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Ad-hoc Mobile Cloud Computing Modeling Using Cloudlet Approach with Secure Data Transfer

Mukta Bhatele
Professor
Department of Computer Science Engineering
Gyan Ganga Institute of Technology & Sciences
Jabalpur (M.P.), [INDIA]
Email: mukta_bhatele@rediffmail.com

Anshita Khare
Research Scholar M. Tech.
Gyan Ganga Institute of Technology & Sciences
Jabalpur (M.P.), [INDIA]
Email: khareanshita13@gmail.com

Abstract*—An ad-hoc Mobile Cloud Computing model with secure data transfer using cloudlet approach is proposed in this paper. Cloudlet, which is local Cloud Data Center located in common areas, communicates with mobile devices. Ad-hoc On Demand Distance Vector (AODV) routing protocol for the ad-hoc network among cloudlets and Random Way Point (RWP) for mobility mechanism has been used in this proposed model. Infrastructure as a service will be provided by cloudlets to the mobile nodes that will be connected to it. Various workload sizes after performing the encryption using asymmetric encryption technique will be offloaded to the cloudlet. After this, the cloudlet will perform the tasks of the mobile devices. The aim of the proposed model is mobility management, to reduce end to end packet delay, better system scalability and secure data transfer.*

Keywords:*—Mobile Cloud Computing, Cloudlet, Ad-Hoc, Wi-Fi Connection.*

1. INTRODUCTION

A Mobile Ad-hoc Network (MANET) is defined as a network that has many free or autonomous nodes, often composed of mobile devices, that can arrange themselves in various ways and operate without strict top-down network administration. Mobile Cloud Computing (MCC) is the combination of cloud computing, mobile computing and wireless networks to bring rich computational resources to mobile users, network operators, as well as cloud computing providers. MCC uses the computational augmentation approaches (computations are executed remotely instead of on the device) by which resource-constraint mobile devices can utilize computational resources of varied cloud-based resources. Cloudlet is one of the cloud based resource namely proximate immobile entity. It is a new architectural element that extends today's Cloud Computing infrastructure. Cloudlet supports resource-intensive and interactive mobile applications by providing powerful computing resources to mobile devices with lower latency.

The critical point is to make data transfer secure when mobile device offloads its data to the cloudlet and receives the result from it. To study the behaviour of the mobile cloud computing model in terms of performance to find out the benefits and drawbacks in order to achieve an appropriate solution for the secure data transfer is the proposal of this research paper. This mobile cloud computing model consists of an enterprise cloud in addition to the cloudlets. It provides infrastructure as a service for mobile cloud applications. The mobile user gets connected to the cloudlet by Wi-Fi. We have proposed a new ad-hoc cloudlet network model over using enterprise cloud to find out the solution of data

transmission security. It also measures the ability of the proposed model to react to the network topology change with the help of the contextual information of the mobile devices. For security purpose, this model will utilize the asymmetric encryption technique so that mobile device and cloudlet will exchange their data in encrypted form. Thus, the security of the data will be achieved. The remainder of this paper is organized as follows; Section 2 presents the related work and Section 3 depicts the proposed architecture. Section 4 describes the additional components of the cloudlet. Finally, we conclude the paper in section 5.

2. RELATED WORK

Mobile Cloud Computing has been defined in various ways in many literatures. In [4], the definitions of Mobile Cloud Computing have been divided into classes. The first refers to carry out data storage and processing outside mobile devices. Mobile devices are simply terminals in Cloud Computing, only intended to provide convenient way to access the services in the cloud. By this, the storage and computing limitations of mobile devices are avoided. In this way, the centralized maintenance is beneficial for MCC. Now the second class of definitions refers to computing where data storage and processing are also carried out on mobile devices. This introduces the concept of the Ad-hoc Mobile Cloud. This kind of Ad-hoc cloud network is advantageous in special cases such as battle field, disaster management etc.

