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Cloudlet Deployment to Balance Energy Consumption in Wireless Networks: A Survey, Issues and Challenges

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***Abstract*—** Cloud computing and wireless networks, both are two different important components in information technology (IT) world. These both wide network components are unlike from each other and their characteristics are providing huge services. By using these services, users getting several computing services at low cost while providing the security and privacy. According to the one survey till end of the 2016, gross payments from the e-commerce business management was spent $4 billion for maintenance of datacenters. Energy consumption is the key component in the information technology world, because due to the wastage usage of computing hardware components like servers, datacenters and network bandwidth etc., business profits will be go down. So, by integration of these two areas, online business management will get more revenues while providing the QoS. The proposed mechanism, deploying the cloudlets for executing the actions, which are belongs to the wireless networks such as Local Area Network (LAN), Metropolitan Area Network (MAN) and Wide Area Network (WAN) etc. The proposed idea addressed better solution to avoid Service Level Agreement's (SLA) violations and poor QoS.

Keywords- *Cloud computing, Wireless Networks, Cloudlets, Energy Consumption and Load Balancing.*

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I. INTRODUCTION

The advantages of cloud computing and wireless networks technologies has allowed to the many areas to be connected together via networks. Both wireless and wired networks are using in daily life to allowing data and information share across the world. However, adopting new technologies in other fields leads many new issues and challenges and opening new areas of research. Wireless Networks area is, one of the essential field in current computer world, but wireless networks are also facing several challenges on the network level and on the sensor node level that from the sensor network. One of the most crucial issues that need to be pointed on the individual network level is the power consumption of sensor nodes. Energy consumption on sensor nodes is consider to be very important in wireless sensor network's due to the fact that sensor nodes have small and limited power supplies.

Similarly, due to the limited memory and configuration, wireless networks always cannot be able to execute few actions on middle hardware. Consequentially, wireless network applications, such as the localization procedures, need to be modified or the pattern of the sensor nodes needs to be altered, in order to reduce excessive maintenance amount and power consumption. In this paper, we proposed cloud based solution to execute wireless network tasks by focusing on the residual energy and request count of each node to discover the heavy load node. The main idea of this algorithm comes from Ant Colony Optimization (ACO), to optimize load of the individual network. The potential performance of the proposed algorithm relies on the best cloudlet to be selected which should have the minimum executing requests, maximum request response rate and high configuration of resources such as memory, storage and network bandwidth etc.

The fundamental goal of cloudlet is to improve the response time of the application that are running in wireless devices using less latency rate and high bandwidth connectivity for example in any of the virtual machines that are physically nearer to the mobile devices that are going to access them. This is used to eliminate the latency drop outs in the WAN that encountered in conventional cloud computing models. The cloudlet is essentially designed to support the interactive and resource-intensive mobile applications for example in speech and language processing and many other virtual reality applications. The main difference between a cloudlet and public data center are the former one represents a form of cloud computing since it provides the services over a computer network and in the latter case it operated by only few of the public cloud provider i.e. AWS in a numerous ways. Initially, a First, a cloudlet is self-managed by the businesses or users that employ it, while a public cloud data center is managed full-time by a cloud provider. Second, a cloudlet predominantly uses a LAN for connectivity, versus the public Internet. Thirdly, a cloudlet is employed by fewer, more localized users than a major public cloud service. Finally, a cloudlet contains only "soft state" copies of data, such as a cache copy, or code that is stored elsewhere.

There exists several architectures and the popular one is Mobile Cloud Hybrid Architecture i.e. MOCHA. It is designed for giving a solution to support massively to parallelize the wireless cloud applications and it is shown in Figure 1. The diagram contains mainly 3 parts i.e. Mobile, Cloudlet and

