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USING CLOUD COMPUTING TO IMPROVE URBAN TRAFFIC MANAGEMENT AND OPTIMIZATION SYSTEM

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ABSTRACT

At the modern society, one of the essential infrastructures is transportation. Performance of transportation systems is important for personal commuting, commerce and economic growth of all countries. Over the years, the modern society has faced increased traffic, increased fuel cost and increased rate of pollutants. According to the abovementioned, improvement of traffic management in urban transportation is an important issue. Development of sustainable intelligent transportation management system needs integration and the capability of cooperation with emerging technologies such as internet-connected vehicles, cloud computing and internet of things (IoT). In this study, architecture is proposed for integration of management of urban transportation traffic, which is sensitive to motion and is error-tolerable and scalable. Using simulation, the performance of this system is tested and the results are discussed.

Key words: cloud computing, integration, traffic management system.

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1. INTRODUCTION

In urban development, transportation department plays key role. Need to transportation is for various reasons such as providing commodities, passenger transfer, supplies and so on. In transportation, important factors include short travelling route, decreased travel time, and comfort during travel. Moreover, need to transportation in cities can provide jobs for people. Hence, transportation can be changed into a basic and inseparable element in urban development. In a traffic management system of urban transportation, if each component is working separately and there is no integration among these components; if the components of the system are separated, the system can't work well. Using cloud computing and internet of things, connection of various activities in different components of a system is provided and whole system can act in integrated form. This purpose can be realized only with an appropriate architecture and effective use of all components of traffic management system. In general, traffic management systems today encounter numerous problems in terms of sensitivity to motion, scalability, error-tolerance, service reliability, comfort and so on. Hence, according to the advancement of technology, cloud computing can be appropriate instrument to use all facilities to improve urban traffic management system. In this study, architecture is presented to integrate all components of traffic management system and the efficiency and effectiveness of the system is discussed. With wide use and development of computer networks, cloud computing is matured gradually and technologies such as virtualization, distributed processing, data processing and cloud storage could also complete the cloud computing approach [2]. Using cloud computing in traffic system has brought considerable economic advantages. Many countries such as America, European countries and Japan have applied cloud computing for the development of intelligent traffic system for purpose of integration. As a result, wide use of cloud computing technology in field of traffic and creating Cloud Traffic Data Center is changed into an unavoidable process [2].

Wireless networks, internet of things, integrated communications, cloud computing and other cases as the most powerful key technologies for innovation in services and applications have paved the way for the modern society to have intelligent cities [1]. Improvement of urban traffic management system in intelligent cities has gained attention of research societies and industrial communities because of intense increase in traffic, cost of fuel and pollutants. Urban traffic management systems are too inefficient; although they have gained abundant advances in emerging technologies.

In the age of cloud computing, analysis of types of large data collected from vehicle internet, internet of things and sensors/intelligent devices can pave the way to provide valuable services [6]. Some well-known applications (Google MAP) can pave the way for loading and sharing image, video, comment and point for other users in addition to provide conditions to observe the route traffic level. However, realization of an efficient intelligent that is sensitive to motion and with high error-tolerance and scalability can be an open problem in intelligent transportation system based on cloud computing.

Intelligent transportation systems (ITS) were developed in the way of making vehicles intelligent. Since mid-1980s, studying and manufacturing intelligent cars (known as driver cars or driverless cars) was begun. Many research centers, suppliers of vehicles and universities began cooperation across the world to design and manufacture intelligent vehicles at the world [3]. Over the decade, advancement in intelligent transportation system technologies has significantly affected development of intelligent cars.

Intelligent transportation system (ITS) helps improvement of efficiency of traffic management and reliability of traffic safety. In this system, collected data by sensors and IoT will be sent to processing center. In this center, the data analysis is done and then, the results will be sent to the thing connected to internet. The challenges of ITS mainly include two issues including 1) calculations and 2) communications. Hence, this study tends to apply the architecture to improve two challenges of calculations and communications. Security and reliability and access are the prerequisites of the system.

