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Augmenting Mobile Cloud Computing through Enterprise Architecture: A Survey Paper

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Abstract

Cloud computing is a concept that provides services on demand and follows pay-as-you-use approach. Mobile devices that uses cloud computational power and Internet accessibility composed to create a new stream which is called mobile cloud computing and provides services like anytime and anywhere for the enterprise. Enterprise architecture will take care of organizational principles that align the business functional principles with information technology. In this paper, we have looked into the usage of mobility through the power of cloud computing for corporate sector. A critical review and gap analysis between existence models is also provided.

Keywords: *Mobile Cloud Computing, Enterprise, Mobility, Mobile, Cloud Computing*

1. Introduction

The concept of cloud computing is to provide hosted services over the Internet. This concept is divided into three layers analogous to a pyramid of services; and from bottom to top it has Infrastructure as a Service (IaaS), Platform as a Service (PasS) and Software as a Service (SaaS). Each layer offers a particular type of services to a particular segment of the market. The client needs to use browser or client software to use these services via the Internet and pay amount according to usage of the services except the SaaS.

Mobile cloud computing is a way to utilize the prospects of mobile domain coupled with the power of cloud computing; and this combination could support businesses and organizations to improve the customer satisfaction through information technology services. Enterprises that implement Enterprise Architecture (EA) are capable to provide the detailed organizational structure and their operational streams. This helps to define how an organization can most effectively accomplish its ongoing and future aims and objectives. However, enterprises need to provide their employees with mobility which is need of the current market for providing better services to customers and organizations.

Mahmood and Hill [16] describe the EA and their close architectural representation with the cloud services as mentioned below:

- Technical layer uses IaaS and PaaS segments of the cloud. The organization only needs to focus on their EA rather than the infrastructure, size and maintenance of IT resources.
- Application layer uses SaaS segment of the cloud and only organization need to build an application as per consumer demands.
- Data layer uses the PaaS and IaaS segment of the cloud and act like Database as a Service (DaaS) to store their data.
- Business layer of EA uses the Management as a Service which highly useful for Enterprise and address business mission, strategy, governance, business process and business functions.

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There are two perspectives of mobile cloud computing [8] generally known as ad hoc based and infrastructure based. Ad hoc based mobile computing only focuses on a group of mobile devices which altogether works as a cloud of mobile and provide services to each other. Whereas, in the infrastructure based category, all the mobile devices get services from traditional cloud. All the computations are performed in the cloud and results are displayed on resource constrained mobile device. [9] According to ABI report, by the year 2015 more than 240 million business related customers will join and take benefits of cloud on their resources constrained smart mobile devices and this commercial activity will provide billions of dollars revenue to the IT industry.

The rest of the paper is organized as follows: Section II describes an overview of the related work pertaining to the security issues, application architecture, trust models and data security frameworks. Section III deals with evaluation of the literature review with respect to the current state of the affairs in mobile cloud computing. Research gaps in the existing techniques and frameworks are outline in Section IV. Some possible dimensions of future research work are outlined in section V followed by a conclusion.

2. Related Work

Popa *et al.* [1] discuss security risks and privacy of cloud outsourced data and its synchronization over the Internet. The core argument proposed by the authors is to discourage the use of SSL/HTTPS protocols because they are high energy consumers for mobile devices. The identified security risks with respect to mobile client are native mobile app, web app, network and physical based attacks 'theft or loss of device' all possible attacks compromise data and applications. Whereas the possible attacks in the cloud environment include: data privacy, data ownership, data access and integrity. The proposed framework *Secure Mobile Cloud* (SMC) is used to secure transmitted data between components and to ensure the integrity of the mobile application installation and up-gradation. SMC consists of the following five managers or components:

a. *Mobile manager*
b. *Mobile and Cloud Security manager*
c. *Optimization manager*
d. *Application manager*
e. *Policy manager*

That helps to overcome the identified problems. Only one module mobile security manager has been implemented yet in Android OS, as coding for other modules is still in progress.

Critical analysis: It looks a complicated architecture with sole purpose to establish secure data and application. Due to its complexity, it can slow down the performance. It needs writing native code for every vendor like Android OS, iOS, black berry etc. and is hard to change according to the vendors requirements.

