Enhancing Smart Cities Development using Big Data Clustering

Mahmoud Farouk[1], Saad M. Darwish[2]

[1]High Institute for Computer-King Marriott, Alexandria, Egypt
[2]Institute of Graduate Studies and Research, Alexandria University, Egypt
kopitan13@gmail.com , saad.darwish@alexu.edu.eg

Abstract

The great challenge facing the creation of smart cities or the transformation from traditional cities to intelligent one is the amount of data extracted and associated with smart cities. Transforming the massive amounts of data into knowledge will leverage the smart cities performance to the maximum. The solution of complex problems will be extracted from the continuous and fruitful analysis of big data after distributing this data to some clusters with same attributes-properties such as:- places available for parking in crowded places, hospitals closest to critical patients, ambulances near the injured, safety disposal of daily citizens waste, excellent use of energy, highest benefit of water. This research discusses how to advance the services in smart cities over big data clustering. The clustering is the main tool of data mining which is used in big data analysis, where extensive volume data should be gathered. Clustering allows decision maker in the smart city to take a sweeping glance of its data en masse, and then form some logical structures based on what is found there before moving far into the analysis. The suggested framework utilizes the Map Reduce – based multiple machine clustering technique to enhance data analysis and aggregation processes with the aim of building smart cities. The smart cities development can be achieved by obtaining aggregated information about each activity and by carrying out analytical processes of this information then the successful decisions are the results which reflecting a better life for the inhabitants of these cities.

Keywords: *Big Data, Smart City, Clustering, Map Reduce* .

1. Introduction

Big data and Internet of Things (IoT) are used in smart cities to share and digest information that improve services and establish smart cities and their efficiency. Experts predict that the urban people (who lives in smart cities) will be 6 billion by 2050 compared to 3.6 billion currently which increasing the pressure and demand for resources available in smart cities [1][2].In several cases, data are just being produced faster than they can be processed and analyzed. The largest of these data are unstructured. Unstructured data are the data that either do not have a pre-explained data format or are not organized in a pre-defined manner [3].Everything will work with IoT when moving to smart cities and IoT will produce different data which called big data. In order to effectively resolve unstructured business or industrial problems in smart cities, big data need to be digested or refined. The key function of this refinery is creating value from big data by evaluating its benefits. In order to discuss the challenges in extracting this value, understanding and conceptualizing the specifications of big data are important [4]. Big data show new challenges to data mining because huge volumes and various ranges must be taken into consideration. The familiar methods and tools for data processing and analysis are weak to deal with such amounts of data, even if powerful computer clusters are used. When working with big data, a data clustering trouble is one of the most essential issues. Often data sets, especially big data sets, composed of some groups (clusters) and it is necessary to catch the groups. Clusters are groups of data points that share similar attributes, and clustering algorithms are the tools that collect these data points into different clusters depend on their similarities[5].Clustering approaches have been executed to many important problems which found in smart cities. This paper aims to enhance smart cities development using big data clustering within the framework of conversion of data to useful information by utilizing Map Reduce based K-means (PK-means) that is a distributed version of well-known clustering algorithm K-means. The proposed framework is useful in dealing with the different forms of data through distributing them into homogenous groups by means of distributed data clustering technique and then processing and analyzing them to extract related information and building knowledge for best decisions.

The rest of this research is organized as follows. Section 2presents some concepts related to smart cities. Section 3 demonstrates the basics of big data and analytics. Section 4 explains the concept of big data clustering and its benefits. Section 5introduces the suggested clustering-based big data model suitable for smart cities. Section 6shows the concluding and remarks.

2. Smart Cities: Concept &Challenges

A smart city is defined as a one application connecting variety of day to day features like transportation, power and buildings in a smart and effective manner, thus enhancing the life manner of city people. The data in smart cities are collected in great abundance from the real-time devices, sensors, video/audio, log files, networks, Web, transactional applications and social media [6]. Further definition includes "*Using all new technology and resources in a smart and integrated manner make city smarter. They are used to generate modern centers that are at once integrated, habitable, comfortable, and sustainable*" [7]. The phrase smart city doesn't describe a city as all. But it defines its different aspects like inhabitants, environment, economy, governance, communication, and transportation. So, the phrase of smart city can explain the smart city along six main axes. These are the smart economy, smart environment, smart government, smart living, smart mobility, and smart people, as demonstrated in Fig. 1.

