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A proactive role of IoT devices in building smart cities

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ABSTRACT

Due to rapid advancement in technology the world is rapidly changed to face the upcoming challenges and going towards automation. The use of various IoT devices is making a vast approach and every happening becomes part of the network and due to that towns are converting into smart cities. The IoT devices collect the data of every happening smartly and send it for further processing. An imperative part of these devices is containing the wireless sensors used for building smart cities. A giant set of data is collected in the sensors and is stored in the data center. Subsequently, the huge data becomes an exorbitant mountain that must be managed smartly if a smooth operation is required. In this study, how such big data can be managed shrewdly is going to explore and the proactive role of IoT sensors are investigated which helps in building the future smart cities more independently. The impact of services such as Smart transport, smart energy, smart infrastructure, smart health, smart agriculture, and smart recreation in respect of smart cities and the old traditional city has been analyzed through an Analytic Hierarchy Process (AHP). The obtained results showed a satisfactory level of local communities about 98% of people living in smart cities are satisfied in contrast to people living in old traditional cities and others having a neutral opinion.

1. Introduction

It is essential to prepare for upcoming technological challenges because when gets more progressive socially, the more requirements are needed. During initial days of the computer networks modems, switches, and routers are connected together to transfer data over the world. The next requirement is internet of everything, that can be cars, devices inside the house (fan, light, door, air controller), health-care, and so on. The sensors are attached to the devices to get more information of the actions, status, and situation of things or to use for the other purposes. There are many research fields to focus on IoT, and the smart city is not an exception field. The survey of IoT is made in paper. The major target is how to build the city better and smarter. One problem of the big city is traffic jam. The congestion appears in the corners in rush hours. The city needs a giant number of traffic police to control the motion of cars at the corners in rush hours. There are few thousand corners therefore, the number of traffic police is not enough! The smart city needs a smart traffic light system to reduce the works of the traffic police [1].

The smart traffic light system means that the traffic lights can automatically change duration of the red light, or the green light to reduce level of the congestion. In addition to, the congestion of the next corner can affect on the observed corner. To do these works, we need at least four cameras at each corner, and controller devices. Besides, the emergency cars need private RFID (Radio Fre-quency Identification) cards [2], to notice a distance between them and the corner. The observed corner needs to turn on the green light immediately to help them passing through the corner faster, and turn back on the red light later. The data is collected from the cameras and RFID is too large, and called IoT big data because of a few thousand corners in the big city. Due to IoT big data of the smart traffic light systems, the controllers at the data center can analysis it and get much important information. Important information will help the controllers to decide to increase or decrease priority level of the ways [3]. The higher priority the way has, the longer duration the green light has. If we can analysis big data, the results will help the traffic controllers too much. Next part of this paper, we make a survey of IoT big data management and analytic [4]. The olden time city and the new smart city concept with role of IoT devices has been illustrated in Fig. 1.

1.1. Finding smart city components

A smart city is typically made up of several components as given in Fig. 2. The first aspect of smart city applications is data collection; the second is data transmission/reception; the third is data storage; and the fourth is data analysis. Data collection is application-dependent, and it has been a major driver of sensor development in a variety of fields. The

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Fig. 1. Old city versus smart city localities.

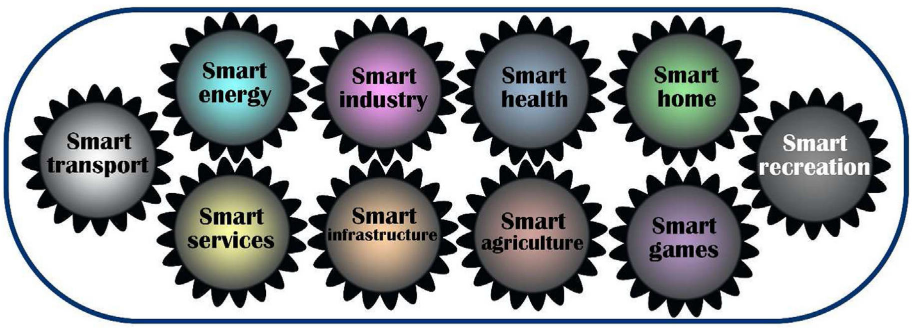

Fig. 2. The imperative components of smart city.

