Enhancing Security and Privacy on Smart City's Collected Data: A Fog Computing Perspective

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Abstract: Smart cities use information and communication technologies to deliver services to their citizens. Use of ICT makes them to be more intelligent and efficient in usage of resources, resulting in cost and energy savings, improved service delivery and quality of life. Smart cities are expected to be the fundamental pillars of continued economic growth and improved services delivery. Smart City technology is having ability to constantly gather information about the city, sharing the data with people, devices and technologies or borrowing relevant data from elsewhere, for analysis to enable informed decision making. For instance internet of things has emerged as a technological driving force in real time service delivery in smart cities. These applications provide new abilities, enhancing monitoring, and provision of action oriented process on control and device management. Smart devices are a major source of big data in smart cities. With expected increase of billions of smart devices and sensors in smart city by the year 2020, more data will be generated which will reduce efficiency of cloud access, due to increased volume. Security and privacy of data is a challenge in smart city, negligence in data security and privacy can be amplified in folds resulting to faulty applications, services along with paralyzing the entire city through Denial of Service (DDoS) attack, Spear Phishing Attacksand Brute-Force Attacks among others.Fog computing FC is a new paradigm that is intended to extend cloud computing CC through deployment of processing and localized units into the network edge, enabling low latency, offering location awareness and latency sensitiveness. Homomorphism for encryption, authorization, authentication, and classification are performed on collected data in smart cities to improve security and privacy. In this paper assimilation and analysis, is performed with fog computing aspects of decentralization, different policies for datacenter transferstrategies being analyzed.Processing time, access time, request time, response time and cost analysis show system efficiency.

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I. INTRODUCTION

Smart cities is refers to cities that use information and communication technologies to deliver services to their citizens. Nowadays city development does not only depends Physical Capital i.e. infrastructure and social infrastructure but also availability and quality of ICT. Information communication technology is a form of capital for urban competitiveness. The dimensions of smart cities include: Smart Economy, Smart Mobility, Smart, Smart People, Smart Living and Smart Governance. [3, 4]

Data is captured, stored, analyzed, managed, and using digital technologies thus helping in resource management, asset management, archaeology, environmental impact assessment and urban planning. Technologies are bringing fundamental changes between the city and its inhabitants.[5]

Internet of things is a source of most of data in smart cities. Basically IOT allows connection of people and things anywhere at any time by using the any path/ network and any service [European commission 2008] most of objects. The internet connects different computers to communicate over a network, IOT connects devices, people,environment and computers with an intention of reducing complexity and integrationand computer based interaction with clients. Connected objects need to have the ability to learn from the surrounding with the ability to think and comprehend on different issues on their own. [1, 2]

Collected data is analyzed to provide valuable insights that accelerate informed decision making. Detailed data provides more insight of various activities going on in smart city; it defines why big data is a part of smart city operations. Advancement of technology has enabled reduction of hardware cost hence enabled wide scale application of sensors in all kinds of hardware devices. Sensors do generate large volumes of data that is stored and retrieved when need arises. [6, 7]

Data processing and storage is mostly based on cloud computing framework. Cloud resources available for computation and storage is generally limited. Ideologicallyhaving all data in smart cities to be sent to the cloud for processing will cause constraints in resource due to the nature of big data that is collected. With expected increase of billions of smart devices and sensors in smart city by the year 2020, more data will be generated which will reduce further the efficiency of cloud access due to increased volume. Security and privacy of data is also a challenge in smart city negligence in data security and privacy can be amplified in folds can result to faulty applications and services along with paralyzing the entire city through Denial of Service (DDoS) attack, Spear

Phishing Attacks and Brute-Force Attacks among others. [7, 1]

Fog computing addresses few limitations of cloud. Fog computing is decentralization of the computing infrastructure enabling data, compute, storage and applications are located between data source and the cloud. Fog computing increases the efficiency by bringing power of the cloud closer to where data is created and acted upon.In fog computing systems operate on the network edge. The implication is that data can be processed locally before sent to the cloud for storage. In the context of internet of things data can be processed at the node rather sending to cloud for processing thus ensuring limited transfer distances thus improving the efficiency. [1]

Our objective is to discuss and illustrate how we can improve security and privacy with introduction of authentication, authorization, classification and encryption performed at the edge thus enabling proper management of data. To analyses the impact of computing at the edge; cloud analyst tool enables assimilation with three objectives in mind: 1) Illustrate the importance of decentralized processing in terms of processing time and costs. 2) Compare the performance of different broker strategy used 3) Analyze different system configuration output in terms of processing time.