Lakshman *et al.* [2] focus on how to increase the enterprise productivity and identity the key challenges and present a framework to over these challenges. The problems identified in the study include: Security and operational and Mobile technology and user interfaces. The proposed framework is based on cloud based mobile application architecture and enterprises services. Enterprise Cloud Service Architecture (ECSA) provides flexible benefits as its thin client written in native mobile app is based on the Cross Platform Application Specification (CPAS) which reside at the enterprise cloud side. The specification provides descriptive representation of mobile client user interface. All the native applications like Android, iOS and Blackberry use cloud specification and renders UI according to the provided specification. The specifications are written in XML to provide uniformity to the client applications. The summarized benefits are:

a. Provide uniform UI
b. Native app based on well-defined specification standards
c. Change in specification can reflect the change in app without re-loading or updating
d. Rapid prototyping for new UI
e. Loosely coupled between UI and enterprise services

Critical analysis: framework provide over the globe customer satisfaction and multiplatform with loosely coupled architecture to incorporate changes easily. On the other hand it is Nonstandard Cross Platform Application Specification.

Muhammad *et al*. [3], mobile cloud computing architecture must provide the reliability, security and validity to system users. The proposed architecture consists of four interconnected layers. A client sends a request to management layer for particular task and management layer works according to the provided configuration. The layers include: *Access layer*, *Management layer*, *Virtual layer*, *Physical layer*.

Possible service level challenges to the mobile devices that are core to mobile cloud computing are listed below:

a. *Network latency*
b. *Various access mechanisms*
c. *Handover latency*
d. *Elastic application model*
e. *Security and privacy*

Some of the challenges that is possible to an enterprise:

a. *Identity Security*
b. *Administrative task*
c. *Auditing and monitoring*
d. *Personal or official data*
e. *Service redundancy and load balancing*
f. *Disaster recovery*

Critical analysis: The authors highlight the issues and define the boundaries between client–mobile user, enterprise and cloud service provider. Whereas the study only describes the layers and their functionality at abstract level beyond any implementation and, hence, needs to be refined for implementation.

Debasish *et al.* [4] proposed certain recommendations for best practices in mobile cloud computing. Enterprises need to redefine their traditional network, security and privacy policies according to new trends like “Bring Your Own Device (BYOD)”. Providing reliable Authentication, Authorization and Accounting (AAA) to mobile cloud is a major challenge for mobile cloud computing. AAA policy provides which users are allowed to access which services and provide tracking which resources they have used. The authors describe possible AAA vulnerable threats and list of control against them.

Possible problems addressed in the study are potential lack of control over data, multi-jurisdiction regulatory requirements, portability and interoperability of authorization or entitlement information. A fishbone analysis on security as well as privacy threats in addition to the top threats list provided by Cloud Security Alliances CSA based on some best practices and analysis proposed in the study

a. *Lost mobile device*
b. *Cross Site Access*
c. *Information Leakage*

Critical analysis: detailed security issues highlighted by the author and proposed best practices in addition to given by cloud security alliances.

Dijiang *et al.* [5], the authors propose a new user-centric model known as Mobile as a Representer (MaaR). According to the service model, a user acts as a virtual system entity whereas mobile device being used by the user is known as physical entity. The proposed

system sends data to virtual system that collected from user's real life behavior, like people, environment and devices, and all the collected information along with their corresponding entities, like email and social networking activities, for analyzing and predicting user's situation by applying data mining and machine learning algorithms. According to the authors, MaaR service model can be used to control the Cyber Physical System (CPS) as feedback, while traditional Internet Cloud allows using for one way operations that used to only submit data from CPS to Cyber Virtual System (CVS). The MaaR uses personal on-demand execution environment (POEM) framework to achieve user-centric service oriented application architecture.

User-centric application scenario is discussed as proof-of-concept. An actor has been created which sends data to CVS while he/she is driving and his/her mobile's on board sensors like GPS, camera and driving speed are used to capture the data. CVS virtualize the representation of the Actor's physical mobile device. And administrative privileges to which data can be shared are assigned to the Actor on virtual representation. This Actor is now capable to share certain information with other Actors such as knowing the current traffic situation in the area where the first Actor is driving. Users of MaaR services can provide the required information to others by using their mobile device and attached sensors.

