



Application Processing Approach for Smart Mobile Devices in Mobile Cloud Computing

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Abstract— Mobile Cloud Computing (MCC) is a combination of Cloud computing and mobile networks. It is a technique or model in which mobile applications are built, powered and hosted using cloud computing technology. Users expect to run computational intensive applications on Smart Mobile Devices (SMDs) in the same way as powerful primary or mainframe computers. However, SMDs are still low potential computing devices, which are constrained by CPU potentials, memory capacity and battery life time. MCC provides practical solution to reduce this incapacitation by extending the services and resources of computational clouds to SMDs on demand basis. The current offloading algorithms offload computational intensive applications to remote servers by employing different cloud models. A challenging aspect of such algorithms is the establishment of distributed application processing platform at runtime which requires additional computing resources on SMDs. This paper describes Distributed Application Processing Approach for SMDs in MCC Environment. The purpose of this paper is to highlight issues and challenges to the existing algorithms in developing, implementing and executing computational intensive mobile applications within MCC environment. It proposes taxonomy of current Application Processing Approaches, reviews current offloading frameworks by using thematic taxonomy and analyzes the implications and critical aspects of current offloading frameworks.

Keywords— Mobile Cloud Computing, Application Processing Approach, Application Offloading, Elastic Applications.

I. INTRODUCTION

Mobile cloud computing (MCC) is a technique or model, in which mobile applications are built, powered and hosted using cloud computing technology. MCC is used to bring benefits for mobile users, network operators, as well as cloud providers. Compact design, high quality graphics, customized user applications support and multimodal connectivity features have made SMDs a special choice of interest for mobile users. SMDs incorporate the computing potentials of PDAs and voice communication capabilities of ordinary mobile devices by providing support for customized user applications and multimodal connectivity for accessing both cellular and data networks. SMDs are the dominant future computing devices with high user expectations for accessing computational intensive applications analogous to powerful stationary computing machines. Examples of such applications include natural language translators [1]-[2], speech recognizers [1]-[3], optical character recognizers, image processors [4]-[5], online games, video processing [6] and wearable devices for patients such as wearable device with a head-up display in the form of eyeglasses (a camera for scene capture and earphones) is a useful application that helps Alzheimer patients in everyday life [7]. Such applications necessitate higher computing power, memory, and battery lifetime on resource constrained SMDs [8]. On the other hand, SMDs are still low potential computing devices having limitations in memory, CPU and battery power. In spite of all the advancements in recent years, SMDs are constrained by weight, size, and intrinsic limitations in wireless medium and mobility.

A key area of mobile computing research focuses on the application layer research for creating new software level solutions. Application offloading is an application layer solution for alleviating resources limitations in SMDs. Successful practices of cloud computing for stationary machines are the motivating factors for leveraging cloud resources and services for SMDs. Cloud computing employs different services provision models for the provision of cloud resources and services to SMDs; such as Software as a Service, Infrastructure as a Service, and Platform as a Service. Several online file storage services are available on cloud server for augmenting storage potentials of client devices; such as Amazon S3, Google Docs, MobileMe, and DropBox. In the same way, Amazon provides cloud computing services in the form of Elastic Cloud Compute. The cloud revolution augments the computing potentials of client devices; such as desktops, laptops, PDAs and smart phones. The aim of MCC is to alleviate resources limitations of SMDs by leveraging computing resources and services of cloud datacenters. MCC is deployed in diverse manners to achieve the aforementioned objective. MCC employs process offloading techniques [9] for augmenting application processing potentials of SMDs. In application offloading intensive applications are offloaded to remote server nodes. Current offloading procedures employ diverse strategies for the deployment of runtime distributed application processing

platform on SMDs. This paper is organized as follows: Section II describes the overview for Cloud Computing and Mobile Cloud Computing and its needs as well Smart Mobile Devices augmentation through Computational cloud. Section III consider Application Processing Approaches for Smart Mobile Devices. Section IV includes various Challenges and issues for Distributed Application Deployment. At last, section V conclude the paper and provides future directions.

II. OVERVIEW

The term “Mobile Cloud Computing” was introduced no longer after the introduction of “Cloud Computing”. It has been a major attraction as it offers reduced development and running cost. This section provides an introduction and definition of Cloud Computing and Mobile Computing and its architecture.

