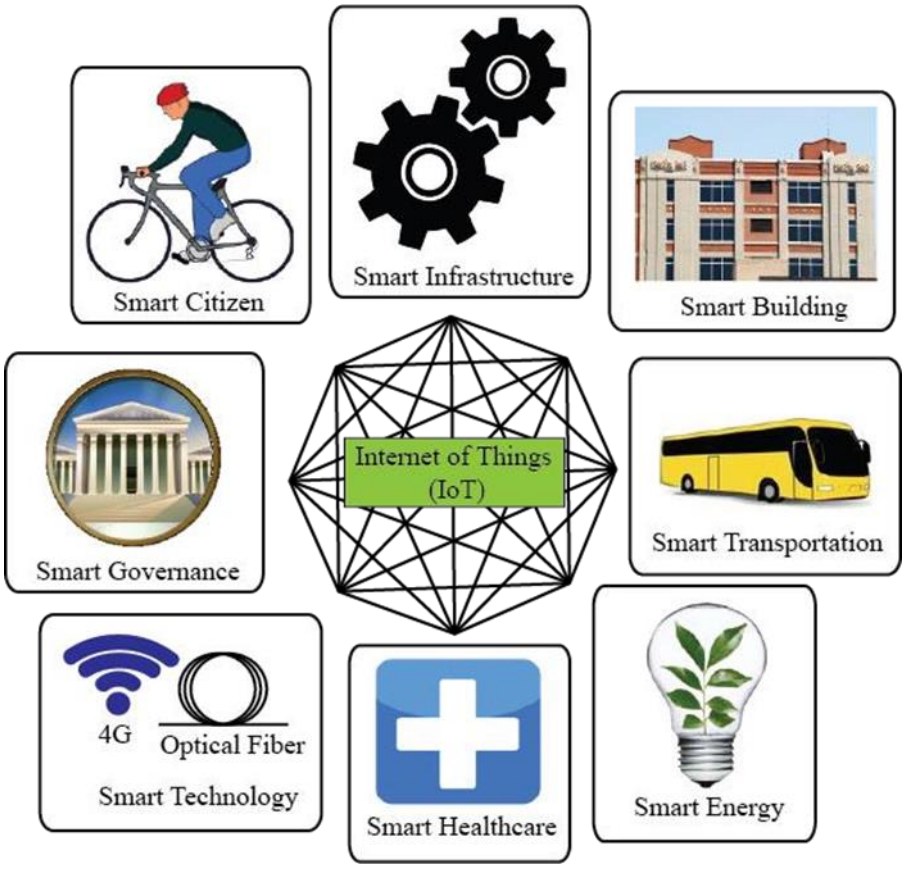
Smart City Components & Characteristics





- The **components of a smart cities** include: smart infrastructure, smart buildings, smart transportation, smart energy, smart healthcare, smart technology, and smart citizens etc.
- The various **attributes of smart cities** include sustainability, quality of life (QoL), urbanization, and smartness.
    - The sustainability of a smart city is related to city infrastructure, energy and climate change, pollution and waste, and social issues, economics and health.
    - The quality of life (QoL) can be measured in terms of the emotional and financial well-being of the citizens.
    - The urbanization aspects of the smart city include multiple aspects and indicators, such as technology, infrastructure, governance, and economics.
    - The smartness of a smart city is conceptualized as the ambition to improve economic, social and environmental standards of the city and its inhabitants. Various commonly quoted aspects of city smartness include smart economy, smart people, smart mobility, and smart living.
- There are **four core themes for a smart city**, namely society, economy, environment & governance.
    - The society theme of a smart city signifies that the city is for its inhabitants or the citizens.
    - The economy theme of a smarty city signifies that the city is able to thrive with continuous job growth and economic growth.
    - The environment theme of a smart city indicates that the city will be able to sustain its function and remain in operation for current and future generations.

- The governance theme of a smart city suggests that the city is robust in its ability to administer policies and combining together the other elements.

- The **infrastructure of the smart city** includes physical, information and communication technology (ICT), and services. The physical infrastructure is the structural entity of the smart city including buildings, roads, railway tracks, power supply lines, and water supply system. The ICT infrastructure is the core smart component of the smart city which glues together all the other components in essentially acting as the nerve centre of the smart city. Service infrastructure is based on physical infrastructure and may have some ICT components.