The rest of the paper is organized as follows. Sections 2 fog computing perspective Section 3 security and privacy on collected data. Section 4 research methodology Section 5result and discussions. Concluding remarks and references.

II. FOG COMPUTING PERSPECTIVE

2.1 INTRODUCTION

Fog computing is emerging technology that uses Internet of Things and extends cloud computing services to the edge of the network. It provides data, computation, storage and applications similar as cloud to the end user with a close proximity to end-users. Fog computing can be viewed development of cloud computing paradigm to the edge.

Fog computing was originally coined by cisco stating that it's an extension of the cloud to the edge. Service and applications delivered the separation through its characteristic nature, low latency, location awareness, mobility, widespread geographical distribution, strong availability and real time streaming, large number of nodes and heterogeneity. This makes fog computing to be more favored. [16]

The architecture is designed to enable collaboration between the end user and devices to communicate using some set configurations to measure and help in management of network at a lower level. [9] It does not really mean that there is only one architecture by fog computing is a presentation of a notion that enhances data analysis to be done at the edge. [10]Analysis can be done by one node or a group of nodes.This horizontal architecture enables resource and service distribution closer to data sources. Many issues are solved like bandwidth and latency that promise future utilization of IOT in further large scale. On the other hand cloud computing is valuable technology that is designed for information technology rather than IOT. The distributed nature of smart city functioning require operational efficiency with minimized with minimized challenges e.g. low latency, bandwidth and so on. [8]

Devices at the edge include electronics, smart phones, home appliances, this objects communicate with each other interact and share data, using internet without human interference. It reduces communication time and cost too. There is a projection of billions of sensors and smart devices in cities that will encourage use of this technology by 2050. Hence there will be an increase in data is generated by physical assets or things deployed at the very edge of the network. With emergence of internet of things this devices are being connected. [17]

Fog nodes areconsidered as the physical device where fog computing is placed. Receives the data from IOT devices in real time. They usually run and enable real time control analysis, response, the over storage transient, along with sending periodic summaries to the cloud. In other interpretation they are always seen as cloud computing layers. [18]

Storage of massive data as in the case of smart cities cloud data services are cost effective to set and run data centers. Cloud data center is a version of data center that is available remotely and accessed through internet. To enhance safety the cloud performs the maintenance and update of data centers in different geographical location. [19]

There is better security features with fog since there is introduction of more firewalls to a network. Fog is an extension of cloud with the ideology of enhancing provision of data, storage on a distant server. Client can buy services from providers who deliver maintenance and the service. [20]

New service has immerged with integration of fog and internet of things called fog services. Where fog nodes are built around a certain geographical market with a service provider. It contains hosting of local computation storage abilities and networking. Faas is unique in that it enables small and big companies to build and operate huge data centers, the main difference with cloud since cloud is mostly operated with large companies. [21]

Devices with storage, computing and network connectivity can qualify to be a fog node. International data corporations estimated the data analyzed on devices that are close physically to internet of things is around forty percent. Thus analyzing data at the fog level close to where it is collected will minimize the latency. It offloads large amount of data

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from the network and keeps sensitive data inside the network. [19]

Fog computing offers basic densely points for accumulating and gathering data that is received from the devices. In previous researches in [22] they identified that fog computing is a better alternative into be applied for internet of things, which is the often case in most of the smart city set up, fog computing is suited for smart cities application

2.2 IMPACT OF FOG COMPUTING

Application of fog computing in smart cities is intended to increase the efficiency in service delivery of smart cities. Areas of application include:

Distributed nature: Distributed nature of the fog computing helps to decentralize service delivery from the cloud. Communication storage and control will be effectively achieved; it provides a way of decongesting the traffic from to cloud whenever a service is requested by the client.

Allocation of functions: since fog is architecture it will involve allocation of functions in IOT of smart cities. It makes it easy for standanization of operation in the network; this will improve service delivery since it's at the edge.

Increased distribution: It provides distribution of services which is the opposite nature of the cloud. Fog resources are available in the network. Fog enables integration between multiple nodes and the cloud.

