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8. Big-Data and Smart Cities: Exploring Futuristic Opportunities

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i. Abstract

Technology has made the expansion and development of countries easier, and the approach has completely changed in the past few years. Big Data technology was introduced in the early 2000s and has helped to store and analyze large amounts of data. The evolution of the Internet of Things (IoT) has contributed to the feasibility of smart city initiatives. Governments are exploring the opportunities to provide better facilities to its citizens. The combination of the Internet of Things and Big Data is an unexplored area and can be exploited for achieving the goal of futuristic cities. India has also declared various cities to become smart cities soon and is considering adopting new concepts in the cities and implementing big data applications to achieve sustainability to provide better living standards.

Future smart cities will utilize multiple technologies to improve the health, transportation, education, and provide better management of resources leading to higher levels of life of citizens. Big data analytics will have a huge impact in shaping the smart cities. Digitization has become an essential part of our everyday lives and Big Data has become the key factor for various businesses. This research will discuss Big Data technology in detail and how it can be used in the smart city projects. It also discusses the challenges that will be faced like the issue of privacy and the need for smarter laws. The research shows that several opportunities are available that are waiting to be explored for utilizing big data, but it can only be successful if all the entities involved work in collaboration for the betterment of the society.

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1. Introduction

Technological advancement is seen to play a key role in the growth of the nations and overall global economic structure. Technological changes are creating immense transformations in the way corporations and nations have started to organize data of all the individuals and using it to organize production, provide better facilities, aid in economic development, provide goods and services as per consumer needs among other things. A large amount of data is generated in big cities which are stored in a pattern that can be used effectively for the betterment of the society. An integrated system of managing and analyzing this data can lead to a better perspective of the society and can also answer several questions relating to policymaking, planning, general governance, and business operations to support decision making which will enable a smarter environment.

According to a survey, almost 50% of the world's population lives in urban areas, which is likely to increase to nearly 60% by 2030[141]. High levels of urbanization are more prominent in developing countries and it will also increase in the near future[142]. Increased urban population can strain the limited resources available with a city leading to many challenges like scarcity of resources which makes the governance difficult. Furthermore, good sustainable development, economic growth, and effective management of natural resources in the urban areas require better planning and collaboration between the different organizations at the urban level. For this purpose, innovation is required, that can provide integrated information for better urban management and governance with the available resources.

In June 2015, in India, the Centre launched a project named '100 Smart Cities Mission'. The cities under this project included major Indian cities like Pune, Jaipur, Kochi, and Jabalpur and as per the mission these were supposed to have better infrastructure, housing facilities for all, open spaces, among other things.[143] Cities in India put up nearly 31% of the total population

[141] . Mutizwa-Mangiza ND, Arimah BC, Jensen I, Yemeru EA, Kinyanjui MK (2011) Cities and climate change: Global report on human settlements. In: Global Report on Human Settlements, p.250. UN-HABITAT.
[142] European Environment Agency (2006) Urban sprawl in Europe - the ignored challenge. Technical report, European Commission. ISBN: 92-9167-887-2, http://www.eea.europa.eu/publications/ eea_report_2006_10/eea_report_10_2006.pdf [Last accessed: 21st January, 2015].
[143] Varun B Krishnan, What is the status of Smart City projects in India?, JULY 15, 2019, https://www.thehindu.com/data/what-is-the-status-of-smart-city-projects-in-india/article28441952.ece, last accessed on 16.05.2020.

and contribute 63% to the GDP (2011 Census). By 2030, the urban areas are anticipated to house 40% of the total population and contribute to 75% of the GDP. To accommodate such a huge population, the urban areas will require a thorough development of physical, institutional, social, and economic infrastructure because these are essential in improving the quality of life and attracting more investment for growth and development. The development of smart cities is a step towards this growth[144]. The 'Smart Cities Mission' initiative will aid economic growth and improve the overall quality of life of people by local development which will generate smart results for the citizens. The smart city project is perceived as a means of solving urban issues through the effective use of information technology.