2. LITERATURE

Li et al (2011) has conducted a study to analyze the history of development of control systems and traffic control systems in evolving calculative model and showed the status of control systems and traffic control systems based on mobile multipurpose technology [5].

Bitam et al (2012) proposed a new model of cloud computing (ITS-Cloud) that is suitable for ITS to improve transportation results such as road safety, increased efficiency of transportation, reliability in travel, travel information, environment protection and traffic flexibility. The model includes two secondary models including static and dynamic models. Static cloud is same traditional form of cloud that vehicle used to apply advantages of static cloud computing. Dynamic cloud is a temporary cloud, which is formed by the vehicles containing cloud data in it temporarily. To test validity of this model, simulation was taken to assess the load balance as a NP-complete problem. The results were obtained using bees life algorithm (BLA) used in ITS- cloud and were compared with the results obtained from BLA in ordinary cloud [7].

Jaworski et al (2011) presented an urban traffic control system based on cloud computing. The system was responsible for increasing the efficiency of road and improving the traffic control to enhance safety of passengers, decrease fuel consumption and decrease emission of pollutant gases. The scenario of this vehicle control system assumes that speed of each vehicle in controlled area is regulated by a control unit out of the limit, which can monitor all traffic intersections. The software component that is responsible for that is an Intersection Control Service (ICS). In view of this system, vehicles can be considered as cloud services and are explored and called using a cloud computing method. Geographical multicast addressing is used to point all vehicles in specified regions. ICS is a part of urban/regional cloud system, which matches the traffic flow in distance of intersections. The system optimization is taken simultaneously in several programming airplanes and the lowest one is a place for a unit intersection and highest one is a total area of a city or a district. ICS collects the traffic data from different sensors around the intersection and from the vehicles and creates a dynamic location map, which can be used to evaluate road status and to take short-term predictions for purposes of vehicle control [8].

Kumar et al (2012) claimed that self-driving vehicles like self-drive cars are produced by the help of intelligent sensors and IoT devices and Artificial Intelligence (AI) techniques. In most cases, intelligent sensors can be connected to the network by IoT devices, so that they can transfer the data in right time. IoT devices transfer the sensor data to processing unit, so that required measures are taken based on output data of sensor. Processing unit sends the tasks to the processors based on predefined instructions with AI techniques. Offloading and constant sending

of raw data of sensors to processing unit and storage of the information in cloud can create huge calculative load in the cloud servers. In order to decrease the amount of load of flow data on the cloud, fog computing or fog-equipped technology comes to help. Processing of raw data is taken before sending the data to the cloud. In fog space, data optimization and analytical techniques are taken as a part of data processing in a datacenter on IoT devices or in a gate [9].

Yang et al (2020) presented the definition of ITS and described the combination and requirements of them. Then, they explained the challenges and the new forms of ITS, which are mainly focused on vehicles and communication network. To present fog computing, ITS architecture is presented along with fog computing. They discussed that how fog computing can meet the technical challenges and make serious support for ITS. Finally, several cases of using ITS with fog such as intelligent vehicles, hybrid intelligent driving and common vehicles were discussed in this study [10].

Zhang et al (2017) conducted a study to analyze issues such as traditional data center (Stovepipe), inadequate use of IT equipment and data resources, which can cause inflexible structure of IT and high maintenance costs and high energy consumption in system function. For example, using Beijing Municipal Committee of Transport (BMCT) data center, the scholars introduced a way to create datacenter of traffic cloud computing distributed based on SOA (service-oriented architecture) combined with cloud computing. In addition, Data- center Energy- efficient Network-aware Scheduling (DENS) algorithm used in cloud datacenter was presented in cloud computing center to realize complete use of types of resource in cloud datacenters. Empirical results show the effectiveness of proposed algorithm compared to DENS traditional algorithms [11].