The core strength of the proposed model lies in suggesting a new service model with well-defined functions and boundaries meticulously explained for future mobile cloud computing. However, the security aspects of the proposed service model are yet to be determined.

Saeid *et al.* [6] proposed a component based framework named Mobile Oriented architecture for Mobile Cloud Computing (MOMCC) based on Service Oriented Architecture (SOA) to portability and interoperability issues. The proposed framework resolves the WAN latency problem by employing a group of mobile device in vicinity that simulates a mobile cloud computing platform. Publishing and discovering services in group of mobile devices raise the issues of security, reliability and service availability and all these issues has been addressed in the framework. In this framework, a service developer, brokers and hosts can get monetized benefits for their public services and the service consumers have to pay in the same fashion as they use traditional cloud computing. The proposed architecture model consists of four modules:

a. *Service Developer*: This layer is responsible for design and development of required specific services for requesters. The developers of the service, either individual or organization.

b. *Service Governor*: This acts as system supervisor that resides on central server to monitor and supervise the system tasks.

c. *Service Host*: It pertains to a device that can be mobile, tablet or handheld device that wish to host deployed or implemented services and execute it for service requester.

d. *Service Requester / Aggregator:* It is a handheld device that acts as service consumer to boost device processing capabilities. Whereas service aggregator request to host possible available service.

A cloud of handheld devices like mobile phones, including smart phones and tablets, in the form of heterogeneous platforms from different hardware and manufacture venders can be created by using proposed SOA based framework. Some of the apparent benefits and advantages of the proposed framework include massive resource availability; enabling unskilled users to host services, providing low cost resources and a step towards green computing. However, the framework also suffers from certain caveats like Hosting mobile device computing limitations, inaccessible in remote areas and absence of offline usability.

Zinwen *et al.* [7] state that elastic applications are especially designed for resource constrained devices like mobile and consumer electronics. The architecture of *elastic* application consist one or more *weblets* that can be launched from mobile or cloud and switch between them according to the provided configuration and the change of

computing environment. The authors analyze systems security and present solution to build secure elastic application. Authors initially propose secure communication between weblets and then secure weblets migration between cloud and mobile. The authors also discuss how to bring about weblet authorization to access users data. Possible security threats identified in the paper are:

a. *Threats to mobile device*
b. *Threats to Cloud Platform and Application Container*
c. *Threats to Communication Channels*

The proposed solution for the identified problems is to create authentication and secure session management.

a. *Secure Installation of Elastic Application*
b. *Building Authentication between weblets*
c. *Secure Migration*
d. *Authorization of weblet*

Possible identified benefits and advantages are virtualization of resources and device flexibility, Consumer Electronic (CE) devices need not to be concerned about device limits while manufacturing, less computation dependability on device when device is low in battery or memory. Possible disadvantages are: unusable to provide benefits in remote areas and no offline usability.

Satish *et al.* [8] the proposed Mobile Web Service Mediation Framework (MWSMF) establish the mobile enterprise using cellular network by using mobile hosts. It describes changes associated with this framework like bottleneck and handling of concurrent users to resolve the associated problem with the help of shifting of framework components to cloud base load balancer. The core of MWSMF is mobile web service which runs on resource constrained devices like mobile phone in the form of Web service provider as mobile hosts and as client in the form of service consumer. Some examples (e-mail, search, translation) and Mobile Host example like providing information about a related person (location, agenda, use of camera and GPS). Moreover, information form mobile host can be integrated to larger information service enterprise for general public domain. To handle increasing number of cloud users, the authors suggest adding horizontal scalability and load balancer to MWSMF. A case study presented in the paper, according to results and findings. It was analyzed that more than 800 concurrent requests create bottleneck for load balancer and adding any other node does not shows desired results. This indicates the need for scaling up system horizontally and cloud environment will help in this regards.

Strength: Mobile Enterprise and associated MWSMF define how to horizontally scale the cloud architecture.

Limitation: The authors did not describe the security aspects of the proposed service model.