In [10], surveyed the existing work in mobile computing through the prism of cloud computing principles. They also highlighted research challenges in the area of mobile cloud computing. Mobile Community Cloud Platform (MCCP) as a cloud computing system has been proposed. It can leverage the full potential of mobile community growth. An analysis of the core requirements of common mobile communities has been provided. The design of cloud computing architecture that supports building and evolving of mobile communities has been presented [5]. In [6], An architecture based on virtual machine (VM) technology has been proposed. It rapidly instantiates customized service software on a nearby *cloudlet* and then uses that service over a wireless LAN. The mobile device typically functions as a thin client with respect to the service.

In [5, 7, 8, 9, 10] analysis of running an application for mobile on a remote resource rich server has been done. While the mobile device performs in the vein of a thin client connecting over to the distant (enterprise) server through 3G. The asymmetric encryption technique is used to protect the user's sensitive data (i.e. data- which is stored on the device or the data when transferred through a network.) It is sure that the user sensitive data will be sent only to the intended person who can decrypt the encrypted message (using the private key). In [12], the current research efforts towards Mobile Computing have been reviewed. The author presented several challenges for the design of MCC services. A concept model has been proposed to analyze related research work. Then, the recent MCC architecture, application partition and offloading, and context-aware services have been surveyed. In [15], the author explored energy efficiency of mobile devices when transferring data securely over various communication networks including high-speed 4G networks such as LTE and Wibro.

A new platform is described in [2], known as Hyrax. It has been derived from Hadoop that supports cloud computing on Android smart phones. Hyrax allows client applications to conveniently utilize data and execute computing jobs on the networks of smart phones and heterogeneous networks of phones and servers. Hyrax allows applications to use distributed resources abstractly, oblivious to the physical nature of the cloud. In [3], CloudExp, a modeling and simulation environment for cloud computing has been introduced. It can be used to evaluate a wide spectrum of cloud components such as the processing elements, data centers, storage, networking, web-based applications. In [14], a large scale BANs system in the presence of

cloudlet-based data collection is presented. The objective is to minimize end-to-end packet cost by dynamically choosing data collection to cloud using cloudlet based system.

Many literatures [1, 10, 11, 13], presented location management in wireless network. In [1], mobility support and management in mobile cloud computing systems has been focused based on the cloudlet approach. The cloudlets will be placed in many common areas, such as coffee shops, universities and airports. A mobile user is able to use the services of the nearest cloudlet that covers limited area to provide the services such as storing, processing, content delivery. But, proper information about the mobile device's recent location if it is moving away from the range of the cloudlet is required to achieve this goal. A possible technique can be the infrastructure based methods- that uses technology such as Wi-Fi with GPS. It becomes a key point to monitor the context of current user's location, when the cloudlet's user going out of the range. In such case, connection should be dynamically adapted for the contexts to keep the job progress while any moves of cloudlet members. For keeping the connection on to the mobile device, an ad-hoc network among the cloudlets will be created. So that the mobile device users will offload their workloads to the cloudlets and receive the computation results while moving from the network of one cloudlet to another.

In [17], comparison of the performance of multi-hop wireless ad-hoc network routing protocols has been done. It was concluded that Destination-Sequenced Distance Vector (DSDV) is good with low mobility. Temporally-Ordered Routing Algorithm (TORA) has large overhead. So it fails to converge with more sources. Dynamic Source Routing (DSR) is very good at all the rates of speed, but has large packet overhead. Ad-hoc On Demand Distance Vector (AODV) is almost as good as DSR, but has more transmission overhead. In [18], Ad-hoc On Demand Distance Vector (AODV) is a Reactive Routing Protocol that acts in response on demand. AODV is an advancement of Dynamic Sequence Distance Vector protocol. It facilitates multi-node, dynamic routing and self-starting in MANET environment. It never generates close loop in the routing table of any mobile node because of the idea of generated sequence number counter. AODV Sequence numbers provide as time stamps protocol and agree to mobile nodes to compare how new packet information reached to other nodes in the MANET architecture.

3. THE PROPOSED MODEL ARCHITECTURE

The work undertaken focuses on the secure data transfer in ad-hoc mobile cloud computing network based on cloudlet approach. All the cloudlets have the same role i.e. to provide the services to the mobile users.

3.1 Problem Analysis

A cloudlet is a resource rich server placed in common regions to provide the services to the thin clients (mobile nodes) when required.