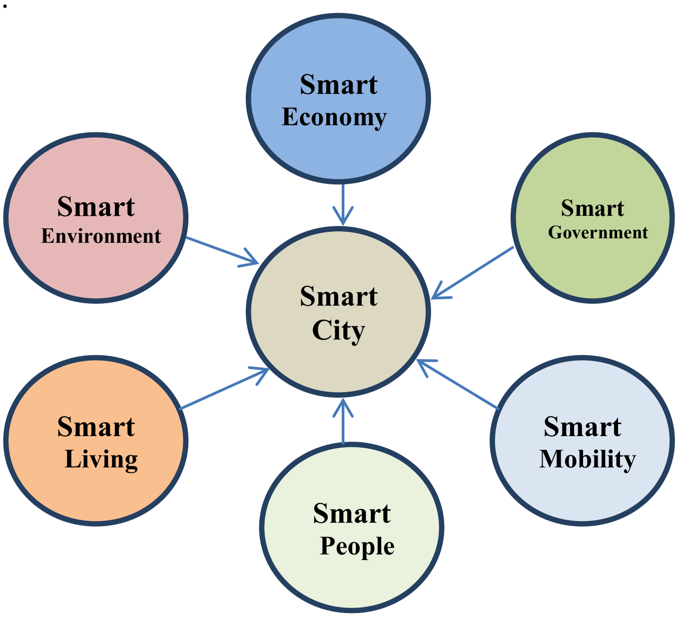

Fig. 1: Smart City's Main Axes

However, to enlarge the services of the smart city, the extracted data should be controlled well. There are many technical challenges which may be faced a smart city application that relay on big data. Therefore, it is important to eliminate these challenges that meet the design, development and deployment of big data applications for smart cities. Table 1 shows some of the technological challenges belonged to big data in the smart city.

3. The Big Data Analytics

The big data points to a great range of massive size of data set almost impossible to control and process using traditional data management tools due to their amount and their complexity within a sufficient time for its user [6]. Big data will be cleared in the finance and business where great amount of stock exchange, banking, online and onsite purchasing data flows through computerized systems every day and are then selected and stored for inventory monitoring, customer behavior and market behavior [8]. It will also be cleared in the life sciences where big sets of data such as genome sequencing (figuring out the order of DNA nucleotides), clinical data and patient data are digested and used to advance breakthroughs in science in research [9]. From data warehouses, web pages and blogs to audio video streams, all of these form sources of great amounts of data which needs to be efficiently processed, stored, shared and digested to retrieve best information [10].

This data have a great forcing, ever increasing complexity, insecurity and risks, and irrelevance. The benefits and challenges of seeking this data are arguable in view of the fact that this analysis may involve access and analysis of records of medical data, interactions of social media, financial data, records of government and genetic sequences [11]. The requirement of an excellent and effective analytics service, applications, programming tools and frameworks has generated birth to the concept of big data processing and analytics [12].

Table 1: Technological challenges related to big data in smart city

Challenges	Description
Privacy	In the age of big data, information on individuals in the smart city is presented to analysis, sharing, and misuse, which is a condition that makes rise to concerns about profiling, stealing, and loss of management. Although many efforts have been made to address such concern, securing the vast amount of special data extracted by smart city technologies from hackers and theft is becoming a challenging problem. Moreover, although successful cyber-attacks on cities remain relatively rare, smart city technologies, develop a number of cyber-security concerns that need attention [13].
Data Analytics	In any urban city, data analysis is taken as the important source of promoting growth and wellbeing. This data come with processing challenges that must be retrieved to exceed citizens' quality of life and make their cities sustainable. In a smart city, the data are collected from different items; gaining insights from the data and making decisions require novel algorithms and visualization techniques, which affect smart city-focused activities. Thus, on-the-fly processing of data becomes increasingly important, whereas traditional store-then-process approaches, in which each company extracts its data and stores it for access it in the future, may no longer be applicable [13].

