OFFLOADING TECHNIQUES IN MOBILE CLOUD COMPUTING: A REVIEW

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Abstract

With advancement in smart phone technology, need of energy and memory is also of great concern with complex mobile applications. Mobile cloud computing brings a solution to this problem. The computation part of applications and data storage work is handed over to cloud server through internet. This is quite beneficial for mobile devices which otherwise need powerful configuration to handle such extensive computation and storage. Although various benefits are related to this technique, there are also some challenging issues related to it. The right partitioning decision and network failure management are very important issues. The In this paper, various offloading techniques have been reviewed in terms of their advantages and limitations.

Index Terms: Mobile Cloud Computing, Offloading Techniques, Remote Execution, Memory Enhancement.

I. INTRODUCTION

Cloud Computing has emerged as new interesting research area for researchers due to its seamless applications in this mobile world. The term 'Cloud' refers to the Internet system where on demand computing is performed with the help of shared resources like storage, network, servers, applications and services instead of using local servers and individual devices. Users can use this computing service when required by paying for it and relieve the service easily with minimum management effort and service provider interaction. This internet based computing can help organizations perform tens of trillions of computations per second for various applications and store huge data online. User can store personal data online, use webmail services like Gmail, Yahoo mail etc., use online applications like Google documents and Adobe Photoshop express, store computer files online and much more. Advantages of using this system lie in its convenience to use and share information and accessing the stored information from any computer. In case, if user's computer fails, user would not lose his information as it is stored online.

II. MOBILE CLOUD COMPUTING

'Mobile Cloud computing' is combination of cloud computing and mobile environment which brings the advantage of using applications on mobile devices that require extensive processing. Mobile devices like laptops, PDAs, smart phones which otherwise require powerful configuration can now send service request to cloud system using web browser and cloud controllers can process these requests to provide services to mobile users. So, mobile through cloud computing applications, the computation work and data storage work can be handed over to the clouds via internet avoiding long execution time.

III. CHALLENGES IN MOBILE CLOUD COMPUTING

The challenges of cloud computing in mobile environment are related to mobile devices, network, mobile applications and security [1] as shown in Table 1.

Table -1 Challenges in Mobile Cloud Computing

Mobile Device Challenges	**Network Challenges**	**Mobile Application Challenges**	**Security Challenges**
Limited Energy Source Resource deficiency	Inherent Challenges of Wireless Network Reducing N/W Latency Internet Problem Seamless connection bandwidth	Interoperability Application Flexibility Mobile Cloud Convergence	Privacy and Confidentiality Operational Security Malicious Attacks N/W Monitoring Incident Response

A. Challenges for Mobile Devices

1) Limited Energy source of mobile devices:

As the battery power of mobile devices is limited, various energy consuming applications need cloud execution. Instead of transferring the whole application on cloud, few parts of application can be partitioned and offloaded to cloud for execution purpose. However, which part of application to be offloaded is a critical decision.

2) Resource deficiency of mobile devices:

Difference between desktop and mobile devices is still there even after the continuous improvement in mobile devices. Various advanced applications require high processing power, huge memory and high network bandwidth, whereas mobile devices lack of all these resources. Cloud infrastructure provides all the resources required for such complex applications.

B. Challenges related to Network

1) Inherent challenges of Wireless network:

Wireless network contain inherent challenges like variable data rates, high latency, less throughput and coverage gaps, subscriber mobility and weather effects .All these challenges further complicate mobile cloud computing.

2) Various Network access schemes:

Implementation of mobile cloud computing require access to network. Various network access schemes like Wi-Max, WLAN, GPRS, 3G have their own policies, offerings and restrictions which require seamless connection handover schemes on subscriber side as he moves from one access point to another.

3) Reducing Network latency:

Reducing network latency can help reducing overall delay response of applications to some extent. Network latency can be reduced by keeping applications containing heavy data like videos as close to user as possible.

4) Problem of fast mobile internet access everywhere:

Various technologies have been developed and in progress to provide better internet access to mobile devices.