Figure 1: Insecure data transfer between cloudlet and mobile devices

When the mobile device gets connected to the nearby cloudlet, it offloads its data to the cloudlet to perform the tasks when such kind of requirement occurs. Since the mobile device has limited resource availability, the mobile device gets benefit of the cloudlet. The mobile device will get the result of the task performed

even when it goes out of range of the current cloudlet network. But, there is lack of data transfer security. So, the security in data transmission has to be achieved.

3.2 Model Architecture

Each cloudlet is able to establish a connection with other cloudlet using the Ad-hoc On Demand Distance Vector (AODV) routing protocol in this architecture. The cloudlets are capable to provide the services to the mobile devices as per their requirement even when the mobile devices are moving from one network to other network. Figure 3.1 shows the components of the cloudlet network.

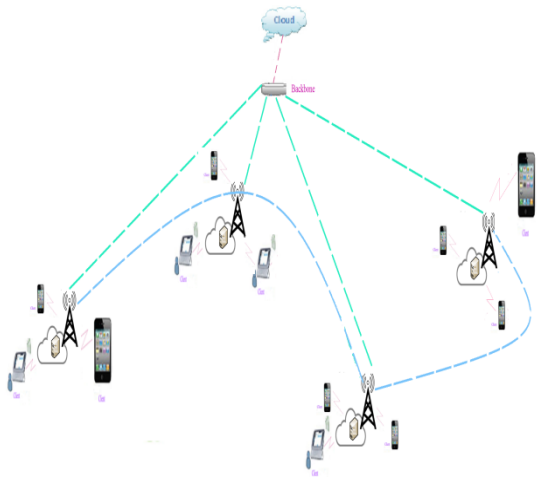

Figure 2 Ad-hoc Cloudlet Network

This network includes the following components:

- An enterprise cloud (3G connection).
- Cloudlets are connected to each other in high bandwidth wireless communication (Wi-Max).
- Mobile devices (laptops, smart phones, tablets) connected to a cloudlet in high bandwidth wireless Communication (Wi-Fi).

The proposed model Architecture consists of number of cloudlets situated in common areas associated with several mobile nodes. Each cloudlet which is a fixed entity, presents services for any around mobile device. All the cloudlets are connected to the enterprise cloud. According to the needs of the mobile devices, they can offload their jobs to be processed by any nearby cloudlet. There will be number of nodes with diversed tasks in the cloudlet network. Each mobile node will be connected to the cloudlet with high bandwidth wireless functionality via wireless links. For the movement of the mobile nodes, Random Way Point (RWP) mobility mechanism has been used.

The routing information will be swapped among the cloudlets by making the use of Ad-hoc On Demand Distance Vector (AODV) routing protocol. Cloudlets will update their routing tables when a mobile node joins or leaves the cloudlet network. Only those mobile nodes will be registered by the cloudlet, that will request to the cloudlet to offload their workload.

There are two kinds of situations that can take place. In the first situation, the mobile node will remain in the same cloudlet network to which it offloaded its job. Then, the cloudlet after processing the job will send the result to the intended mobile node. This is also called the traditional approach. In the second type of situation, the mobile node offloads its data to the cloudlet to be processed and leaves the network while the cloudlet is processing its job. Thus, the mobile node goes out of the range without receiving the result. This cloudlet will perform the computation and stores the result, if it does not find the mobile node in its network range which made the request.

The mobile node reaches in the range of another cloudlet's network range. When the node requires the offloaded job results, then in which cloudlet's network it is present, it requests to that cloudlet for the result. This cloudlet after updating its routing table, sends to the other cloudlets. The other cloudlets will check the mobile node ids if they have any stored result of the mobile nodes' id which are present in received routing table. Now the cloudlet which stored the result of the mobile node request will respond to the cloudlet with

the result. Then, the mobile node will receive the result from the corresponding cloudlet. An additional component for secure data transfer is to be added in the cloudlet.

4. ADDITIONAL COMPONENTS OF THE CLOUDLET

There are three additional components of the cloudlet have been assumed: Security handler, job handler, and context handler as in Figure 3 Since the main focus is on the secure data transfer issue in mobile cloud computing model, this model is based on the security handler part with respect to other components' benefits.