Follow Table 1: Technological challenges related to big data in smart city

Challenges	Description
Data Integration	Smart city data included different data formats using a great variety of intelligent things embedded throughout the city. However, the vision of the smart city is to combine such a great amount of data from several sources; data integration within the smart city is one of the essential challenges to be marked. In recent years, multiple technologies have been integrated into smart cities, which decrease the technical barriers of addressing the data. Nevertheless, data nature is one of the challenging complications in any data integration mechanism, specifically if the data are false, missing, use the wrong format, and/or are incomplete [13].
GIS-based Visualization	Geographic information systems (GIS) are applied for mapping and analyzing spatial data; GIS has recently taken popularity in urban planning, environmental planning, traffic controlling, and transportation forms detection. Good GIS-based visualization is essential to smart city application because it can extract interactive and simple-to-use platforms for the users. These platforms, however, call for the integration of 3D and touch screen technologies with smart city applications. Such combination can allow policy makers to change data into knowledge, which is essential in fast decision making. Generating good and flexible devices and software applications based on new technologies for the smart city is indeed an attractive area toward realizing the vision of a smart environment [13].
QoS	To build a smart city, a number of technologies should be integrated. The Quality of Service (QoS) presented by various technologies is another challenge for smart city approval. For instance, reliable, soft, scalable, and fault-tolerant networks must not be negotiated to achieve the aim of a smart city. Similarly, deeply scalable data storage and processing platforms that are supported by good cloud-based services selection are an open challenge. The QoS provided by these technologies must be valid before smart city application is fully integrated. The frameworks and methodologies for finding and applying QoS parameters in a smart city are essential [14].

There are more efficient tools which dealing with big data analytics like Apache Hadoop, SAS,R – Programming, Knime, Open Refine, Skytree, Talend [15]. Big data analytics uses these tools to derive conclusions from both structured and unstructured data to provide insights that were previously beyond our reach [15]. Structured data represent 10% of all informatics data, semi structured data represents a few parts of data 5%, and the last type unstructured data represent around 85% of data, so analysis on smart cities considered only the 1st type and 3rd one. Big Data analytics help smart cities dealing with data to influence not only future decisions but present decisions as well. The big data consist of the three V's:- volume, variety, velocity. Consequently, the term "big data" is used when all of the three constitutive appearances are presented as: large volumes of data, diverse data formats (variety), and fast data (Velocity) [16]. Fig. 2 explains big data 3 V's model.

The main source of data is media. By increasing technical convergence, which means that more and more media offers can be consumed via a single terminal, the data volume increases exponentially, the 2nd V, **Velocity**, shows the rate of data inflow of a non-homogenous structure. The 3rd V, **Variety**, implies to the range of data types within multiple structured or unstructured formats (e.g. text, audio, video or even data noise collected by sensors of IoT). Beside the basic 3Vs, practitioners 'and scholars' initiatives in analyzing and handling big data propose one another V.

As the 4th V, **Value** indicates the significance of extracting the benefit from the accessible data sets [17]. As a work of academia and the industry for explaining big data expand its characteristics by identifying new V's. **Veracity** defines as the accuracy and trustfulness of the information within the existence of complexities, anonymities and inconsistencies. **Variability** is about the differences in the meaning of collected data. **Visualization** defines as transformability of data to be readable [18]. Discussions on characterizing big data are still insufficient. The character of big data expanded from **3V**s to **7V**s but it is still weak in generating complete image of each V and clarifying the relationships among them. Therefore, big data are still pure ground for research and study.

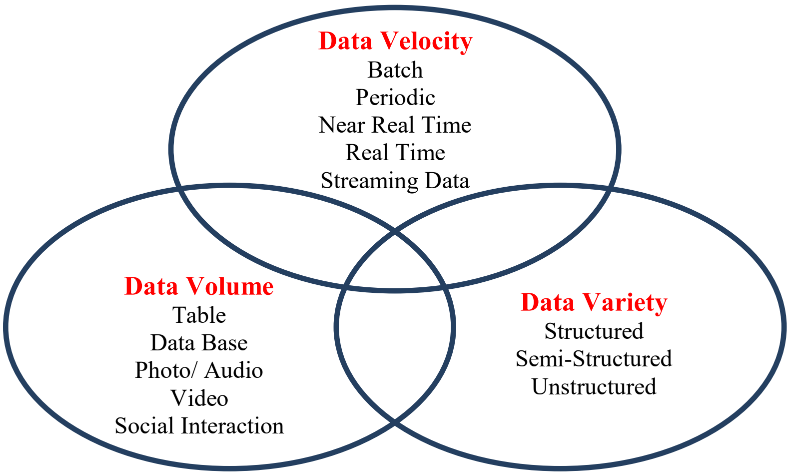

Fig. 2: Big Data 3 V's Model [19]