data transfer from the data collecting units to the cloud for storage and analysis is the second phase. Many smart city initiatives include city-wide Wi-Fi networks, 4G and 5G technologies [5], are being employed, as well as various forms of local networks that may transmit data on a local or global basis. The third step is cloud storage, where various storage techniques are utilized to store and organise data so that it may be used for the fourth stage, data analysis. The extraction of patterns and inferences from acquired data to aid decision making is referred to as data analysis. Simple analysis, such as fundamental decision making and aggregation, may be sufficient in some cases. The cloud's availability enables for not just heterogeneous data gathering/storage and processing, but also real-time analysis using statistical approaches as well as machine and Deep Learning algorithms for more complicated decision making [6].

1.2. IoT devices for smart cities

The internet of things (IoT) is at the core of smart city efforts; it is the enabling technology that has enabled ubiquitous digitalization, giving rise to the notion of smart cities. The internet of things (IoT) refers to the pervasive connecting of objects to the internet, which allows them to communicate data to the cloud and perhaps receive instructions for executing activities. IoT entails the gathering of data and the use of data analytics to extract information to aid decision-making and policy-making. More than 75 billion gadgets are expected to be connected to the internet by 2025 [7], spurring even more application development. IoT allows sensors in smart cities to gather and communicate data on the status of the city to a central cloud, which is subsequently mined or processed for pattern extraction and decision-making.

Recalling our problem in big data of the smart traffic light systems,

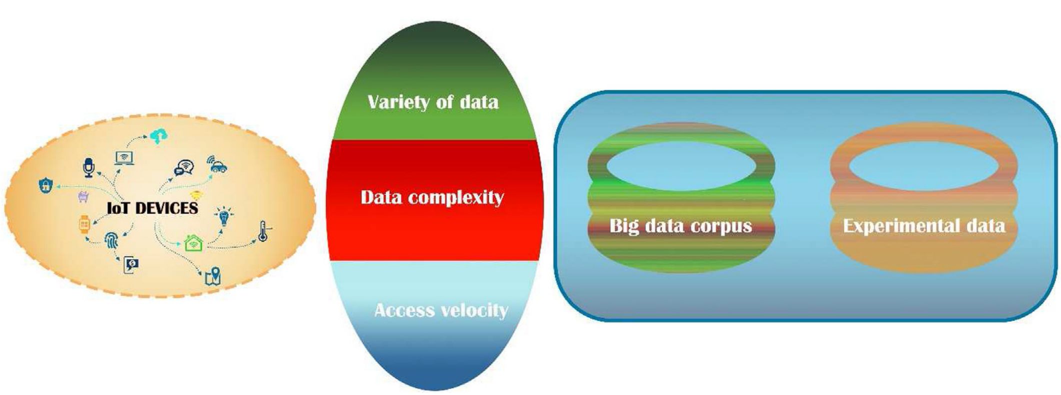

Fig. 3. IoT devices dealing with big data management process.

the important things is classifying the position of data. Data of the corners belongs to which district, or to which exactly position in Google map [8]. In addition to, the data has time field that shows duration of congestion. That all will help to find out what duration and what position, when and where the congestion appears every day with higher congestion, and longer duration. The necessary of survey of IoT big data management [9], and analytic are very important.

An entire view is illustrated in Fig. 3. The first branch is IoT Big Data Management, second branch is Analytic, and the remaining one is Security, Privacy, Energy-Efficient [10]. IoT big Data Analytic is divided into two branches including Analytic and Mining, and Deep Learning. Big data getting from IoT environment has many incomparable features such as size of data, kind of data, and important level of data. There are three types of data: structured, semi-structured and unstructured [11]. The big data framework must have ability to classify the data and save the data to database, but it should focus on unstructured data specially. Besides, scaling big data is also very important function to reduce size of data storage.

In some special cases, it is essential making important decisions for control the traffic light system. To do this, data should be analyzed to help actuators to do some actions. However, big data of the sensors is really a big problem because of storing and analyzing. Management process classifies big data in some attributes for storing and later analyzing.