A. Cloud Computing

Your Computing is virtualized compute power and storage delivered via platform-agnostic infrastructures of abstracted hardware and software accessed over the Internet. These shared, on-demand IT resources, are created and disposed of efficiently, are dynamically scalable through a variety of programmatic interfaces and are billed variably based on measurable usage. In Cloud computing, services can be used from assorted and pervasive resources, rather than remote servers or local machines. Generally it consists of a bunch of distributed servers known as masters, providing demanded services and resources to different clients known as clients in a network with scalability and reliability of datacenter. The distributed computers provide on-demand services. Cloud Computing provides its extensive shareable resources on utility or meteoroid based structure. Cloud computing is a style of computing where extremely scalable IT-related capabilities are provided “as a service” across the internet to numerous external customers [10]. This term effectively reflects the different facets of the Cloud Computing paradigm which can be found at different infrastructure levels. Fig. 1 represents Cloud Service Models based on value visibility to End users, namely IaaS (Infrastructure as a Service), PaaS (Platform as a Service) and SaaS (Software as a Service).

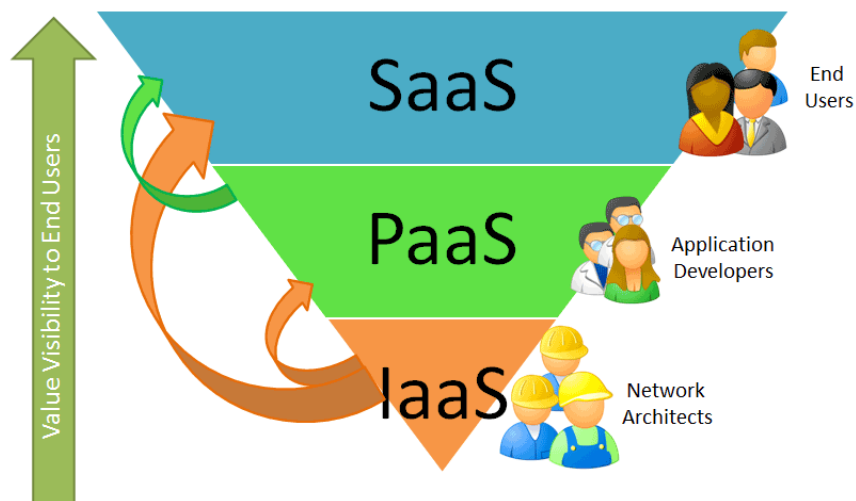


Fig 1. Cloud Computing Service Model

B. Mobile Cloud Computing

The term “Mobile Cloud Computing” was introduced no longer after the introduction of “Cloud Computing”. It has been a major attraction as it offers reduced development and running cost. Definitions of Mobile Cloud Computing can be classified into two classes; first one refers to carrying out data storages and processing outside the mobile device i.e on cloud [11]. Here mobile devices simply acts as a terminal, only intended to provide an easy convenient way of accessing service in cloud. The benefit of this is that the main obstacle of mobile low storage and processing power are avoided and level of security is provided via acute security applications.

The second definition refers to computing where data storage and computing are carried out on mobile device. Using mobile hardware for cloud computing has advantages over using traditional hardware. These advantages include computational access to multimedia and sensor data without the need for large network transfers, more efficient access to data stored on other mobile devices, and distributed ownership and maintenance of hardware. Using these definition one can clarify the differences between mobile computing and cloud computing. Cloud computing aims at providing service without the knowledge of end user of where these services are hosted or how they are delivered. Whereas Mobile computing aims to provide mobility so, that users can access resources through wireless technology from anywhere.

Mobile cloud computing is the latest practical computing paradigm that extends utility computing vision of computational clouds to resources constrained SMDs. Aepona [12] defines MCC as a new distributed computing paradigm for mobile applications whereby the storage and the data processing are migrated from the SMD to resources rich and powerful centralized computing data centers in computational clouds. The centralized applications, services and resources are accessed over the wireless network technologies based on web browser on the SMDs. Successful practices

of accessing computational clouds on demand for stationary computers motivate for leveraging cloud services and resources for SMDs. MCC has been attracting the attentions of businesspersons as a profitable business option that reduces the development and execution cost of mobile applications and mobile users are enabled to acquire new technology conveniently on demand basis. MCC enables to achieve rich experience of a variety of cloud services for SMD at low cost on the move. [13]- [14]. MCC prolongs diverse services models of computational clouds for mitigating computing resources (battery, CPU, memory) limitations in SMDs. The objective of MCC is to augment computing potentials of SMDs by employing resources and services of computational clouds. MCC focuses on alleviating resources limitations in SMDs by employing different augmentation strategies; such as screen augmentation, energy augmentation, storage augmentation and application processing augmentation of SMD. In [15], we study mobile augmentation techniques and devise a taxonomy including three main approaches, namely high-end resource production, native resource conservation, and resource requirement reduction. We analyze a number of approaches and argue that MCC lessens need to high-end hardware, reduces ownership and maintenance cost, and alleviates data safety and user privacy.