Improved latency: Fog computing reduces the latency. Latency is the delay in transfer of data following an instruction to transfer the data. Since fog services have a smaller latency they are able to enable real time operations they include: real time streaming, virtual reality, real time looping and so on.

Scale levels: fog computing has a high value applications but with challenges in terms of network bandwidth and resources. Scale is an acronym for security latency and efficiency.

III. SECURITY AND PRIVACY ON COLLECTED DATA

Lack of proper security in cities may lead to invasion on individual privacy. Collected of data faces a number of attacks including Denial of Service (DDoS) attack, Spear Phishing Attacks and Brute-Force Attacks among others. Internet of things in smart cities enables massive collection of data thus increasing security and privacy challenges. Attacks may be launched as the data during collection, transfer, access or storage.

Smart cities have numerous Global Positioning and surveillance system that collect a lot of very sensitive information mingles with ordinary data which endangers the privacy of citizens of the smart city. In our current study we propose use of classification, encryption, authorization and authentication with services performed at edge level. (Fog layer)

3.1 CLASSIFICATION

Classification is grouping of data depending on similarities. In this s study data was classified based on priority levels of high, low and medium. The algorithm preferred was random forest classifier due to its popularity and more so its effectiveness.

3.2 Random forest classifier

Random forest classification is a popular algorithm. It is a supervised classification algorithm which operates by creating a forest with a number of trees. The higher the number of trees in the forest, the algorithm accuracy will be on the higher side. Importance of Random forest classifier is usage by both classification and regression, can handle missing values also when there are more trees it won't over fit.

FIGURE 3.1
CODE PSEUDOCODE

1. Randomly select k features from a total of m features
   Where k<<m
2. Calculate the node d using best split point from k features
3. Split into daughter nodes using best split
4. Repeat step 1 to 3 until reach I nodes
5. Repeat process 1 to 4 until n number and trees are reached.

3.2.1EXPECTED RESULT

The study choose used random forest classifier based its effective nature. Classification involves data collected ready for processing which is sent to service provider. These data is split based on their priorities of higher level, medium level and low level using Random forest classifier.

TABLE 3.1
EXPECTED RESULT

Sensitivity	Model 1	Model 2
High	Confidential	Restricted
Medium	Internal use	Sensitive
Low	Public	Unrestricted.

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3.2 ECRYPTION

In transfer and storage of data there are different attacks can be encountered. Generally encryption process will encode the data in a way that only authorized parties can gain access to it those who are unauthorized cannot gain access. Encryption does not prevent interference, but denies access of content to a would-be interceptor

3.2.1 HOMOMORPHIC ALGORITHM

It is a form of encryption that enables computation on cipher texts, generating encrypted result, when decrypted, will definitely match the result of operations similarly like when performing encryption on plain text. Homomorphic encryption enables privacy-preservation during computation process. [23]

Improvements of homomorphism Encryption have been continuous which has increase optimization thus improving efficiency. The research identifies with homomorphism as one of the powerful technique that is used to present transitional data.

3.2.2 GENERATION OF PRIVATE AND PUBLIC KEYS

Public keys and private keys used for encryption and decryption of the data, provided by the user when they want to access the cloud must match with the one registered in the database for one to get access.

The system automatically generates public and private key upon request from the users. The keys comprise of unique related cryptographic keys. They are commonly numbers e.g. 0496 0231 22C8 17GH BADA F01H

FIGURE 3.2
GENERATION OF PRIVATE AND PUBLIC KEYS

FIGURE 3.3
ENCRYPTION AND DECRYPTION

```
Public static void main (String args[])
{
HME hm=new HME();
System.out.println(hm.Encryption(new
BigInteger("20")));
System.out.println(hm.Decryption(new
BigInteger(hm.Encryption(new
BigInteger("20")))));
System.out.println(new Random());
}
```

3.2.3 AUNTHORIZATION & AUNTEHICATION

Authentication is a process to recognize the identity of users. A Set of credentials are stored in the database they are matched along with incoming application. If they a match the user is guaranteed access to the cloud to view the files.

Cloud services security is essential because sensitive data is uploaded containing details of smart city citizens. Access only guaranteed to owners of public key and private key. Verification is compulsorily before access and download of data.