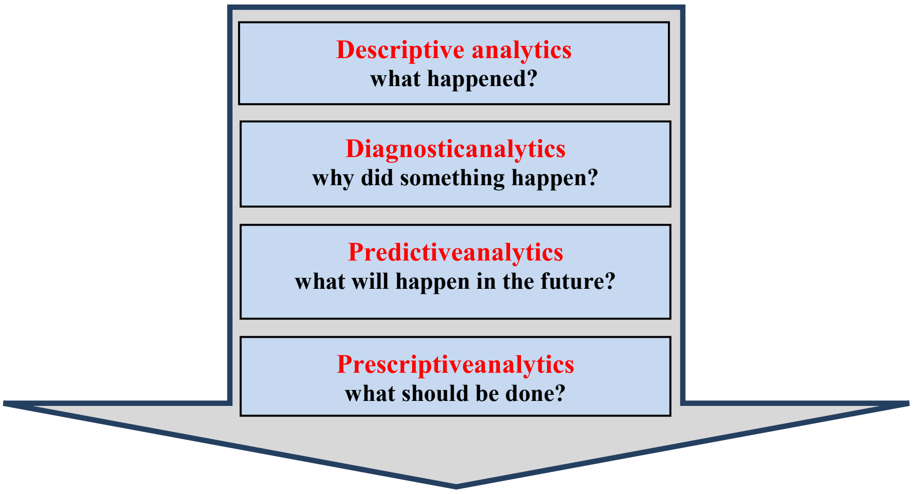

Fig. 3: Big Data analytics [21]

Big data analytics points to when data scientists, analysts and statisticians work on powerful tools and techniques to extract trends and patterns from great unstructured data sets and make these easily and quickly accessible to business pioneers, managers and other key stakeholders. These ideas are used to inform and develop business strategies and plans [18]. There are four types of data analysis which shown in Fig.3[18].

- **Descriptive analytics**:- This part of analytics tries to answer “what happened.” This part of analytics works on data and uses a lot of traditional research approaches. Generally, classical or Bayesian statistical methods are used to learn about the data set. An example would be the average amount of money in a bank account on a monthly basis.
- **Diagnostic analytics**:- Diagnostic tries to answer “why did something happen.”An example when a customer visits a location and purchases a TV made by one company while there are many alternatives next to it on the shelf and even more online.
- **Predictive analytics**:- Predictive model tries to answer “what will happen in the future.”This branch of analytics concentrated on predicting what you may do. An example may be a sales prediction for your business.
- **Prescriptive analytics**:- Prescriptive analytics tries to find “what should be done.”A stock portfolio enhancement model is an example of this branch of analytics to guess what might happen and to tell us how we should allocate our portfolio as well.

In general, to implement effectively the above types of big data analysis, data clustering techniques are needed to find clusters containing similar data sets.

4. Big Data Clustering

Clustering can be considered the most essential unsupervised learning problem; so, as every other problem of this type, it works with finding a structure in a group of unlabeled data [19]. A wide definition of clustering might be “the process of organizing objects into groups whose members are similar in some way”. A cluster is a group of objects which are “similar” between them and are “dissimilar” to the objects relating to other clusters [5]. Big data clustering techniques can be separated into two main categories: single-machine clustering techniques (sample based techniques, and dimension reduction techniques), and multiple-machine clustering techniques (parallel clustering, and Map Reduce based clustering)[20][21]. Recently multiple machine clustering techniques has attracted more attention because they are more flexible in scalability and offer the faster response time to the users. In this research, the proposed framework relies on multiple machine clustering. It utilizes Map Reduce-based clustering technique. The Map Reduce algorithm includes two main tasks, namely Map and Reduce. The map presents a set of data and converts it into another set of data, where individual elements are broken down into tuples (key/value pairs). Secondly, the reduced task, that presents the output from a map as an input and combines those data tuples into a smaller set of tuples. As the sequence of the name Map Reduce implies, the reduced task is always performed after the map job [19][21].