1.3. About data mining

Data mining is a technique of extracting and identifying patterns in big data sets using approaches at the confluence of machine learning, statistics, and database systems, and it is critical to grasp the idea [12]. The IoT Big Data Analytic Framework has been presented [13], also known as IBDA Framework, which is built on the Python programming language and the Cloudera Big Data Platform [14]. The python code has been used to simulate Virtual sensors, and similarly PySpart has utilized to analyze the data. After receiving data from sources (virtual IoT sensors) [15], it is transferred to HDFS storage via Flume Agents [16]. A Flume Agents being a unit of data flow and the events flow is transferred from an external sources (like web sever) to next destination (hop). The hop is HDFS storage in next layer. Then the authors use Spark as major Software for analyzing data as soon as it arrives into HDFS storage. The final layer is actuator (turn oxygen pumps, fire alarms and lights ON and OFF) and visualization data in Cloudera [17]. Spark is unified Analytics Engine for Big Data developed by Apache [18]. Spark also is necessary soft for future researches on building smart traffic light system. Maybe, we also can use Python Code to simulate virtual sensors before applying them in the real life.

1.4. Data mining and deep learning

First step of Deep Learning Systems is a suitable Deep Computation model [19]. The Deep Computation model uses stacking tensor auto-encoder for data. The paper also defines how to calculate reconstruction error function for training sample. The survey on this part will not explain it in more detail, and focus on the results and problems of IoT big data. Considering basic knowledge of Deep computation model, an adaptive dropout deep computation model for Industrial IoT Big Data Learning [20], is proposed by the same authors. The adaptive dropout deep computation model uses an adaptive distribution function with activating rate (has probability p). The distribution function has some attributes as Monotonically decreasing, activating rate of middle hidden layer, and activating rate of current layer. The authors also propose a Probabilistic Model and Maximum Likelihood Estimation. The experiment is applied on two representative data sets as CUAVE (bi-model dataset- 1800 utterances of digit 0–9) and SNAE2 (four groups of video clips) with mat-lab R2014 and laptop i7- 3.2 GHz, 8G ram, 1T HDD). In CUAVE Example, the results are DCM 13.3–21.3%, DDCM 14.4–18.5%, and ADDCM 10.5–16.4% according to Top1- Top2 Error rates. The paper is a good reference on deep learning to build an adaptive model for smart traffic light system with some suit-able changes.

2. Literature review

A comprehensive literature review has been conducted to investigate the current available approaches and these approaches have been compared with proposed proactive strategy. The Francesco Furfari et al. [21] proposes a HEP Framework (Unified Heterogeneous Event Processing Framework) to receive streaming data of events. Data of RFID, Click-stream, sensor network, and smart objects is wrapped throughout Common Event Adapter (CEA). Then it is transferred to Event Space with two kind of streams such as Relational Event Stream, and XML Event Stream. In Event Space, there is a cache to save the data streams for formatting or some pre-processing work. Next layer of the framework is Event Processing space. Finally, the data streams are transferred to the end points as user, web service, and so on. The HEP Frame-work is very suitable for the data streams in the real time, but it cannot help us to build the smart traffic light system.

Mohamed Saifeddine et al. [22], proposes a Cognitive Oriented Framework for IoT Big-data (called COIB-framework) to manage it effectively. The framework has five layers in the process. The first layer is IoT big-data aggregators. It has a task of aggregating all big data source from IoT environment. The data is divided into segments that are converted into IOT raw-data streams. The streams are raw-data source with highly unstructured data, but they still ensure the name, scale, and abstraction level exactly. The streams also include the other features as in-consistency, redundancy, incompleteness, and other anomalies. In addition to, this layer has data fusion operation to check and eliminate those anomalies from IoT big-data streams. The second layer, called IoT big-data classifiers, classifies the cleaned data into multiple clusters due to data behaviours, and characteristics. The domain or cloud need ensure accessible ability of the framework. The next layer, named HBase storage, performs scaling and storing the data clusters into storage nodes. The HBase storage has a table to set data relationship of storage nodes, and save in rows and columns with key names. The table is primary key for next analysis. Due to it, the big-data can be scaled effectively. Next, IoT big-data analysis (Cognitive CI-Tool) layer and Cognitive Decisions Plans Actuators layer are final layers. Nowadays, there are many cognitive and computational intelligent tools to do the cognitive decisions. And the authors believe that the COIB-framework will be successful in the automation environment. The study also shows how to deploy the Framework with cloud computing in the real life. However, all things are just ideal without any stimulation or de-ployment. And there is need to find the way to attach characteristics of the data such as position, number of congestions, priority level of the way. This helps us to build the smart traffic light systems.

