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An architecture for Mobile Cloud Computing with support of middle-ware technologies.

Rocky Ramchandani, Aveek Bardhan, Dr.N.Ch.S.N. Iyengar
Departement of Computer Science Engineering, VIT University

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ABSTRACT

In the current era of computing, mobile devices are playing a significant role of information processing systems in day to day life. Current trend suggests that smart phones are going to be the first-most computing devices which many people will carry with them for maximum time, particularly in less developed countries. However, smart phones are still lacking behind the essential resources. This demands the need for Mobile Cloud Computing, where the key elements of data storage and data processing are carried outside the mobile devices. So this provides flexibility to mobile users as, the application and the data stored remotely can be accessed on-the-fly with high speed networks. Variation among the mobile network on basis of elements such as, bandwidth, unstable network and its uncertain availability are barriers for Quality Of Services in the performance. Thus the solution is to connect the mobile devices heterogeneously where they work collaboratively as resource providers. Our mechanism suggest for "Mobile to Hub to Cloud" model which can tackles the network disparity problem. A scenario gives the perfect example for the need of such model, mobile users in areas with infrastructure where the costs of accessing the network is too high, such as traveler who doesn't wished to pay high roaming charges. Thus the suggested model can evaluate the following options: storing data in mobile hubs and improving the message delivery performance. So as in our example, traveler now can push the data onto the mobile buffers or hubs which in turn will send it to the cloud server.

Corresponding Author:

Dr.N.Ch.S.N. Iyengar,
Departement of Computer Science Engineering,
VIT University,
School of Computing Science and Engineering at VIT University, Vellore-632014, Tamil Nadu.
Email: lsntl@ccu.edu.tw

1. INTRODUCTION

World is growing faster than ever, where it is approximated as one mobile phone for every pair of persons in the world [1]. Introduction of smart phones has brought an evaluation into the computing market, which also brings the high sophistication and power embedded together in handheld device serving to its users. Simultaneously the rise of cloud computing has motivated to improve the capabilities lacking in smart phones, thus the need for Mobile Cloud Computing (MCC) demands into the market. The barrier of Internet connectivity is major constraint for performance in mobile cloud. The nature of wireless network is bit different than wired network in terms of available bandwidth for communication, instability in infrastructure and other cellular connectivity issues. While the problem becomes more challenging when the point of low speed Internet accessing areas are brought into the picture, particularly in the remote areas where the speed is in proportion with quadratic of its cost to access such networks [2].

In these challenges use of opportunistic network can help to improve the availability and accessibility of information stored on remote networks [3]. Opportunistic network consisting of mobile and stationary nodes, can communicate with each other using the local area wireless technologies such as: Wi-Fi or Bluetooth. The prima of such communication involves human interaction as the opportunity of forwarding any message on local network which depends upon the nature and behavior of the social interaction. Limitations such as unavailability of network infrastructure and high speed Internet access costs can be overcome by the use of opportunistic networks, for example, a traveller in a foreign network is willing to gain access to cloud application with help of local user's mobile phone.

The aim of this paper is to provide solutions for the questions such as:

1. Using opportunistic network how to provide cloud services to a traveller that lack access to network?
2. Does the help from local user's mobility and social interactions give an efficient way of exchanging information?
3. How the social interactions between the traveller and the local users are integrated with cloud networks so as to form a model for opportunistic mobile cloud platform?

The goals of the paper are divided into two. First the investigation on how to build an opportunistic mobile cloud infrastructure using the local wireless network for travelers and available helping local users, which enables the needy to exchange the data to or from cloud network. Second the model for communication between the cloud services and the local users which buffers the necessary information on behalf of the travelers.

Such solution contributes the new terms mentioned as follows:

1. Introduction of "Mobile to Hub to Cloud" architecture enables the travellers to interact with cloud application without any necessity of Internet connection.
2. A model of social interaction among the helping local users and the needy traveler depends upon the nature and behavior of the local network.
3. Information exchange for traveler is assisted by the number of local mobile users, which first collects the data from them and routes back to cloud application on behalf of the travelers. Similarly the response for message from cloud server can be re-routed back to traveler via local users.

