Enhanced Performance and Faster Response using New IoT LiteTechnique

Kassem Ahmad[1,2], Omar Mohammad[1], Mirna Atieh[3], and Hussein Ramadan[4]
[1]Department of Computer Science and IT, Lebanese International University, Lebanon
[2]Department of Computer Engineering, Islamic University of Lebanon, Lebanon
[3]Department of Economic Sciences and Administration, Lebanese University, Lebanon
[4]Olayan School of Business, American University of Beirut, Lebanon

Abstract: *Internet of Things (IoT) as a concept wasn't officially named until 1999 where it still used by big computer and communication companies***.** *It is the connection objects with each other anywhere, anytime, via internet communication without human intervention. Communication is the main part of IoT. With the development of technology and the revolution in a smart cell phone, the connected devices reach billions which lead to a fast increase in the transmitted data through the network. This rapid increase results in a heavy load on servers which need more processing and routing time. Fog Computing and Cloud computing paradigm extend the edge of the network, thus enabling a new variety of applications and services. In this paper, we focus on the modeling of the fog computing architecture and compare its performance with the traditional model. We present a comparative study with traditional IoT architecture based on classifying applications,define a priority for each application, and use the cell operator as the main fog center to store data. Then we givea solution to decrease data transmission time, reduce routing processes, increase response speed, reduce internet usages, and enhance the overall performance of IoT systems.*

Keywords: *Fog computing revolution, processing time, speed, reliability, and bandwidth drop.*

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1. Introduction

Internet of Things (IoT) technology contains a wide collection of networked objects, frameworks, and sensors, which take the benefits of development in computing power, electronics miniaturization, and network interconnections to provide new capabilities that are unrealistic [1].

This innovation guarantees to be beneficial for individuals with disabilities, enabling improved levels of independence and quality of life at a reasonable cost [2]. It was broadly utilized in smart homes, smart wearable, smart city, smart environment, and smart enterprise [3]. On the opposite side communication is the main part of IoT: Device-to-Device, Device-to-Cloud, and Device-to-Gateway [4].

Cloud computing, in recent years, has added a new dimension to the traditional means of computations and data storage. Nevertheless the expanding number of connected devices which will reach 50 billion as Cisco claims by 2020 [5]and a large number of the newly connected devices will be at the edge of the network require support for mobility, low latency, real-time, and location-aware services, these challenges the traditional cloud architecture and launches a new computational paradigm, named fog computing. It should be clear that fog computing is not a substitution of cloud computing, these paradigms are a complement to each other to support real-time, low latency applications that happen at the edge of the network.

The rest of paper is organized as follows; section 2describes the architecture of IoT. Section 3 identifies the Challenges. Solutions will be listed and described in details in section 4, section 5 consist of a comparison between the three models, section 6 explains the experimental result and Finally, section 7 the conclusion of the work.

2. Architecture

There is no common architecture for IoT, distinct architecture proposed by various researchers. The most fundamental architecture (Figure 1) is three layers: Perception, Network, and Application [6].

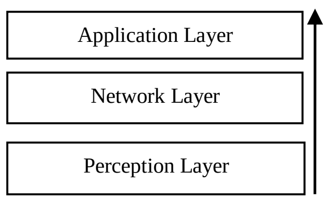

Figure 1. Three-layer basic architecture.

2.1. Perception Layer

Perception layer additionally can be named as a recognition layer [7]. The primary job of this layer is sense and accumulates data from the environment and converts them into digital information. Sensors, cameras, Radio Frequency Identification Devices (RFID), and Global Positioning System (GPS) are examples of objects that present in this layer [8]. Sensors are the real item that gathers information and Actuators do the action. Theses sensor communicate with each other and other object using various short-range communication protocols like ZigBee, WiFi, and other technology [9].

2.2. Network Layer

Network layer or the brain of the system support secure data transmission between the perception layer and the application layer [10], also provide services that enable seamless connectivity between devices and services such as addressing, routing, resource optimization, security, Quality of Service (QoS) and mobility support [11].

