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Smart cities: Understanding policies, standards, applications and case studies

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ABSTRACT

This paper presents the integration of required basic facilities of living such as healthcare, education, and infrastructure for building the smart cities. The administrations of smart cities should have the smart governance, safety measures with cultural and social stimulus. Four building blocks of smart cities, i.e., people and environment, smart utilities, smart technology and smart administration are described in the present paper. The aim of this paper is to give a clearer perspective of the key decisions with spatial reference that may assume a key part in the plan of a smart city technique. Application of various technologies, for examples big data, artificial intelligence, machine learning, internet of things (IoT), cloud computing, block chain technology to the smart cities are discussed in this paper. Various challenges of smart cities such as information technology (IT) infrastructure, cost, privacy, security, efficiency, fossil fuel dependency and congested commutes with proposed solutions are also presented in this paper.

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1. INTRODUCTION

With the advent of technology, there is an urge for smarter living space, and the smart city can provide better living by focusing on improving the quality and economic conditions which can be achieved by the implementation of IT systems at different infrastructures of a city [1]. Three best smart cities in the world are Singapore, London and Barcelona. Three most critical requirements for a smart city are citizen engagement, open data/sharing of data, and enhanced services for citizens. Key components of a smart city are city-wide connectivity, inter-operability of systems, and security [2]. The main aim of smart cities are to provide high-quality services to the citizens of the country, make the best use of public resources, and enhance the people's quality of life [3].

In 1999, the internet of things (IoT) is named, but it is popular as IoT. With the advent of time, most of the IoT can make the smart grid smarter. The main objective of the IoT technologies is to make the traditional devices to intelligent and which can be operated or managed from anywhere and anytime over the web. IoTs can able the machine and the man to interact with many devices such as sensors, relays, measuring instruments, actuators, and many other devices connected to the web. IoT plays an important role in many applications like smart grid, business, education, healthcare, smart building and cities and smart irrigation system. The IoT is widely used in smart grid applications such as power generation, transformation, transmission and distribution. However, security is the main challenge in IoT. The web is not a secure medium of communication for the IoT. Grid security plays an important role in the smart grid. In the similar

lines, the big data is widely used in smart grid applications.

Big data technologies can provide cheaper and more accurate data for analysis purposes. If the data is not up to date or not accurate, the analysis becomes an empty talk. Data can be classified into three categories: structure data, unstructured data, and semi-structured data. Unstructured data contains of data in an unknown format or structure, and it creates a lot of challenges while it's processing. Semi-structured data contains both structured data and unstructured data. Structure data contains the data in a fixed format. There are three V's of big data: volume, velocity, variety. A lot of data has been generated in power enterprises, and this data may be dispatching operation data, load monitoring data, customer service data, watt-hour meter data, maintenance record data, and so on. Power measurement data is widely used to forecast the distribution and detects the faults. Data can be collected by using various data-generated devices and sent to the master station by using wired or wireless transmission. To avoid the data damage, we can do a backup work, so that the storage of data can reduce the risk of data damage. Data identification, collection, storage and filtering, classification and extraction, cleaning and summarization, analysis and processing, and visualization are the various life cycles of big data analysis. Various applications of big data analytics in the smart grid are demand-side management, renewable energy forecasting, energy production optimization, state estimation, electric theft detection, and predictive maintenance.

Trindade *et al.* [4] analyzes the scientific studies which are focused on both smart city concepts and environmental sustainability to understand the relationship between these two. A comprehensive overview of literature on smart governance, which is defined as the technology enabled collaboration between the local governments and citizens to advance sustainable development is presented in [5]. Lim *et al.* [6] contributes to policy development and urban planning in modern data-rich economy. El-Gazzar [7] discusses about smart city, sustainable development, sustainability, and smart sustainable city. Corcuera *et al.* [8] describes the issues that need to be handled for moving towards the cities of future and the future sustainable opportunities for smart cities. A comprehensive overview of available possibilities and relating them to the specific city challenges is presented in [9]. A state-of-the-art overview of smart cities in relation to the sustainability and related big data analytics is presented in [10].

