

Revolutionizing smart cities using IOT and Big Data

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Abstract: A smart city is a concept which integrates multiple information and communication technology (ICT) solutions in a secure way to manage a city's assets. City's assets include, but are not limited to, transportation systems, waste management, water management, safety systems, local department's information systems and other community services, and data management as well. Idea of the Smart city project is to made traditional networks and services more efficient with the use of digital and telecommunication technologies, with emphasizes on Internet of Things (IoT) and Big Data, to improve quality of life of citizens and for the benefit of its businesses. IoT and big data form a perfect blend in bringing an interesting and novel challenge to attain futuristic smart cities. These new challenges mainly focus on business and technology related issues that help smart cities to formulate their principles, vision, & requirements of smart city applications. In this paper, the role of big data and IoT technologies with respect to smart cities is analyzed. The benefits that smart cities will have from big data and IoT are also discussed. Various challenges faced by smart cities in general related to big data and IoT have also been described here. Moreover, the future statistics of IoT and big data with respect to smart cities is also deliberated.

Keywords — Big data, benefits, challenges, IoT, smart cities

I. INTRODUCTION

Smart Cities are using big data and Internet of Things (IoT) for exchange of digitized information and communication in order to improvise the city services with respect to performance, quality, and wellbeing of citizens. The applications related to Smart City are developed keeping in mind the improvement of urban flow management. The people living in cities are expected to get doubled by 2050. The experts predict the urban population will reach to six billion by 2050 in contrast to 3.6 billion as of now. This will increase the enormous pressure on the available resources [3]. IoT and big data are together very significant technologies which will be implanted into each smart device and become available to billions of people directly or indirectly. As the Internet is ubiquitous, with the government's initiative towards making every city smart, everything will be IoT enabled and will produce enormous data. Thereafter, big data analytics will be applied to deduce various inferences and give an insight into the Service industry. Thus IoT and big data will eventually raise the standards of quality of people's lives in years to come give an insight into the Service industry. Thus IoT and big data will eventually raise the standards of quality of people's lives in years to come.

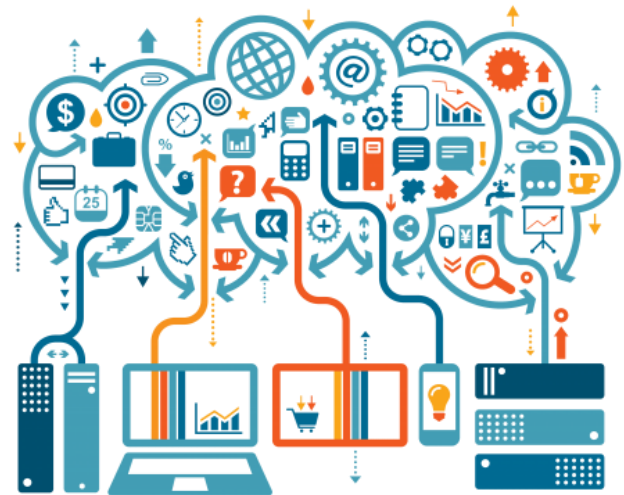


Figure 1: IOT and Cloud in smart cities.

II. UNDERSTANDING BIG DATA, IOT AND SMART CITY

"Big data" is a field that treats ways to analyze, systematically extract information from, or otherwise deal with data sets that are too large or complex to be dealt with by traditional data-processing application software. Data with many cases (rows) offer greater statistical power, while data with higher complexity (more attributes or columns) may lead to a higher false discovery rate. Big data

challenges include capturing data, data storage, data analysis, search, sharing, transfer, visualization, querying, updating, information privacy and data source. Big data was originally associated with three key concepts: volume, variety, and velocity. Other concepts later attributed with big data are veracity (i.e., how much noise is in the data) and value. SaS defined as, "Big data is a popular term used to describe the exponential growth, availability, and use of information, both structured and unstructured". IBM defined big data as "Data, coming from everywhere; sensors used to gather climate information, posts to social media sites, digital pictures and videos, purchase transaction record, and cell phone GPS signal to name a few". The big data system will stock, mine information from smart cities applications in an effective way and provide enhanced information regarding smart city services. In addition, this enhanced information help the decision-makers in planning various new smart city services.

A. Features of Big Data:

1. **Volume:** It talks about amount of data.
2. **Variety:** It talks about structured and unstructured data from multiple sources which can be diverse in nature.
3. **Velocity:** It talks about the speed in which the massive and continuous big data flows in from different sources.
4. **Variability:** It talks about the constantly changes taking place in the structure and meaning of data.
5. **Value:** It talks about the advantages big data provides to a business w.r.t. good big data collection, analysis, management.

In order to achieve goals in smart cities, big data requires correct tools and methods that give efficient and effective results.

Big data, has huge potential to increase and make use of smart city services. Big data is basically huge amounts of data that can be analyzed by businesses to make appropriate strategic moves and business decisions. Big data analysis is implemented to study large volumes of data to uncover patterns and get insights to extract valuable information.