Figure 3: Additional Components of the Cloudlet.

Security Handler

- Creates secure connections between the mobile devices and cloudlet.
- Performs encryption of the data that has to be transferred.

Context handler

- Maintains connections and communicates with the mobile devices.
- Monitors the mobile nodes entering or leaving the coverage area.

Job Handler

- Partitions the application and data set required into separated subtasks.
- Returns the result of each subtask to the owner of the job or to the destination cloudlet.

To achieve the data transmission security, asymmetric encryption technique is to be used. So that the user's data can be protected. The asymmetric encryption algorithm AES128 and hashing have to be used for creating signature out of the data that has to be sent through a network protocol HTTPS. It is made sure that the user's data will be sent only to that particular entity which is able to decrypt the encrypted message by using the private key.

Steps to authenticate the server and to enable the communication with JWT token are as follows:

- A JWT token is created that contains a header, payload, signature and public key appended to each other with a "dot"(.).
- The header and payload consists of an algorithm – in JSON format (which is bas64 URL encoded).
- The signature is calculated by appending both header and payload with "dot".
- Finally, bas64 string from the header, payload, signature and public key of the mobile node are appended together with "dot"(.) which is known as JWT token.
- The JWT token is sent to the cloudlet while the mobile node requesting for access.
- The cloudlet validates the token and sends a token in response which also consists the public key

that is used to further communication with the cloudlet.

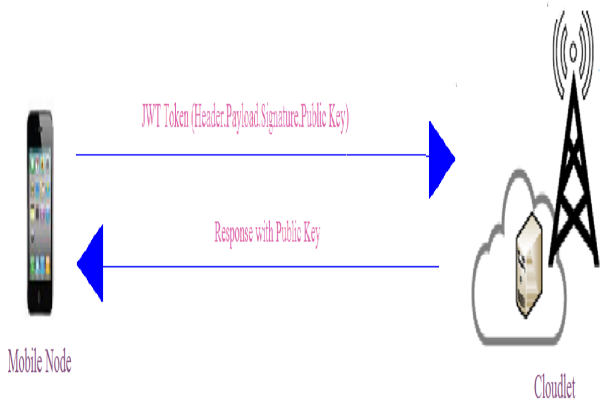

Figure 4. Registration of the Mobile Node.

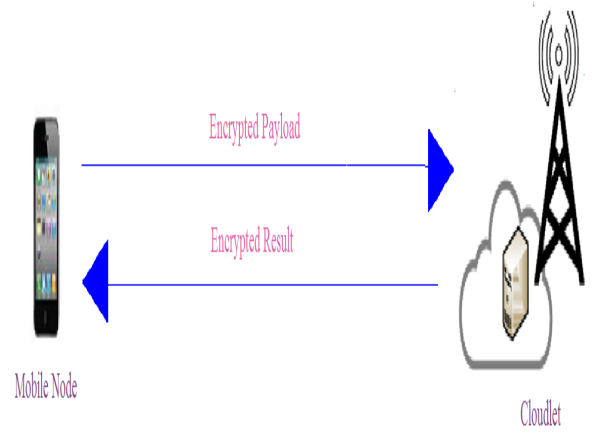

Figure 5: Secure Data Transfer Between the Mobile Node and Cloudlet.

The mobile node encrypts the payload that has to be sent using AES 128 encryption and a public key as provided by the cloudlet.

- The mobile node then sends the encrypted data to the cloudlet.
- The cloudlet now decrypts the data and performs the requested tasks.
- The cloudlet sends the result after processing the requested job in encrypted form to the mobile node.
- Secure data transfer can be achieved in this way.

The entire process uses HTTPS protocol to communicate with the cloudlet, and this helps to resolve man in middle attacks.

5. CONCLUSION

The proposed model presents an Ad-hoc Mobile Cloud Computing model which makes use of cloudlet as service provider with secure data transfer. Random Way Point (RWP) and Ad-hoc On Demand Distance Vector (AODV) routing protocol have been used for mobility management and communication among cloudlets respectively. The mobile device offloads its encrypted data to the cloudlets to perform its task. Thus, the model achieves secure data transfer between mobile device and the cloudlet.

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