2. Big-Data

Big Data is the usual data but it is a term used to describe a huge collection of data. Such kind of data exists as a collection and grows exponentially with time. The data is so large and complex that it is not possible to process it using traditional methods. The accessing and storing of large amounts of data for analytical purposes has been done for a long time now, but 'Big Data' as a concept gained popularity in the early 2000s. In 2001, an industry analyst Doug Laney had come up with 3 V's of big data which have now become a part of its definition:

Volume: It refers to the huge amount of data that is generated every day through both online and offline sources. The amount of data needs to be assessed for relevance to provide better options. All organizations collect user data from their personnel or through social media and storing such large amounts of data becomes an issue as conventional methods of storage will not satisfy the purpose of collecting this data, it can only be utilized if stored effectively for future use. Facebook for example has more than 2.6 billion active users while Twitter has almost 330 million active users per month, and every day these users add on to the already existing data in the form of images, videos, posts, tweets, etc. Such huge volumes of data are produced every minute and it presents a challenge because to process such volumes a proper structure of storage is to be prepared.

[144] Smart Cities Mission, National Portal Of India, https://www.india.gov.in/spotlight/smart-cities-mission-step-towards-smart-india.

Velocity: It refers to the pace or speed with which data is being produced every minute through different sources. By the use of social media itself, millions of photos and videos are uploaded in an hour and this is like an explosion of data. Big Data technology enables an organization to control the flow of data and simultaneously process it to prevent any issues that might be experienced later. The advancement in internet technology is the reason behind the inflow of data at an unprecedented speed that must be handled promptly. Normally, the high-velocity data is stored directly into memory and all the data needs to operate in real-time for evaluation and action.

Variety: It refers to the diverse structured and unstructured data that is generated by both humans and machines. Unstructured data are difficult to deal with but still are an important aspect of Big Data. Variety is the classifying ability of the incoming data into various categories. The data rarely comes in a perfect order which can be processed without any changes. Sources of data are diverse and therefore the diversity or variety in the data received. The reason for the variety in data could be the use of different software versions by different people to communicate data, withholding of parts of information, different browsers send different data, and it is also most common to expect error and inconsistency when information is expected to be entered by humans[145]. The use of big data processing is to separate the useful information from the variety of unstructured data and store it in an orderly manner.

Therefore, Big Data involves a Large Volume of data coming in at a high Velocity in a Variety of forms. Data is being generated every second of every day; nothing can stop the data inflow from various sources. This data is what is currently known as Big Data. Data sources are around us everywhere, right from the smartphones we use to the computer systems and environment sensors. Various websites have contributed to accelerating data generation in the past few years[146]. There is no single definition of Big Data as different definitions provide different perspectives but all point to the same concept. Big Data is stored at different places and it is owned by different entities, yet most of it goes unused. The potential for use in Big Data is very high but it is so much in volume and unstructured that a lot of time is spent on sorting the

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[145] Edd Dumbill, Volume, Velocity, Variety: What You Need to Know About Big Data, Jan 19, 2012, https://www.forbes.com/sites/oreillymedia/2012/01/19/volume-velocity-variety-what-you-need-to-know-about-big-data/#411928fb1b6d.

[146] Khan Z, Anjum A, Kiani SL. Cloud Based Big Data Analytics for Smart Future Cities. In Proceedings of the 2013 IEEE/ACM 6th International Conference on Utility and Cloud Computing. IEEE Computer Society; 2013. pp. 381–386.

relevant information from the immense pool of information. If proper technique is used, the data can be sorted at the source itself and insights can be obtained through analysis, data intelligence, and data mining. Now, Cloud technology has also become a huge part in supporting big data analytics. It provides an efficient solution to store large amounts of data and is good for intensive applications.