Information and communications technology (ICT) plays a major role in smart cities by making data that's collected through information technology components available. This technology, also called the Internet of Things (IoT), works by communicating between connected devices while exchanging data that requires internet, wireless connections, and other communication mediums.

Mainly, smart cities make use of IoT devices to fetch data and efficiently process it for implementing it in a particular area. Smart city sensors and connected devices collect data from various smart city gateways installed in a city and then analyze it for better decision-making.



Figure 2: IOT and Big data

Other technologies can impact the smart city process. Indeed, cloud platforms and analytic applications offer an economical means of managing transportation data and solutions, creating insights that deliver more efficient and safer traffic routes on roads that already exist. Machine learning applications that pull data from connected devices can provide real-time updates to travelers through smart phone applications.

Three layers of Data:

First is the technology base, which includes a critical mass of smartphones and sensors connected by high-speed communication networks.

The second layer consists of specific applications. Translating raw data into alerts, insight, and action requires the right tools, and this is where technology providers and app developers come in.

The third layer is usage by cities, companies, and the public. Many applications succeed only if they are widely adopted and manage to change behaviour.

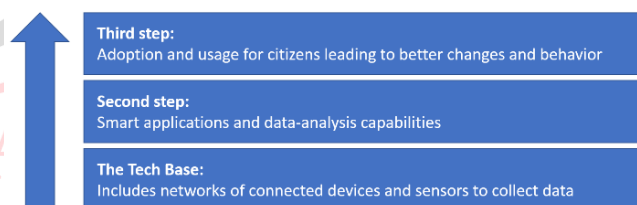


Figure 3: Three layers of data

Internet of things (IoT): It may sound new to many people around, but it is the buzzing word for the world of smart gadget users. IoT is an enormous network of devices that can connect and share the information with the help of these physical objects or "things" ranging from smartphone, wearable gadgets, and headphones to smart television sets [2]. The IoT permits objects to sense and control remote access across given network infrastructure, and provide a direct link between the real world and PCbased systems, thus increasing accuracy and efficiency and improving economic benefits [3]. Hence IoT can also be described as providing connection between internet connected objects such as consumer electronics, environmental sensors, security monitoring equipment and wearable devices and record and/or transmit data that can be used for various purposes .

Smart City: A smart city is best described as a one solution connecting variety of day to day aspects like transportation, power, and buildings in a smart and effective manner, thus improving the life quality of city people. The data in smart cities is gathered in huge abundance from the real time devices, sensors, video/audio, log files, networks, web, transactional applications and social media. Hence smart cities incorporate IoT, smart infrastructure, M2M connectivity to manage power, resources and improve urban planning [1].

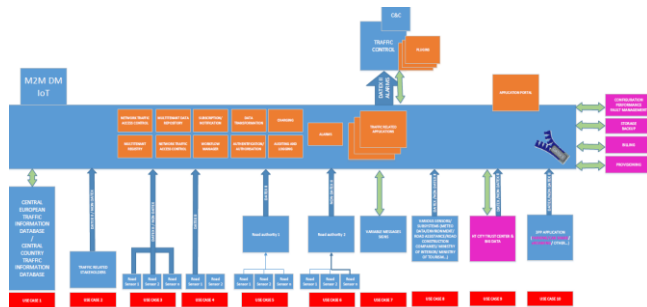


Figure 4: M2M connectivity to manage power, resources and improve urban planning

III. BIG DATA & IOT BENEFITS IN SMART CITIES

The first paragraph under each heading or subheading Big data and IoT together provide various benefits to the citizens of the smart city and thus improve the power, resources and inculcate excellent urban planning. The IoT sensor network gives numerous benefits to both its citizens and the government authorities.

Some of the benefits are listed here as under:

- Water waste management
- Increasing Relevant Use of the Resources only when it is required
- Avoiding the unnecessary use of Irrigation systems during rain or street lights during day time.
 - Automating public transport using cloud based big data automation
- Traffic management
 - Avoiding time wastage at bus stops using locationbased advertising
- Smart metering that monitors the optimum usage of energy, gas, water etc.
 - Monitor pollution levels in city streets and enable automatic alarms above alarming levels.
 - Noise and Pollution management
- Water Management –wastage of water due to leaks can be detected and curbed.
 - Waste disposal management
 - Waste management
- Citizen Information system
- Energy management, for example, the city of Santander in Spain saves tons of money due to utilization of RFID

sensors, GPRS and IEEE standards and provides cost-effective waste and energy management.

- Transport management – Enable smooth traffic flow with the use of Real time traffic maps, also provide information regarding free parking slots available in nearest parking slot in advance will save time and fuel and reduce traffic jams and pollution level, thereby improving quality of life[5].
- Saving millions of wealth if better fuel efficiency is shown regarding heavy goods train and locomotive engines based on carrying heavy cargo weight and engine type.
- Using big data, information taken from vehicles can be used to reduce pollution levels. IoT technology can also be applied in the form of sensors fitted beneath the roads that could calculate amount of traffic in a day. Such information can be used by traffic controllers to divert the extra traffic and thus reduce carbon emission from particular road. For example, the Los Angeles city in USA has deployed road sensors and cameras that regulate traffic and avoid congestion.