2.3. Application Layer

The application layer is the top layer in IoT architecture. This layer gives customized based services based on user relevant needs [12]. This layer's main responsibility is to link the major gap between users and applications. This IoT layer combines the industry to achieve the high-level intelligent applications type solutions such as the disaster monitoring, health monitoring, transposition, and fortune, medical and ecological environment and handled global management relevant to all intelligent type applications [13]

3. Challenges

IoT is a network of networks in which a huge number of objects, sensors, and devices are connected through a communications infrastructure to provide valued services [14]. By 2021, 94 % of workloads and compute instances will be processed by cloud data centers while 6 % only will be processed by traditional data centers [15], while mobile devices into the most method for service applications [16]. Therefore, there will be a gigantic focus on the cloud which lead to heavy load on it [17], hence the performance will be affected. By merging cloud and fog network we can overcome the issue of overloading. According to literature research, the most important challenges are:

3.1. Processing Time

Processing delay is the time it takes the routers to process the packet header for error checking or determining next the destinationwhile fog network for local user and cloud network for roaming user.

3.2. Routing Traffic

Routing is the process of selecting a path for traffic in a network, or between multiple networks. Distributing data on fog and cloud will help in reducing the routing table and routing process by eliminating the upper edge (Cloud) when we are on the local network.

3.3. Speed

Fog network is closer for the user than cloud network which means that using fog is faster than cloud, Moreover fog is the link between user and cloud retransmitting data from fog to cloud will take more time in sending and receiving.

3.4. Bandwidth

In a network, Bandwidth is the amount of data that can be transmitted in a fixed amount of time. The lack of bandwidth will interrupt the IoT services.

3.5. Performance

By achieving the first four challenges the performance will be much better. Reduced routing process help deliver data in less time by reducing the time needed for routing processes, Also the increased speed of data transmission give fast response time. Moreover, the more bandwidth you have, the more data you can load at once.

4. Solution

A scalable and reliable technique should be implemented to pass the challenges with the fast development of IoT and the rapid growth of connected devices. This section covers the present systems, the cloud-centric, fog offloading, and our new system that merges the two systems in one to take their advantages.

4.1. Cloud Centric

Cloud computing supports infrastructures, platforms, software, and storage as a service for the IoT system and users. Aneka is a cloud-centric system which offers a wide variety of services with multiple programming models for all kind of clients; In addition, Aneka uses resources and computing power of public and private cloud to give better performance and scalable storage [18]. The cooperation of public and private cloud requiresan extra handling processes in the background to guarantee the QoS and privacy because of information sharing among private and public. Cloud-centric still relies on a middleware layer to deliver user data to cloud storage which implies that data needs more transmission time and introduce more routing delays.

4.2. Fog Offloading

Offloading is the process of distributing the load on many fog nodes to reduce IoT service delay. It can help mobile devices with overcoming resource limitation by offloading the computationally intensive tasks to the remote cloud servers [19]. A new framework presented in [20] that minimizes the processing delay when offloading requests but, still use cloud network for storage and transparent tasks to choose when to offload. The problem is when taking the decision to offload to another fog which is busy we check for another fog which derives increment in waiting time, Moreover, offloading present additional queuing time.

4.3. IoT Lite

Our new framework (Figure 2) depends on merging cloud network and fog network together but with independent of each other. The process goes through three phases: hosting in cell operator directly, classify applications and sensors, operate the IoT system without real internet services.

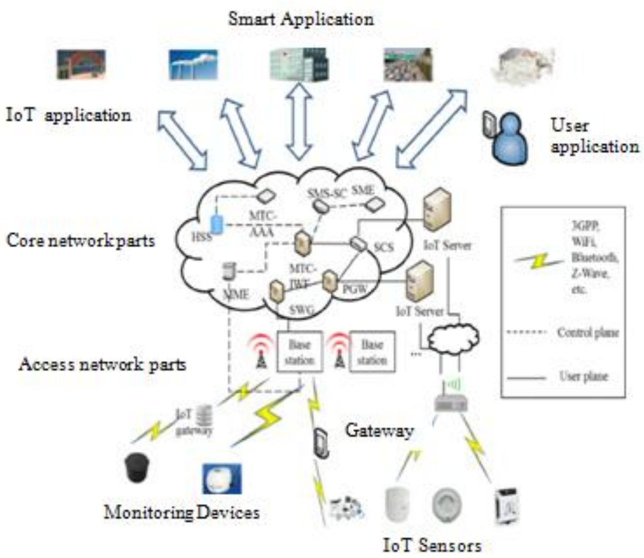

Figure 2. Hosting IoT on fog and cloud centers.

4.3.1. Hosting in Cell Operator

As known that in IoT data processed and stored sent or used whenever and when required, while the IoT is a two way centered connection where data from perception layer is sent to the network layer and the application layer request the data from network layer the data goes forward and reverse ward. In our system, we use a cell operator as a primary storing center, by relying upon these nearby servers the routing process is decreased, and the response will be quicker. Cloud is used only while roaming.