Richard *et al.* [9] presents an application named MiLAMob that works as middleware layer between mobile and cloud. According to the author, cloud providers are required from client to submit multi-security credentials whereas mobile device on the client side needs to perform high intensive computations during authentication and authorization process with the cloud. The authors proposed a framework that provides an optimized authentication process and minimizes the HTTP traffic between the mobile and cloud end point. There are four major components of proposed framework:

a. *Mobile Platform*
b. *Social Network Cloud and OAuth 2*.0
c. *Middleware Platform*
d. *IaaS Cloud Platform*

Strength: The proposed framework can ensure credentials security and restrict unauthorized access to cloud resources. It is flexible to change and one can easily

integrate new IaaS server layer for enterprise clouds without changing mobile client application.

Problems: the proposed framework provides central functionality to its clients and the whole enterprise depends on it. It will be critical if system goes down or its security is compromised.

Vladi *et al.* [10] describe the use of mobile application in the field of Small and Medium size Enterprises (SME) and focus on collective business intelligence and identifies several challenges and issues. The use of mobile device as anytime anywhere service in the business sector can increase the business efficiency and reduce the costs. It provides faster and better services to the clients. SME has limited resources and infrastructure in the form of human and computational power, and some possible mobile application scenarios are discussed in this domain.

a. Intelligent advertisement
b. Consumers profiling and loyalty
c. Collective Intelligence
d. Collaborative team work
e. Coordination and synchronization in Mobile Team

The authors discussed an implementation solution of identified services and integration in application.

a. *Events Notification Services*: Notification of events can be done by using pull or push depending on user choice by using publisher and subscriber mechanism.

b. *Synchronization Service*: A key element in teamwork that aim to ensure the same data to one or more locations like the data to be same on different mobile phones or team members.

c. *Notification Service*: It pertains to awareness service. Two types of notifications are possible which include system events notification and warnings.

d. *Contact List and Calendar Synchronization*: The authors point out that the use of Android google calendar and contact synchronization is used for this service. Possible drawback of this implementation is that the users are forced to use Google account only.

Strength: Possible areas are identified in SME where one can use mobile technology for system improvements.

Problems: The authors did not provide details about system implementation and its security aspects.

Byung et al. [11] presented a framework that off load partial portion of computation from resource constrained device to resource rich computation infrastructure. Augmentation is execution engine that host the smart phone's capabilities like image as clone to nearby cloud. Architecture mainly focuses to boost the smart phone application by utilizing heterogeneous computing platform through cloning and computation transformation. The proposed architecture transforms (semi)-automatically single-machine execution into distributed execution. The resource hungry part is transformed to powerful clones and is executed. The clone-able architecture has another benefit such as if mobile phone is lost or destroyed, the clone can be used as a backup. The authors concluded that remote execution work needs to be carefully designed and partition application between remote and local execution. The approach which is presented in the paper is the first to CloneCloud which replicate the whole smart phone image to run the application code in powerful virtual machine. It helps to transform a single machine execution to distributed semi or automated computation.

Benefits: CloneCloud concept provides benefits to resource constrained devices for better application performance.

Problems: Paper does not present any implication guideline, it describe only architecture without security risk identification.

Bhuvan et al. [12] state that mobile technology is very fruitful for enterprises. The authors proposed new taxonomy of mobile application development for enterprises which helps to classify mobile applications into five categories:

a. *Mobile Broadcast (m-broadcast)*
b. *Mobile Information (m-information)*
c. *Mobile Transaction (m-transaction)*
d. *Mobile Operation (m-operation)*
e. *Mobile Collaboration (m-collaboration)*

The authors identify possible challenges to the development and designing of mobile enterprise system are *Device and Platform, User Location, Usage, and Content, Dynamic Communication and Networking.* A six layer Mobile Application and Development Framework (MADF) presented by the authors to address the identified challenges. Proposed framework helps developer to place focus on identified key aspects of application design and development with respect to organization and business model. The Layers comprise communication, information, middleware and binding, application presentation and security layer which lies orthogonally.

a. *Communication*: This layer provides communication services to application and while designing application there should be focus on possible network options.
b. *Information*: Data processed by mobile application should be secured and stored at location where it can be reused.
c. *Middleware and Binding*: This layer provides application and service binding.
d. *Application*: Enterprise business rules are implemented in this application layer.
e. *Presentation*: How to present data on different type of devices. Designer should consider suability, user profile and privacy requirements.
f. *Security*: Information security, integrity and availability are main concern of mobile enterprise application. During application design, possible vulnerabilities should be identified and controlled with adequate level of securities.