- As less energy is consumed, the environment will surely be more clean, green and cool. The Bristol city is a good example of using an IoT- based wireless network which is considered to consume less energy and bandwidths than the traditional networks. This in turn will make mobile phone batteries to work longer and stay better [4]. As Internet of Things and big data are changing the scenario of the world by acting on issues like traffic control, waste management and energy conservation, it is needless to say that smart cities will also get benefitted with this technological transformation.

IV BIG DATA & IOT CHALLENGES IN SMART CITIES

As smart cities are evolving and have dynamic environments, following challenges may be faced during design and implementation of smart city solutions Using Big Data and IoT.

- The biggest challenge that can be seen is related to multiple sources and their various formats. Processing such varied data using traditional software is very difficult.
- Another important challenge is data integration from various environments, organizations, and variety of intelligent devices. The scenario becomes all the more challenging when information is passed among various departments. Smart City solution should be designed to prevent the privacy of the people’s lives.

As the data is collected from various organizations, maintaining the quality if data is a challenging task. With big data incorporated in the form of big data warehouses, data needs to be stored in a specific format without tampering the quality of data. Proper mechanism should be applied while dealing with third party data and ensuring data integrity and quality.

- The data security in a big data environment is even more challenging as the size and volume of data here is quite high. Data security refers to the fact that correct data should be disseminated to correct person and correct time. While designing a secured smart city, data breaching needs to be avoided; data should be masked and encrypted properly so that it doesn't fall prey to unauthorized access.
- Another challenging issue is to keep pace with the ever changing technology. The smart city solutions should be so designed that they may be able to get accustomed and adapt themselves as the technology advances with time. The upgrading of entire system should be flexible.
- There are no standards and protocols set with respect to smart city and IoT or big data and their use. Hence lack of common platform is a challenging aspect.

A. Building the digital infrastructure to handle challenges:

APIs:

Sharing data unlocks efficiency and open APIs are the best way to do it. An easy exchange of data via APIs and/or data marketplaces, along with the ability to easily add partners to the ecosystem, are critical components of any smart-city platform. There is also a growing trend for city authorities to release APIs to encourage developers and community organizations to use **open data**.

Technology	Mission
Network	For gathering data
Field gateways	For facilitating data gathering and compression
Cloud gateway	For ensuring secure data transmission
Streaming data processor	For aggregating numerous data streams and distributing them to a data lake
Data lake	For storing data the value of which is yet to be defined
Data warehouse	For storing cleansed and structured data
Data analytics	Tools for analyzing and visualizing data collected by sensors
Machine learning	For automating city services based on long-term data analysis
User applications	For connecting smart things and citizens

Figure 5: Digital infrastructure

The perfect data-sharing platform

A data-sharing should enable cloud-based data sharing . It will improve privacy, interoperability, security and secure data sharing, agile app development and testing. A platform on which many applications can run also offers these capabilities for specialized, domain-specific applications as well as provides access to the most up-to-date technology.

The platform should support both public and private sharing. If solutions are going to intermix data, then the governance, security and usage monitoring and management becomes more important to control access.

Finally, it should offer the ability to understand and manipulate data into information that people from many different roles can understand and leverage to create other solutions. Big Data stands at the forefront of this endeavour to provide pervasive connectivity at a citywide scale. These

technologies will play a primary role in this growing trend to create the city of the future

IV. FUTURE OF BIG DATA & IOT IN SMART CITIES

The technology advances are rapidly paving the way for smart cities. One of the surveys conducted by an organization predicts that 26 to 28 billion connected devices will be in use by year 2020. The companies around the world are ensuring that products developed in the future should incorporate IoT to keep pace with the future market [2]. A smart city is one urban area that will believe in IT advancements in order to improve the quality of life of citizens, maintain available resources like roads and water in sustainable manner and reduce environmental pollution. As per facts given by New Jersey Institute of Technology (NJIT), smart city technology will raise to an industry costing \$27.5 billion by 2023. Thereafter, the entire world will have around 88 smart cities by 2025[6]. Hence the companies have to gain experience and use big data and get equipped with this latest technology. 30 to 40 percent organizations are utilizing Big Data; out of which around 40 percent have started taking advantage of IoT. Analyzing current trends we assume that Big Data and IoT will rule IT technology world and give new prospects to the smart city development [2].

V. CONCLUSION

The role of Big Data and IoT is essential in building smart cities. Consistent technology & infrastructure is required that can challenge M2M, machine to human, communication and provide public services to all cities. Big Data will assist to analyze, predict information collected by smart devices in smart cities. Various benefits that can be applied with the help of big data and IoT have already been discussed in the paper. The scenario has some challenges also as the data is from various heterogeneous sources. Hence, the technology must be implemented with proper understanding. Thus, managing big data and applying IoT related technology infrastructure will soon transform normal cities into smart cities.

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