SECURITY, PRIVACY AND CHALLENGES IN MOBILE CLOUD COMPUTING (MCC)

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ABSTRACT

Mobile Cloud Computing (MCC) is a combination of three main parts; they are mobile device, cloud computing and mobile internet. With the help of MCC, a mobile user gets a rich application delivered over the Internet and powered by cloud-backed infrastructure. The importance of Cloud Computing is increasing and it is receiving a growing attention in the scientific and industrial communities. Now a day's the major concern for mobile user is security and protection in mobile cloud computing. MCC refers to the availability of cloud computing services in a mobile environment. There are number of loopholes and challenges exist in the security policies of MCC. This paper present a review of MCC, its security & privacy issues and vulnerabilities affecting cloud computing systems, analysed andcomparedvarious possibleapproaches proposedbytheresearcherstoaddress securityandprivacyissues inMCC.

KEYWORDS: *cloud computing; mobile computing; mobile cloud computing; mobile cloud security; vulnerabilities; privacy*

INTRODUCTION

Mobile devices are increasingly becoming an essential part of human life as the most effective and convenient communication tools not bounded by time and place. The rapid progress of mobile computing (MC) becomes a powerful trend in the development of wireless communications technology as well as commerce and industry fields.

MCC is the combination of mobile computing and cloud computing, this provides full access to all technology resources through the cloud "Anytime, Anywhere, Anyhow". Mobile cloud computing is a model for transparent elastic augmentation of mobile device capabilities via ubiquitous wireless access to cloud storage and computing resources, with context-aware dynamic adjusting of offloading in respect to change in operating conditions, while preserving available sensing and interactivity capabilities of mobile devices [1].

Recently, the MCC is becoming a new hot technology. And the security solution for it has become a research focus. With the development of the mobile cloud computing, new security issues are there, which needs more security approaches.

This paper is organized as follows: - Section II introduces the concept of mobile cloud computing. Section III presents security architecture of MCC. Section IV outlines the types of security breaches and issues. Section V analysed and compared various technique proposed by the researcher to solve security issues of MCC. Finally, Section VI concludes the paper followed by futurework.

MOBILE CLOUD COMPUTING

Cloud computing is a general term for the delivery of hosted services over the Internet. Mobile Cloud Computing refers to an infrastructure where both the data storage and the data processing occur outside of the mobile device. Mobile cloud applications move the computing power and data storage away from mobile phones into the cloud, bringing applications and mobile computing not only to smart phone users but also to a much broader range of mobile subscribers[5].

Mobile devices are increasingly becoming an essential part of human life as the most effective and convenient communication tools not bounded by time and place. Mobile users accumulate rich experience of various services from mobile applications, which run on the devices and/or on remote servers via wireless networks. The rapid progress of mobile computing (MC) becomes a powerful trend in the development of IT technology as well as commerce and industry fields. However, the mobile devices are facing many challenges in their resources (e.g., battery life, storage, and bandwidth) and communications (e.g., mobility and security). The limited resources significantly impede the improvement of service qualities [9].

There are so many cloud storage service providers around e.g. One Drive (Microsoft Corporation), Dropbox (Dropbox Inc), Google Drive (Google Inc), Box, Amazon Cloud Drive and Apple icloud. Cloud computing applications are the cloud-based services e.g. Mobile Email, Google Maps, Google Cloud Print (Google Inc), Other Apps (Real Estate, Insurance, Surveying, Navigation app)[7].

SECURITY ARCHITECTURE OF MOBILE CLOUD COMPUTING (MCC)

Protecting user privacy and data/application secrecy from adversary is a key to establish and maintain consumers' trust in the mobile platform, especially in MCC. A general architecture in a broader sense depicted in Figure1.
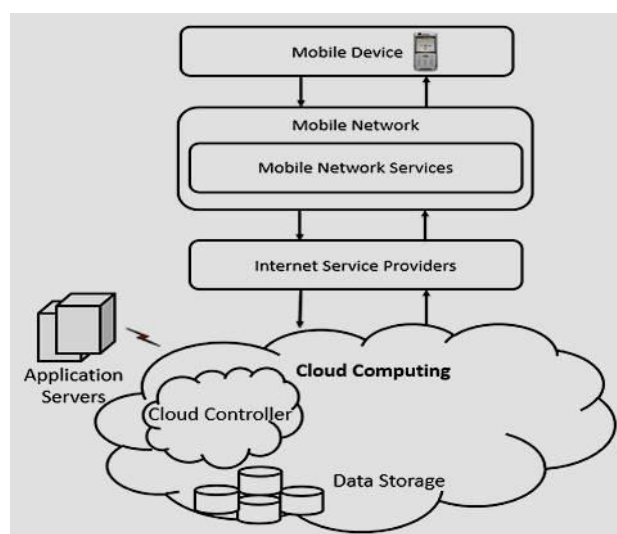

Fig 1: End to End Mobile Cloud Computing Security Architecture

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The security related issues in MCC are introduced in two categories: the security for mobile users and the security fordata.