Depending on cell operator will partition the-out traffic on the cloud that will result in a decreasing of the overall load which hides a masked Distributed Denial of Service attack (DDOS) on the cloud by processing all demand to the cloud. Rather than guiding all traffic to the cloud, the load will be distributed in cell operator as the Virtual Local Area Network (VLAN) in a network system which can help in limiting broadcast packet, enabling logical grouping of the end station, and provide easier management.

Processing time will be decreased when hosting directly on cell operator, The packets received on the cloud are being filtered (Figure 3) before storing on the server, the more request received the more additional filtering process will be done, hosting on cell operator will decrease this procedure by distributing the work and load on the station which will prompt more process speed and less processing time.

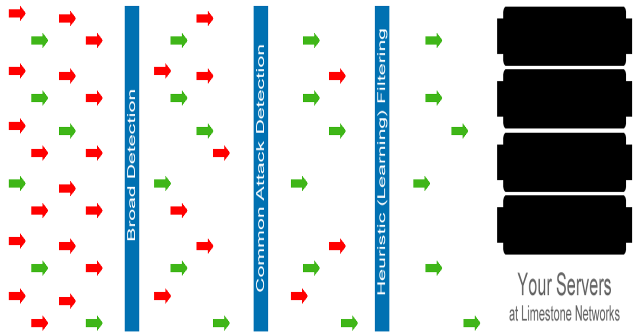

Figure 3. Filtering request on the cloud.

Also routing and processing time will be decreased (Figure 4) by removing the upper layer edges, rather than routing data from fog network to the cloud, the data directed once to the cell operator. The Internet Protocol (IP) addresses of hosts on stations are changes over and over while moving from cell to cell or when connecting and disconnecting mobile data, this process prompts a refresh in routing table but the process will remain local instead of updating locally and globally in the cloud core network.

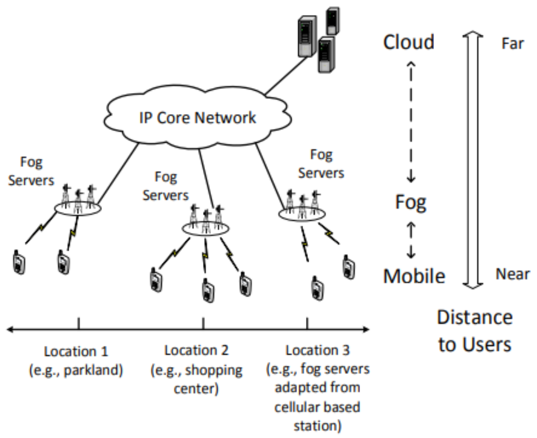

Figure 4. Routing distance.

4.3.2. Classifying Application and Sensors

In this process application and sensors,anode is arranged according to its function, priority, and level of served objects. Priority is varied from application to other for example an application that delivers body temperature of patient man has more prior on the application that sends temperature of his home while a similar individual uses the same application same detected information but in a different situation.

This step plays a major role during maintenance, monitoring, and busy hours. Although sometimes the bandwidth drops down due to various reasons like noise, rain, and others. During this drop, data must be managed and served according to its value. Priority can be done (Table 1) using the Media Access Control Address (MAC) address, or International Mobile Equipment Identity (IMEI).

Table 1. Application classification and priority level.

Application	Health	Industrial	Smart City	Smart Home
Priority Level	Very High	High	Medium	Low
Mac Classification	List of Mac	List of Mac	List of Mac	List of Mac
IMEI Classification	List ofIMEI	List of IMEI	List ofIMEI	List of IMEI

4.3.3. IoT Without Real Internet Services

Most mobile devices are connected to cell operator stations, when connecting the mobile, devices assigned an IP address from the cell located in, hence its logically connected to the hosting center which mean that a devices can send and receive data locally (Figure 5) on the cell infrastructure without using internet services as Data Service Provider (DSP) company which connect remotely and allow sharing of data using their Wide Area Network (WAN) infrastructure.

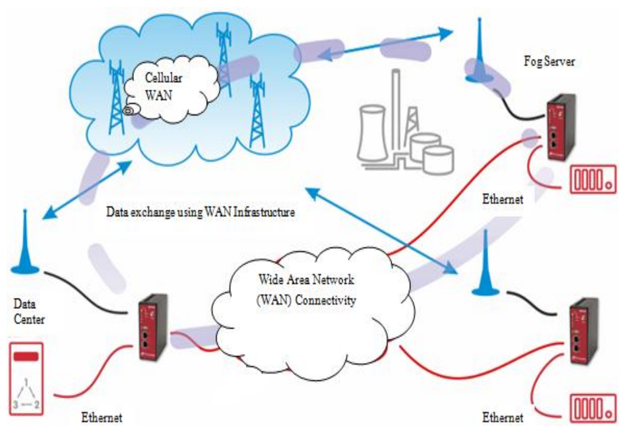

Figure 5. Wide area network.