5) Bandwidth:

Bandwidth is the problem with mobile cloud computing when running online gaming and other applications that require high computation and minimum network latency. Data transfer within the cloud and other devices can be improved by improving the bandwidth.

C. Challenges related to Mobile Applications

1) Interoperability:

BYOD (Bring your on device) policy adopted by organizations brings interoperability challenges along with it. This creates challenge in pulling and pushing data across multiple devices.

2) Cloud Application Flexibility:

Various applications require different cloud infrastructure attributes like processing intensity, network bandwidth and network latency which decides whether the particular application is supported by cloud infrastructure or not.

3) Mobile Cloud Convergence:

Mobile cloud convergence is important for low processing mobile devices and requires inter process communication for successful convergence.

D. Challenges regarding Security

1) Information security:

Cloud computing deals with organizations data storage so data security is most important for organizations. Various security policies can be adopted or threat detection capabilities can be moved to cloud.

2) Privacy and confidentiality:

This is very important to maintain consumer's trust. Various encryption schemes or cloud based mobile digital rights management schemes can be adopted to retain security.

3) Malicious Attacks:

Various potential attacks on network are Denial of service (DoS) attacks,Side channel attacks, authentication attacks etc. Security control methods must be adopted to unauthorized access through websites or social media tools.

4) Network monitoring:

Network performance monitoring is important issue which needs to be considered in mobile cloud computing.

These challenges in mobile computing can be resolved using cloud platform for storage and processing backup in mobile cloud computing. Security problems for data exchange, malicious attacks and possible solutions have been discussed. The limitation of this paper is that problem of managing different states of application processing on mobile device and cloud when there is network downtime was not considered and there was no an experiment performed to support the authenticity of the solutions as well. Various cloud service models and deployment models for implementation of mobile cloud computing have been discussed in [2].Another important challenge discussed for mobile cloud computing is absence of open standards which leads to problems like limited scalability, unreliable availability of a service, service provider lock in etc. However, none of the techniques have been discussed in this paper for adapting or scaling MCC based applications throughout the models.

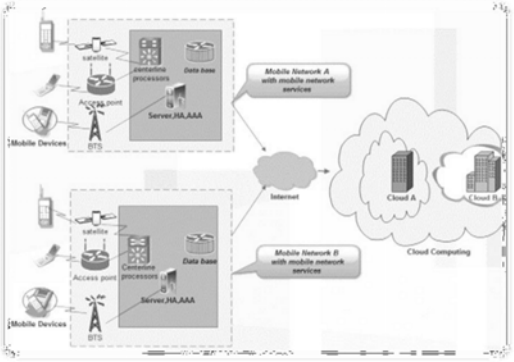

Figure. 1. Mobile Cloud Computing Architecture

Need of mobile cloud computing, general purpose mobile cloud computing (GPMCC) and Mobile cloud computing with application specific (MCCAS) has been discussed in [3].The barriers in implementation of MCC that hinder its success are listed but the solutions are not explained in detail. In [4], author discuss about Mobile Cloud computing, its architecture and programming concepts, typical services needed by client and mobile cloud server, challenges and possible solutions in mobile cloud computing but does not discuss adequate safety measures required. With growth of Smart phones today, need of energy is primary limitation with these devices. Remote execution is the popular technique where code execution is delegated to remote servers. This uses two approaches; one is portioning the program and send the right part for remote execution whereas in second approach individual applications send their code automatically to remote infrastructure. First approach relies on programmer for partition decisions whereas second approach doesn't put much burden on programmer.