A. Security for Mobile Users: Mobile devices such as cellular phone, PDA, and Smartphone are exposed to numerous security threats like malicious codes (e.g., virus, worm, and Trojan horses) and their vulnerability. In addition, with mobile phones integrated global positioning system (GPS) device, they can cause privacy issues for subscribers[6].

B. Securing Data on Clouds: Although both mobile users and application developers benefit from storing a large amount of data/applications on a cloud, they should be careful of dealing with the data/applications in terms of their integrity, authentication, and digital rights[6].

Cloud computing permits customers to utilize cloud services on the fly as pay-as-you-go manner through the Internet. There are various layered architectures available for cloud computing to provide the aforementioned services as a utility. One such cloud computing layered architecture is presented in Fig. 2 [18].
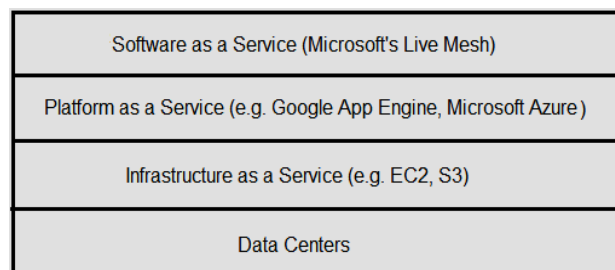

Fig 2: Layered architecture of cloud computing

Generally, a cloud computing is a large-scale distributed network system implemented based on a number of servers in data centers. The cloud services are classified based on a layer concept. In the upper layers of this paradigm, Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) are stacked [16].

- *Data centers layer*: This layer provides the hardware facility and infrastructure for clouds. In data center layer, a number of servers are linked with high-speed networks to provide services for customers. Typically, data centers are built in less populated places, with high power supply stability and a low risk ofdisaster.

- *Infrastructure as a Service (IaaS)*: IaaS is built on top of the data center layer. IaaS enables the provision of storage, hardware, servers and networking components. The client typically pays on a per-use basis. Thus, clients can save cost as the payment is only based on how much resource they really use. Infrastructure can be expanded or shrunk dynamically as needed. The examples of IaaS are Amazon EC2 (Elastic Cloud Computing) and S3 (Simple StorageService).

- *Platform as a Service (PaaS)*: PaaS offers an advanced integrated environment for building, testing and deploying custom applications. The examples of PaaS are Google App Engine, Microsoft Azure, and Amazon Map Reduce/Simple StorageService.

- *Software as a Service (SaaS)*: SaaS supports a software distribution with specific requirements. In this layer, the users can access an application and information remotely via the Internet and pay only for that they use. Salesforce is one of the pioneers in providing

thisservice model. Microsoft's Live Mesh also allows sharing files and folders across multiple devicessimultaneously.

Although the cloud computing architecture can be divided into four layers as shown in Figure 2, it does not mean that the top layer must be built on the layer directly below it. For example, the SaaS application can be deployed directly on IaaS, instead of PaaS. Also, some services can be considered as a part of more than one layer. For example, data storage service can be viewed as either in IaaS orPaaS.

TYPES OF SECURITY BREACHES AND ISSUES

A. *DataOwnership*

Cloud computing provides the facility to store the personal data and purchased digital media such as e-books, video and audio files remotely. For a user, there is a chance of risk to lose the access to the purchased media data. To avoid these types of risks, the user should be aware of the different rights regarding the purchased media. MCC utilizes the context information such as locations and capabilities of devices and user profiles, which can be used by the mobile cloud server to locally optimize the access management [13].

B. *Privacy*

Privacy is one of the biggest challenges in the mobile cloud computing environment. Some applications which hire cloud computing store user's data remotely. Third party companies may sell this important information to some government agencies without the permission of the user. For example: Mobile devices use location based services which help their friends and other persons to get the updates about the location of the user [17].

C. *SecurityIssues*

Mobile devices are famous for malicious code. There are many chances to lose or steal the data because mobile devices are mostly unprotected. An unauthorized person can easily access the information stored on the mobile devices [24]. The top mobile threats that affect security are mentioned as under.

1. Data loss from lost/stolendevices.
2. Information stealing by mobilemalware.
3. Data leakage through poorly written third partyapplications.
4. Vulnerabilities within devices, Operating Systems, design and third partyapplications.
5. Insecure network access and unreliable accesspoints.
6. Insecure or roguemarketplaces.
7. Insufficient management tools, capabilities and access toAPIs.
8. Near Field Communication (NFC) and proximity basedhacking.