5. Comparison

The three frameworks provide many solutions at different levels to support IoT services with better performance and quality.

5.1. Processing

The size of data processed in the cloud center is bigger than the data in fog center which means that the cloud needs more processing time. Also in fog computing, the load is distributed which helps in reducing processing time [21]. But there is a condition for deciding which is better in case of fog centric (Fog offloading or direct host in cell operator with the priority of application). The first is better when the fog centers are available by distributing the load on several units. But if the centers are overloaded, offloading becomes slowest due to additional queuing delay and the need for more routing update.

5.2. Routing

In the case of a fixed user (Figure 6), there is a single routing update for cloud-centric and more than one update when offloading fog centers. While in our method, there is no need for routing update, since the user is connected to the cell operator station directly.

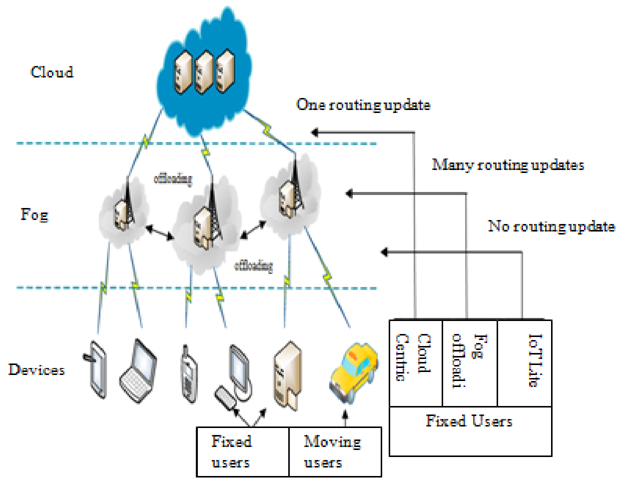

Figure 6. Routing update for fixed users.

In the case of moving a user (Figure 7), there is a single routing update for our method while there are multiple updates for the other methods. This shows that hosting directly on cell operator reduces the routing delay.

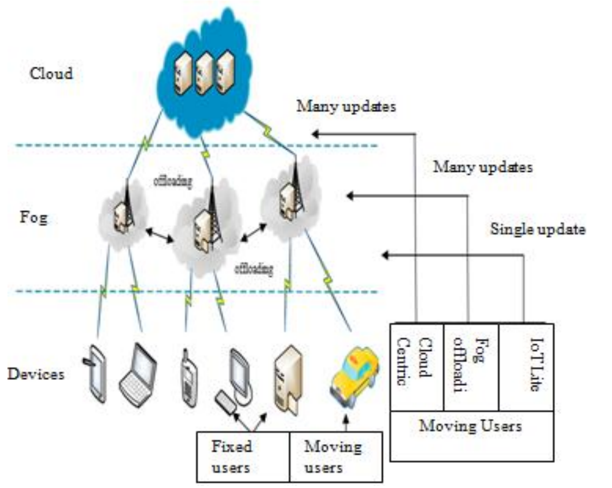

Figure 7. Routing update for moving users.

5.3. Speed

Response time is better in our method and fog offloading than the cloud-centric due to the presence of a user in a close distance to the fog edges (Figure 8).

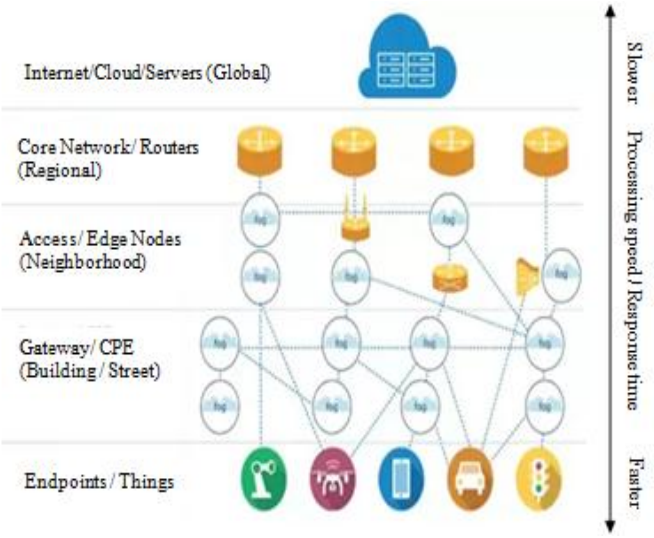

Figure 8. Response speed between users and edges level.