3. METHODOLOGY

In this study, needs are identified and predicted. Then, the facilities are predicted and finally, the best method is identified to use facilities to meet needs. Before analyzing the architecture of proposed model, some concepts such as fog computing and IoT are shortly explained and then, the proposed model is presented.

3.1. Internet of Things (IoT)

Today, various devices in different types are connected to computer networks. Some connected devices have high processing and storage power and some others have limited hardware sources and have lower processing and storage power. Intelligent mobile phones, tablet, computer, intelligent home appliances, small cellular station, network routers, traffic and speed control cameras, intelligent vehicle, intelligent counters, energy controllers, intelligent building sensors, control systems of production line are examples of internet-connected things.

Over the decade, transfer of processing, control and data storage to cloud computing has had uprising process. Processing, storage and network management were transferred to centralized datacenter. Today, cloud computing encounters various challenges to meet new requirements in internet of things (IoT) as an emerging technology [12].

3.2. Challenges with Internet of things (IoT)

- Necessity of system responding with high speed
- Limitations of network bandwidth
- Limitation in hardware sources of devices
- Necessity of non-stop connection to cloud computing servers
- New security challenges in IoT

According to rapid growth of population in cities, some infrastructures and services should be provided to meet needs of citizens. Accordingly, need to digital devices is significantly increased. For example, sensors, stimulants and intelligent phones are going towards huge commercial potential for IoT, because all devices can be connected to internet and communicate each other [13]. The primary sample of IoT is exposed to intelligent and configured things, which can be interconnected through a worldwide network infrastructure. IoT is mostly aimed at improving the reliability, performance and safety of intelligent city and its infrastructures as real things and wide spread with low storage space and processing capacity [14]. Knowingly, this study has presented a review of intelligent city deployed in IoT [15].

4. FOG COMPUTING

As it was mentioned before, IoT can cause development of innovation and enhancement of life quality. IoT can produce large volume of data and traffic. Processing such volume of data and management of traffic load produced by IoT is hard to do for the traditional cloud computing systems. Fog computing is a model designed to overcome the restrictions.

Fog computing is s distributed processing model, which acts as a mid-layer between cloud computing servers and IoT devices and sensors. Total schema of fog computing environment is presented in figure 1.

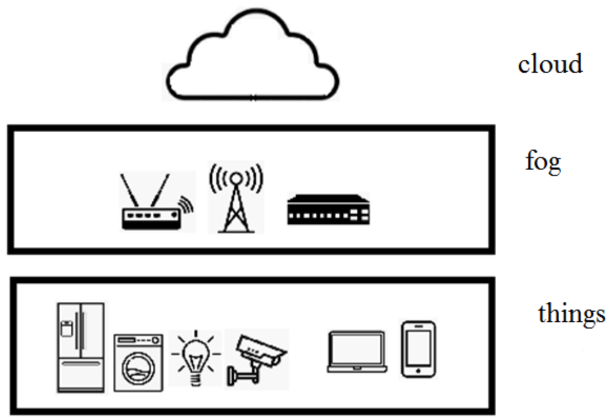

Figure 1 fog computing environment

In fog computing architecture, data processing, control and other services with need to fast access can be taken with the help of near-user components. This kind of architecture can decrease system responding delay to high extent. For computing architecture gets the data in hierarchical mode along the route from central servers of cloud computing to internet-equipped devices. In other words, it can pave the way to take processing in a place that balance is provided among needs of things and processing sources. This can also decrease the volume of data sent to central servers of cloud computing. Fog computing can take the tasks needing hardware sources instead of devices with restricted hardware sources. The tasks may not be transferred to cloud computing servers for any reason and may be done in fog computing components. This can reduce the complexity of devices, maintenance cost and energy consumption in the devices. A local fog computing system can work independently to make sure of service and lack of making stop. The local system acts independently even in case of instability of network connection between fog computing and cloud computing servers.

A fog computing system can act as the mediator of devices with source restriction, so that it can help management and update of security validity of controlling software access in these devices. It can also take wide part of security tasks such as data scanning and prevention of influence of bad sectors and can have supervision on safety of connected devices and detect the threats right on time [12].