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Cloud. It formulates a solution to allow mobile-cloud computing applications, such as object recognition in a battlefield, by introducing an edge-server, which is called a cloudlet [15]. A cloudlet is used as an intermediary between the mobile devices and the cloud servers and determines how to partition the computation, in terms of tasks, among itself and multiple cloud servers to optimize the overall quality of service (QoS), based on continuously updated statistics of the QoS metrics. Running many resource-intensive applications far exceeds the capabilities of today's mobile devices, such as conducting real-time face recognition of known criminals. Several limitations of a mobile device are less processing speed, less memory, and the limited storage capacity. Facing these challenges, cloud servers with tremendous computing power and storage space as well as access to particular databases are suitable choices to accelerate applications run on mobile devices. Nevertheless, several major hurdles limit these benefits, such as long network latency, which hurts the user experience in mobile-cloud computing. As a result, powerful, well-connected and safe cloudlets are necessary to intercept the data sent from the mobile and perform smart task division algorithms to minimize the overall communication latency to and from the cloud. There are many applications that can benefit from utilizing an edge server (cloudlet in MOCHA), such as battlefield support applications, natural language processing, airport security, an enhanced Amber Alert system, among others. The Source of Figure 1, The MOCHA architecture: mobile devices interact with the cloudlet and the cloud via multiple connections and use dynamic partitioning to achieve their QoS goals (e.g., latency, cost) (reprinted from (Soyata, T., Muraleedharan, R., Funai, C., Kwon, M., & Heinzelman, W., 2012) with permission of the authors).

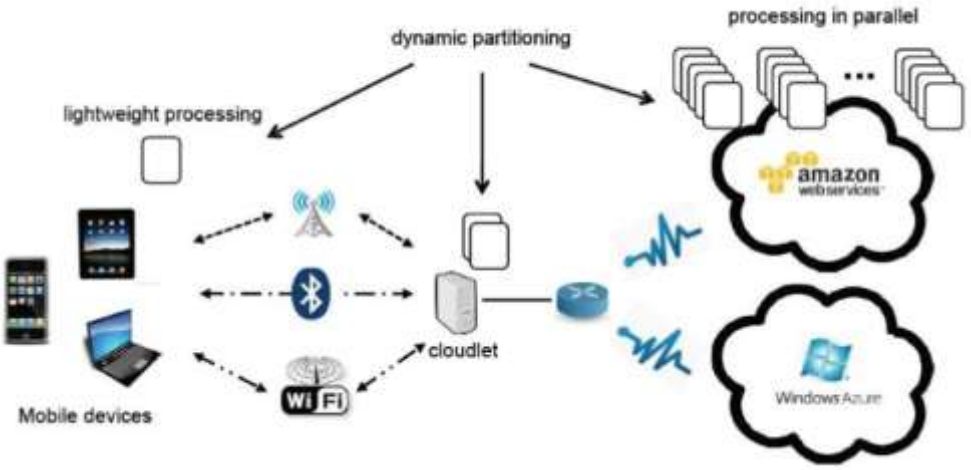

Figure 1: MOCHA Architecture.

There exist numerous ways to set up a connection channel between a terminal computer and a mobile device from Bluetooth, Wi-Fi, 3G or 4G. Wi-Fi is most commonly used channel to do this task. There are two ways to create a connection between a PC and Mobile node.

(1) Set up a wireless adhoc network

(2) Set up a WAP.

To set the WAP you need to follow these steps:

(a) Run cmd.exe with Administrator Privileges

(b) Start and Set the "Virtual Wi-Fi" Mode

(c) Start Internet Connection Sharing

(d) Start the Wireless Network in the Command Line Window.

The rest of this paper is organized as follows: section 2 describes related work for cloud computing, wireless networks and load balancing algorithms in order to deduce their advantages and suitable ways to formulate the problem are presented in section 3. Section 3 describes about proposed method to reduce energy consumption in wireless networks. Section 4 presents results and finally, a conclusion and future enhancement are presented in Section 5.

II. RELATED WORK

2.1 Cloud Computing

In distributed computing, cloud computing has been developing vastly for the past few years, towards achieving technical improvements in distributed computing. Cloud computing is one of the trending models that has progressed from adopting virtualization technology, utility computing and service oriented architectures. Cloud computing providing many services such as data storage services, web applications and network structures that could be allotted and departure with less effort of cloud owner management.

Figure. 2 presents complete architecture of cloud computing with deployment models, characteristics, cloud services and cloud users. In Figure 3, predicted that until 2016,

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revenues from the online business management spent $4 billion for data storage. The term cloud refers to a network or internet. In other words, Cloud is a remote location which is used for data storage but that services are extended too many other resources. Cloud computing providing services through public and private networks, i.e., LAN, WAN, and MAN. Cloud computing offers to manipulating, accessing and configuring the hardware and software resources remotely.