5.4. Bandwidth

In the cloud-centricsystem, the bandwidth is shared across the global users. While in fog offloading, users can benefit from sharing multiple bandwidths if some centers are abused. In both cases, there is still a need for more bandwidth during busy hours and when heavy load data is processed. But in our method, there is no starvation for bandwidth, since the useruses the wan infrastructure to share data. The bandwidth, in this case, is the whole capacity of the transmission channel. The lack of bandwidth or any error on the internet will cause an interruption in the system and a drop in QoS or a stop of the service for cloud computing and fog offloading. But it can run normally in our system because it is independent of real internet services (Figure 9).

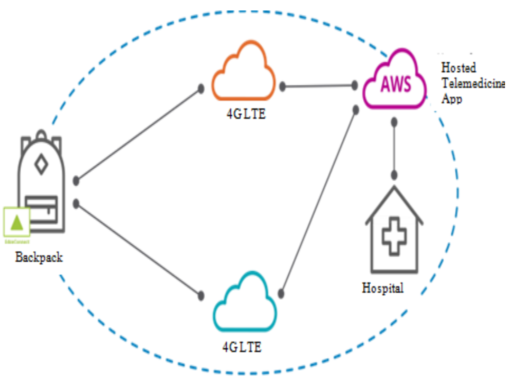

Figure 9. WAN hosted IoT application.

5.5. Performance

Cloud-centric model provides scalable storage with a variety of platform but still depend totally on the middleware layer to serve users. Fog offloading improves the first one by offloading data process and minimize processing time, but still depends on cloud and introduces more queue delay. Our method takes the benefit of fog in fast response and a short distance to serve users and the scalability of the cloud network to ensure reliable services. Furthermore, IoT Lite eliminates the additional tasks used in the first two methods and givesstatic parameters to take decisions. In all challenges, fog computing is better than cloud computing where our method has an extra point over fog offloading by serving application according to its valued data and by operating without real internet services which make it better during bandwidth drop and busy hours.

5.6. Theoretical Study

There are four sources of packet delay in network, processing, queuing, transmission, and propagation.

Nodal delay:

$$dnodal = d\,pro + dqueue + dtrans + dprop\ eq. \quad (1)$$

In our study, we will eliminate the propagation delay, and processing delay and queuing delay except for fog offloading which introduce an additional queuing delay but offloading reduce processing delay then queuing delay will be neglected. The calculation is done in a single packet of 1460 bytes by excluding IP and TCP headers. The same resources are used in the three models 4G technology for mobile connection with 100Mb/s transmission rate and fiber-optic as backbone link between edges with 1Gb/s transmission rate.

Transmission delay is the time needed to transmit L-bits into link over. L-bits represent the size of data to be sent in bits and R-bits is the speed of link transmission in bit per second.

Transmission delay:

$$d_{Transmission} = \frac{L(bits)}{R(bits/s)} eq. \quad (2)$$

5.6.1. Cloud Computing

In cloud computing (Figure 10) the transmission takes place 3 times from mobile to middleware and from middleware to the cloud in the forward request and the same in the response.

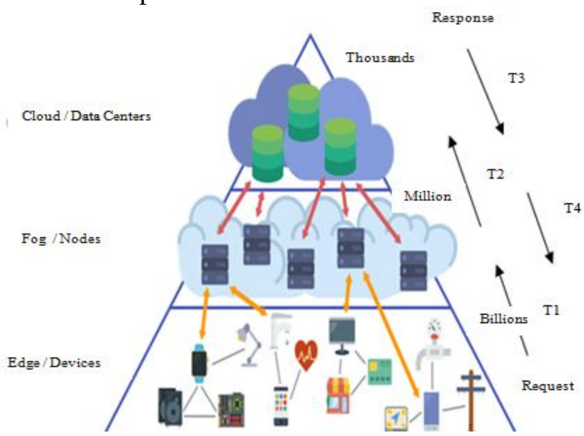

Figure 10. The transmission time of fog computing.