A detailed overview and applications of blockchain in smart grid environment in a smart city has been presented in [11]. Ferrer [12] presents a unique opportunity, in which the recent technologies represent for the smart cities to embark on a more sustainable path, and it is realized by engaging the citizens. Kummitha [13] presents an overview of state-of-the-art literature how the smart cities influence entrepreneurial business models and the field to contextualize the role that an entrepreneurship plays in building the smart cities. Bouzguenda *et al.* [14] introduces a new hierarchical model between sustainability and the digital citizen participation based on exhaustive review.

This paper presents the four building blocks of smart cities, i.e., people and environment, smart utilities, smart technologies and administration. The smart living, smart environment and smart mobility are focused areas for smart utilities. Smart utilities need latest technologies such as real time monitoring, control and optimization of asset for proper smart city functioning. The smart city scene is formed under nearby attributes, needs and the necessities of urban communities, notwithstanding worldwide market powers and accessible innovation. The utilities of smart city should use renewable energy sources (RESs) for environment friendly operations employ automated solutions for effective operations and ease availability of data to the customer.

The rest of this paper is organized as follows: Section 2 presents the description about the building blocks of smart cities. Policies and standards of smart cities are presented in section 3. Section 4 presents various technologies and their applications to the smart cities. Social impacts of smart cities is described in section 5. Finally, the paper is concluded in section 6.

2. BUILDING BLOCKS FOR SMART CITIES

For supporting the smart living, the utilities must have latest, real time technologies which are user friendly and environment friendly. The building blocks of smart cities are depicted in Figure 1. Four building blocks of smart cities are: people and environment, smart utilities, smart technologies and administration. The brief description of these building blocks is presented next.

2.1. People and environment

Two important stakeholders involved in the smart cities are people and environment. People will enjoy and drive the smart governance, living and economy. However, the environment requires to be nurtured and should not get adversely affected in achieving the vision of smart cities. The important goals of smart cities include easy and online access to information in real time, smart and fast commutation, digitization of economy, effective governance, technology up gradation, and new technology adoption [15].

Environment friendly development and new technology adoption inherently brings about an environment friendly development. A simple example for this is the utilization of RESs by the utilities.

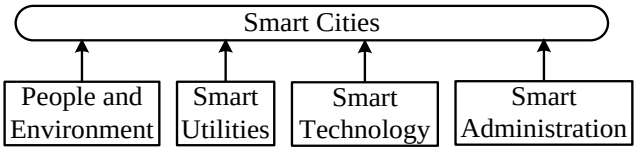

Figure 1. The building blocks of smart cities

2.2. Smart utilities

Smart utilities are the organizations which operate and maintain necessary infrastructure to provide services to the public. These are the second building block of smart cities play a vital role in making the city smarter for its citizens. Four major types of utilities are electric, gas, water and sewage. The entire four sectors have very close relation with environment, and every utility affects environment directly or indirectly such as increase in carbon emissions in the air or injecting harmful chemicals in surrounding environment during their operation. As environment is a vital stake holder for smart city, utilities should take steps to reduce carbon emissions by adopting latest technologies which can reduce carbon foot print. They should also adopt technologies which result in injecting less or clean by-products to surrounding environment. Also, they should engage their customers in their day-to-day operations to get the optimum results [16]. Smart customers and smart technology are the two major components of smart utilities. Figure 2 depicts the major components of smart cities and smart utilities.

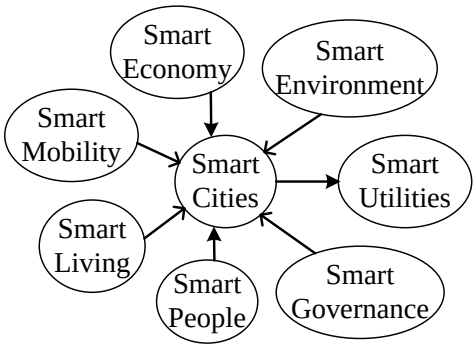

Figure 2. Major components of smart cities and smart utilities

2.3. Smart technologies

Utilities need to embrace the advent of technology to strengthen the grid operations. With the progress of smart cities concept, utilities should focus on real time monitoring of grid and employ analytics on the data fetched in real time [17]. This will improve grid operations and optimization. Growing concern about changing environment has created the need for use of smart technology in utility. Smart technology can be realized with advanced information technology (IT) and operational technology (OT) systems, enterprise level integration, real time analytics and grid optimization. Smart utility development will result in mutual growth and benefits for the customers, utility and environment. The realization of smart customers can be achieved by smart metering infrastructure, customer engagement and social media integration [18]. The critical areas of benefits will be;