FIGURE 3.4
AUTHORIZATION AND AUNTHENTICATION

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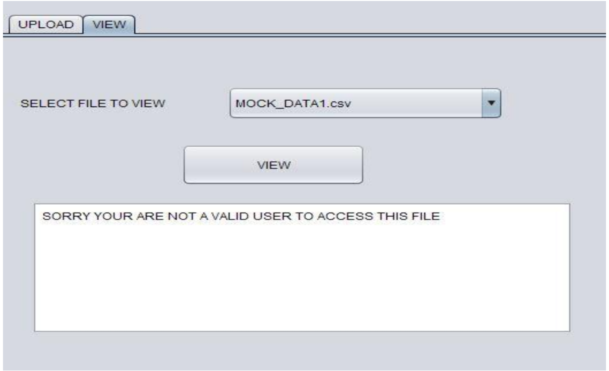


IV. RESEARCH METHODOLOGY

4.1 Research strategy

Our research is informed by pinanki [4] who reviewed smart cities and the data that is numerously generated in the cities.Internet of things was singled out as the source of big data in smart cities. Big data was identified to be useful in making real time informed decisions in smart cities. [11, 12, 14]

Cloud computing a predominant framework for service processing faces some challenges in terms of bandwidth and latency. Fog computing is an alternative to provide services at edge solving some challenges thus increasing efficiency. [1]

Our study will show improved security with increased efficiency by ensuring more services are done at the fog level.

4.2Implementation tools

Net beans environment is used to develop and run algorithm. Its integrated in nature can be used in windows Mac and Linux. It‵s open source that enables developers to develop web enterprises desktop and other applications. It is beneficial since it runs in many platforms and is being supported by most of the languages. Cloud analyst tool is used to perform assimilation it was developed to support geographical analysis of social networks tools in distribution of users and data centers. Users and data enters evaluate the load from users based on location parameters while using social networks.

4.3Data source

The data source of the research is secondary data. The data was collected from face book which is one of online platform having large followers with numerous volumes of data being exchanged.

For instance it had 2.121 billion users in 2019. On June 30, 2017 the statistics released by the world stat are approximately: North America 260M, South America 370M, Europe 340M, Asia 740M, Africa 160M Oceania 20M.

4.4Problem encountered

The problem uncounted in our assimilation include: inconsistence of assimilation environment, a lot of time is needed to analyze some strategies.

V. RESULT AND DISCUSSIONS

Result of assimilation is a product of algorithm implementation. The data collected in smart city is in a large scale internet based applications of internet of things connected across network over the internet. For instance a large scale application of our program can benefit from face book for example, one of the most popular networks across the world, with 2.121 billion users in 2019. On June 30, 2017 the statistics released by the world stat are represented in the table below.

The present study will illustrate the impact of decentralized processing in terms of processing time and costs, comparison of the performance of different broker strategy along with analyze different system configuration output in terms of processing time. Different scenarios are setin order to establish the impact of decentralization.

A SIMPLE APPLICATION WITH MULTIPLE DATACENTER ACROSS THE WORLD

TABLE 5.1

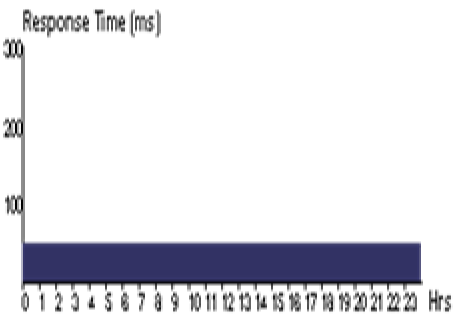
OVERALL RESPONSE TIME SUMMARY			
	Avg (ms)	**Min(ms)**	**Max**
Overall response time	123.02	37.06	392.87
Data center processing Time	1.84	0.07	10.86

The average response time for multiple data center based strategically in different regions of the world after assimilation will be 123.02Ms with processing time being 1.84Ms. Minimum response time of 37.06Ms and processing time of 0.07Ms the maximum time response time is 392.87 and processing time being 10.86Ms.