Data can be sniffed by the intruders during wireless communications. Data access can be interrupted due to multiple points. This leads to the data locked in particular services. To protect the mobile devices from data loss, thin client like anti-malware, antivirus should be installed to monitor the malicious code. Malicious code includes not only viruses but also phishing from malicious social networks and domains, botnets, spam and identity theft. Wireless protocol encryption provides secured communication where intruders cannot hack the network.

The concept of data breach is that any malicious person or unauthorized person enters into a corporate network and stolen the sensitive or confidential data. Another serious threat is the potential incapacity to prevent data loss because many of the companies treat their data as a valuable asset. In our networked world, most people know that loss of data is unavoidable at one point or another. There is increasing amount of sensitive data which is relayed to cloud computing providers and this data could get lost in any number of ways, including through accidental deletion or corruption of stored data[27].

Security risk in MCC is inherited from cloud computing. Mobile Cloud Computing suffers from following risk.

- In mobile cloud computing, user does not know where his data is stored, so user has little or no control over the location ofdata.
- Because of physical damage of cloud server, loss of encoding key or due to malicious insider, risk of data loss mayarise.
- A customer with ill intent may plant virus of phishing attack in to cloud server which may compromise data of other customers and cloud provider may not be able to track it because of privacy policy of thecompany.
- A gap in security of application interface of cloud services can lead to attacks like bypass attack of APIattack.
- When cloud provider services a number of users, flaw in encryption algorithm can lead to unauthorized access to one'sdata.
- As per regulatory compliance cloud provider has to maintain required securitylevel
- In IaaS security risk may arise due to lack of isolation in virtualization when number of virtual machines are hosted on a single server.
- Mobile user stores and transfers critical personal and corporate information while using mobile applications like online payment, social networking etc, that can be an attacker's newtarget.

SECURITY ISSUES OF MOBILE CLOUD NETWORK

In this section, different types of possible attacks in MCC are considered.

SQL Injection Attack: In this type of attack a malicious code is inserted into a standard SQL code. Thus the attackers get unauthorized access to a database and are able to access sensitive data [14].

Browser Security: Every client uses browser to send the information on network. The browser uses SSL technology to encrypt user's identity and credentials. But hackers from the intermediary host may acquire these credentials by the use of sniffing packages installed on the intermediary host [16].

Cross Site Scripting (XSS): It enables attackers to inject client-side script into Web pages viewed by other users. There are two methods for injecting the malevolent code into the web-page that is displayed to the user. Stored XSS and Reflected XSS. In case of Stored XSS, the malicious code is permanently stored into a resource managed by the web application. However in case of a Reflected XSS, the attack script is not permanently stored; in fact it is immediately reflected back to the user. A cross-site scripting vulnerability may be used by attackers to bypass access controls such as the same origin policy[16].

Denial of Service Attacks: This attack prevents the consumer from receiving the service from the cloud [31].

Cookie Poisoning: Cookie poisoning involves changing or alerting the contents of cookie to have an illegal access to a webpage or an application [20].

Locks In: Locks in is a small tender in the manner of tools, standard data format or procedures, services edge that could embark on data, application and service portability, not leading to facilitate the customer in transferring from one cloud provider to another or transferring the services back to home IT location [21].

Flooding Attacks: In this attack the invader sends the request for resources on the cloud rapidly so that the cloud gets flooded with the ample requests. Cloud has a property to expand on the basis of large amount of request. It will expand in order to fulfill the requests of invader making the resources inaccessible for the normal users [29].

Incomplete Data Deletion: Incomplete data deletion is treated as hazardous one in cloud computing. When data is deleted, it does not remove the replicated data placed on a dedicated backup server. The operating system of that server will not delete data unless it is specifically commanded by network service provider. Precise data deletion is majorly impossible because copies of data are saved in replica [30].

Xml signature element wrapping: As clients are typically able to connect to cloud computing via a web browser or web service, the web service attacks also affect cloud computing. Although Cloud security uses XML signature in order to protect an element's name, attributes and value from unauthorized parties, it is unable to protect the particulars in the document [30]. Comparative views of various technique, frameworks and models proposed by the researchers to provide security and privacy in MCC and their advantage and disadvantage are discussed in Table 1.

Table 1. *Comparisons analysis of various technique proposed by the researcher to solve Security and Privacy Issues in MCC*

Researchers	Approach /Cloud Trust Level	Security Attribute provided	Trusted Third party	Advantages	Disadvantages
J. Oberheide et al. *Virtualized in-cloud security services for mobile devices*[20]	CloudAV/ Fully trusted	Antivirus, Security as a Service	No	Reduced On Device software complexity andpower consumption	Disconnected operationand privacyloss
Zhang et al. *ACM workshop on Cloud computing security* [21]	Cloudlet/ Semi-trusted	Task partitioning	No	Goodtradeoffs between processing overhead and communicationcost	Security of Web-letcanbe Improvedwith othertechniques.