3. Application of Big Data to Smart City Projects

The practice of turning cities into smart cities has suddenly gained momentum and governments are trying everything possible to provide a better living. A city becomes a 'smart city' because of various reasons like better water and waste management, good transportation, safety, and welfare of all residents among other things. A smart city can promptly respond to the needs of its citizens. Governments are starting to embrace smart city ideas to improve the standard of living by implementing Big Data applications as the information is utilized in developing better infrastructure and facilities for the residents. Big data can transform every sector in a city to make it a smart city. To start the process of developing a smart city, various areas should be first identified that need to be worked up on to provide quality life.[147]

A smart city will employ different technologies relating to artificial intelligence and machine-based algorithms to process the huge volume of data inflow that will be made available to a person for processing using their sense of judgment. These programs will make use of rapid improvements in computing and networks in the coming years.[148] The technical development of smart cities is proceeding very quickly due to developments in Big Data, Cloud technology, and the Internet of things, but the governments still lack a cohesive understanding of the concept of the smart city as a whole. The technology has its downside; with varied complex units and operations for creating good opportunities, the government will have to face many challenges.

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[147] Bhushan Aher, How Big Data Impacts Smart Cities, Apr. 20, 18, https://dzone.com/articles/how-big-data-has-the-biggest-impact-in-smart-citie.

[148] THE SMART CITY STORY IN THE 21ST CENTURY, October 02, 2018, https://publicpolicy.wharton.upenn.edu/live/news/2632-the-smart-city-story-in-the-21st-century.

Few of the benefits of smart cities and technology are:

1. **Efficient utilization of resources**: The resources available with a nation are not sufficient to provide for the fast-growing population; scarcity of resources can already be seen and therefore, there is a need for effective solutions to control the use of resources. The data collected from smart cities will help in realizing the need and then the proper allocation of the resources to different sectors. It will promote sustainable development and aid in growth without compromising with the future.

2. **Data-driven decision making**: The decisions made for the development and welfare of citizens will be based on the data provided by the citizens themselves. The decisions will be supported by the facts and figures and the government will not be able to make any arbitrary decision. The data will show the existing scenario clearly and the use of the software will provide what can be done to address the issues or what can be done for the betterment of the citizens.

3. **Better quality of life**: As the majority of the population resides in urban areas, the smart city projects will be able to provide a better quality of life to most of the citizens of the country. Better services, an efficient work environment, and better amenities will all be possible with the Big Data used for smart city projects. With the available information, informed discussions will be made and better planning of living/workspaces will be possible.

4. **Transparency and openness**: Big Data will lead to a higher level of transparency as all the possible data will be store at a fixed location for analysis. Also, the same information will be accessible at all levels of the management. Information and resource sharing will become the new norm. The need for better management and control of smart cities will drive the interoperability and openness to a great extent. The transparency in information will encourage collaboration and free communication between all entities involved in the smart city project that will further enhance the output and there will be even better facilities for the people.

Big data applications used can serve many sectors in a smart city to provide better customer experiences by which businesses will achieve better performance. Healthcare system can also be improved drastically by the improvement in care services, diagnosis, and treatment, with

the use of records. User information will help in optimizing the transportation system as per the needs; route and schedules can be adjusted for varying demands and it can be made more environmentally friendly.

Use of Big Data applications require Information and Communication Technology (ICT) infrastructure. It is essential because it provides unique and useful solutions for better use of data. The large amount of data generated in cities is in various formats and from various sectors; this data is collected in massive amounts and offers a real-time view of the ongoing task at different places in the city. Big Data technology allows utilization of this data by providing suitable tools, which properly structure the data into desired categories so that it can be used for the development of a smart city. Advanced software with data management features are required that can easily recognize the formats and sources of data and also provide for scalable handling of massive data for offline applications.

4. Challenges

While the Big Data technology offers a lot of benefits and is a futuristic approach, it comes with its challenges. Big Data allows for an in-depth analysis of the information received by forming patterns and such information is widely used in a lot of projects and businesses. There has been a lot of investment for Big Data research and infrastructure because of its benefits. But lately, the researches point out the legal issues of privacy, government regulation, international access of stored data, and increased criticisms of digital information gathering[149]. Also, Big Data is so huge in volume that even though new technologies are continuously being developed for its storage but the rate at which its volume increases, it is difficult to keep up with it. There are so many systems sending data at the same time and failure of even one can affect the whole system.