USER BASE HOURLY RESPONSE

FIGURE 5.1

UB1



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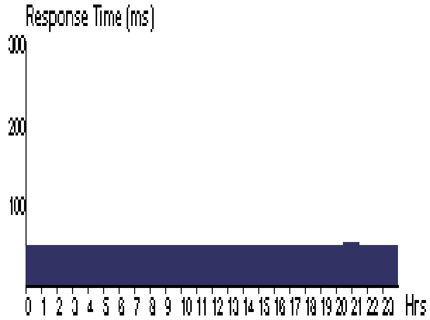
UB4



The spikes are visible in peak hours of UB4. UB1 does not show any spike during peak hours. Uniformity in UB1 can be attributed to normalization of the number of requests and the load size of the requests considering the surrounding user bases too.

The virtual cost of the process is $ 600.16 with the transfer cost amounting to $ 22.65. The result show that the cost of the virtual machine per data center remains constant throughout while the data transfer cost varies from one data center to another. Reason being the equal number of virtual machine used per data center during our assimilation.

APPLICATION HOSTED BY A SINGLE DATACENTERS ACROSS THE WORLD (50MV)

TABLE 5.2

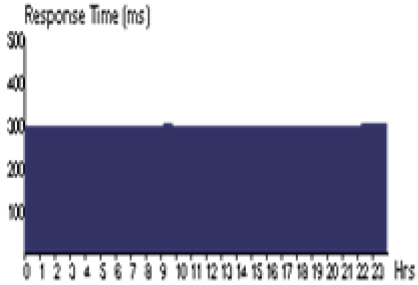
OVERALL RESPONSE TIME SUMMARY			
	Avg (ms)	Min(ms)	Max
Overall response time	245.06	36.04	645.66
Data center processing Time	0.98	0.06	4.30

The average response time for a single data center somewhere in Europe based strategically to process and respond to data from different regions of the world will be 245.06Ms with processing time being 0.98Ms. Minimum response time of 36.04Ms and processing time of 0.07Ms the maximum time response is 645.66Ms and processing time being 4.30Ms.

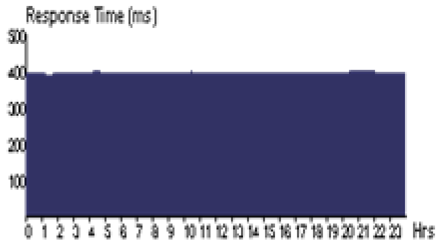
USER BASE HOURLY RESPONSE

FIGURE 5.2

UB1



UB7

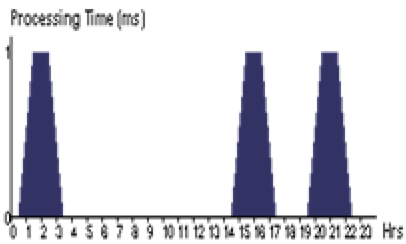


UB1, and UB7, have a similar uniform response pattern with small spikes seen in uniform intervalsthroughout the 24 hour period. Attributed to peak hour of the user bases and neighboring user bases.

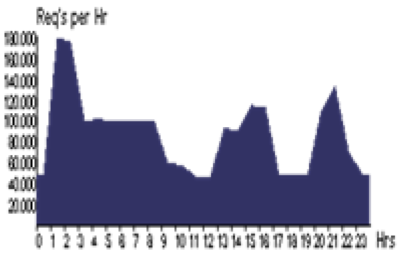
DATA CENTER HOURLY PROCESSING TIME

FIGURE 5.3

DC1



DC1



The processing time of data center one is uniform with three spikes noted in specific hour of the day, attributed to peak hours of different user bases in different regions. The different time zones of the users request contributes to shape of the graph of request verse the time lack of uniformity is attributed to requests popping in from different regions of the world.