4.1. Architecture of Proposed Urban Traffic Management System Based on Cloud Computing

In this section, architecture of proposed system model for urban traffic management is explained. Just like fog computing, this architecture is formed of 3 layers including 1) final user 2) transfer layer and 3) created cloud layer, with the difference that storage and processing sources are placed in mid-layer (transfer layer). In this part, an image of 3 layers from final user to cloud layer are presented first of all. Afterwards, the structures, functions and interaction of the layers are explained. In architecture of the proposed model, to reduce the load on cloud computing servers, processing and storage sources are placed on mid-layer between cloud computing servers and final user.

4.2. Overall form of Proposed Model

The proposed cloud architecture model takes benefit of conventional cloud that is stable and static and on the other hand; it uses the local calculative tools placed in the area due to traffic load. In rest of this section, for better understanding of the proposed architecture, the layers are shown in figure 2 and each layer is explained.

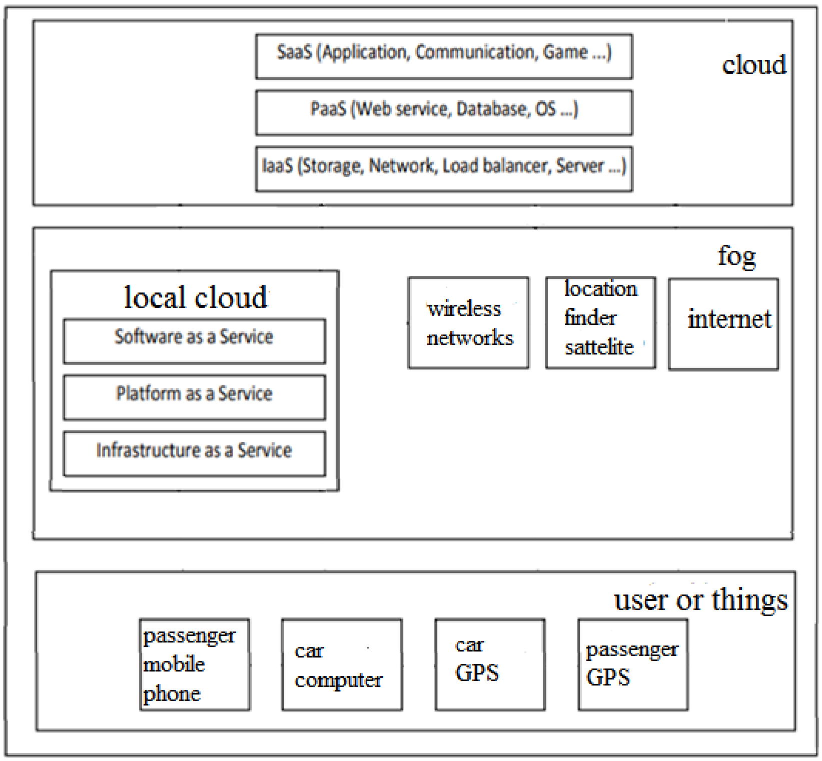

Figure 2 overall form of proposed architecture model

4.3. Cloud Layer

A series of physical and virtual servers are used in centralized or distributed mode as a complete processing system. Users of this system use required services through internet (public cloud) or through private networks (private cloud). Cloud layer provides processing services in 3 overall forms:

Software as a service, in which required software of user are run remotely through datacenters; platform as a service, in which operating system is provided for clients. Users of these services can own required operating system to run applied software programs with low cost and with least complexities. In general cloud layer provides all facilities needed by user to run the applied software and the services can be made, supported and presented through internet; infrastructure as a service: this form of processing service in cloud layer includes providing hardware equipment used by user. The equipment includes storage devices, hardware, servers and network components.