The total delay of this model is:

$$T1 = \frac{1460 \times 8}{100 \times 106} = 1.68 \times 10^{-4} s.eq \quad (3)$$

$$T2 = \frac{1460 \times 8}{10^9} = 1.68 \times 10^{-5} s.eq \quad (4)$$

$$Ttotal = 2(T1) + 2(T2) = 2.336 \times 10^{-4} + 2.336 \times 10^{-5}\ eq \quad (5)$$

$$T = 2.5696 \times 10^{-4} s.eq \quad (6)$$

5.6.2. Fog Offloading

The aim of offloading is to distribute the load on several centers to reduce processing time. But distribution needs transmission of data between centers (Figure 11).

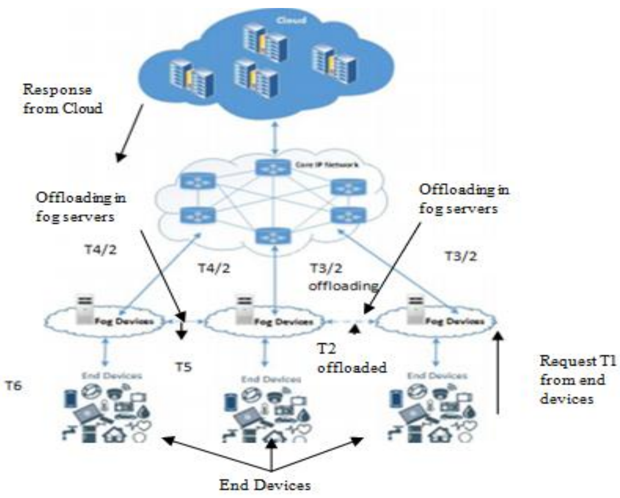

Figure 11. Offloading request on fog centers.

$$T1 = \frac{1460 \times 8}{100 \times 10^6} = 1.168 \times 10^{-4} s.eq \quad (7)$$

$$T2 = \frac{1460 \times 8}{10^9} = 1.168 \times 10^{-5} s.eq \quad (8)$$

$$\frac{T3}{2} = \frac{\frac{1460 \times 8}{2}}{10^9} = 5.84 \times 10^{-6} s.eq \quad (9)$$

$$\frac{T4}{2} = \frac{\frac{1460 \times 8}{2}}{10^9} = 5.84 \times 10^{-6} s.eq \quad (10)$$

$$T5 = T2 = \frac{1460 \times 8}{10^9} = 1.168 \times 10^{-5} s.eq \quad (11)$$

$$T6 = \frac{1460 \times 8}{100 \times 10^6} = 1.168 \times 10^{-4} s.eq \quad (12)$$

$$Ttotal = T1 + T2 + 2\frac{T3}{2} + 2\frac{T4}{2} + T5 + T6\ eq \quad (13)$$

$$Ttotal = 4(1.168 \times 10^{-4} s) + 2(1.168 \times 10^{-5} s).eq \quad (14)$$

$$Ttotal = 4.672 \times 10^{-4} + 2.363 \times 10^{-5}\ eq \quad (15)$$

$$T = 4.9056 \times 10^{-4} s.eq \quad (16)$$

6. IoT Lite

Hosting directly on cell operator allow users to share and store data directly on fog servers (Figure 12).

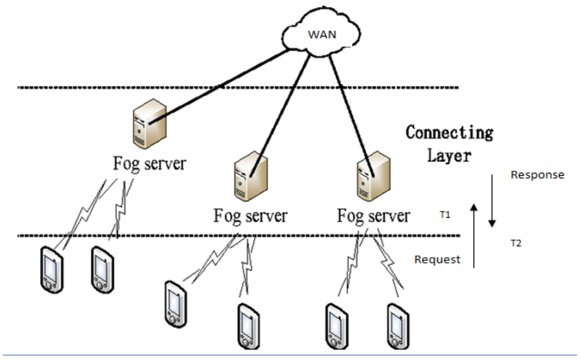

Figure 12. Hosting on cell operator.

$$T1 = \frac{1460 \times 8}{100 \times 10^6} = 1.168 \times 10^{-4} s.eq \quad (17)$$

$$T2 = \frac{1460 \times 8}{10^9} = 1.168 \times 10^{-5} s.eq \quad (18)$$

$$Ttotal = 2.336 \times 10^{-4} s.eq \quad (19)$$

We conclude that our framework has a smaller transmission time and faster response than other models (Table 2).

Table 2. The transmission time of models.

Model	Cloud-centric	Fog offloading	IoT Lite
Number of hops	4	6	2
Total transmission Time (sec)	2.5696×10^{-4}	4.9056×10^{-4}	2.336×10^{-4}

The overall evaluation is presented in (Table 3).

