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Implementation challenges in mobile cloud computing

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Abstract: **Cloud computing has become the technology of the day and have even found their way into the thin clients – the mobile phones. Mobile cloud computing is going to become the dominant way of communication in mobile phones in the years to come. This can be attributed to the need for ease of access of a variety of applications through mobile phones in clouds without having to worry about how to get them. As this notion becomes prevalent, several issues prop up concerning the efficient implantation of cloud computing in mobile devices. The performance factors need to be taken into account and the drawbacks if any, must be rectified before mobile clouds become widely implemented. This paper highlights the complications involved in mobile cloud computing and the various strategies currently adopted to minimize or prevent them. An overview of the proposed efficient strategies is also presented. Various mobile cloud computing applications that are in use currently are elucidated.**

1. Introduction

In fact, cloud computing in mobiles is one of today's hottest new technology markets gaining popularity. Thanks to the success of companies like Amazon and Sales Force, many people are familiar with the term *cloud computing*. However, fewer people understand how mobile cloud computing is different. Mobile cloud computing shares with cloud computing the notion that some level of services is provided by a cloud and accessed by mobile platforms. Mobile cloud computing was defined in a 5 March 2010 entry in the Open Gardens blog as "the availability of cloud computing services in a mobile ecosystem. This incorporates many elements, including consumer, enterprise, femtocells, transcoding, end-to-end security, home gateways, and mobile broadband services. Companies are being driven to the mobile cloud by demand. Customers are demanding smart phone and tablet applications so they can access companies' key applications. Employees are demanding access from their mobile devices. devices available depending on the application requirements. However, from the technical point of view, there are many considerations to be analyzed before implementing mobile cloud computing. They include factors such as bandwidth, resource utilization, cloud security and battery life etc.

2. Problem statement

To increase the feasibility and performance efficiency of cloud computing in mobile devices which are gaining popularity now and will achieve ubiquitous network connectivity in the years ahead; Analysis of various parameters to guarantee a safe and user-friendly cloud computing in mobile devices.

2.1 *Complication factors in performance*

The considered mobile cloud computing environment is complicated by the following factors: In cloud computing through mobiles, resource-intensive computing is reverted to the cloud to utilize the cost advantages of massive data centers. Concerning this view, user perception of cloud computing performance relies on minimizing the overall delay response of these applications. The main contributing factors include:

- Processing time at the data center
- Processing time on the device
- Network latency
- Data transport time
- Network latency and data transport time, among these, are very important from the user's perspective for mobile applications.

2.2 *Main implementation challenges*

Mobile cloud computing poses challenges due to the intrinsic nature and constraints of wireless networks and devices. These challenges complicate the design of distributed processing more so than fixed cloud computing. Unlike wired networks, where most of the factors are predictable, mobile clouds always involve wireless networks which pose some challenges as follows:

- Variable reliability, less throughput, longer latency**.**
- Limited energy source of mobile devices
- Resource poverty of mobile devices versus fixed devices.
- Special considerations for mobile cloud computing.
- Cloud service distance
- Conservation of battery life
- Cloud application feasibility matrix

2.2.1. *Variable reliability, less throughput, longer latency*

Unlike fixed broadband where a physical link supports consistent network bandwidth, wireless connectivity is characterized by variable data rates and intermittent connectivity due to gaps in coverage. The dynamic nature of application throughput demands, subscriber mobility and uncontrollable factors like weather can cause bandwidth capacity and coverage to vary. Moreover, mobile broadband networks generally have longer network latency than fixed broadband.

The future of cloud computing in the mobile world may be pretty dark and foreboding. The biggest problem is not about reliance on an Internet connection - ubiquitous broadband networks should pretty much deal with that. What will likely make mobile cloud computing a challenge in the long run is bandwidth scarcity. Pushing the processing and storage into the network generally means far higher throughput requirements for mobile networks that are already being strained in many urban areas.