4.4. Fog Layer

This layer is aimed at making sure of connection between final user as client and datacenter as cloud layer. This layer is formed of several communicating device and patterns such as internet, wireless networks (VANETs ،WSN 3،G Networks 4،G Networks), mobile masts, satellites, private networks and so on. Choosing technology is also depended on type of final user and datacenter (cloud layer). An important issue in this architecture is the layer embedded in this layer, which can decrease traffic load and processing load on cloud layer through adding processing and storage sources.

4.5. Local Cloud Sub-Layer

This layer includes a series of interconnected servers, which are firstly placed as client in the area of vehicles and then accept to allocate their calculative sources to other clients. In terms of architecture, this layer is similar to conventional cloud. The service asked by each user may be provided by local clouds. As a result, local cloud provides same common services in capacity of its sources. These servers can be used as storage sources, processing sources and as virtual contest and so on.

4.6. User or things Layer

Final users are the main members of this layer and the members are mostly moving based on nature of the members and the topic discussed in this study. Final user can be car GPS, smart phone of driver or passengers, traffic control sensors and so on. Final users send their requestthrough communication device such as smart phone, laptop, computer, GPS, Wi-Fi and other devices and get the response from upper layers.

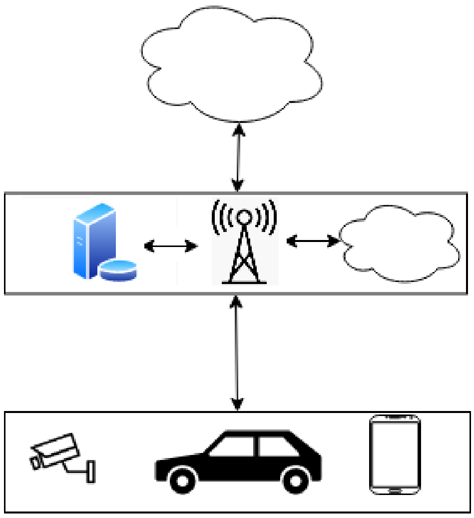

Figure 3 the interaction of fog layer with things and cloud layers

5. MODEL EVALUATION

For purpose of validation of proposed model, a study is presented in this research. Proposed model is considered as a service that is charged to process requests of users of cloud. This study is done in proposed model and the results are compared with the results obtained from a conventional cloud with no local cloud on fog layer. Here, the discussed issue is modeled. Then, the genetic algorithm is used for optimal distribution of load between local servers and cloud servers in proposed model as a meta-heuristic algorithm. In cloud computing, optimal distribution of load between servers is done using different methods. The distribution should guarantee least running time for the applications. To model this problem, following phases should be passed. The applications sent by user should be transferred at the first to local servers. After processing the application inside the local servers, it should be transferred to next layer (cloud layer). In last level, cloud layer servers are present. Here, deviation is in fact considered as the loads placed on local servers. Clearly, the less the value is, the better distribution of tasks would be. Therefore, target function as variance of length

of created lines for servers is defined as:

$$\sigma = \frac{\sqrt{\sum_i^n (L_i - AvgLoad)^2}}{N} \tag{1}$$

Where; L_i refers to the load on server i; Avg Load is average load on servers and N refers to number of tasks in line.

For purpose of more emphasis on maximum load and reducing that, the eq.2 is presented, in which fit function is considered for genetic algorithm.

$$Fitness = \frac{1}{ml} + \sigma \tag{2}$$

Where :refers to maximum load estimated.

Accordingly, here the requests are firstly sent to local server and if the estimated load balance of eq.2 is desirable, new request is also allocated to same server; otherwise, it should be delivered to another local server.

In this study, a series of experiments was done on two types of proposed architecture and conventional cloud computing architecture and each includes 6 servers. It is assumed that loud data can run 3 applications.