1. Smart Infrastructure

- The ICT infrastructure is fundamental to the construction of smart cities. The ICT infrastructure includes communication infrastructure such as fiber optics, Wi-Fi networks, wireless hotspots as well as service oriented information systems.

- The smart infrastructure may have physical infrastructure, sensors, software, and middleware as its overall components. The "middleware" which is a specific type of software typically plays a crucial role in the quick response of smart infrastructure. Middleware accumulates data and combines them into a common platform for analytics and reporting.

- When experiencing high energy usage, abnormal maintenance costs, and many normal and abnormal situations, the prompt attention of the operation staff is requested. The middleware provides the operation staff information like carbon footprint count.

- A specific example of smart infrastructure is a **smart power grid** or **a smart grid**. It is a renovated electrical grid system that uses information and communication technology to collect and act on available data, such as information about the behaviours of suppliers and consumers. A smart grid

uses computer-based remote controls with two-way communication technology between power producers and consumers to increase grid efficiency through self-monitoring and feedback. It can provide consumers with information about their energy use and allow them to manage their usage based on both their needs and their affordable prices.

2. Smart Building

- Smart building can be considered as a part of the smart infrastructure or they can be considered as independent components of smart cities. A smart building can have different hardware, software, sensors, and smart appliances, for different automated operations including data network, voice-over-IP (VoIP), video distribution, video surveillance, access control, power management, and lighting control.
- Smart buildings can easily connect to other buildings, people and technology, the global environment, and smart power grids. Smart building can easily adapt to its energy demand as well as that of the grid to have effective and low cost power utilization.
- The advantages of the smart building include: data driven decision-making for high efficiency and low-cost operations, higher resource utilization, reduced capital and operational cost structure, risk identification and management, and sustainability.

3. Smart Transportation

- Smart transportation also known as the Intelligent Transport Systems (ITS) which includes various types of communication and navigation systems in vehicles, between vehicles (e.g. car-to-car), and between vehicle and fixed location (e.g. car-to-infrastructure). ITS also covers the rail, water, and air transport systems, and even their interactions.
- The smart transportation system allows passengers to easily select different transportation options for low-cost, shortest distance, or fastest routes

- Specific example of smart transportation technology include **sensors in vehicles** for collision avoidance to increase the safety of the system. A **radio frequency identification (RFID) based toll collection** is another example of smart transport technology. In the RFID toll collection drivers need not stop at a physical toll booth which typically takes time, blocks the traffic flow, as well as requires manpower for toll collection. **Automatic passport control at airports** is an emerging technology deployed in smart transportation. In automatic passport control, the passengers can use RFID based passports or electronic passports for fast and reliable entry without the need for manual passport check. Another example of smart transportation is the use of **smart apps in mobile phones to hire taxis** and even tracking the exact location of the taxi and driver information in the same smart app.

4. Smart Energy

- Smart energy consists of three independent building blocks that must be stitched together and effectively communicate with each other to form a unified smart energy system.

i. **Low-carbon generation** systems such as a green energy, photo-voltaic, solar thermal, bio-gas, and wind energy can be an important part of a smart energy system.

ii. **Efficient distribution** in the smart energy system is made possible by the use of smart infrastructure, smart grid, smart meters as well as utilization of ICT. The core of a smart energy system is the information infrastructure which is responsible for collecting the energy consumption information. The ICT can be used to control the operations with appropriate level of energy consumption for smart appliances like dishwashers and water heaters. ICT can be effectively used to purchase energy from diverse sources such as solar panels systems, wind turbine systems, and other possible energy sources.

iii. **Optimized consumption** of the system is the third key component of the smart energy system. The effective use of efficient energy storage, smart

metering, and effective energy management can be keys for optimizing energy consumption in a smart energy system.

5. Smart Healthcare

- Smart healthcare is a combination of various entities including traditional healthcare, smart biosensors, wearable devices, ICTs, and smart ambulance systems.
- In smart hospitals, various mechanisms including ICTs, cloud computing, smart phone apps, and advanced data analysis techniques, are used for their operation. The patient data can be made available at various offices in a smart hospital or even various smart hospitals in different cities or the same city. Doctors can see the information to make judgments on a patient's condition. Thus real-time decisions on patient health conditions and medication can be made possible.
- **Telemedicine** can be considered as a specific example of smart healthcare. Telemedicine uses information and communication technologies for providing clinical health care at a long distance, in rural areas or in remote locations.
- Another example in which smart healthcare can have significant impact is in **assisted living** for elders. In assisted living, seniors have as much independence as possible in their daily activities with minimal need of skilled nursing care. Smart healthcare can further add to the quality of life in assisted living for seniors where a doctor, a nurse, a health report are easily available for them.