Similarly, U.C.Nkwunonwo et al. [23], proposes Smart Flood Management Framework for IoT, big data and HPC (High Performance Computing). The Framework has 3 layers as follows:

(i). First layer is Internet of Things with level sensor, satellite, mobile devices, and buoys.
(ii). Second layer is Food Data Storage that has some functions such as Data Pre-processing, Cluster Analysis, Hold-winter's, and Dimension Reduction.
(iii). Final layer is Presentation Layer with Flood Map where each colour presents a level of Flood correspondingly. The authors setup Food Attributes included Velocity of Catchment, Density of Forests per Acre, and Food Preventing Attributes included Current season, Drainage system, and soil type.

To classify and store big data, the food causing Attributes [24], are divided into 5 levels such as very less, less, moderate, high, and extreme. In addition to, Flood Preventing has the same 5 levels such as >1000, 800–1000, 500–800, 100–500, and <100. This is good ideal to build 3 levels of attributes as normal, medium and high inside the smart traffic light project in future. The attributes, such as velocity of car, level of congestion, and distance from emergency car to corner. The detail of all future researches will be explained in more detail later.

Khaled Alwasel et al. [25], introduces other software for stimulating and analyzing IoT applications named IOTSim. The IOTSim have total 5 layers: CloudSim Core simulation Engine Layer, CloudSim Simulation Layer, Storage Layer, Big Data Processing Layer, and User Code Layer. First layer is simulation of CloudSim included Event Queue and Cloud System Entity. The second layer is simulation of ClouSim included Network, Cloud Resources, Cloud Services, Virtual Machine Services, and User Interface Structure. The Network can be Topology types, and also has Delay calculation. The Cloud Resource, where builds sensors of IoT system, has some functions as Events Handling, Cloud Coordinator and Datacenter. Whereas the User Interface Structures have IoT Application Cloudlet and IoT Application for users. Although the IOTSim supplies cloud datacenter, it doesn't support MapReduce job because of complexity of MapReduce workflow. So, if the IOTSim is used for simulating IOT systems, we need to build MapReduce workflow by ourselves.

The Fundamentals and IoT Stream Mining Algorithm has been explained by Taiwo Kolajo et, al [26]. The paper also focuses on some open source tools to mine big data such as Spark, Flink, Storm, and Samza. This study is good reference for beginner who need to be used to data mining tools. Data mining can help to get map of congestion distribution in the city. Data mining will be discussed in more detail in the future researches part later.

2.1. Analyzing security measures during extraction of experimental data from the big data corpus

The security and privacy requirements and an innovative demand of users is marked by Ref. [27]. The author has described clarifying the challenges in future researches. Further, the request-based, secured and energy-efficient architecture for handling IoT big data is prosed by Chong Feng [28]. The nodes (sensors) has small battery as power source to keep them acting. The power source has a relationship with a distance be-tween source and destination. The distance is farther, the energy is used more for transferring. Besides, type of activity also affect on the power source. The authors propose RBSEE architecture applies relay nodes and multi-hop communication. The relay nodes have responsibility on relaying data between source and destination. This helps to decrease the distance and energy. Besides, the inactive sensors take a rest until the event of interest happens. The multi-hop communication is also used for transferring the data from source to the sink. And it helps to increase overall efficiency and lifetime of the IoT ecosystem.

2.2. The proposed proactive role of IoT devices

While investigating the current progress of smart cities and handling the big data corpus, the proposed study came up with epitome recommendations.