- Improved customer interaction: Customers will have better interaction channels available. Also, the empowered customer will help utilities to operate in a smarter way.
- Improved grid optimization: With the help of technology and customer participation, real time monitoring and control of grid will help optimize the grid's output and develop self-healing capability.
- Sustainable tomorrow: Smart city's important stakeholder is environment. With the use of environment friendly technology will help to have a sustainable tomorrow.

2.4. Smart administration

Various challenges of smart cities include technological challenges, financial constraints, lack of collaboration among different stakeholders and governmental restraints, managerial and organizational challenges, and social challenges. The smart administration deals with smart and open managers, and with their citizenship and professionalism, they are going to use efficient instruments to carry out their activities [19]. Smart administration is the;

- Smart and open administration, which uses their civility and professionalism. By using this, they can exploit the instruments efficiently to carry out their activities.
- Sustainable development of informative and serving activities towards the citizen.
- Open data, which will be useful for reshaping of relations between the governance and the citizens.

The cities of the future, asks the intelligent individual to create an efficient and intelligent relationship with the nature, society, and labor [20, 21]. It is not a coincidence that public administration is considered as an important link to guarantee a sustainable development. A smarter way of working for the city administration allows the objectives within and outside the municipal organisation, and the true integration of smart city aims.

3. POLICIES AND STANDARDS

The smart urban areas' point is still to a great extent under investigation. The focal points and hindrances of each key decision were introduced, refined after a thorough audit of ongoing smart city writing. These diverse ways rise as double or multi-faceted, prompting a scope of choices that fundamentally separate the result of smart city. Which accessible alternative is best available to exchange [22, 23]. Surely, a few proposed or connected smart city methodologies lay some place in the middle of extremes of the accessible vital decisions. Besides, this paper has just tended to key options with a spatial reference. There is a scope of other key decisions without spatial reference that should be handled in the smart city configuration process [24]. One could be, for instance, regardless of whether the methodology will be founded on an open advancement or shut development show. Another could address the plan of action and its social ramifications behind the smart city wander. These vital decisions have been referenced haphazardly all through the smart city writing yet have never really been ordered completely and archived starting at yet [25].

Smart city investigate can be seen as a strand of neighbourhood electronic government see into region, it may be a city that got to have a shrewd city government in charge of speaking to the city by applying the palatable courses of action towards savvy city purposes. It may be an urban zone that has to behave the way of life of innovativeness and progression, tall calibre of life, money related improvement, be secure, and be socially, fiscally and soil temperate. Shrewd organization as a key calculates for the execution of sharp urban communities. Where a savvy city government utilizes a shrewd organization displays for fulfilling their smart urban ranges purposes by applying the appropriated methodologies towards those reasons [26]. The measures behind a smart organization demonstrate can enable and potentiate basically the creativity and improvement within the utilization of savvy urban ranges. The grouped assortment of a city settings, (eg. monetary, social, political, definitive and innovative), challenges (eg. political, regulatory, social and specialized), perils (eg. authoritative, utilization and human constrain) and execution targets (eg. targets, approaches, organization and advancement) found within the dissected exercises, plainly demands contextualized savvy urban ranges arrangements [27].

An investigation by subject uncovers that universally, activities are pointed principally at the supportable improvement of urban communities by characterizing prerequisites and estimation markers, and at normalizing the framework utilized [28]. In the assembled kingdom, the emphasis has been on distributing an advancement system to give a technique to characterizing a smart city procedure. Interestingly, France has tried endeavors to institutionalize its framework and the nature of portability, and also to characterize the prerequisites and supporting rules and procedures for economic advancement and for the estimation markers [29]. In Spain, institutionalization endeavors have been overwhelmingly gone for institutionalizing foundation, trailed by activities including government and smart goals. Thinking about the difference in the methodologies, clearly this is as yet a work in advance, however gauges can, to a huge degree, help institutionalize imperative parts of our urban areas. They are along these lines a vital part to consider later on, however they will require union [30].