Critical Analysis: The proposed framework is well-defined and provides guidelines to build enterprise mobile application. Developers only need to place focus on key layers according to organization and business model. Whereas focused only mobile application development, cloud implementation data security level is missing.

Dijiang *et al.* [13] propose a framework named MobiCloud that uses mobile device as service node to enhance communication by addressing trust management, service routing and risk management issues. The objective of this research is to investigate technologies like cloud computing and mobile *ad hoc* network (MANET) to understand the capacity of cloud computing for securing MANET applications.

The authors identify that the main challenging research issues in mobile computing are to establish the form of building a trustworthy MANET communication system. Possible issues include: i) lack of inter-operability and security issues in a heterogeneous commutation environment existing MANET infrastructure; ii) there is a significant impact of MANET mobility on the security and communication performance relating to location tracking, communication privacy, reliability and survivability.

MobiCloud is a communication framework for MNAET and helps secure its technology. The proposed framework provides service oriented communication in which each mobile node act as Service Node (SN) and each SN can be a service provider and service broker depending on its capability. Each SN incorporated as virtualized node which mirrored to one or more Extended Semi Shadow Images (ESSI) in the cloud to address the communication and computational issues of the mobile device. Each ESSI can be extended clone of device, partial clone and an image containing extended function of the device. It also creates MANET virtual communication and routing that used to assist

physical mobile devices. Possible identified benefits and advantages are that it provide well define framework that help *ad hoc* network of mobile devices. It provides security, data isolation. Possible disadvantages in the form real-time performance which has been identified in the paper.

Wonjae *et al.* [14] identify some basic requirements of Mobile Cloud and proposed a framework named Web Application Framework for Mobile Cloud (WAFMC). The proposed framework is used to customize mobile cloud services and it also supports customization for user groups, the Ajax (Asynchronous JavaScript and XML) application model and scalability. According to the authors, the main requirements are:

a. *Customization*.
b. *Ajax Application Model*.
c. *Scalability*.

The proposed framework WAFMC implements mobile web client for cloud services using customization for user groups, Ajax application model and scalability. Architectural level which is presented in the paper shows that a client like a web browser – mobile user send request to web application server which is responsible to executes user interface code, business logic and may access database depending on request. A software data server layer is added which is responsible to manage namespaces – customization and search data from namespaces depending on user request. This kind of architecture provides scalability and availability of the system by adding multiple servers at cloud level and dynamic execution of user interface enable runtime customization of interface without restarting the server. Namespaces as described to provide inheritance, polymorphism which used to implement for customization of user groups in generally it provide reuse of the components. Requests which received from clients are mapped according to namespaces. It provides loosely coupling architecture which enables us to change backend files without restarting servers and also support scalability by adding new server at cloud level. Possible limitation is that paper does not provide any security discussion and extra communication overhead.

Ashwin *et al.* [15] discussed challenges and increasing complexity of development in mobile and cloud domains and provided a platform named Cloud Mobile Hybrid (CMH) application by adopting methodology of Domain Specific Language (DSL). A numbers of mobile venders like Android, iOS and blackberry provide development environment of native application development, and similarly in the cloud domain, Google App Engine and Amazon EC2 provide different ways to development and application integration. Possible difficulties highlighted in this paper are:

a. Different cloud service providers offer different paradigms, programming environment and persistence storage.
b. Each mobile vender provides its own set of Application Programming Interfaces (APIs) and programming guidelines.
c. Development of communication channel between cloud and mobile platforms. The communication service points like RPC and web service etc. have to manage versions and have to maintain at the level of the least capable client.