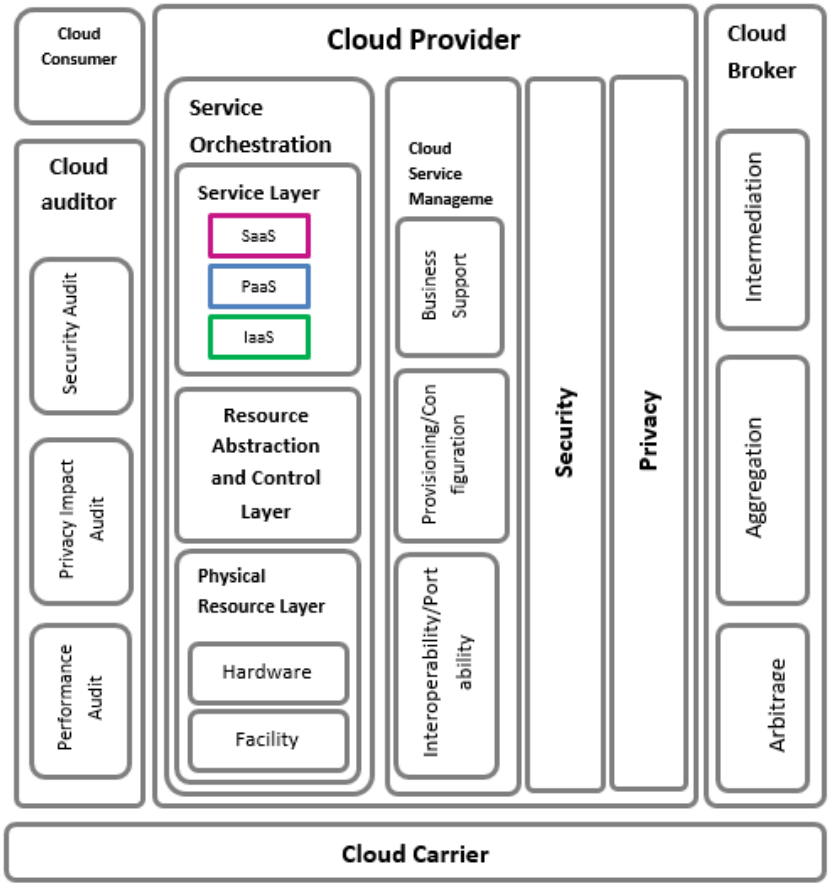

Figure 2: Cloud Computing Architecture

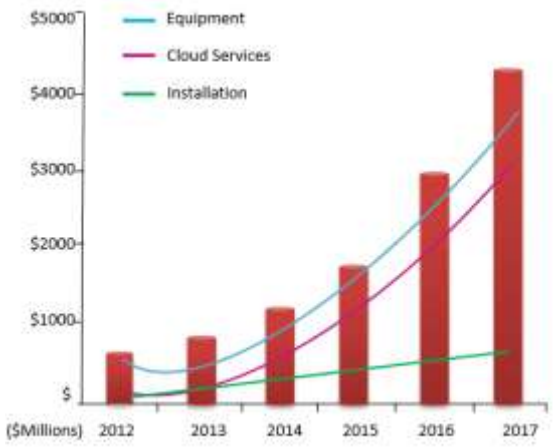

Figure 3: Online business management revenues spent for data storage

Cloud computing mainly offers the platform independency, as the software is no need to be installed locally on the PC. In cloud computing environment, two users play key roles: cloud owners and cloud consumers. On one side, cloud provider maintains the huge computing services in their large server centers [2] to cloud users on the rent-usage basis.

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On the other side, there are cloud consumers use services from cloud owner to deploy their applications.

2.2 Wireless Networks

Wireless broadband service providing the internet access to several devices like mobile, PC's, laptops and PDA etc., and additionally allowing network operators to expand their networks beyond the range of their wired connections. Connecting computer to the internet network by signals offers many advantages over connecting the same computer through a wired connection. The main advantages of the wireless network is providing convenient access for portable computers without using wired connections. It allows a user to establish a connection from more than one location and to maintain a connection as the user moves from place to place. It provides the distributed access for network managers without wired connections. Accessing without cables means that the owner of a device can move any places while using internet service and connect to the internet network by simply turning on the device and running a communication program. Figure. 4 represents wireless network, which is connected to several devices.