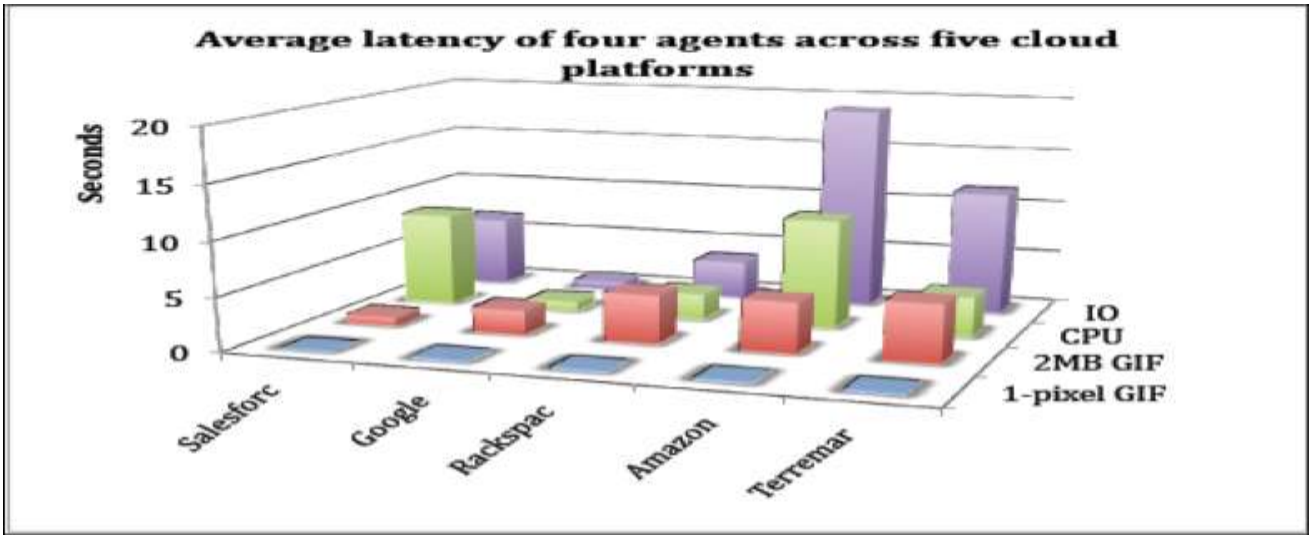

Figure 1. Latency analysis across mobile cloud platforms

2.2.2. ***Limited energy source of mobile devices***

Another fundamental challenge arises from the fact that mobile devices are generally less powerful and use batteries, whose capacity is fundamentally limiting. It is therefore important to maximize battery life through the careful partitioning of application functions across servers and devices.

The display element and cellular connectivity are the two biggest contributors of energy use in a mobile phone; application-rich devices tend to have larger battery packs to run larger displays and sophisticated applications. Non-display applications (for example, audio podcast, utilities like virus scanning and so on) would likely be well suited for mobile cloud computing, as these applications do not require display usage. Hence energy source is to be given due attention.

2.2.3. ***Resource poverty of mobile devices versus fixed devices***

The challenges presented by the resource-poor nature of mobile devices are, in one sense, drivers for adoption of mobile cloud computing. In an effort to offset device limitations, resources can be added to the cloud infrastructure to provide seamless user experiences for advanced applications.

Although mobile technology has improved significantly over the past several years, there is a significant cost of mobility for a given cost and level of technology available. A comparison of a Dell Inspiron 580 desktop with the iPhone 4 and iPad, for example, reveals this tradeoff cost of mobility. As compared to a fixed device, mobile devices in general have:

- 3 times less processing power
- 8 times less memory
- 5 times less storage capacity
- 10 times less network bandwidth