Regarding privacy challenge within big data, a clustering algorithm must be applied to original data as a pre-process and then clustered data would be anonymized with an algorithm to keep data lossless more than enough. For data analytics challenge, Hadoop-based technologies and libraries are the best solutions for big data analysis and clustering. To solve problem of data integration, big data clustering can be used to collect data in suitable groups. In GIS-based visualization, clustering can help by generating data sets of every location in the smart city. Enhancing QoS is made by clustering to avoid male functions of services applied in smart cities [20].The contribution of big data clustering into smart cities is a fundamental shift in the smart cities enhancement and thus increases the power, resources and generate excellent urban planning. Examples of the benefits are listed here:-

- **Traffic management systems:-**The exceeding traffic jam in the urban context generates an important rationalization of urban processes to enhance life quality and energy saving. Citizen services must examine and plan urban routes in the city's context to be a relevant smart service. For this purpose, driving features are identified and used for driving segment clustering. Furthermore, extract information regarding free parking slots available in nearest parking slot in advance using clustering will save time and fuel and minimize traffic jams and pollution level, thereby enhancing quality of life[22].
- **Smart energy management systems:-** Smart Energy presents a cheaper energy in an environmentally and sustainable manner. It relies on using new smart energy technologies such as smart grid meters, micro-grids, smart street lighting, renewable energy sources, solar energy, and advanced distribution management. Smart meter data can be used to obtain aggregate forecasts with higher accuracy using the so-called Cluster-based Aggregate Forecasting (CBAF) strategy, i.e., by first clustering the households, forecasting the clusters' energy consumption separately and finally aggregating the forecasts [22].
- **Smart water management systems:-** Using the information and communications technology manage water, decrease cost, and expand both the reliability and transparency of the water management. It saves, enhances, and secures water quality by decreasing the leakage. A smart reducing for the consumption of irrigation water can do an extension of parks and forests in cities. The partitioning of water distribution system is a complex process achieved defining network clusters arranged in sectors, with the complete isolation of clusters through gate valves, or arranged in districts, inserting both gate valves and flow meters [23].
- **Smart weather management systems**:- As less energy is used, the environment will surely be more clean, green and cool. The IoT's and weather sensors' system through its capabilities in weather forecasting can proactively gather the information. Thus, it gives for context-aware evaluation of the link between environmental themes including weather and related social dynamics. Using clustering in smart weather management systems gives many outputs like:- representation of the environment in a map, heat maps, and real-time air quality updates [24].
- **Smart waste management systems:-** Using big data, information extracted from vehicles can be worked to eliminate pollution levels. IoT technology can also be applied in the form of sensors fitted beneath the roads that could calculate an amount of traffic in a day. A proper technology such as software applications and Geographic Position Systems (GPS) will guide the trucks in finding the shortest path for garbage collection. Prevention of waste generation has the highest priority in the management hierarchy, so clustering is used to measure the following:- real-time emission information, fine dust, and garbage collection places with high density [25][26].
- **Smart Healthcare systems:-**Permit healthcare companies and practitioners to gather, analyze, and utilize patient information, which can also be participate by insurance companies and some government agencies. Support processing difficult occurrences to follow, analyze, and flag potential health changes either on a daily basis or on a demand basis. Clustering enhances healthcare systems. For example, global high-technology

medicine clusters, which bring together a large number of members representing various industries and technology areas, and whose products and services are widely in demand abroad [22].

- **Smart governance systems:-** Enable the integration and collaboration of different government agencies and mix or streamline their processes. This will give more efficient operations, better handling of shared data, and stronger regulation management and enforcement. Clustering is used to help governance systems in many areas like:-provides information to various departments of a city, better overview of urban interrelations, and improves the quality of government services [27].
- **Smart parking systems**:- Smart parking helps drivers to extract a nearby parking spot. The information presented to the driver can have many different forms, from public displays placed next to roads to mobile apps directing the driver to a free parking spot. Automated car parking system used clustering technique to handle the following:- reduced waiting times and stress for parking area users, overall enhancement of mobility within the city, and availability of Car parks in the city [28].