(i). Regarding attributes of the systems for IoT management, the attributes should include congestion levels of observed corner, congestion levels of next corner, velocity of emergency cars, distance between emergency car and the observed corner. All attributes have 3 levels as normal, medium, and high. If the congestion of next corner is medium or high level, the observed corner increases duration of red light automatically to decrease a number of cars running to the next corner. The duration of red light is maybe increased 30–60 s accordingly to medium and high congestion level. The increasing duration depends on target countries. Besides, when the emergency cars come nearly to the observed corner, the corner need to turn on green light, and turn back to red light later. This helps the emergency cars pass through the corner as soon as possible. The velocity and distance are used to calculating the remaining time of emergency cars. So, it is easy to define when the yellow light needs to be turned on first, and then the green light is turned on after 3 s.

(ii). To use some tools such as PySpart, Spark, Flink, Storm, and Samza [29], and some platform as COIB, IBDA, the survey of Management, analytic, and deep learning helps to build architecture to manage big data in storage and get a map of congestion distribution. Basing on level of congestion in areas, computer can calculate and define automatically priority level of ways in the areas. The higher the level of congestion is, the longer the duration of green light is. All process of computing and acting occur automatically.

(iii). To apply relay nodes and multi-hop communication system, the survey helps to decrease spending power. Besides, the inactive nodes need to be turned off to save energy. The efficiency and lifetime of the IoT ecosystem are very important things because the nodes use small batteries.

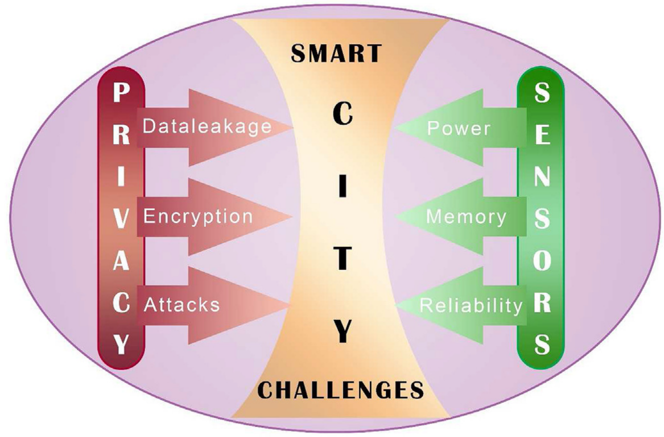

Fig. 4. Most common smart city challenges.

2.3. Smart city challenges

In every area of a city's operating mechanism, the digitization process necessitates the growth of sensing nodes. With such a large application scope, developing and deploying IoT systems in smart cities presents tremendous problems that must be considered. The problems that IoT system designers encounter while making deployments in smart city applications are discussed in this section. This research focuses mostly on the technological problems associated with IoT deployment in smart cities, which have been the attention of researchers. The numerous obstacles that Smart City IoT system implementation faces are shown in Fig. 4, which include Security and Privacy, Smart Sensors, Networking, and Big Data Analytics [30].

2.4. About smart city privacy

In smart cities, security and privacy are the most important considerations. Any anomaly in the functioning of the city's services would cause discomfort to its inhabitants and put human lives and property at danger. Smart cities require key city infrastructures to be online and therefore security hassles will not be major issue. In an age where cybercrime and warfare have become a tactic in global politics, smart cities are increasingly vulnerable to such hostile attacks. In this case, data transmission over the network must be encrypted. Citizens' trust and involvement are required for smart city programmes to succeed. The development of sensors in smart cities, which collect data on people's activities on a continuous basis, may expose residents' everyday activities