4. APPLICATION OF TECHNOLOGIES TO THE SMART CITIES

Smart city is characterized by the integration of technology and intra strategic approach to sustainability, citizen’s wellbeing and economic development [31]. The key drivers and trends which influence a move toward smarter and sustainable cities are ageing city infrastructure and increasing size and

density of cities has created complex service delivery challenges for city authorities; increases in awareness towards RESs; move towards efficient energy infrastructure, homes and appliances; and regulatory compliance to reduce carbon emissions [32]. Various technologies and their applications along with examples is presented in Table 1.

Table 1. Application of technologies to the smart cities

Internet of things (IoT)	Water management	IoT as water management plays a major role in leak detection, optimized contamination monitoring, maintenance, quality control, and more.
	Smart surveillance	IoT physical security include facial recognition, tampering alerts, intelligent monitoring, perimeter protection, and automobile tracking.
	Chemical detection	Detect leakages and wastes of factories in rivers.
	Monitoring energy consumption	IoT provides a service of energy consumption detection of whole community thereby providing citizens of energy consumed by various services like transportation, and public lightning.
Big Data	Health care	Permit healthcare vendors and practitioners to acquire, examine and utilize patient's information, which also can be utilized by insurance agencies and a few government organizations [33].
	Education	Optimize educational research; for example, an astronomer can examine a massive astronomy dataset with aid of effective computer systems rather than guide analyses. By analyzing excessive quality digital images taken from area, new discoveries may also show up in the fields. That is applicable to many science and research areas which includes clinical experiments, production operations, environmental research, economic and financial evaluation [34].
	Smart grid	Integrating, analyzing, and use real time power generation and consumption of various environmental data.
	Transport management	Information of public buses, traffic free area, modes of transport, attached sensors to the vehicle indicating near parking lot, petrol bunks thereby reducing queue length.
Artificial intelligence (AI) and machine learning (ML)	Transportation	According to the Department of Transportation, averagely adaptive signal control technology, a method of artificial intelligence (AI) improves travel time by 10 percent; in areas where signal timing information is outdated the improvement percentile is expected of about 50%.
	Automated networks	A key enabler is the use of ML and AI techniques to drive network automation. ML and AI have seen a resurgence in investment with renewed promise because of 2 changes in recent years: availability of many more data points, and deployment of specialized silicon providing highly parallel computation increasing processing capacity for data processing making AI and ML technology less "brittle'' [35].
	Parking	VIMOC technology is using AI to make parking simpler in Redwood town. The enterprise hooked up car detection and reporting in metropolis's massive parking garages. The amount of available parking is displayed outdoor the garages on large LED signs and shared with an open platform to be used via app developers. It offers the immediate advantage letting individuals know wherein parking is to be had, and within the long term, the wealth of information gathered will permit the city to make planning and pricing decisions [36].
Cloud computing	Business	The technology offers nearby communities to collect cash for social and charitable purposes. It offers organization the ability to co-finance tasks such as: i) For urban environment improvement, ii) Social entrepreneurship, iii) Skill knowledge and technology based youth entrepreneurship.
Block chain technology	Energy management	Block chain technology is used in power systems to create a marketplace for the electrical power supply. Micro generation of electricity through home power generation using traditional power supply, solar energy supplements and promotes the use of RESs.
	Public safety and justice	Block chain could make the public safety more efficient by resolving the problem of interagency coordination by providing a unified source of truth in which each agency independently interfaces with it based on the predefined conditions.

5. SOCIAL IMPACTS

Smart urban centre conception is based on learning of a wad of information. The potential of this information is exceptionally gigantic and can uncover a part of things approximately the individual [37]. Administration sureness ought to guarantee the privateer's angles are uncovered. A smart city concept as is being talked is within the creating nations, such as India, Brazil, where a huge number of populaces are digitally illiterate when digital services are thrust upon non-technical knowledge people, they are susceptible to lot of self and system damage. This issue need to be addressed on priority. For illustration, senior mortal is restricted to broadband due to the lack of abilities. Therefore, people might need data on how to utilize a few innovations such as: smart meters [38].