5. The Proposed Framework

The purpose of this research is to solve the problem of scalability of big data in smart cities to enhance their development and give them an added value. The big data in smart cities needs big storages and this volume makes operations such as analytical operations, process operations, retrieval operations, very complex and hugely time consuming. One way to overcome these difficult problems is to apply big data clustering techniques in a compressed format (to remove irrelevant and redundant data) that is still an informative version of the entire data. Such clustering techniques aim to generate a good quality of clusters/summaries. Fig.4 shows how data are collected to represent a big data clustered to retrieve the useful result as final process. The proposed framework consists of several phases (four phases) as follows:

- **Phase 1 (data collected):-** Big data can originate from sensors. Another essential source for big data is the World-Wide-Web. The web mining may be used to extract unstructured data (Bitmap images, objects, text, Banking, Credit card Transaction, etc.) related to everyday events happening in a city. In this view social media, such as Facebook and Twitter can provide information about problems and citizen sentiments. Many government organizations and private companies offer open data sets online that can be used for analysis.
- **Phase 2 (job distribution):-**Job distribution process is the distributed file systems that stores data across a large number of cheap servers. Job distribution process assumes that it runs on many inexpensive commodity components that can often fail, therefore, it should consistently perform failure monitoring and recovery. Furthermore, it can store many large files simultaneously, and it is optimized towards appending data to existing files in the system.
- **Phase 3 (data clustering):-**Clustering analysis is one of the famous approaches in data mining and has been widely used in big data analysis. The aim of clustering includes the task of separating data points into homogeneous groups such that the data points in the same group are as similar as possible and data points in different groups are as dissimilar

as possible. It is still a problem for good querying and exploiting data in an intelligent way from a gigantic database which is the result of big data to representing it in a structured way. It will be almost impossible to handle or access this large amount of data if database operation is not performed in an optimized way or data are not properly clustered.

Herein, a parallel K-means algorithm (PK-means) based on Map Reduce is utilized, in which the distance between each point and cluster is calculated and the new cluster ID to each point is assigned by Map function, new cluster centers are calculated by Reduce function, then iterative calculation and only the distance between center point and points in the relevant cluster is calculated in intermediate iterations. The rationale of using this technique is that it is a simple yet powerful parallel programming technique with the aim of saving computational cost.

- **Phase 4 result collection:-** Big data is analyzed by categorizing it in some clusters. Enabling the analytics in data helps in identification of business patterns and behavior of citizens. Finally, the result is collected to help in decision making.