6. Smart Technology

- Smart technology is key for the design, implementation, and operation of smart cities. Green or **renewable energy resources** such as solar power and wind power are examples of smart technology which is key for smart cities.

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- **Green buildings and green neighbourhood development communities** are also important for smart cities. Green buildings and hence the corresponding communities using them are categorized by standards programs like Leadership in Energy & Environmental Design (**LEED**) and Building Research Establishment Environmental Assessment Methodology (**BREEAM**). The LEED program identifies the best-in-class building strategies and practices. In order to achieve the LEED certification, the building projects must satisfy prerequisites and earn scores to obtain different levels of certification. For example, LEED certification includes important aspects like materials of the building, indoor environmental quality, smart grid, and water efficiency. Similarly, BREEAM includes several categories for the assessment, including management, energy, pollution, materials, waste, water usage, and healthcare.

- A sustainable transport system is a key technology for smart cities. Sustainable and smart transport systems, for example **mass rapid transit systems (MRTS),** can transport large numbers of people from one destination to another. This can reduce traffic congestion and is helpful in reducing greenhouse emissions which have a negative impact on global warming.

- Smart communication technology and ICT are important technologies which include fiber optics to home, citywide Wi-Fi, near field communication (NFC), and Bluetooth. Citywide Wi-Fi can make use of basic services such as calling a taxi easier. NFC can revolutionize the way credit cards are used. These NFC cards help one to make payments without having to physically swipe or dip the card. All one has to do is tap the card against the card reader, and the transaction is complete.

- A specific example of smart technology are smart meters that can measure and record consumption of various utilities such as electricity, gas or water and communicate that information for monitoring and billing to central facilities.

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Benefits of a smart city

1. **Efficient resource utilization:** With many resources becoming either scarce or very expensive, it is important to integrate solutions to have more controlled utilization of these resources. Starting with technological systems like Geographic Information System (GIS) & Remote sensing will be useful for resource management.
2. **Better quality of life:** With better services, more efficient work and living models, and less waste, smart city citizens will have a better quality of life. This is the result of better planning of living/work spaces and locations, more efficient transportation systems, better and faster services, and the availability of enough information to make decision.
3. **Higher levels of transparency and openness:** Adopting ICT, Cloud and big data solutions will help to address issues such as providing the storage and analysis tools. This will encourage collaboration and communication among entities of a smart city. This can be done by building big data communities to work as one entity to foster collaborative and creative solutions addressing applications for areas like education, health, energy, law, manufacturing, environment, and safety. This also helps in real-time solutions to challenges in agriculture, transportation, and crowd management as applications.

Smart City Design: Challenges

i. Cost is the most important factor of the smart city design that includes both design cost and operation cost. The design cost is a onetime cost of the smart cities while Operation cost is the cost required to maintain the smart city. Design cost needs to be small to make a smart city realization possible. At the same time small operation cost will make it easier for cities to operate on a long run with minimal burden on the city budget. **Cost optimization** over the complete system lifecycle can be **a challenging problem**.

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ii. **Operation efficiency** of the smart cities is **an important challenge**: higher efficiency can reduce the operational cost and improve sustainability of the smart city. Cutting down carbon emissions and city waste is needed to enhance sustainability and efficiency, and reduce operation cost, which is really challenging. Moreover, Smart cities need to cope up with population growth while ensuring long-term sustainability with optimized operation cost, which is also challenging to maintain.

iii. Smart cities **need to be resilient to disasters and failures**. Disasters can come from nature. Failures can originate for many reasons in the system such as a failure in ICT, or power failure. Natural disasters also can lead to failure of various components of smart cities. Any smart city design needs to take these disasters and failures into consideration so that the smart cities can quickly recover from such situations within minimal time. The design and operation cost of the smart cities will be affected by these challenges.

iv. Smart cities are made possible due to the effective use of many smart components including ICT, sensors, and IoT and will need to process and store large volumes of data. **Security of the information** and infrastructure is an important design challenge.

v. Above all, **public safety** is a critical design challenge for smart cities, which can also increase design and operation budgets.