MCC utilizes cloud storage services for providing online storage and cloud processing services for augmenting processing capabilities of SMDs. Processing capabilities of SMDs are augmented by outsourcing computational intensive components of the mobile applications to cloud datacenters. The following section discusses the concept of augmenting smartphones through computational clouds.

C. Augmenting Smartphones through Computational Clouds

MCC implements a number of augmentation procedures for leveraging resources and services of cloud datacenters. Examples of the augmentations strategies include; screen augmentation, energy augmentation, storage augmentation and application processing augmentation of SMD [15]. In MCC, two categories of the cloud services are of special interest to research community; cloud contents and computing power. Cloud contents are provided in the form of centralized storage centers or sharing online contents such as live video streams from other mobile devices. A number of online file storage services are available on cloud server which augments the storage potentials by providing off-device storage services. Examples of the cloud storage services include Amazon S3 and DropBox. Mobile users outsource data storage by maintaining data storage on cloud server nodes. However, ensuring the consistency of data on the cloud server nodes and mobile devices is still a challenging research perspective.

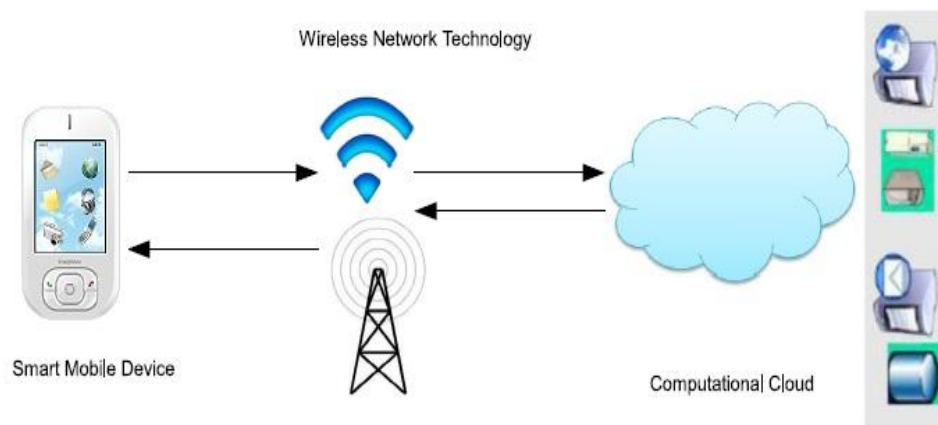


Fig 2. Mobile Cloud Computing Model

SmartBox [16] is an online file storage and management model which provides a constructive approach for online cloud based storage and access management system. Similarly, the computing power of the cloud datacenters is utilized by outsourcing computational load to cloud server nodes. The mechanism of outsourcing computational task to remote server is called process offloading or cyber foraging. Smart mobile devices implement process offloading to utilize the computing power of the cloud. The term cyber foraging is introduced by Satyanarayanan [17] to augment the computing potentials of wireless mobile devices by exploiting available stationary computers in the local environment. The mechanism of outsourcing computational load to remote surrogates in the close proximity is called cyber foraging [18]. Researchers extend process offloading algorithms for Pervasive Computing [19], Grid Computing [20] and Cluster Computing [21]. In recent years, a number of cloud server based application offloading frameworks are introduced for outsourcing computational intensive components of the mobile applications partially or entirely to cloud datacenters. Mobile applications which are attributed with the features of runtime partitioning are called elastic mobile applications. Elastic applications are partitioned at runtime for the establishment of distributed processing platform.

III. APPLICATION PROCESSING APPROACH FOR SMART MOBILE DEVICES

The current approaches for SMDs employ a number of strategies for the establishment of runtime distributed application execution platform. This section provides thematic taxonomy for current approaches and reviews the traditional approaches on the basis of framework nature attributes of the taxonomy. Further, it investigates the advantages and critical aspects of current approaches for SMDs.