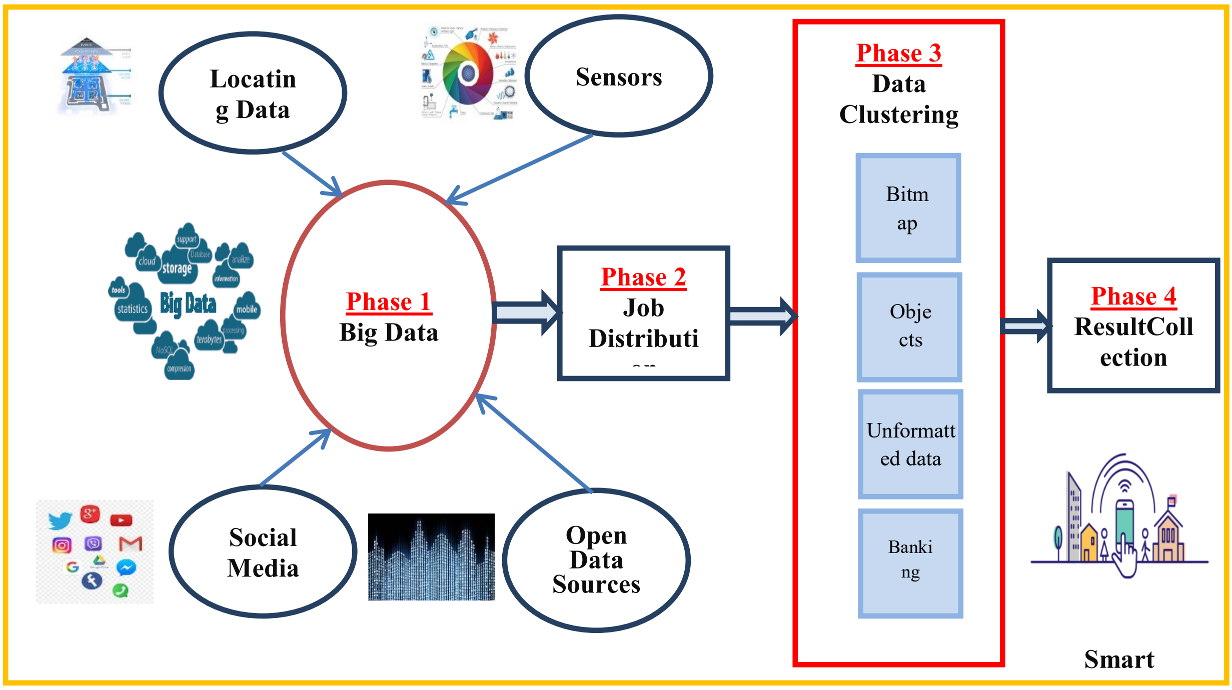

Fig. 4: Proposed big data clustering framework for smart cities

6. Conclusion

The using of big data clustering is necessary in enhancing the development of smart cities. Consistent technology & infrastructure are important that can handle M2M (machine to machine), M2H (machine to human), communication and present public services to all cities. Big data can present a main role in terms of collecting valuable information and for decision-making purposes.

Big data will help to analyze, predict information collected by smart devices in smart cities. Different benefits that can be applied with the help of big data clustering have already been explained in this paper. Also, some challenges are discussed as the data is from different heterogeneous sources, so a problem of scalability of big data is solved by introducing the framework of big data clustering. Hence, the technology must be implemented with proper understanding. Thus, managing big data clustering technology infrastructure will soon convert normal cities into smarter cities. The proposed distributed clustering framework is simple and able to deal with different type of data within big data environment. Furthermore, this framework can be used in smart cities at low cost because its four stages depending on cheap technologies. This type of distributed analytical processing can help developing countries to build smart cities on their lands and profits from their data to make smart decisions according to different situations.

References

[1]. S. Gürsoy, and M. Yücelen, " Can Big Data Analysis Make Cities Smarter? Emerging Issues and Stakeholder Implications in Smart Mobility", European Journal of Economics and Business Studies, Vol. 8 No.1, 2017, pp. 23–28.

[2]. J. Gantz, and D. Reinsel, "The Digital Universe in 2020: Big Data, Bigger Digital Shadows, and Biggest Growth in the Far East – United States", IDC Analyze the future, 2012, pp. 1-16.

[3]. A. Kumar, and A.Prakash, "Role of Big Data and Analytics in Smart Cities", International Journal of Science and Research, Vol.6,No.14,2014, pp.12-23.

[4]. N. Nagpal, "Analyzing Role of Big Data and IoT in Smart Cities", International Journal of Advanced Engineering, Management and Science, Vol.3, Issue 5, 2017, pp. 584-586.

[5]. S. Das, A. Abraham, and A. Konar, "Metaheuristic pattern clustering–an overview", In Metaheuristic clustering, Springer, Berlin, Heidelberg, 2009, pp. 1-62.

[6]. E. Al Nuaimi, H. Neyadi, N. Mohamed, and J. Al-Jaroodi," Applications of Big Data to Smart Cities", Journal of Internet Services and Applications, Vol. 6, No. 1,2015,pp. 6-25.

[7]. Albino, Vito, U. Berardi, and R. M. Dangelico, "Smart Cities: Definitions, Dimensions, Performance, and Initiatives", Journal of Urban Technology, Vol. 22, No. 1, 2015, pp. 3–21.

[8]. D. Bhattacharya, "Big Data Management and Growth Enhancement", International Research Journal of Engineering and Technology, Vol. 5, Issue 10, 2018, pp. 1769-1774.

[9]. Prasad, B. Rohit, and S. Agarwal, "Comparative Study of Big Data Computing and Storage Tools: A Review", International Journal of Database Theory and Application. Vol. 9, No. 1, 2016, pp.45-66.

[10]. Phinyomark, Angkoon, E. Ibanez-Marcelo, and G. Petri, "Resting-State FMRI Functional Connectivity: Big Data Preprocessing Pipelines and Topological Data Analysis", IEEE Transactions on Big Data, Vol. 3, No. 4, 2017, pp. 415-428.