Addressing the heterogeneity at both ends increase the efforts required in all stages of software development lifecycle, which ultimately increase the cost. It is also difficult to manage number of single application versions that are designed for different mobile venders and for different cloud service providers. The proposed DSL for Hybrid applications typically provides operations like Create, Retrieve, Update and Delete (knows as CRUD operations) that uses multiple data structures in data centric back-end and uses mobile or web based front end to manipulate these data. This kind of application generally implement design pattern named Model View Controller (MVC). It is a well-defined approach to create domain independent applications, which definitely reduce the cost of project and help to build and manage the projects easily. However, the paper does

not provide implementation details about cloud as a whole application using MVC model. Security issues are not discussed.

References [17-48] reviewed different techniques in different domains and reported their critical evaluations along with a workable framework where necessary.

3. Critical Evaluation

Mobile Cloud Computing (MCC) and ad hoc network of mobile devices are areas that are highlighted in the contemporary literature to facilitate the enterprise and individuals. Security aspects are main issues and require more elaboration. Communication channels between mobile to mobile and mobile to cloud are discussed accordingly. Concepts of domain specific languages are introduced to overcome problem of mixture of development. Non-industry standard specification is hard to follow which require extra layer to hide the complexity and provide ease to developers and designers. Different applications and domains are identified where MCC can facilitate and provide monetized benefits and services to clients and employees. In this section we provide a critical evaluation of the different approaches discussed in the previous section in tabulated form.

Table 1: Critical Analysis of Security Models for Mobile Cloud Computing.

Ref	Framework	Strengths	Weaknesses	Suggestive Improvements
[1]	Secure Mobile Cloud (SMC)	Clearly identified application security, deployment and implementation problems	Complex Architecture which slow down performance of device. Vender dependent implementation	Application level security could be imposed at component and communication level
[2]	Enterprise Cloud Service Architecture (ECSA)	Multiplatform support over the globe loosely coupled architecture to incorporate changes easily	Nonstandard cross platform application specification Hard to follow by the industry unlike standard HTML or other specifications	WYSIWYG editor tool should be added on top of it to design application and hide complexities of non-standard platform script
[3]	Architecture of Mobile Cloud Computing for Enterprise	Highlight the issues and define the boundaries between client–mobile user, enterprise and cloud service provider	The study only describes the layers and their functionality at abstract level beyond any implementation	Implementation of layers and the communication protocol between layers should be discussed
[4]	Proposed certain recommendations for best practices in mobile cloud computing and Enterprises need to redefine their policies accordingly	Detailed security issues highlighted by the authors and proposed best practices in addition to given by cloud security alliances	Security issues that are associated to mobile and cloud communication are not disused.	Cloud related security and possible threats are not addressed
[5]	User-Centric Mobile Cloud Computing (MCC)	A new service model with well-defined functions and boundaries are explained for future mobile cloud computing	Paper did not describe the security aspects of the proposed service model	Security and basic implementation should be highlighted and can be a future work on this paper
[6]	Market Oriented architecture for Mobile Cloud Computing (MOMCC)	Framework provides massive resource availability; enabling unskilled users to host services, providing low cost resources and a step towards green computing	Framework also suffers from certain caveats like Hosting mobile device computing limitations, inaccessible in remote areas and absence of offline usability	SOAP type services require heavy computation whereas light weight REST type of services should suggested in this regard
[7]	Authentication and Secure session management of Elastic Application in Mobile Cloud Computing	Virtualization of resources and device flexibility Consumer Electronic (CE) devices need not to be concerned about device limits while manufacturing Less computation dependability on device when device is low in	Unusable to provide benefits in remote areas and no offline usability	Group of mobile devices nearby should be addressed for computation as a mix mode if cloud services are not reachable