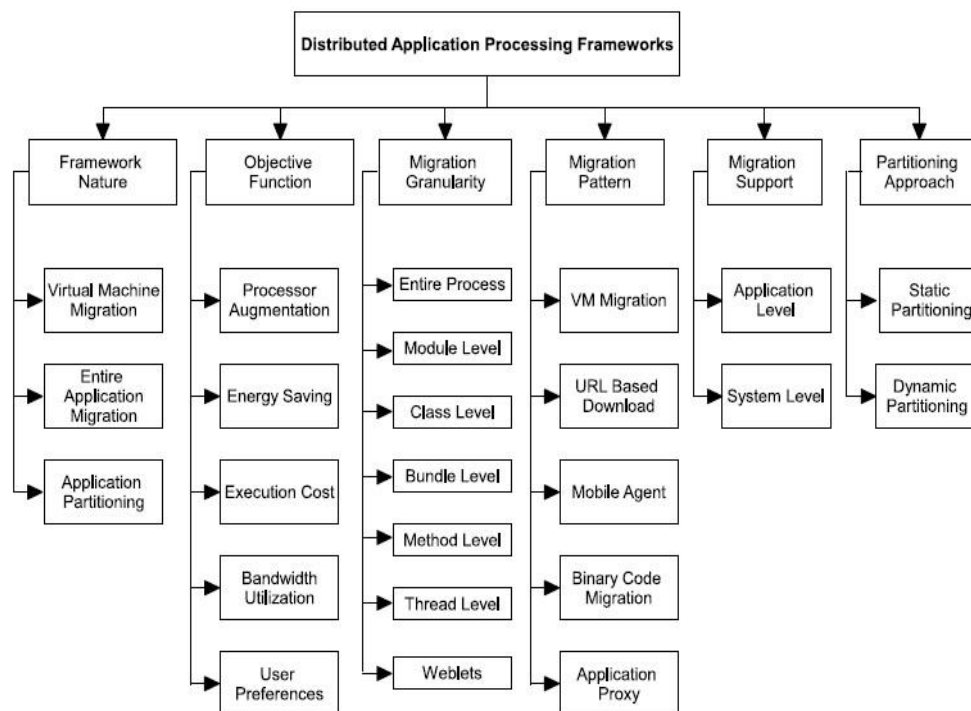


Fig 3. Application Processing Framework

A classification of application offloading frameworks by using their attributes is shown in Fig. 3. This section analyzes current application offloading frameworks and investigates the implications and critical aspects of current approaches.

1. VM Migration Based Application Offloading: In [18] cyber foraging framework is employed to utilize computation resources of computing devices (stationary or mobile) in close proximity of SMD. The framework implements client/server architecture. Mobile devices request for process offloading and surrogate server provides the services on demand. The framework supports configuration of multiple surrogate servers simultaneously and employs virtual machine technology for remote application processing. A single surrogate server is capable to run a configurable number of independent virtual servers with isolation, elasticity, resource control and simple cleanup mechanism. Each offloaded application executes on isolated virtual server. The framework ensures secure communication by deploying cryptographic measures for communication between SMD and surrogate server. The framework includes the benefits of low latency, local accessibility of remote surrogates and fewer concerns of security and privacy. The critical aspects of such approach is the deployment of template based virtualization approach which is a highly time consuming and resources starving mechanism for VM deployment [22]. The framework requires the annotation of individual components of the application as local or remote which is an additional effort for application developers. Further, surrogate based cyber foraging is restricted to the availability of services and resources on local servers.

VM based cloudlets framework [7] differs from cyber foraging [18] by migrating image of the running application to the explicitly designated remote server. A cloudlet is a trusted resource rich computer or cluster of computers that is connected to internet and is accessible for SMDs. Mobile device serve as a thin client providing only user interface whereas actual application processing is performed on the cloudlet in distributed environment. The proposed framework is based upon transient customization of cloudlet infrastructure using hardware VM technology in which VM encapsulates and detaches the temporary guest software environment from the cloudlet infrastructures permanent host software environment. The framework employs variant procedures for VM migration. The critical aspects are that the framework requires additional hardware level support for the implementation of VM technology and is based on cloning mobile device application processing environment to remote host which involves the issues of VM deployment and management on SMD, privacy and access control in migrating the entire execution environment and security threats in the transmission of VM.