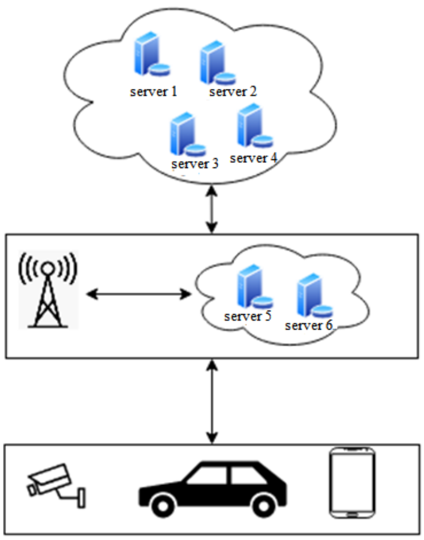

Figure 4: architecture of proposed model with local cloud

In conventional cloud computing architecture (fig.5), all servers are in cloud layer. In the architecture of proposed model (fig.4), servers 5 and 6 are placed on fog layer as local clo ud. Each request of users can be divided to a series of tasks, which are done by a series of servers. Applications 1 and 2 include 3 tasks and application 3 includes 4 tasks. All tasks have same running time, which is equal to 5ms.

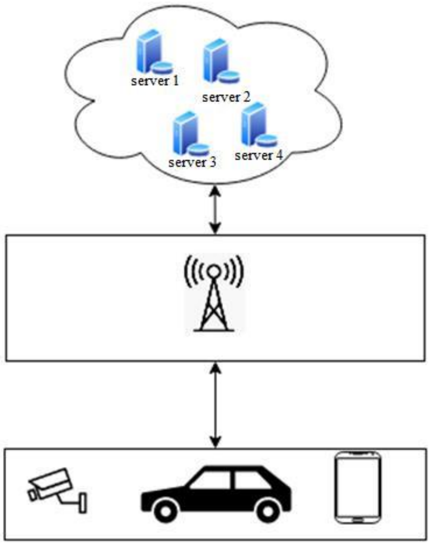

Figure 5: architecture of traditional cloud without local cloud

The parameters considered for this problem are presented in table 1.

Table 1 Problem's parameters

Parameter	Value	Notes
Number of users	10	
Number of things	14	
Number of applications	3	
Number of application tasks	Various	Application 1 and 2 include 5 tasks and

Based on lack of existence of criterion in this field, the empirical data are proposed according to table 2. The table has presented the maximum running time for a task in cloud servers per ms.

Table 2 Based on lack of existence of criterion in this field

Server	Server 1	Server 2	Server 3	Server 4	Server 5	Server 6
Running	6	11	7	14	7	9

6. RESULTS

Using genetic algorithm in the proposed model and conventional cloud computing model, the best solutions found for load distribution are:

1) Conventional cloud computing model

Application 1: task 1 and server 1; task 2 and server 2; task 3 and server 3

Application 2: task 1 and server 1; task 2 and server 2; task 3 and server 4

Application 3: task 1 and server 1; task 2 and server 2; task 3 and server 4; task 4 and server 6

2) Proposed architecture model

Application 1: task 1 and server 5; task 2 and server 6; task 3 and server 4

Application 2: task 1 and server 6; task 2 and server 1; task 3 and server 3

Application 3: task 1 and server 5; task 2 and server 1; task 3 and server 2; task 4 and server 4

According to the above presented solution, total time for each model is:

1) Conventional cloud computing model: 24+31+40=95

2) Proposed architecture model: 30+22+38=90

The number of tasks done by cloud servers in cloud computing model was equal to 10 and number of tasks done in cloud servers in proposed model was equal to 6.

The results show that the proposed architecture model is more optimal than conventional cloud computing model in terms of efficiency and has better performance in terms of load distribution. Moreover, the load volume on cloud computing servers and the traffic of this server are significantly decreased.

7. MODEL EVALUATION

In order to evaluate the proposed model, we implemented it in MATLAB and compared the performance of the proposed model with the traditional model. To evaluate the performance of the proposed model and compare it with the increasing number of requests and increasing the number of requests tasks. The results of these studies are presented in Figures 6 and 7.