MAUI [5] uses benefits of both approaches. In this technique, the decision whether the particular method should be offloaded to remote server or not is taken at run time by considering the cost of offloading it in terms of Energy saving and number of CPU cycles saved. Code offload decisions are made by MAUI solver and implemented by two proxies generated by MAUI by handling the control and data transfer based on this decision. This technique shows good results in terms of energy saving and performance while providing fine grained code offload. The ability to offload portions of a single application is the key advantage of this technique compared to techniques that move entire OS and all its running applications. However, this technique does not takes into consideration the problem of sscaling of execution in cloud. In [6], author represented CloneCloud system that is a flexible partitioner. The right part of the execution of unmodified mobile applications is offloaded from mobile devices to clones working in the computational cloud. It can be said that single machine computation (smart phone computation) is transformed in to distributed computation (smart phone and cloud computation).The system is made flexible enough to move threads from device to cloud at runtime. Dynamic profiler and Optimizer is used to decide threads to be moved from mobile to clone in the cloud. Thus, Elastic system using clone in cloud is a good implementation in terms of saving energy and resources and other advantage is that the Dynamic profiling leverages the elasticity to

move threads among local and cloud node making more efficient decisions at runtime . This technique is successful and worth paying if and only if execution on the cloud takes significant less time compared to execution on the mobile device. The limitation with this technique is that applications with native code have to carry overhead of saving all native context for transfer if migration is taking place at a point where a thread is executing the native code. So, Clone Cloud is not able to migrate native state and to export unique native resources remotely. Another problem with this technique is that it does not provide virtual access to native resources like GPS, Camera which are not virtualized already and not available on the clone. In [7] represents an approach that reduces power consumption through server offloading without partitioning as opposite to, MAUI, a partition based approach and also keep mobile applications resilient in case of network outages. Proposed technique uses the byte code enhancement instead of partitioning and uses checkpoints to synchronize the state between mobile device and the cloud. When the network goes off during offloading process, the remote execution is redirected back to the mobile device from latest checkpoint. Proposed method has a good EOI (Execution offloading index) improvement; a metric used for evaluation and also handles exceptions well. This approach is not applicable to every application due to design constraints. Also, It does not recognize the cost of offloading in terms of bandwidth/latency due to its underlying middleware and does not switch to local execution if required.

Think Air [8], addresses the scalability issue of MAUI scheme by creating virtual machines of complete smart phone system on the cloud and removes the restrictions on inputs/ applications/environmental conditions that Clone Cloud induces by using an online method-offloading. This scheme focuses on parallelization using multiple virtual machine images as it reduces the execution time and energy consumption of mobile applications significantly. It also provides on demand resource allocation which is critical requirement for cloud providers in order to satisfy their customer who request different computational power based on their work.However, paper has not considered communication failures between mobile and cloud.

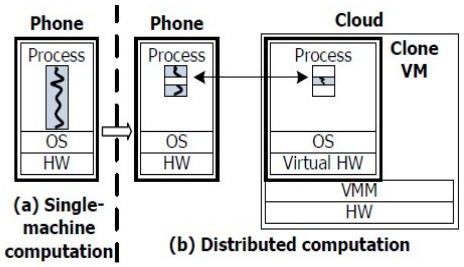

Figure 2. Clone Cloud System which transforms single computation in to distributed computation

C-RAM is another system which uses cloud based memory to increase the memory limit of mobile devices [9]. It divides the application into device and cloud node so that the heavy applications can occupy more memory as it needed and execute on cloud. Fig. 4 shows that the system has three main components: *Profiler* which collects information about memory usage of objects of each class and average execution times of object methods on both local and remote nodes, *Practitioner* which performs efficient partitioning based on information collected by profiler and *Compiler* that realises the partitioning by rewriting the application source code.

Figure 3. C-RAM system components

This system uses snapshot based fault tolerance system to handle the network failures in which the changes to remote memory have the back up to the device. After failure or when network usage exceeds a given limit, execution can be continued from the last snapshot. The limitation of this paper is that the experiment conducted has been limited to IOS which has limited scope. This scheme uses a mechanism network usage throttling to deal with significant increase in network usage due to state snapshotting for applications that periodically update large amount of remote state. Also, with C-RAM, applications can consume 10 times more memory than device capacity without affecting the performance of application.

IV. CONCLUSION

Mobile cloud computing has become the need for today's smart phones and their complex applications. Remote execution on cloud brings challenges like network Failure, partitioning technique and scalability issues which need to be handled carefully. Every technique has few

limitations which need to be taken in consideration by researchers.

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