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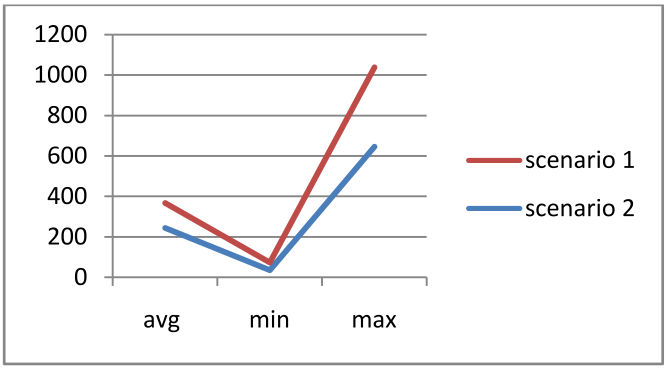
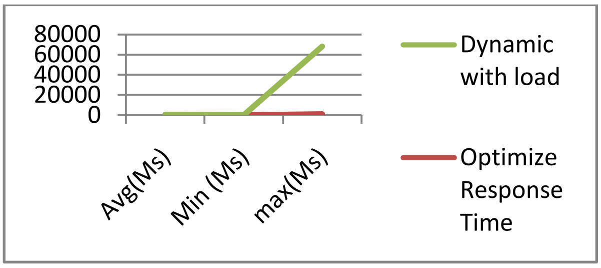
The result of application of a single datacenter to respond to user bases across the world the cost is: virtual machine cost is $ 120.03; total transfer cost is $ 22.65 with grand cost amounting to $142.68.

COMPARISON BETWEEN DIFFERENT DATACENTER DISTRIBUTIONS STRATEGIES
FIGURE 5.4



The summary of assimilation in results in table 5.1&table 5.2 are shown above. Response time for distributed data center strategy (table 5.1) less compared to a centralized data center strategy (table 5.2). It implies that decentralization of services reduces the response time.

COMPARISON OF DIFFERENT SERVICE BROKER POLICY
FIGURE 5.5



Assimilation result of dynamic with load, optimize response time and closest data center is shown above. The three strategies show a slight difference in response time with closest data center strategy displaying the minimal time.

5.1 COMPARISON OF OVERALL RESPONSE OF DIFFERENT DATA CENTERS

The result of different experiments conducted is displayed below.

Comparison of overall response of different data centers
TABLE 5.3

		Less powerful system		Fairly powerful system	
No.	**Scenario description**	**Overall response time in (milliseconds)**	**Overall processing time in (milliseconds)**	**Overall response time in (milliseconds)**	**Overall processing time in (milliseconds)**
1	1 data center with 5oVMs	336.39	0.91	300.77	0.91
2	2 data centers with 25VMs each	312.22	1.06	314.5	0.83
3	2 data centers with 100VMs each	312.45	1.29	315.57	1.91
4	1 data centers with 100VMs	556.5	2.85	336.98	1.53
5	3 data centers with 25,50,100VMs each	133.55	1.89	336.98	1.53
6	3 data centers with 25,50,100VMs each using optimize response time strategy	133.55	1.89	151.29	1.77
7	3 data centers with 25,50,100VMs each using reconfiguring dynamic with load strategy	212.22	89.33	151.28	1.77

Difference of configuration of systems used in experiment. Less powerful System configurations are:Data center processor speed -1000, VM size-10000, VM Memory - 512mb, VM band Width – 100. Fairly powerful System configurations are:Data center processor speed -1000, VM size-1000000, VM Memory - 10240mb, VM band Width – 1000000.

Overall response time and overall processing time of different experiments conducted using fairly powerful systems and less powerful systems is flip flopping depending on the work load with no clear illustration of a better option. Both systems in particular situation of the experimenters have shown good results.

VI. CONCLUSION

Smart cities uses information and communication technologies to deliver services to their citizens. Use of ICT brings intelligence and efficient in allocation of resources. Internet of things has emerged as a technological driving force in real time service delivery in smart cities. These applications provide new abilities, enhancing monitoring, and provision of action oriented process. Security and privacy of data is a challenge in smart city negligence in data security and privacy can cause a nightmare in functioning of smart cities. In this study authentication, authorization has been used to enhance security purposes and homomorphicencryption to preserve the privacy of data. Encryption of homomorphism is deliberated in lengthy noting that its improvements have been continuous which has improved efficiency. It enables full encryption and privacy-preservation during computation process.Random forest classifier and data tree has best accuracy levelsthat and handle missing values also when there are more trees without over fit.Fog computingFC will impact smart city positivelywith intended expansion of cloud computing CC through deployment of processing and localized units into the network edge, enabling low latency and increased efficiency. Application used can identify the overall usage pattern also identify how different configuration will effectively tackle the load available. New insight were discovered through simulation they include: Decentralization which is associated with fog computing reduces that processing time by half, difference in response time among services broker strategies with closest data center giving the best response time, lastly as expected a fairly powerful system configured system will give a better processing time.

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