Clone cloud based framework [6] is a significant approach for offloading application of diverse nature in different manners. Clone cloud differs from other approaches [7], [18] by employing three different offloading algorithms for different types of applications. However, the attribute of offloading image of the running states of the application to remote server resembles to the VM based Cloudlet [7] approach. The framework reduces the dynamic transmission overhead of application code by deploying a simple approach for synchronization. Clone cloud employs Primary functionality outsourcing by offloading computational intensive tasks to remote host whereas simple tasks such as user interfaces are executed on mobile devices. Examples of the applications include speech recognition, image processing and video indexing. Background augmentation is implemented for applications demanding no user interaction. Background augmentation offloads the entire application to remote host and communicates results from background process to the mobile device. Examples of the applications include; antivirus and file indexing for faster search. Mainline

augmentation policy is deployed for applications having mixed nature; having some computational intensive computational load and need to interact with other parts of the applications such as debugging applications. Clone cloud [6] is a significant framework for offloaded processing which includes a simple approach for synchronization between SMD and remote server. The critical aspect of the Clone cloud is the migration of execution environment to remote server which involves the issues of security, privacy, access control, VM deployment and management on SMD. The deployment of variant strategies for application migration on the basis of application nature results in enlarged overhead on mobile devices. Clone cloud deploys a single thread approach which increases jitter in the execution time of the application components.

The elastic CloneCloud [23] extends the concept of local Clone cloud [6] to remote cloud datacenters. The framework is based on partitioning of the application on thread basis. Partitioning and integration of the application occurs at application level. The running states of the outsourcing components of the mobile application are encapsulated in VM instance and VM migration is employed for partition migration to cloud node. The framework is implemented at application level and centralized monitoring mechanism is used for the establishment and management of distributed application execution platform. CloneCloud [23] is a productive approach for extending the concept of VM based offloading from local distributed platform to centralized cloud servers. Offload processing is monitored through a centralized mechanism. The framework reflects on execution time and energy consumption at mobile device for cost metrics. CloneCloud implements a complicated architecture on SMD for the establishment and management of distributed platform. The framework is based on VM instance migration to the cloud node which involves the concerns of secure communication of running application states encapsulated in VM and privacy and access on remote server node. A major limitation of the architecture is that a single thread is migrated to the cloud at a time which reduces concurrency of the execution of application components. Virtualized execution environment for mobile applications [24] is a VM migration based framework for application offloading. The framework utilizes application level process migration and employs android platform for distributed application deployment. A running application is encapsulated in VM on SMD and VM is migrated to remote cloud computing environment. Cloud server creates fresh VM instance, and the offloaded application VM is cloned into the newly created VM instance on server. A synchronization mechanism is provided between SMD and cloud server. A middleware is placed between mobile device OS and hardware to support runtime workload migration and to better utilize the heterogeneous resources of mobile device and cloud servers. The framework deploys pause and resume scheme of the android platform for state transfer. The framework employs application level process migration strategy for offload processing and employs hardware base trusted platform module. The framework provides mechanism for storing encryption keys and performs cryptographic operations on sensitive data. The critical aspects are that the framework requires heavy and traffic intensive synchronization mechanism for ensuring consistency between SMD and cloud server. The framework entails a separate program called agent to be installed on SMD and cloud server which results in additional overhead on mobile device.

2. Application Partitioning Based Application Offloading: Partitioning of the mobile application at runtime is a prominent approach for outsourcing the intensive components of mobile applications. Elastic mobile applications are capable to be partitioned at runtime for coping with the resources constraint on SMD. Elastic applications are partitioned either statically or dynamically at runtime. The following section classifies and reviews existing approaches on the basis of static or dynamic *offloading*.

Static Partitioning Based Application Offloading: In static application partitioning the application is partitioned in fixed number of partitions either at compile time or runtime. The computational intensive partitions of the applications are outsourced to remote servers for offload processing. Current approaches deploy a number of approaches for making the decision of partitions outsourcing. In the primary functionality offloading [7]; application is statically partitioned in two major partitions. Such applications involve two types of processing; user interface required on mobile device; and computational intensive parts of the application are offloaded to remote surrogates or cloud servers. In MISCO [25] the application is statically partitioned into two types of functions; map and reduce. Map function is applied on the set of input data and produces intermediary $\langle \text{key}, \text{value} \rangle$ pairs; such pairs are grouped into a number of partitions. All pairs in the same partition are passed to a reduce function which produces the final results. Application developers are responsible for implementing the map and reduce functions and the system handles all the remaining mechanism. The worker nodes process map and reduce functions and results are returned to master server.

The implications of elastic application model are that the framework accomplishes application level partitioning and migration of applications. The framework employs a comprehensive cost model to dynamically adjust execution configurations and optimizes application performance in terms of a set of objectives and user preferences. The framework provides a security mechanism for the authentication and authorization of weblets migration and reintegration and provides support for synchronization between application on mobile device and weblets running on cloud node. The critical aspect is the establishment of runtime distributed platform for SMD which necessitates additional computing resources exploitation for the establishment and management of distribute platform. The framework deploys replication of the application both on the mobile device and application manager of the cloud server. The framework implements a sophisticated mechanism for the migration of weblets between SMD and remote cloud nodes. The framework imposes extensive overhead of application profiling, dynamic runtime partitioning, migration, reintegration, and rigorous synchronization on mobile devices for offload processing. Fig. 4 shows a generic flowchart for application partitioning based offloading frameworks. The profiling mechanism evaluates computing resources requirements of mobile application and the availability of resources on SMD.