The rest of the paper follows as Section II, Surviving techniques which give the background study for the topic. Section III, Motivation behind the topic. Section IV, Proposed architectures and models. Section V, Methodology and tools used for implementing the experiment.

2. Surviving Techniques

The work in this paper provides a mobile cloud computing in the absence of dedicated network infrastructure. Many researchers have suggested the models for integrating mobile applications and cloud infrastructure. Some of these models are:

1. Mobile-Cloud Computing Device to Cloud (MCC D2C)
2. Mobile-Cloud Computing Cloud to Device (MCC C2D)
3. Mobile-Cloud Computing Device to Device (MCC D2D)

These models describe the use case for traditional cloud-computing applications work on mobile devices via mobile-cloud application, where the network infrastructure is more reliable. But paper emphasize on enabling the services where network infrastructure is either weak or too expensive or not available itself.

Hung et al. (2011) modeled a 'Smart Tourism' system which builds mobile application for a cloud platform [4], which requires expensive Internet connection. Christensen (2009) presents the requirements to gain the objective of mobile cloud computing [5], where the analysis on smart phone, restful cloud-based web services and context awareness are being introduced in the research. Giurgiu et al. (2009) uses cloud as the box for mobile applications [6]. Depending upon the context of the user applications are pre-processed, hence the small module is always executed whereby minimizing the communication overhead.

Marinelli (2009) introduced the concept of Hyrax, a client bundled package for mobile cloud computing which allows mobile phones to use the cloud computing platform [7]. Felipe Gil-Castineira and Raja Bose (2011) introduced the remote virtual peripheral [8], for controlling the machines in cloud server via input command from mobile devices. For example, the GPS on modern smart phones can be used as input devices for cloud-maps applications

3. Motivation

In terms of economic facts, accessing the cloud services includes processing costs of two types: the cost for network infrastructure usage plus the cost of using cloud services. As introduction of various free cloud services from giants like Google, Amazon, Rackspace etc., using the latter is not so costly now-a-days. Also there many free cloud service available for mobile devices, but on the other hand wireless data charges are very high for normal users. As example, in India the 3G subscription plans for 1GB of data usage may charge upto 5-10 USD. Besides, using 3G connectivity consumes large battery usage and is quite slower than when compared with network interactions from WiFi.

While proposed model serves with extra benefits to consider: First, preserving the conventional offloading benefits, such as allowing applications to be executed despite of unavailability of resources. For example, if network infrastructure is not strong enough to support the application execution then by using the ad hoc wireless connections from several ready to help local users, application data can be exchanged back and forth from the client to cloud. Here local users serve as buffer in between. Second, performance can be improved if the sequence of execution is reordered to get computed on parallel architecture. For example, a traveler on foreign network wishes to transfer several photos which have occupied his phone memory completely. The transfer has to take place from his phone back to the cloud. As the cost of roaming for data is prohibited to him, hence now traveler can connect across the model, looking for the number of local users ready to help. In turn depending upon the various constraints of current ad hoc network local users are selected dynamically which will work on behalf of traveler, thereby balancing load equally and finishing task efficiently for traveler.

Such examples show the potential of this application in which an ad hoc mobile cloud solution can be advantageous. So in summary, local mobile devices can act as virtual cloud service provider, where such social interaction provides us to create communities in which shared-tasks can be executed, further a certain level of parallelism is also achieved.

4. Architecture

To provide travelers with access to the cloud services in the absence of infrastructure, as model proposed “Mobile to Hub to Cloud” that leverages local users’ mobile network connections. As shown in Figure 1, it shows the use case of MobICloud architecture.