		battery or memory		
[8]	Mobile Web Service Mediation Framework (MWSMF)	Mobile Enterprise and associated MWSMF define how and when to horizontally scale the cloud architecture	The authors did not describe the security aspects of the proposed service model	Secure services for communication should be properly defined and light weight REST type of services should be incorporated
[9]	A middleware layer Application MiLAMob between mobile and cloud for authentication process	Architecture can ensure credentials security and restrict unauthorized access to cloud resources It is flexible to change and one can easily integrate new IaaS server layer for enterprise clouds without changing mobile client application	Architecture provides central functionality to its clients and the whole enterprise depends on it. It will be critical if system goes down or its security is compromised	Backup strategy should discuss so that smooth service ensured to clients.
[10]	Presented challenges and issues Small and Medium Enterprises (SME) while using mobile application	Possible areas are identified in SME where one can use mobile technology for system improvements	Paper did not provide details about system implementation and its security aspects	
[11]	Framework that off load partial portion of computation from resource constrained device to resource rich computation infrastructure - CloneCloud	CloneCloud concept provides benefits to resource constrained devices for better application performance	Paper does not present any implication guideline It describe only architecture without security risk identification	Cloned object of device must be secured.
[12]	Enterprise Mobile Application and Development Framework (MADF)	The proposed framework is well-defined and provides guidelines to build enterprise mobile application Developers only need to place focus on key layers according to organization and business model	Focused only mobile application development Cloud implementation data security level is missing	Communication between layers should be highlighted and enterprise cloud domain should defined accordingly
[13]	MobiCloud	It provide well define framework that help *ad hoc* network of mobile devices It provides security, data isolation	Possible disadvantages in the form real-time performance which has been identified in the paper	
[14]	Web Application Framework for Mobile Cloud (WAFMC)	It provides loosely coupling architecture which enables us to change backend files without restarting servers Support scalability by adding new server at cloud level	It does not provide any security discussion Extra communication overhead between two backend servers	By adding backup or secondary server, we can achieve identified problems.
[15]	Mobile Hybrid (CMH) application by adopting methodology of Domain Specific Language (DSL)	It is a well-defined approach to create domain independent applications Reduce the cost of project and help to build and manage the projects easily	The paper does not provide implementation details about cloud as a whole application using MVC model. Security issues are not discussed	WYSIWYG editor tool should be added on top of it to design application and hide complexities of non-standard platform script

4. Future Work

Based on the systematic literature review conducted for this study, the following have been identified as the possible future work areas in the security domain for cloud computing:

a. Security domain: It is much needed to secure end-to-end communication from mobile devices to the cloud. Mobile device itself poses a threat to enterprise services due to its high vulnerability in case of its intentional or unintentional loss as well as malfunctioning due to certain glitch. Therefore, it is a challenging job for application designer to secure mobile applications as well as the attached devices to avoid loss of data as well as the revenue. Data and information of enterprise on cloud needs to be secured so that only authorized users of the enterprise can access the data without delay of services. Public communication channels are the main source of communication between mobile device and the cloud which need to be amicably addressed from security point of view.

b. The concept of write once and run everywhere needs to be addressed specifically. A number of different flavors of application development environments are available which create extra load on the developer and employer. In this view, the technique of vibrant scripts that support write once and run everywhere concept approach needs to be adopted. A possible future work in this connection is to explore new avenues that help improve design methodology for write once and run everywhere scripts which meet the industry standards.

c. Possible benefits and use of ad hoc cloud for mobile devices and mobile to cloud communication are further needed to be explored to promote this technology.

5. Second and Following Pages

Mobile Cloud Computing is an emerging concept in general which uses cloud provided services over the mobile device. Today we are using cloud ready devices and cloud services in our daily life. Enterprises are adopting MCC technology for promoting their businesses and are getting several benefits from it. It provides boundaries independent environment to employees and customers. It also changes our habits and work patterns. Besides this, it also raises different kind of issues for different stakeholders of the enterprise that need to be addressed. Possible security threats to mobile device, security issues of cloud computing, services and data, security issues in communication channels have been studied in this research work.

Different forms of mobile computing have been identified during the literature survey. The core emphasis of most of the contemporary work is on discovering ways to offload heavy or normal computation from resource constrained devices to the targeted platform, which could be mobile device itself or the cloud.

The development of mobile application for cloud is a challenging job for developers. Each cloud and mobile vender is providing its own development environment which eventually create extra load on the developers and also require putting in additional efforts to manage different builds for different versions and platforms. Based on the different methodologies explored during this study, it has been observed that it would be more appropriate for developers and enterprises to use industry standard technology like HTML5 for future application development.

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