Organizations somehow manage to store the data, but storing is not enough as it needs to be curated into something valuable. Sorting the data requires a lot of work and for a smart city

[149] Cayce Myers, BIG DATA, PRIVACY, AND THE LAW: HOW LEGAL REGULATIONS MAY AFFECT PR RESEARCH, June 11, 2018, https://instituteforpr.org/big-data-privacy-and-the-law-how-legal-regulations-may-affect-pr-research.

project; the amount of data generated will require a lot more effort. The Big Data technology is also evolving rapidly, analysts need to keep up with the latest technology as well[150]. In a survey, it was found out that data scientists generally spend 60% of their time in cleaning and organizing the data collected and 19% on collecting the data sets; it means they spend around 80% of their time on preparing and managing data for analysis. 'Data Munging' was a term popularized by data scientist Mike Driscoll in 2009, which means the "painful process of cleaning, parsing, and proofing one's data"[151]. The evolution of smarter cities presents many challenges for local governments as well as IT professionals. As cities become more reliant on technology than ever before, IT professionals will be exponentially more important. The introduction of new technology will have to be braced with the development of new skills.[152]

Security Concerns: The data collected for the smart city projects will contain private and sensitive information of individuals, therefore, it is required by the authorities to ensure that the maximum level of security and privacy mechanisms are in place. The information if leaked, can pose several threats to the individuals. Because of possible illegal access, the safety, wellbeing, and privacy of individuals is at stake. Malicious attacks by hackers are now common because technology advancement has made that possible as well. Such attacks can lead to catastrophic results affecting the lives of individuals as well as the infrastructure developed under the smart city project. Big data application developers must ensure the utmost levels of security and develop privacy policies and procedures as an essential part of their design. Clear guidelines and strict laws should also be made by the government to ensure the security of its people.

Since smart cities require large volumes of data and such analytical models to achieve the desired goals, data security experts have continuously warned against the effects that hacking, data loss, and technical glitches can pose in a smart city. This concern is not unfounded because the system that will be the center will be based on cloud computing technology and all the

[150] What Is Big Data?, https://www.oracle.com/big-data/what-is-big-data.html.
[151] Gil Press, Cleaning Big Data: Most Time-Consuming, Least Enjoyable Data Science Task, Survey Says, Mar 23, 2016, https://www.forbes.com/sites/gilpress/2016/03/23/data-preparation-most-time-consuming-least-enjoyable-data-science-task-survey-says/#4cb53df16f63.
[152] WORLD DEVELOPMENT REPORT 2016, http://documents.worldbank.org/curated/en/896971468194972881/310436360_201602630200228/additional/102725-PUB-Replacement-PUBLIC.pdf.

information will be stored on it and the smart city will heavily rely on this for the storing of data. Although cloud computing technologies are continuously developing, yet their usage for smart city integration introduces various threats that are to be considered for security management[153].

Privacy is too valuable for everybody that it cannot be compromised with. Every individual or organization involved in a smart city project will have to understand and acknowledge what data privacy means. Smarter cities can easily be made, but in doing so, all aspects need to be considered equally otherwise there is no benefit of developing complex systems.

Smarter Laws: It is very important to bring necessary changes in India's existing legal framework to help in sustainable urbanization and the development of smart cities in the country. New laws are necessary to make the government's Smart Cities Mission successful and to implement it as intended. The cyber law in our country has been amended continuously to suit the needs but it is not yet sufficient to provide for data privacy which is required for Big Data technology. As cities are developed, they utilize new and disruptive technology; all types of data is gathered and stored, from a person's location to their daily activities – all this to develop a smart city. Such data collection gives rise to several legal questions on the issue of responsibility for the protection of this data, its exploitation, and how the citizens can be protected from all possible threats and also who is responsible for providing such protection. The issue of consent is also equally important; consent needs to be there before capturing and processing data of individuals.