MobICloud architecture consists of the components as follows:

1. Travelers’ mobile device,
2. Local users’ mobile device,
3. Storage Hub,
4. Cloud gateways
5. Cloud servers.

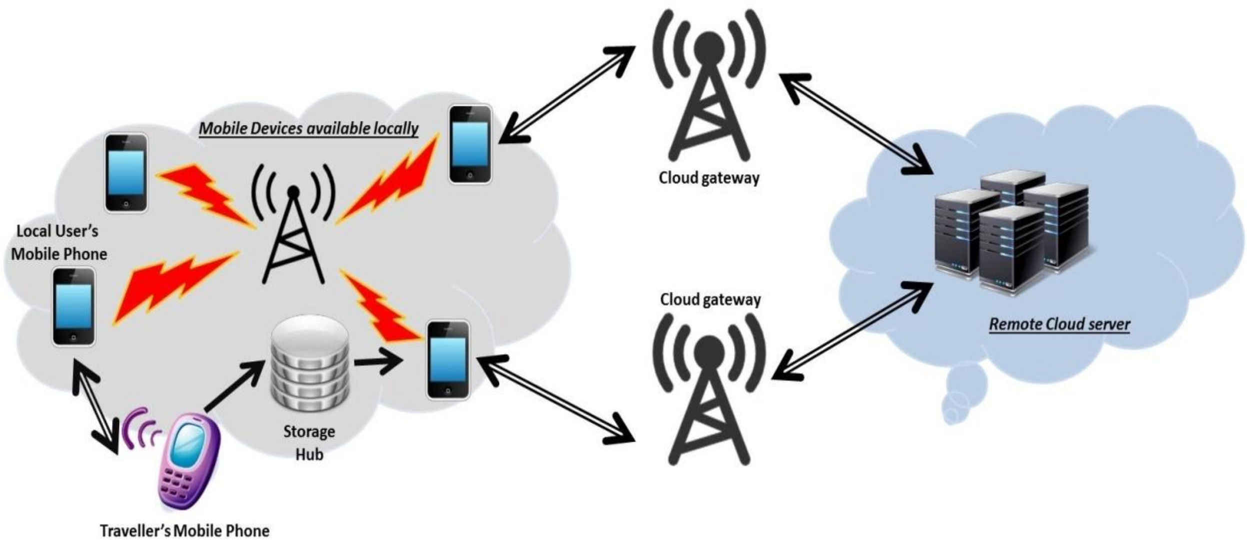

Figure 1. The MobICloud architecture, is where travelers search for local users who may help to store photographs or perhaps help to understand the meaning of a rare painting. Local users may help travelers by giving storage or information by providing local mobile network infrastructures or with the help of the local users’ mobile networks tourists can access cloud applications themselves.

In the scenario, traveler's mobile devices cannot directly access cloud services but in turn via ad hoc network, they can communicate with local users and storage hub. While local users have access of network infrastructure, so they can reach to cloud gateways via Internet. Since travelers are too conserve about the energy consumption of their devices and also about various resources such as storage, network and more. Mostly these travelers wish to store the data before power runs out from their devices.

Hence the role of Storage hub comes into picture, where the stationary placed Hub provides the infrastructure to traveler. These storage hubs can be placed in tourist spots, where the travelers can store their data using local wireless network. Transfer of data can take place via WiFi or Blue-tooth. Now when local user willing to help, visits to an ad hoc network collects the data from hub or directly from travelers' mobile phone. Further the local user sends the travelers' messages to the cloud servers via cloud gateways using the Internet connections from their device.

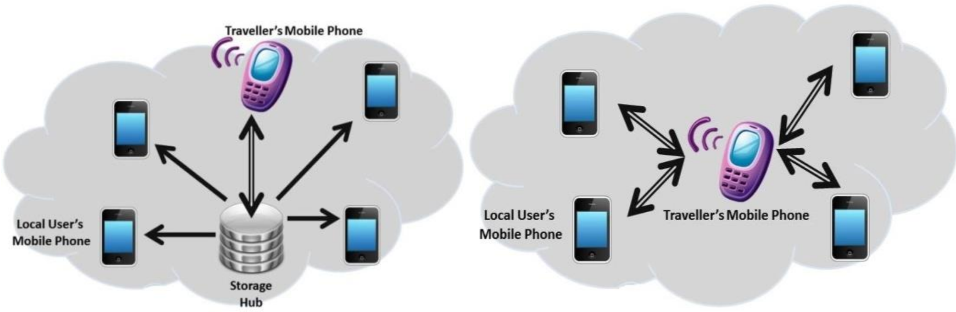

Figure 2. Both the diagrams represent an ad hoc network, where the connections are represented using arrows. Directions of arrows are the flow data movement among nodes. Left sided figure is case (a) where the presence of Intelligent Storage Hub involves smooth exchange of data, while right sided figure is case (b) where even the absence of Storage Hub wouldn't affect the framework.