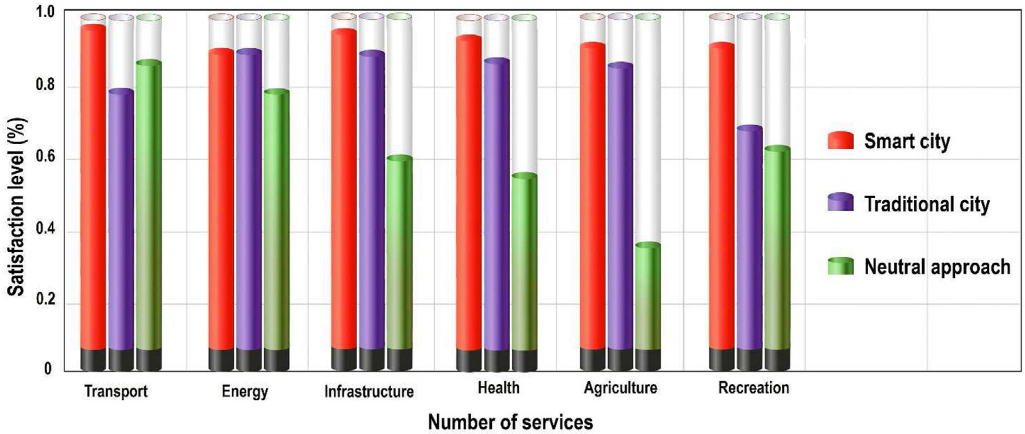

Fig. 5. Locality level satisfaction.

to unwelcome parties. Furthermore, organisations and corporations on the IoT network may utilise citizen data without their consent for purposes like as targeted advertising and eavesdropping. Solutions will necessitate procedures that anonymize data gathering while preserving the context of the measured task so that appropriate decision making is feasible. Throughout this article, security and privacy issues have been addressed in depth.

2.5. About smart sensors

Sensor equipment must be able to share data, schedule tasks amongst them, and aggregate data in order to make conclusions in smart cities. The development and adoption of open protocols and data formats as a solution to this problem will enable manufacturers to design equipment that can interact with one another, accelerating the implementation of IoT systems. Another option is to create 'standard' access point nodes for IoT systems that can interact with devices using a variety of communication protocols and interpret the information received. As noted [31], several manufacturers have made their equipment interoperable with alternative protocols. Another issue with smart sensors is their dependability and robustness. The dependability and accuracy of the IoT system are referred to as reliability and robustness. The Internet of Things (IoT) is the backbone of future smart cities, and since it is so important to their functioning, the IoT system must deliver a seamless experience to its users. This necessitates a prompt and correct response to service requests submitted by app users. Every person in the smart city must have access to high-quality services. Decentralized systems should be used to supply vital services like transportation and energy. The dispersed connection points will improve the robustness and dependability of the system.

3. Result and discussion

In order to analyze the impact of proposed proactive approach of IoT devices for smart cities and the old traditional city system, the data has been collected on different grounds from various localities living in smart city and in old city. An Analytic Hierarchy Process (AHP) questionnaire was conducted to gather external factors and detailed factors from the peoples through different sources. experts via e-mail. On the basis of gathered data, a comparative analysis has been made shown in Fig. 5. These results vouch for a real-time satisfactory level of the local population in regards to Transport facilities, the energy utilization, the overall infrastructure of the cities, the most important health facilities, the agriculture norms, and the availability of recreation vicinity. From these statistics, a judgment can be easily made regarding the living satisfaction in smart cities, in old traditional cities, and some people who never experience the difference between the smart and old city and have neutral opinions. According to results, about 98% of people living in smart cities are satisfied with available smart facilities but even a substantial number of people living in old cities are also satisfied with available facilities just because their approach is limited and never have experience of smart facilities and about neutral approach, locality doesn't bother about this race most them are living in suburbs or in villages where even proper roads are not available for transportation and they thinks their lives are better at their vicinity.

4. Conclusion

The development of IoT is very fast in nowadays. In the first days of IoT, smart house is researched very much. The light, television, and air-condition become smarter and bring more convenient for human life. The other researches focus on agriculture, manufactory, government, company, and so on. The traffic is also not trivial. To build a smart city, there is necessary to build a smart traffic light system. The smart traffic light system is a system that has ability to change duration of red and green light automatically. The changes depend on congestion level of observed corner, congestion of next corner, and priority level of the way. All attributes are divided into 3 levels as normal, medium and high. The data flow is classified and stored in HDFS storage. The survey of IoT big data also give out some ideals of frameworks such as COIB and IBDA. However, there is a necessary to change the framework a bit to suit for smart traffic light system. That is reason why we will replace 5 levels by 3 levels of attributes. Next step, PySpart, Spark, Flink, Storm, and Samza are applied on management and analytic. Final, we can apply relay nodes and multi-hop communication system as a solution for increasing lifetime of IoT ecosystem. The smart traffic light system can be simulated by IOTSim or Python in the lab before applying it in the real life.

Data availability

All relevant data is available within the manuscript.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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