Table 3. Evaluation of models.

Framework	Cloud-centric	Fog offloading	IoT Lite
Storage	Cloud	Cloud	Fog and cloud
Decision parameters	Dynamic	Dynamic	Static
Parameters type	Aneka Scheduler, Data analyst	The business of fog center	Application priority
Enhancement	QoS, Storage	QoS, Processing time, reliability	QoS, Processing time, routing delay, response time, reliability
Advantages	Large and Scalable Storage	Low processing delay	Fast response and low transmission delay
Disadvantages	Major depend on fog network to serve users	High transmission time	Need for installing extra storage units

7. Experimental Results

This part describes the experiments done and shows the importance of priority in some cases to enhance performance. The experiments are done on multiple devices uses different applications and real data stimulation. When comparing the results, we found that some application interrupts the services of IoT and affect users. Using the priority, we can help solve some problems.

7.1. Results

This section compares the different parameters of connected mobile devices and how these parameters affect the performance of devices. Figure 13 shows multiple devices connected to the access point.

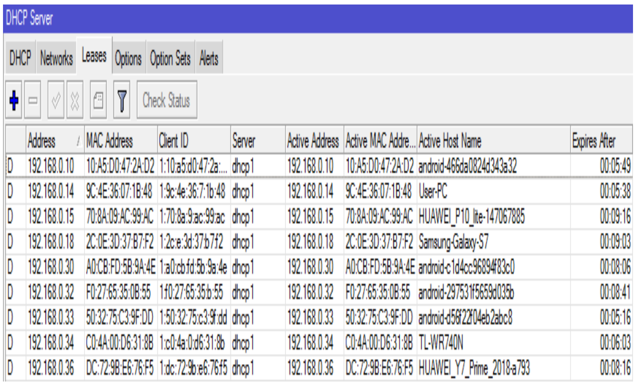

Figure 13. Active host on the access point.

Each device connected on the access point has signal strength as shown in Figure 14. The signal strength of devices affects other parameters as Throughput, Transmission/reception rate (Tx/Rx) rate, and transmission/reception quality (Tx/Rx)CCQ.

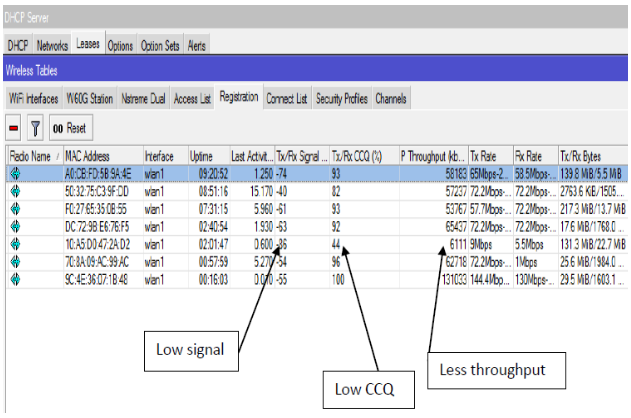

Figure 14. Parameters of connected devices.

Figure 15 shows that a single device is taking the whole bandwidth using a simple application. The device with IP address 192.168.0.15 perform speed test consuming the whole internet and the other device have 0 bit/s during the test. Torch analyzer is used to determine the usage of each device.

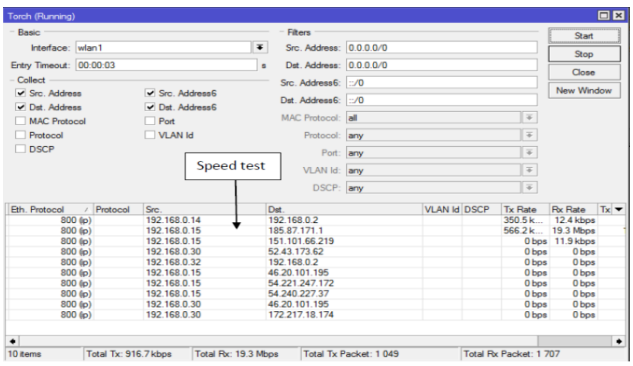

Figure 15. Bandwidth usage of connected devices.

After this test, we apply priority on devices to enhance performance and get rid of consuming the whole bandwidth by a single device. We apply priority rules on 2 devices and perform the same test (speed test) and we get the result in figure 16 below. We create 2 priority rule with priority level 8 for device using the internet and priority level 4 for device perform speed test, Also we limit the total speed of Access Point to 5 Mb/s in the first half of the test then we increase it to 8Mb/s to ensure that priority is working in a proper way. Priority levels can be set from 1 to 8 according to the application classification.