From Figure 2, architecture classifies the communication model into two cases mentioned as follows:

Case (a): the presence of Intelligent storage hub, which as acts as an intermediate in communication and we call this case as an Intermediate Communication.

Case (b): here local communication is not tied to any hubs/nodes in between. In turn its free to match up with any ready to help device to enable the cloud communication and this case is called as Free Communication.

Aliases:
Intermediate Communication, as, IC.
Free Communication, as, FC.
Local User Phone, as, LP.
Travelers Phone, as, TP.
Cloud Agent, as, CA.
Intelligent Hub, as, IH.

4.1. Communication Model:

As discussed earlier interactions between Cloud and User is categorized in 2 cases, namely Intermediate Communication (IC) and Free Communication (FC). Both the cases have their own pros & cons.In IC, the presence of an Intelligent Hub as intermediary provides the best available network resource around the local network by managing a resource constraint table called best-of table which keeps the entries of ready to help LP's available in local network. Using different approaches LP node can be selected from the table, following are some of the constraints which helps to go for particular LP node:

1. Node which is connected to network from long time (as this node would be less mobile).
2. Node which posses high signal strength in terms of ad hoc networking scenarios.
3. Node which is free (having maximum available bandwidth).

Through these points IH now can select LP by measuring all the load balancing entities in order for the provision of data transfer from TP to CA. At any point new LP's are discovered by IH and noted into best-of table, similarly the absence of LP from a network is also noted back into the table. Although the risk has to be bare if LP disables in middle of the communication and such a case is handled carefully by IH by selecting different candidate LP from the best-of table.

Where as in case of FC, nodes are provided the flexibility to connect among themselves such as any ready to help LP can be selected by TP itself. In this case the absence of IH from the scenario leaves TP to opt into self-initiated system which selects available LP and hence the data is traversed back & forth from TP to CA via selected LP.

4.2. Security Management:

As observed in architecture; TP's personal data is moved through different untrusted nodes which may bring the user at stake. This concerns the user about the security to ensure its data's safety, integrity & intrusion free.To provide such needs, we consider a Trusted Third Party in scenario which manages the certificates about the authenticity of the users and cloud agents. Certification Center in this case manages such important role. With this measure TP's user identity can directly be omitted from the message envelope, which helps to ensure that the identity of the actors in communication remains integrated in the act of intrusion. Using sender anonymity mechanism such Onion Routing helps to achieve this anonymized messaging.

4.3. Control Flow:

So summarizing the overall architecture the control data flow moves as:TP is a mobile user on foreign network willing to access the cloud service in absence of its mobile network, equally TP is tied up with Hubs around which also ties several other ready to help LPs. Such local infrastructure can be implemented using Wi-Fi available on every nodes. Cloud agent which anticipates the requests by its user from anywhere and anytime. For security a trusted third party, Certification Center issues certificates to both of Cloud agent & its Cloud user, which also provides the necessary public parameters pertaining to its. Hence system operations can be describe as follows:

1. Cloud user while registering for the services obtains his/her service certificate, possessing the private key with access privilege from the certificate center. Similar registration is made by cloud agents too.
2. Now envelope is made by encrypting the TP's data using its private key & further embedding the public key of its cloud agent, having source information of TP & the destination information includes the address of cloud agent.
3. This envelope is made ready to move into the local network to its nearest IH, which in turns checks the request of the data flow is from inside the network. Further it finds the suitable LP from best-of table to complete the job.
4. A copy of data is kept on IH, whereas a copy is handed over to LP which forwards the data to mentioned destination address of cloud agent.
5. After receiving the data, a step of validation ensure the data integrity & authenticity of the cloud user (in this case TP), which in turn creates the acknowledgement packet back to same path.
6. When this acknowledgement is received by IH, it notifies TP about the successful transaction, and if no acknowledgement is received then after a time-out period, IH finds another LP to associate a job with.