The laws are not well equipped to protect the specific uses of data that mobile apps and other sources used for smart cities. Personal information of an individual belongs to him only but can be shared or accessed legally if the individuals or organization receiving it have a legitimate reason to do so. Generally, companies, local authorities or councils are viewed as data controllers and are expected to comply with all the associated obligations to ensure data privacy. Current laws were not made to deal with smart cities or other futuristic approaches, so regulators should issue more guidelines to make the process transparent and suggest how individuals can protect themselves against inappropriate use. Unfortunately, as technology is

[153] Chris Giarratana, How City Engineers will Address Big Data Challenges in Smart Cities, February 17, 2019, https://www.trafficsafetystore.com/blog/how-city-engineers-will-address-big-data-challenges-in-smart-cities.

advancing, those looking to exploit loopholes are often looking for inventive techniques to obtain users' data[154].

Involvement of private entities: A successful smart city project will require effective horizontal and vertical coordination between all departments of the central and state governments as well as the private entities involved. The project will involve different institutions offering different services, and proper implementation will have to be done for various issues like distribution of finances, best practices, and service delivery processes. In any country, various private vendors are also involved in a project, so is the case in India. It will be a challenge to handle all the components from different vendors and bring them together to produce the desired result[155]. In big projects, government agencies and private sector organizations are often reluctant to share information easily amongst each other. The information contains sensitive data and can be related to common networks, tools, or infrastructure; if shared properly, it can be used to prevent external attacks and aid in better amenities.

The government can create stakeholder groups of service providers to encourage them to share information, and also try to offer them incentives to encourage open collaboration. A common digital infrastructure can be built to support intelligence-led policing, which will allow agencies to monitor data, establish patterns, and get insights. Private organizations should treat the city as their valued customer, and this way they can also collect information about other players in the smart city market and make potential future partners in effective ways and promote convergence of all smart city stakeholders. Building smart easy is not an easy process, a lot of challenges are faced and it must be viewed as a long-term infrastructure project by all the stakeholders. Immediate needs should be addressed by short term solutions to simplify the ever-increasing and digital complex world. Smart cities' potential can be maximized by the trust of citizens, combined with private businesses and governments that should aim to prioritize safety, sustainability and welfare of the society[156].

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[154] Stuart Pearson, Smart laws: exploring data and privacy regulation in smart cities, 17 December 2018, https://www.intelligenttransport.com/transport-articles/74198/smart-laws-data-privacy-regulation.

[155] Pratap Padode, The top 10 implementation challenges for smart cities in India, Jul 21, 2015 02.35 PM IST, https://realty.economictimes.indiatimes.com/realty-check/the-top-10-implementation-challenges-for-smart-cities-in-india/776.

[156] Mike Beevor, 6 Challenges Smart Cities Face and How to Overcome Them, Dec 5 2018, https://statetechmagazine.com/article/2018/12/6-challenges-smart-cities-face-and-how-overcome-them.

5. Conclusion

Developing a smart city is not just about new technologies, but it is about but it is more about implementation, finding the solution to the real-life problems, and improving the general city operations while equally focusing on the civic quality of life. Futuristic smarter cities will put forth numerous new questions, concerns, and possibilities that will have to be considered. The smart city projects are on such a large scale that they will require resource management at a different level and accordingly actions will have to be taken by the authorities to ensure a properly integrated system.

Many cities are competing to become smart cities to reap some of the economic benefits and benefits to the environment and society in general. For this purpose, they are trying to make the most out of the opportunities generated by the applications working on Big Data technology. The actual potential of Smart Cities can only be realized by the development of proper governmental framework and economic models in the beginning. Economists and governments mainly view smart cities as a technological problem only, or which a technical solution is sufficient, but technology is not a single issue as it gives rise to other issues as well. To make a city smarter, a focused and forward-looking approach is to be taken which will help in the long run.

Online and offline sources of information will continuously transmit an individual's information to the central database where it will be analyzed and processed. Algorithms will be formed to help in creating a smarter city and better facilities will be available for all. With the development of more smart cities, the government is enacting different policies that ensure that the goal is achieved without compromising with anybody's personal information. Technology will continue to advance making more and more cities smart, therefore systems need to be developed and modified as and when the need arises. The government needs to devise a comprehensive smart city plan to overcome all the existing and probable future challenges to mitigate any sort of risk that might arise.