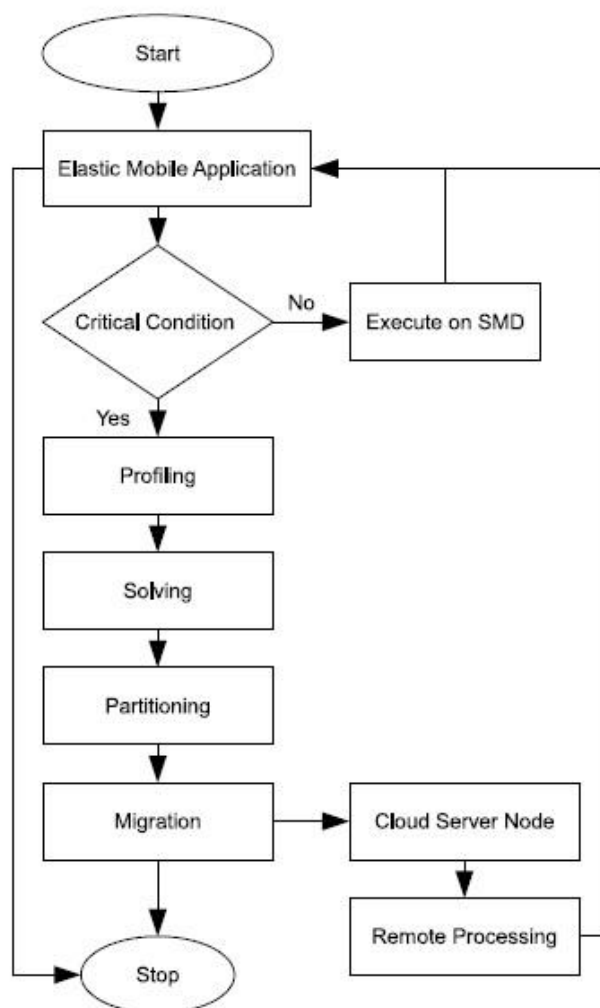


Fig 4. Partitioning Migration based Application Processing Approach

Profiling mechanism works differently in different frameworks. The critical situation indicates the unavailability of sufficient computing resources on SMD. Therefore, the computational intensive components of the application are separated at runtime. SMD negotiate with cloud servers for the selection of appropriate server node. At that moment partitions of the application are migrated to remote server node for remote processing. Upon successful execution of the remote components of the application, result is returned to main application running on SMD.

IV. CHALLENGES AND ISSUES FOR DISTRIBUTED APPLICATION DEPLOYMENT

Issues indicate the unsolved problems in current approaches whereas challenges indicate the issues of research in distributed application processing for MCC that remain to be addressed. This section describes issues in current offloading frameworks and identifies challenges to the cloud based application processing of resources intensive mobile applications.

A. Distributed Application Deployment

In current approaches, resources intensive distributed platform is established at runtime. Mobile applications offloading frameworks are developed on the basis of standalone application architecture, whereas the processing of application is performed in the distributed fashion. As a result, current approaches establish a resources intensive and complex computing environment at runtime. Application offloading techniques are primarily based on either entire application/job migration or application partition migration to remote servers. The implementation of distributed architecture for virtual mobile cloud is hindered by the following obstructs. a) Local distributed processing models lack in the availability of centralized management; for that reason it is difficult to configure explicitly defined client and server components for the mobile applications. b) Virtual clouds necessitate special requirements for the establishment of distributed platform which is challenging to maintain for mobile devices which are participating in adhoc cloud. The special requirements include; SMDs remain in the close proximity, follow the same movement patterns, voluntariness for service and provision, implementation of specific service architecture. SMDs in the virtual cloud exploit additional computing resources for the configuration of distributed platform and management of distributed services provision to the requesting client devices. Further, shorter battery life time of SMDs is major challenge in virtual/adhoc distributed application processing models. Therefore, the ad-hoc and virtualized nature of local distributed platform is another

obstacle in explicitly defining client and server components of the mobile application. However, the availability of centralized resources and services and centralized management mechanism in cloud datacenters are the motivating factors for incorporating distributed architecture for the intensive mobile applications. The implementation of client/server model can be a potential alternative for the traditional standalone intensive mobile applications for mobile cloud computing. On the other hand, traditional client/server model has the limitations of reliability of client application on server application. Applications are configured in such a manner so that client applications remain dependent on the server application. Whereas, the wireless access medium is the main inhibiting factor for implementing highly dependent client/server model for intensive mobile applications in MCC. Hence, it is challenging for distributed mobile application to incorporate the principles of distributed applications in such a manner so that mobile applications can operate in the situations of inaccessibility of cloud server nodes.