5. Methodology and Tools

A prototype of the proposed framework can be implemented using Java. It provides most of the capabilities in terms of intercepting the loading, modifying the classes and also there are many implementations available for cloud computing providers and clients on this platform, some of the implementation of cloud services available in Eclipse IDE are Google, Amazon and more.

Project consists of following sub-implementations:

1. Cloud computing provider client.
2. Ad Hoc mobile cloud framework

Mobile interface for discovering the local users or Storage Hub can be made using Android Development Kit, where SDK can be embedded in Eclipse IDE. While the transfer of data among the nodes can be implemented using Android SDK itself.

The part of local user’s mobile phone communicating (on behalf of traveler's phone) with the cloud services includes several modules. At the cloud server the open points for simple transactions such as uploading the collected data is a main objective, also the use of digital signatures and hash functions while implementing the server will provide a certain level of user authentication. Now the module of local user’s smart phone application should be able to detect the cloud gateway which enables the data movement. Also the part of user authentication should be demanded while receiving any stream of requests.

6. Result Analysis

The analysis of the proposed model can be carried out by the activity diagram shown by Figure 3. Whenever a traveler finds a need to connect the cloud service in a region where there is no network connectivity available, Intelligent Hub sub-ordinates its users nearby in network as described in the model. In the presence of such a back-bone network traveler connects and proceeds the cloud communication via hub. Traveler sends the data which has to be stored on respective cloud network, build a message consisting of envelope. This message is encrypted using the assigned private key for traveler generated by third party agent and stored on traveler's phone. Using onion routing techniques the identity of cloud user is hidden on local network. Further the best of helper node selection algorithm on the hub selects and assigns a task to complete the cloud transaction. Cloud decrypts the envelope using it's assigned private key, extracts the user details and reads the transaction query, completes the procedure and initiates the acknowledgement message on the same path as received in request message. The pictorial representation of transaction can be depicted as follows:

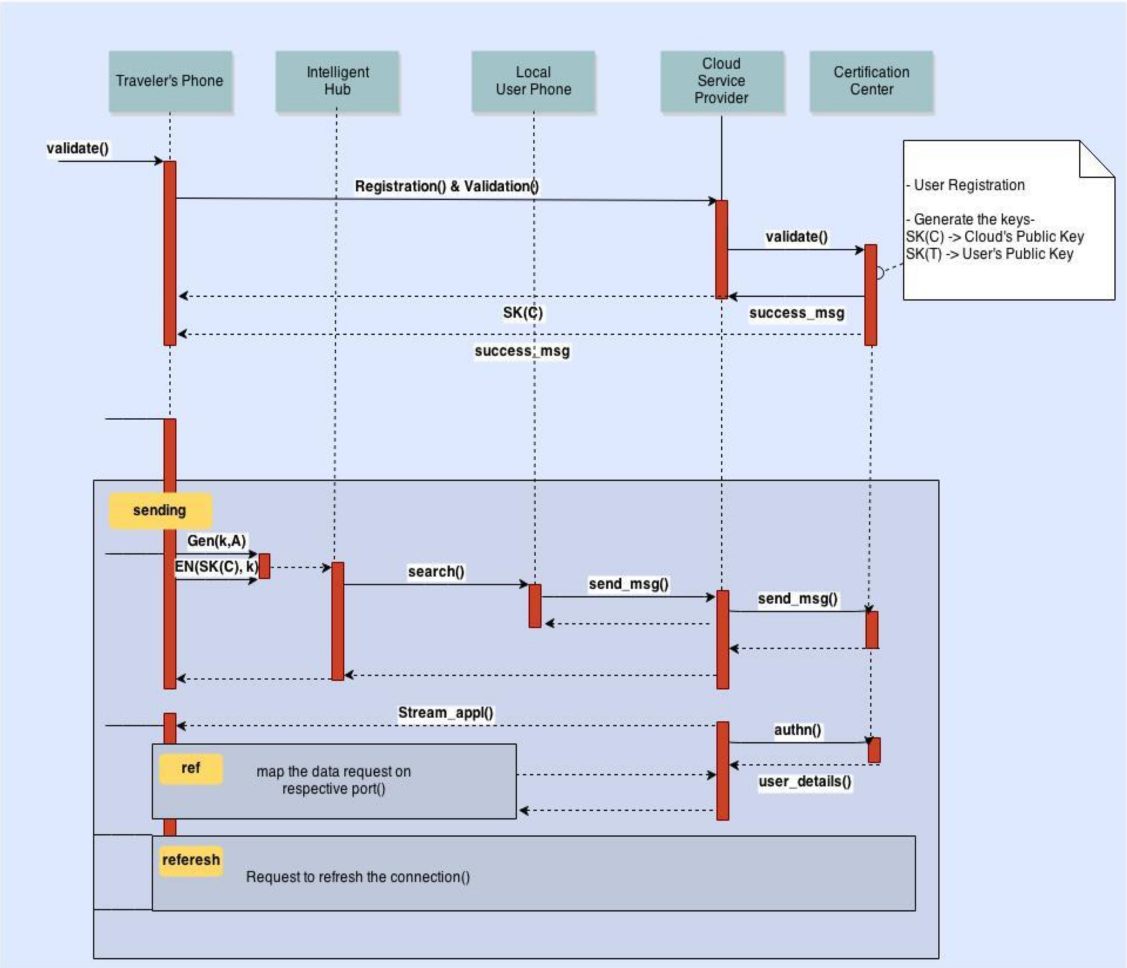

Figure 3. Activity diagram

1. Setup(1^k, A): Takes a security parameter k & A is a set of attributes. This function returns the master key Mk and the public-key PKa.
2. Genkey(Mk, u, P): Parameters for the function follows as, P is the user's transaction access privilege and Mk is the master generated from setup() function. u is the user related unique ID.
3. Encrpyt(PKa, L): L is an access constraint and PKa is generated public-key. It outputs the ciphertext header H and a random session key Ek.
4. Decrypt(SKp, H): Skp is user's private-key and H is a ciphertext input, which outputs the session key Ek.

7. Conclusion & Future work

Thus in this paper, we have proposed a collaborative approach for extension of cloud computing to mobile users. We have also proposed a designed framework providing the model for mobile to hub to cloud communication, which to some extent provide an intimate solution of network disparity problem. The described framework would be able for serving many mobile users simultaneously, by leveraging the elastic resources in the pre-existing infrastructure of cloud. In future work, our emphasis would be to implement the work as per on described platforms; such that architecture would provide configurable & manageable solution for ISP's and ready to implement in market.

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BIBLIOGRAPHY OF AUTHORS

	**Rocky Ramchandani** is pursuing M.tech at School of Computing Science and Engineering, VIT University, Vellore. He completed his B.E. degree in Information Technology from University of Pune, India. His area of interests are Algorithm design an Pattern Recognition.
	**Aveek Bardhan** is pursuing M.tech at School of Computing Science and Engineering, VIT University, Vellore. He took his B.Tech. degree in Electonics and telecomunication from Mumbai, Maharashtra. Currently he is doing his research in advanced computer architecture. He has completed P.G.-Diploma certification in Embedded System Design From Central Government Institute{ TCIL-IT } and has pursued RHCE certification in redhat linux operating system. His areas of interest include Embeded system, Network security, operating system and storage. He is member in ISTE.
	**Dr.N.Ch.S.N. Iyengar** (b 1961)currently Senior Professor at the School of Computing Science and Engineering at VIT University, Vellore-632014, Tamil Nadu, India His research interests include Agent-Based Distributed secure Computing, Intelligent Computing , Network Security, Secured Cloud Computing and Fluid Mechanics. He has authored several textbooks and had nearly 167 research publications in reputed peer reviewed international journals. He served as PCM/reviewer for many international and IEEE conferences. He is Editor in Chief for International Journal of Software Engineering and Applications(IJSEA) of AIRCC, Guest Editor for Special Issue on Cloud Computing and Services of *Int'l J. of Communications, Network and System Sciences* and Editorial Board member for International Journals like **IJConvC (Inderscience -China), IJCA (USA) etc.,**