Figure 4: Wireless Network

While installing our own network, it's often easier to use Wi-Fi connection to expand network because a wired connection requires a physical wire connection among network routers or switches and each device. But in wireless connection, all devices can connect to the access point through radio signals as shown Figure 4.

2.3 Issues and Challenges

In large-scale Wireless Networks the workload balancing consumption is an inherent problem in many-to-one traffic patterns. According to [5], reliability and scalability is the essential property for the successful performance of any network involving a large number of devices which are connected to the those networks, as is the case of wireless network devices consisting of large numbers of cooperating low-powered nodes capable of limited computation, wireless communication, and sensing. A scalable network [6] is a net-work which grows with increasing network workload. Protocols must thus scale well with the number of nodes. This may often be achieved by using distributed algorithms, in which sensor nodes of network routes only communicate with in the nodes in their neighborhood, whereas centralized approaches are not applicable, especially because of the single point of failure problem.

Ad-hoc routing algorithms focus on avoiding traffic issues or on maintaining connectivity among devices when faced with mobility of nodes, they do not consider the limited energy supply of nodes in the network. For wireless networks devices, however, with a large number of energy constrained devices, it is very essential to design a fast algorithm allowing the wireless network devices to minimize the energy used to communicate information from the nodes to the processing center. The problem with many routing algorithms is that they minimize the total energy consumption in the network by concentrating on improved methods to reduce energy consumption on network nodes. In this paper, the proposed method seeks to investigate the problem of balancing energy consumption by exploiting the nodes which have enough residual energy.

Low capacity devices are sensible to failure due to their small size and limited on-board energy supply, in particular when they are deployed in a huge workload environment. For

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a single node the failure may be caused by battery depletion, malfunction due to external hazard, or it may come from simultaneous failure of a multiple set of nodes. In our proposition, we have a multiple entrance in the routing table for each target to ensure energy aware expending and fault tolerance by selecting the second target in case of losing a node on the best routes.

Resource-intensive and delay-inducing systems can easily affect wireless device users like mobile user experience. Therefore, it is essential to enhance the strategies to optimize the execution of mobile applications. In this case, the term 'optimal execution' presents to an enhanced performance of an application executed in the cloud, when compared to its local execution. Applications in mobile cloud computing can be optimized with respect to three different aspects:

Application Design: can be optimized through minimizing data exchange by reducing component dependency, using light migration frameworks that reduce runtime overhead or shift non-interactive features to the cloud side, or by reducing the number of method calls by implementing similar operations in a single method.

Deployment: can be optimized through reducing the distance to the available resources, lowering bandwidth utilization, and diminishing runtime cost in the execution environment.

Execution: can be enhanced by caching data for subsequent access and using parallel execution to reduce overall execution time in the cloud.

2.4 Motivation

Now a days, the increase in the use of wireless devices such as mobile devices, PDAs and tablets etc. Wide usability of internet access through mobile internet technologies and advances in portability have created the new era of mobile application frameworks. Now, mobile devices have become more powerful enough to support a different of day to day computing requirements ranging from multimedia, gaming, and e-commerce to social media. These type of applications requires huge resources like storage and battery to satisfy the users' requirements. To overcome these problems, researchers have collaborated mobile applications services to the cloud technology. The cloud computing and its associated services is a very useful paradigm to overcome the limitations of wireless networks.

III. PROPOSED APPROACH

A Cloudlet is a self-managing resource in cloud computing technology which has high speed access to the Internet and cloud computing services. Cloudlet consists of one or more networked machines with high speed connectivity and available computing resources. Cloudlets often several advantages over the cloud computing such as higher bandwidth, low latency, cost-effectiveness and offline availability etc. These cloudlets providing services such as offloading code and application to a cloudlet for processing the application tasks, providing cache services and data storage for data storage, processing and retrieval and improving the network QoS by providing flexible mechanisms to optimize different network components. Cloudlet systems have been attracting interest from the IT industry as well as from diverse research institutions around the globe. The main research topics related to cloudlets include cloudlet configuration and architecture, application offloading optimization and inter-cloudlet communication. Furthermore, most of cloudlet systems that have been deployed are focused on audio and image offload processing (e.g. speech recognition, video processing, etc.) using virtual machines and smartphones or other mobile devices that have considerable more resources than wireless sensors. In this paper, the proposed idea about implementation of a cloudlet architecture focused on wireless networks. The following table shows main difference between cloud and cloudlet. Here H is High, L is Low and M is Medium.