B. Seamless Connectivity and Consistent Distributed Platform

Mobility is an important attribute of SMDs. Mobile users enjoy the freedom of computing and communication on move. However, a number of obstacles hinder the goals of seamless connectivity and consistency in the distributed platform of mobile applications; for example handoffs, traveling with high speed, diverse geographical locations and different environmental conditions. As a result, providing seamless connectivity and uninterrupted access to the centralized cloud datacenters in distributed application processing is a serious research issue for MCC. It is important that distributed application model provide versatile access to cloud resources and services on move with ubiquitous attributes and high degree of transparency. However, it is challenging to ensure the transparency of distributed environment. In particular to SMD, the issues and limitations in wireless medium hinder the transparency goals of distributed processing of mobile application. The seamless and transparent deployment of distributed platform for computational intensive applications is a challenging aspect for mobile cloud computing. It is mandatory for distributed model to mask the complexities of distributed environment from mobile user and give the notion as the entire application is being processed locally on SMD. Similarly, it is important to ensure successful execution of remote processing and returning results to SMD. Sustaining consistency of the offloaded components of the application with lightweight implementation procedures is a challenging aspect of existing approaches. Consistency is an issue for the components offloaded at runtime, the replicated applications using proxies [26], and transactions involving related updates to different objects. It is important that the distribution and replication of intensive mobile applications and data should be transparent to the mobile users and application running client device. Cloud based distributed processing of mobile application are required to fulfill Atomic, Concurrency, Isolation and Durability (ACID) properties of the distributed systems. It is challenging to provide location transparency, replica transparency, concurrency transparency, and failure transparency in cloud based application processing of mobile applications.

C. Homogenous and Optimal Distributed Platform

Homogenous and optimal cloud based application processing is an important research perspective in mobile cloud computing. Heterogeneity of SMD architecture and operating platform is challenging for distributed application processing in MCC. Mobile device vendors employ different hardware architecture and operating system platforms for the specific mobile product. Traditional application offloading frameworks focus on the implementation of platform dependent procedures for outsourcing computational intensive loads. For example, Weblets and MAUI [26] are application offloading frameworks which are applicable for .Net framework, whereas virtualized execution framework [24] and mirror server are suitable frameworks for android platform. Therefore, homogenous access to cloud services are highly expected wherein SMD are enabled to access widespread computing services of computational clouds irrespective of the concerns about operating hardware architecture and operating system platform. A homogenous distributed application deployment solution for the heterogeneous available SMDs platforms is a challenging issue for MCC. It describes important metrics such as heterogeneity, under this tripod which are crucial for the success of cloud mobile applications. Similarly, the deployment of distributed application processing platform at runtime [18], [22], [26] is a resources intensive mechanism. It uses computing resources on SMDs for the evaluation of computing resources utilization on SMDs and partitioning of intensive mobile applications at runtime. Current, approaches necessitate continuous assessment of application execution requirements on SMD which is a resource intensive operation. Application Processing Framework employs runtime profiling and solving mechanism on SMDs periodically or casually to evaluate application processing requirements and the availability of computing resources on SMD [26]. The centralized distributed application deployment models require arbitration of SMD with centralized server for the selection of appropriate server node. As a result, computing resources (CPU, battery power) of SMD are exploited abundantly for the entire process of application profiling and solving. The deployment of distributed platform, management and operation of remote application processing in the optimal possible fashion is an important perspective of cloud based application processing. It is challenging to provide homogenous solution for heterogeneous devices, operating platforms and network technologies with minimum possible resources utilization on the SMDs.