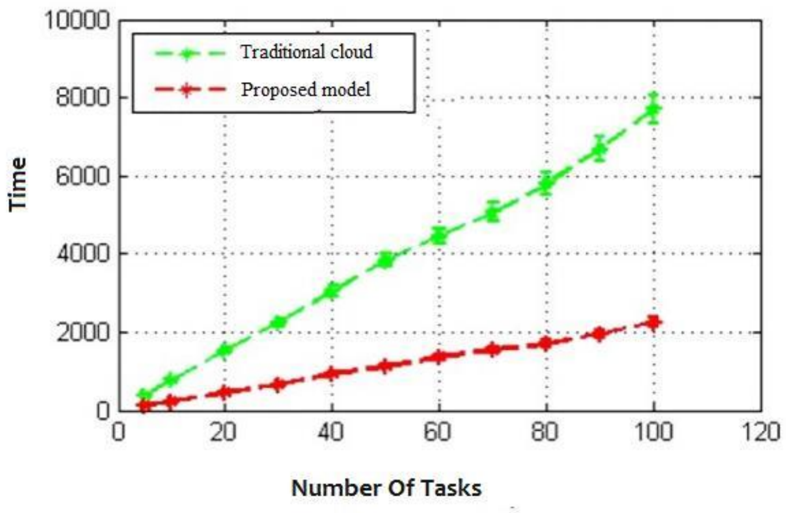

Figure 6. Comparing Traditional cloud with proposed model by increasing number of tasks

As shown in Figure 6, compared to traditional cloud, the application runtime is expected to decrease significantly with increasing number of tasks in proposed model.

Figure 6 and 7 compares the time consumed by the application implementation in the two proposed model and traditional cloud models based on the number of Tasks and also number of requests. As expected, the running time of a request increases with the number of its tasks. According to the figure, the proposed method performs better with proper prediction and better utilization of resources and utilization of local cloud. Due to the fact that in larger scales, the accuracy of decision making is more important, the performance difference between the two methods is more significant with increasing number of components.

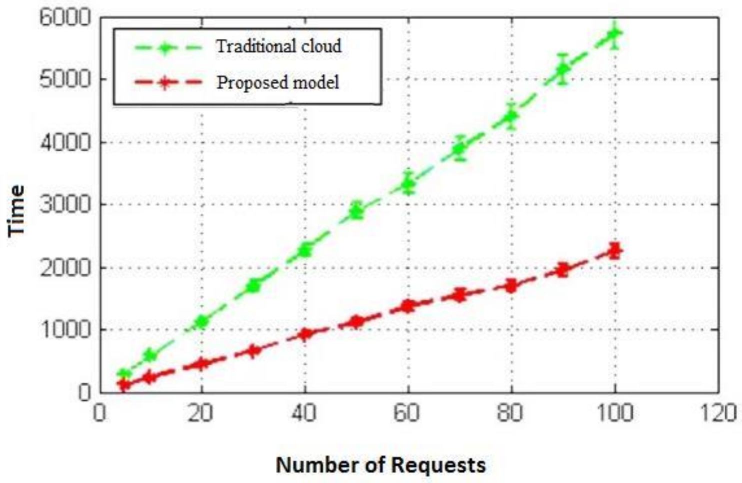

Figure 7. Comparing Traditional cloud with proposed model by increasing number of requests

8. DISCUSSION AND CONCLUSION

In this study, an architecture model based on cloud computing is presented to improve urban transportation traffic management system. The model was designed with the help of fog architecture and adding processing and storage sources. For validation of advantage of the proposed model, the problem of load distribution on cloud computing servers and local cloud servers was analyzed and compared using genetic algorithm. The results obtained from the study show that in the time of running applications in proposed model, significant reduction was observed compared to conventional cloud computing model. The limitations of this study included lack of access to data and appropriate benchmark to measure real processing time and time of running each task in cloud servers. For further studies, it would be better to run the load distribution in proposed model by other algorithms. On the other hand, to have access to macro data files, analysis and optimization should be taken. Moreover, various hybrid scheduling methods should be also examined and compared.

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