Feature	Cloud	Cloudlet
Computing power	H	M
Cost	H	L
Elasticity	H	H
Latency	H	L
WAN requirement	H	None
Disaster Impact	H	L
Data Safety	H	H
User Experience	L	H
Management	Centralized	Decentralized
Network Sharing	L	M
Availability	H	H
Storage Capacity	Pay as you go	H

Table 1: Difference between Cloud and Cloudlet

Unlike the Cloud, a Cloudlet exists at physical proximity to the mobile device, usually at a1l hop distance and is accessible using a high speed wireless link such as Wi-Fi. Also referred to as a "data center in a box", a Cloudlet is a self-managing, resource-rich system, which can have high speed access to the actual Cloud. Architecturally speaking, a Cloudlet consists of one or multiple systems with high speed internal connectivity and readily available computing resources to leverage. In a Mobile Cloud Computing paradigm, a Cloudlet based approach offers the following advantages over a cloud-based approach.

WAN latency: The strongest advantage a Cloudlet has over a Cloud is the improvement it offers in WAN latency. Since a Cloudlet is located at a one-hop distance it uses high speed WLAN links that do not suffer from latency issues.

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Many applications with real time latency requirements such as video streaming, real time image, speech processing, and interactive applications will benefit greatly from Cloudlets.

Higher bandwidth: The communication link between a mobile device and a Cloudlet is usually a WLAN (Wi-Fi) link. The bandwidth capacity of a WLAN link is typically two orders of magnitude higher than the bandwidth offered by wireless Internet links (EDGE/GPRS) used by mobile devices to access Cloud services on the Internet. Consequently an application which relies on bulk data transfer such as image processing, file transfer, and video editing/streaming will experience a huge difference. While an improvement is expected in mobile Internet bandwidth with the introduction of technologies such as 4G and LTE, the proportion of improvement in WLAN band width is expected to be even larger.

Offline availability: Cloud services can only be provisioned if an active Internet connection is available. In the case of non-availability of an Internet connection, Cloud services are inaccessible. Cloudlets on the other hand are deployed on the local LAN or near by1-hop devices. The connection to the Cloudlet and its services do not depend on the availability of an active Internet connection. Mobile devices can therefore utilize Cloudlet services ubiquitously at any time.

Cost effectiveness: Accessing Cloud services incurs two types of expenses namely the cost of the Cloud service itself as well as the cost incurred for the Internet service used to access the Cloud. Cloud providers are commercial enterprises whose business model relies heavily on profits gained from Cloud services. Therefore Cloud services today are more feasible for corporate clients, while individuals shy away if the cumulative cost exceeds a particular threshold. On the converse Cloudlets can be very cost effective in that a user does not need to pay for the Internet service as Cloudlets are available at one hop LAN/WLAN links. Cloudlets will be mostly deployed in small organizational entities similar to the deployment of Wi-Fi hotspots. This ensures that Cloudlet services can be provided either free of cost (to attract clients to buy a special product) or provided at minimal price. Certain deployment models exist e.g. adhoc Cloudlets where services will be available in return for extending one's own resources to the Cloudlet.

Disaster recovery: A Cloudlet, as opposed to a Cloud, maintains a minimal amount of data or soft state of a mobile application. The data transferred to the Cloudlet is either generated code or cached copy of data present on the mobile device for processing or storage. Loss of data or abnormal execution of application at the Cloudlet therefore causes minimal damage.

Management: The Cloud architecture supports a "pay-as-you- go" model which provides as eam less mobility experience for the user. However, the provider has to deal with a number of technical issues behind the scenes to manage a highly dynamic environment. Complex issues such as workload, capacity, and network management require extensive planning, implementation and administration effort. Cloudlets exhibit a similar and transparent user experience but unlike the Cloud, a Cloudlet provider provides a substantially simple services to a comparatively smaller number of users. This allows Cloudlet services to be self-managed, requiring minimal management effort.