Xiao and Gong et al. *International Conferenceon MobileData Management*[22]	Lightweight algorithm/ Semi trusted	Authorization of user's data in cloud	No	Automatic Dynamic updating of credential information	More processing andenergy burden on mobile device
Wang and Wang et al. *11th International Conference on MobileData Management, MDM* [23]	Top down spatial cloaking/ Distrusted	Privacy preserving framework in location based Scheme	No	Reduced communicationcost by doing spatial cloaking based on the historical datain cloud.	More energy consumption and processing burden on mobile device
Huang et al. *MobiCloud: building securecloud framework for mobile computingand communication*[24]	MobiCloud/ distrusted	Security in Storage as a Service in MANET	Yes	Secured datawhile using PublicCloud	Increased cost due to two cloud providers
G. Portokalidis et al. *Annual Computer Security Application Conference (ACSAC) [25]*	Threat detectionin Samrtphone based on CloudAV/ Fully trusted	Security as a Service	No	Reduced transmission overhead and energyconsumption	More Cloud usage cost.
R. chow et al. *ACM Cloud Computing Security Workshop [26]*	Policy based cloud authentication platform/ Fully trusted	Authentication of users	No	Authentication based on behavioral data of user	Privacy threat
Jia et al. *IEEE Conference on Computer Coomunications Workshops, INFOCOM WKSHPS [27]*	Proxy reencryption (PRE) scheme and Identity based encryption (IDE) scheme/Semi trusted	Secure data Service	No	Reduced cost of updating of access policy and communication cost.	More processing and energy burden on mobile device for encrypting the secret information
Yang et al. *Provable data possession of resource constrained mobile devices in cloud computing [28]*	Extended the public provable data possession scheme/Distrusted	ensures privacy,confidentiality and integrity of user data stored on cloud	Yes	Reduced energy and processing requirement on mobile device	Degradation of performance with the increase in no. of users in Trusted Party Agent (TPA).Cost also increases due to two cloud serviceproviders.

Saman Zonouz et al.*Science Direct journal of Computers and security* [29]	Secloud for smartphones/ Trusted	cloud based comprehensive and lightweight security for smart phones	No	Reduced energy and processing requirement on mobile device for providing security in mobile device	Cloud assumes to be fully trusted which needs to be reconsidered .The personal data of users accessed to the cloud can affect the privacy issues.
Vijay Varadharajan et al.IEEE Transactions On Network and Service Management [30]	Security as a Service	Virtualization technology and VMM security functionalities	No	Offers a baseline security to the provider to protect its own cloud infrastructure	Insider attack from Tenant Domain and Cloud Service Provider
Qiao Yan and F.Richard Yu et al. IEEE Communications Surveys & Tutorials [31]	Software-defined networking (SDN)	Networking-as-a-service (NaaS), control and data planes are decoupled	Yes	software-based traffic analysis, centralized control, global view of the network, dynamic updating of forwarding rules.	Security of SDN itself rebe addressed and mains to potential DDoS vulnerabilities exist across SDN platforms.

Different researchers have come up with different approaches to solve the issues of security and privacy in MCC, but none of the existing approaches offers a concrete solution against these issues. Due to resource limitation, proposed security schemes for the cloud computing environment cannot be directly applicable to the mobile device. There is a need for a lightweight secure framework that provides security with minimum communication and processing overhead.

CONCLUSION AND FUTURE WORKS

Cloud computing is clearly one of the most enticing technology areas of the current times due, at least in part to its cost-efficiency and flexibility. Security and privacy are one of the most challenging issues in MCC. The security threats have become obstacles in the rapid adaptability of the MCC paradigm.

The lack of an in-depth study of the security and privacy in MCC was detected in current available literature. Therefore, this paper has attempted to provide more insight to this field of research by studying and theoretical comparison of different approaches proposed by the researchers to provide security and privacy in MCC.

The limited processing power and memory of a mobile device dependent on inherently unreliable wireless channel for communication and battery for power leaves little scope for a reliable security layer. Thus there is a need for a lightweight secure framework that provides security with minimum communication and processing overhead on mobile devices.

There is a need for a secure communication channel between cloud and the mobile device. The secure routing protocols can be used to protect the communication channel between the mobile device and cloud. We also need to address issues pertaining to data security, network security, data

integrity, authentication, authorization and access control.

To achieve a secure MCC environment, security threats need to be studied and addressed accordingly. In the future, our research work focus on to propose a security model framework to enhance security and privacy in MCC.

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