5.1. Road map

An innovative resilient city is centering on the financial framework, beau monde, framework, portability, vital arranging, and a solid family relationship with all inhabitants. Ever since the mechanical gyration, citizenry have been urbanizing at an exponential rate. Hundreds of thousands of modern residences are as of now being built each day. As of 2015, roughly 52% of the human creature's populace lives in city. Each hebdomad, there are more than a million unused individuals moving into urban center, around the world. By 2050, the united nations (UN) anticipate that 6 billion individuals will be activity in cities [39]. Since cities expend around 70% of the worldwide imperativeness utilize, the strain on asset and the size of challenge that cities human confront is phenomenal. As a result, it is basic to create solvent that make strides the livability of city whereas strikingly lessening asset utilization. Individuals, oblivious handle, and innovation are three backbones of shrewdness city activities that can be utilized to ease such a challenge. Cities and provinces ought to report their community of interface, make approaches, and execute mechanical root to meet the wants of their neighborhood communities [40].

Local, state, and fed administering must be imaginative and create a street outline to address and give arrangements to moderate dangers and challenges to make a maintainable from now on for their citizens. Advanced move is one choice that governments can depend on to overcome numerous of these challenges; other choices may incorporate embracing e-government, locks in inhabitants, and frame in strong cities. Political science official must construct a consolidation to collaborate, leveraging, and coordinated innovations to form genuine financial openings by support a citywide, smart, secure, and strong transformation [41].

5.2. Challenges and solutions

By 2050, world's urban populace may reach 6.3 billion. As of 2017, 33.5% of add up to Indian populace lives in urban regions [42]. Shockingly, for the primary time since autonomy, the development in urban populace is higher than country. This combined with rising movement to these created cities require that our cities to be 'smarter'. Realizing this requirement, the Indian government has shortlisted 20 savvy cities out of 98 for its 'Smart Cities Mission' [43]. Table 2 presents some of the challenges of smart cities and proposed solutions.

Table 2. Challenges of smart cities and proposed solutions

Challenge	Proposed solution
IT infrastructure	Zone wise execution of each open benefit does not require all frameworks at once [3, 5].
Cost	Zone wise execution of each service may not require tremendous speculation at once. In a long run, utilization of ICT to provide open administrations will change the speed and viability of open benefit conveyance and organization, in turn, giving made strides benefit conveyance decreased customer costs and social benefits [5].
Privacy	Uncovering data administrations as web services can make information benefit data open to a wide assortment of client. Web administrations make it conceivable for frameworks to coordinate with each other autonomous of fundamental stage [3, 5].
Security	The proposed smart city engineering prescribes uncovering information as web benefit. WS-security is especially valuable since it gives encryption-based, message-level security information [3, 5].
Efficiency	In real time, questions from numerous spaces is served by primary information zone level consequently the proposed design works with way better effectiveness. Through web benefit different offices can facilitate and co-operate rapidly subsequently increments effectiveness. As real information is accessible for investigation so asset arranging at each centres and central information administration framework helps in effective arranging and utilization of assets [3, 5].
Fossil fuel dependency	Distributed energy management use new business models, renewable energy, and more astute storage to improve sustainability [29].
Congested commutes	Digital mobility systems can oversee constrained street space to improve transportation value and discuss quality [29].

6. CONCLUSION

This paper presented four building blocks of smart cities, i.e., people and environment, smart utilities, smart technologies and administration. The important areas of smart city development include smart building, smart energy, smart transportation, smart water, and smart government. Cities and districts confront numerous challenges and chance of introduction, such as unemployment, destitution, dealings blockage, tall wrongdoing rates, cyber attack, and moderate bureaucratic frameworks for preparing line of work exchanges. The smart living, smart environment and smart mobility are focused areas for smart utilities. Smart utilities need latest technologies such as real time monitoring, control and optimization of asset for proper smart city functioning. The smart city scene is formed under nearby attributes, needs and the necessities of urban communities, notwithstanding worldwide market powers and accessible innovation. The utilities of smart city should use renewable energy sources (RESs) for environment friendly operations employ automated

solutions for effective operations and ease availability of data to the customer. Smart customers and smart technology are the two major components of smart utilities, and they are presented in this paper.

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