[11]. S. Vijayarani, and S. Sharmila, "Research in Big Data – an Overview", Informatics Engineering, an International Journal (IEIJ), Vol. 4, No. 3, 2016, pp. 1-20.

[12]. Goswami, Puneet, and S. Madan, "A Survey on Big Data & Privacy Preserving Publishing Techniques", Advances in Computational Sciences and Technology, Vol. 10, No. 3, 2017, pp. 395-408.

[13]. Jin, Jiong, J. Gubbi, S. Marusic, and M. Palaniswami, " An Information Framework for Creating a Smart City Through Internet of Things", Internet of Things Journal, IEEE, Vol. 1, No. 2, 2014, pp.112-121.

[14]. Bellavista, Paolo, A. Corradi, and A. Reale, “Quality-of-Service in Data Center Stream Processing for Smart City Applications”, Handbook on Data Centers, Springer, New York, 2015, pp. 1047-1076.

[15]. M. Padmavalli, "Big Data: Emerging Challenges of Big Data and Techniques for Handling", IOSR Journal of Computer Engineering, Vol. 18, Issue 6, 2016, pp. 13-18.

[16]. D. Laney, “3D Data Management: Controlling Data Volume, Velocity and Variety”, META Group Research, Note, Vol. 6, 2001, pp. 1-3.

[17]. Ohlhorst, and Frank, ” Big Data Analytics: Turning Big Data into Big Money” ,John Wiley & Sons, 2012.

[18]. Sivarajah, Uthayasankar, M. M. Kamal, Z.Irani, and V.Weerakkody, “Critical Analysis of Big Data Challenges and Analytical Methods“, Journal of Business Research, Vol. 70, 2017, pp. 263-286.

[19]. Hall, and O. Lawrence, "Exploring big Data with Scalable Soft Clustering", In Synergies of Soft Computing and Statistics for Intelligent Data Analysis, Springer, Berlin, Heidelberg, 2013, pp. 11-15.

[20]. Havens, C. Timothy, J. C. Bezdek, and M. Palaniswami, "Scalable Single Linkage Hierarchical Clustering for Big Data", In Processings of IEEE eighth international conference on intelligent sensors, sensor networks and information, 2013, pp. 396-401.

[21]. McCallum, Andrew, K. Nigam, and L. H. Ungar, "Efficient Clustering of High-Dimensional Data Sets with Application to Reference Matching", In Proceedings of the sixth ACM SIGKDD international conference on Knowledge discovery and data mining, ACM, 2000, pp. 169-178.

[22]. Liu, Dejian, R. Huang, and M. Wosinski, “Development of Smart Cities: Educational Perspective in: Smart Learning in Smart Cities”, Lecture notes in educational technology, Springer, Singapore, 2017, pp. 3-14.

[23]. Mizuki, Fumio, K. Mikawa, and H. Kurisu, “Intelligent Water System for Smart Cities”, Hitachi Review, Vol. 61, No. 3,2012, pp. 147.

[24]. IHS Markit, “The Benefits of Safe Cities - Safer Cities Creating a Better Life”, Retrieved from https://cdn.ihs.com/www/Technology/Security/IHS_Markit-Benefits_of_Safe_Cities_WhitePaper.pdf, 2017, pp. 4.

[25]. Shyam, G. Kirshna, S. S. Manvi, and P. Bharti, “Smart Waste Management using Internet-of-Things (IoT)”, In 2017 2nd International Conference on Computing and Communications Technologies, IEEE, 2017, pp. 199-203.

[26]. Gutierrez, M. Jose, M. Jensen, M. Henius, and T. Riaz, “Smart Waste Collection System Based on Location Intelligence”, Procedia Computer Science, Vol. 61, 2015, pp.120-127.

[27]. Morabito, and Vincenzo, “Big Data and Analytics for Government Innovation Big Data and Analytics”, Springer, 2015, pp. 23-45.

[28]. Chowdhury, Prasun, P. Bala, S. Giri, A. R. Chaudhuri, and D. Addy, "RFID and Android Based Smart Ticketing and Destination Announcement System", Advances in Computing Communications and Informatics, IEEE,2016, pp. 2587-2591.