Cloudlet providing elastic augmentation for wireless networks via executing actions. Cloudlet is a fairly recent addition to the wireless networks paradigm, which aims at enhancing resource-poor wireless devices with cloud services. In the recent days, the hardware configuration capacity of wireless devices has improved considerably rivaling that of desktop PCs from half a decade ago. The argument is, if it's continues, future wireless networks will not be effective for executing the workload of the devices. Enhancing computing resources such as RAM, disk capacity and processing power, on the other hand, enhancing usability features like size, weight and battery life etc., will always keep wireless networks at an advantages in terms of trade-offs. The proposed idea aims to allow a wireless device to access cloud resources to execute different tasks over a wireless link in a "pay-as-you-go" model. By using cloudlets to execute various tasks, definitely it improves user experience by augmenting a wireless devices so that it can overcome limitations faced due to shortage of resources like storage capacity, computing power and energy etc. Cloudlet is used to improving the battery life of devices.

Cloudlet can reduce the power consumption during compute-intensive task execution. Reducing power consumption can be done by offloading the compute intensive task to the cloud. It also improves the storage capacity of a wireless devices by saving large chunks of data on online cloud storage. This technique is improving data reliability as a cloud services make use of several redundant storage servers. Figure 5, represents types of cloudlets. These cloudlets can be use according to the requirements of the wireless device applications. At first stage, computation offloading provides the virtualization images like resources to perform their actions. Virtualization migration, provisioning and overlay etc., performs in these stage. At second stage, data forming, arranging and distributing etc., can be done. At third stage, all wireless network information and communication can be processed.

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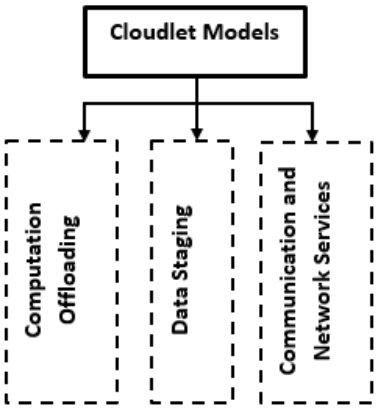

Figure 5: Cloudlet Models

Cloudlet service follows the same service as does cloud computing technology. This proposed model consists of three components: (a) wireless networks (b) access technology and (c) cloudlets. A wireless device utilize the wireless signals to access the cloudlet services is bandwidth constrained and suffers from reliable issues. These cloudlets are a decentralized and widely spreads internet infrastructure whose compute cycles and storage resources can be accessed by wireless devices. Figure 6, describes working methodology of proposed model. The proposed method has three components to perform the actions.

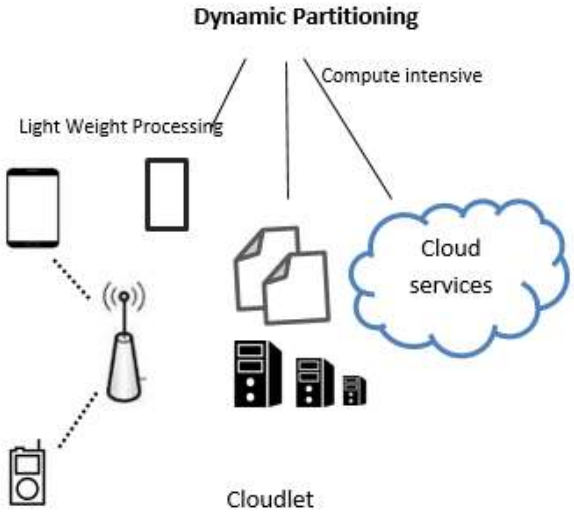

Figure. 6: Proposed Model

Wireless device actions can be forwarded to the network, according to the workload of actions cloudlet can be used to executing the action. Cloudlet information stored at cloud network.

IV. CONCLUSION

In this paper, we proposed cloudlet framework which is becoming popular technology because it addresses the issues of wireless network devices. The proposed method, address the taxonomy of cloudlet models and solutions to execute the wireless device actions by using cloud services. Cloudlets addressing the solution to optimize various single or combinations of components including localization time, messages sent during localization, and the power consumed.

V. FUTURE SCOPE

The integration paradigm of cloud computing and wireless networks solves the several issues of network areas. Cloud optimization techniques such load balancing algorithm can make more effective of workload management system of wireless networks. So load balancing algorithms can be achieved better solutions of the heavy workload problems.

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