D. Security and Privacy in Cloud Based Application Processing

Privacy in the distributed platform and security of data transmission between mobile device and cloud server node are important concerns in cloud based application processing. Privacy measures are required to ensure the execution of mobile application in isolated and trustworthy environment, whereas security procedures are required to protect against network threats. Security and privacy are very important aspects for the establishing and maintaining the trust of mobile users in cloud based application processing. Security in MCC is important from three different perspectives: security for mobile devices, security for data transmission over the wireless medium and security in the cloud datacenter nodes. SMDs are subjected to a number of security threats such as viruses and worms. SMDs are the attractive targets for

attacker. According to a report [27] the number of new susceptibilities in mobile operating systems increased 42 percent from 2009 to 2010. The number and sophistication of attacks on mobile phones is increasing speedily as compared to the countermeasures. Data transmission over the wireless networks is highly vulnerable to network security threats. For example, using radio frequencies, the risk of interruption is higher than with wired networks therefore attacker can easily compromise confidentiality. Similarly, in cloud datacenters the security threats are associated with the transmission between physical elements on the network, and traffic between the virtual elements in the network, such as between virtual machines within a single physical server. Therefore, in order to leverage the application processing services of computational clouds, a highly secure environment is expected at all the three entities of MCC model. In current approaches, transmission of the running states of mobile application which is encapsulated in VM [6], [7], [24] or binary transfer of the application code at runtime [25] is continuously subjected to security threats at mobile device, wireless medium and cloud datacenters. Therefore, secure transmission of the entire components of the application is a challenging issue for MCC. It is imperative to implement reliable security measures for the data transmission, and synchronization between SMD and cloud datacenters in distributed processing platform. Similarly, access control, fidelity and privacy of distributed application components in the remote cloud datacenters is an important consideration for the distributed application processing in MCC. Cloud datacenters provide augmentation services which are unapproachable to mobile users. Therefore, it is highly demanding to ensure the privacy of data and computing operations in remote server nodes. A trustworthy distributed application model is highly expected to cope with such important issues and ensure the trustworthiness of remote computing environment. A reliable distributed environment is expected to provide authentic access to authorized mobile user for legitimate operations on cloud server nodes. Considering the aforementioned research issues and challenges for distributed application deployment in MCC, lightweight and optimal distributed application deployment solution is extremely important. Such a solution should incorporate optimal procedures for the development, deployment and management of runtime distributed platform for MCC.

V. CONCLUSIONS AND FUTURE WORK

The paper gives ideas about cloud computing, mobile cloud computing and explains the different techniques to augment smart mobile devices resources based on availability of resources in cloud. It analyzes current approaches by using taxonomy and highlights the similarities and deviations in such frameworks on the basis of significant parameters. It discusses issues in current approaches and highlights challenges to optimal and lightweight distributed application frameworks for MCC. Current approaches accomplish process offloading in diverse modes. Several approaches exploit entire application migration; others focus on part(s) of the application to be offloaded. A number of approaches employ static partitioning, others exercise dynamic partitioning. Variant migration patterns are used; downloading application by providing URL to remote host, VM cloning, Mobile agent such as USMC, application binary transfer and use of proxies. Diverse objective functions are considered; saving processing power, efficient bandwidth utilization, saving energy consumption, user preferences, and execution cost. Objective of all approaches is to augment the application processing potentials of resources constrained SMDs. We conclude that current approaches for MCC are the analogous extensions of traditional cyber foraging frameworks for pervasive computing or local distributed platforms. Hence, existing approaches are deficient in the deployment of distributed system standard architectures. As a result, additional complications arise in the development, deployment and management of distributed platform. Current frameworks focus on the establishment of runtime distributed platform which results in the resources intensive management overheads on SMDs for the entire duration of distributed platform. SMDs exploit computing resources in arbitration with cloud servers for the selection of appropriate remote node, dynamic assessment of SMDs resources consumption and application execution requirements at runtime, dynamic application profiling, synthesizing and solving for application outsourcing, application migration and reintegration and rigorous synchronization with cloud servers for the entire duration of distributed platform. As a result, additional computing resources of the SMDs are exploited for the runtime orchestration of distributed platform. Therefore, current distributed application deployment algorithms employ heavyweight procedures for distributed application deployment and management.

The mobile nature, compact design, limited computing potential and wireless medium attributes of SMDs necessitate for optimal, lightweight and rich local services procedures for distributed application deployment in MCC. The incorporation of standardized design and development principles of distributed systems seem to be an optimal solution for coping with the challenges of lightweight distributed application deployment for MCC. The incorporation of distributed client/server architecture of distributed applications with the elastic features of the traditional offloading frameworks appears to be an appropriate optimal solution for addressing the issues of existing approaches for MCC. The development of such lightweight model will result in reducing developmental efforts and enhancement in overall performance of application deployment, management and processing in mobile cloud computing.

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