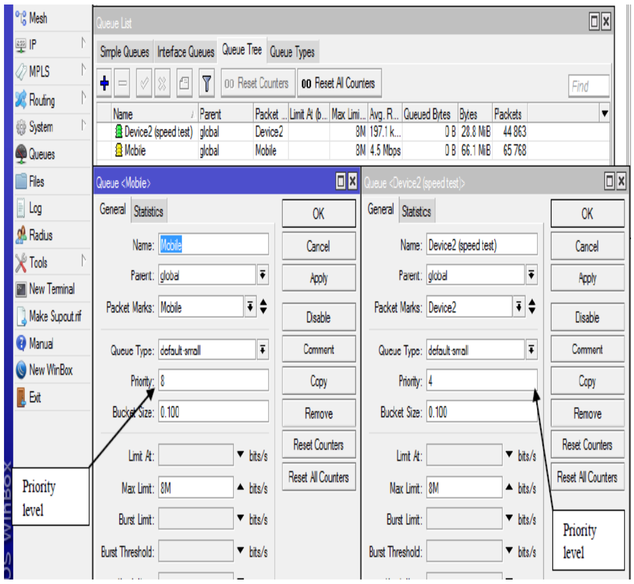

Figure 16. Bandwidth consumption using priority.

During the test, the total bandwidth is 5 Mb/s. Priority shows that device with the highest priority level (Mobile) have more bandwidth than another device that performs a speed test (Device 2).

8. Conclusions

We have outlined the key characteristics of Fog Computing, a platform to deliver a rich portfolio of new services and applications at the edge of the network. Theidea to benefit from fog computing is to be a complement of cloud computing. We introduced a framework for handling heavy IoT data and the growth of connected devices. We showed how IoT Lite minimized the processing and routing time, provided better quality, and enhanced the overall performance. As a future work, the processed and stored data on cell operator can be used as fuel for data mining research to deduce the greatest valued data and find the most transferred IoT data which can help in developing of the system. Moreover, the application can be classified in a proper way according to user relevant needs. The limitation of this paper is the lack of security and power consumption study about the three different proposed models.

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Kassem Ahmad obtained his Ph.D. degree in Telecom and Networks security in 2013 from EcolePolytechnique of the University of Nantes (France). Also, He has received his Master's degree in Telecommunication Networks from the University of Quebec, INRS-EMT (Canada). He obtained his Bachelor in Computer and Communication Engineering from IUL University. He worked on different European projects in developing solutions and protocols for the next generation of mobile networks and IoT. He, currently, works as an assistant professor and Researcherin the school of Arts and Sciences at Lebanese International University. He worked at CNJF (Committee National des Jeux de la Francophonie) as an IT manager. He was honored with several awards from different institutes like the Order of Engineers and Architects of Beirut, and from IEEE International Conferences. Hehas published several papers in different international conferences and journals.

Omar Mohammad is a teacher in Lebanese National School NLS. Obtained his MS degree from Lebanese International University in 2018, obtained his BS degree from LIU in 2016. His field of interest lies in the area of Internet of things, Robotic control, Wireless communication, Wireless body sensor, Security, and Application development.

Mirna Atieh obtained her Ph.D. in Informatics and Artificial Intelligence in February 2008 from the "InstitutNational des Sciences Appliquées INSA de Rennes" (France). She is currently Assistant Professor and Researcher at the Lebanese University in Lebanon – Faculty of Economic Sciences and Business Administration – Department of Business Computer. Her main research interests are in the areas of Artificial Intelligence (AI), Networking and Telecommunication, and the Internet of Things (IoT). She has multiple scientific collaborations with some universities in France and Canada. She has published several papers in International Conferences and Journals.

Hussein Ramadan is a researcher in telecommunications mainly focusing on Machine Learning and Deep learning. He is also the Co-founder of Software Factory Lebanon and Head of Operations and Projects for Global Contracting SARL. He received his engineering degree from the Islamic University of Lebanon and pursuing his executive MBA from the American University of Beirut. During 2009 and 2015, Hussein was working with Middle East Telecommunications Co-headquartered in Kuwait and completed major transmission projects with Zain Kuwait in addition to Ericsson Managed Services in Iraq and Kuwait Ministry of Defense. Hussein has thorough experience in operations, technical and project management.