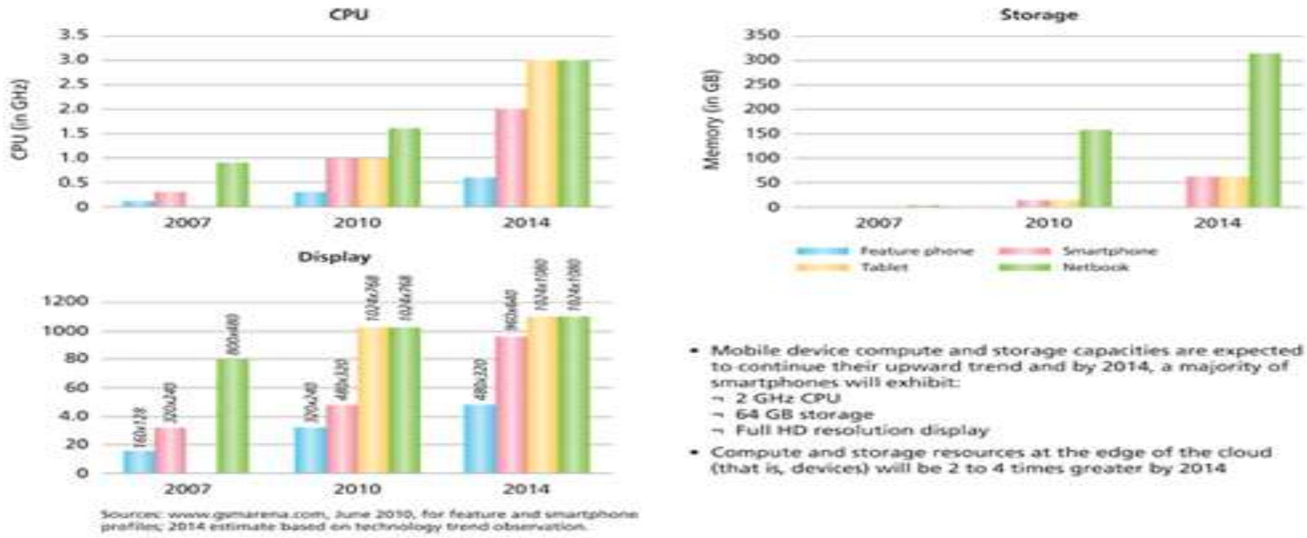

Figure 2. Latency analysis across mobile cloud platforms

While mobile device performance will continue to improve in absolute terms (Figure 2), the disparity between the resource constraints of mobile and fixed devices will remain and must be accounted for in the types of application selected for mobile cloud computing.

2.2.4. ***Special consideration***

The offloading of computer-intensive applications onto ubiquitous, unlimited computing resources in the cloud, requires special considerations in network design and application deployment in certain kinds of communications. Immersive communications are a leap forward from traditional video-conferencing or even tele-presence. Immersive applications incorporate mixed reality and natural interactions, where the user feels as though he/she is a part of the simulated environment. For example, people and objects can be captured in 3D and brought together in a virtual setting on any device.

2.2.5. ***Cloud service distance***

The latency of a mobile broadband network, or the service distance to access application or content, is typically 'long.' With the trend toward data center consolidation among large enterprises and major Internet content providers, content and application sources are often located far away from end devices. This 'long' service distance is more pronounced for mobile devices, where 'last mile' network latency in terms of round trip time can be 200 ms (versus 50 ms for fixed networks). On top of longer latency and lower throughput (25 Mb/s nominal data rate for fiber versus 2 Mb/s for HSDPA), mobile broadband networks generally require longer execution times for a given application to run in the cloud.

Although network latency of 200 ms may not be so noticeable for web browsing, it becomes critical for highly interactive and immersive applications, where even modest network latency can result in a noticeably degraded user experience.

Similarly, for content-heavy applications like video streaming, transmission delays at 2 Mb/s (HSDPA) versus 25 Mb/s (fiber) can be quite significant; for example, 40 seconds against 3.2 seconds to stream a 5-minute, 10MB video at standard YouTube quality. For cloud services, especially those requiring highly immersive user interactions, content/application data centers must be close to end users to alleviate bandwidth and latency issues.

2.2.6. ***Conservation of battery life***

Limited battery life is another major challenge in bringing mobile cloud computing to the masses . Smartphones are often charged daily, based on moderate use of messaging, web browsing, phone calls and accessing social networking and other Internet applications. The forecast increase in mobile computing and display technologies makes the use of more sophisticated and immersive applications highly likely, based on past trends. Given the unlikelihood of significant leaps in battery technology, it is crucial to consider battery-saving strategies in the context of more sophisticated and immersive applications running on mobile devices.

In general, more execution in the cloud means more battery savings, as the application execution burden is offloaded. For any application, however, execution offload is linked to device functions and cannot be completely transferred to the cloud. For instance, user-facing functions like user/sensor input and display output naturally need to run on the device.

For immersive applications, execution offload flexibility is even more constrained, as separate application functions running on servers and devices are tightly coupled. For this reason, the battery-saving strategy for immersive applications typically comes down to finding the least costly path to the cloud servers and minimizing latency to maintain high interactivity. For smartphones, Wi-Fi represents the less costly path, with 23% less energy consumption versus GPRS in a web browsing scenario. If maintaining the GPRS connection can be discounted (for example, for non-phone devices like tablets), then the power consumption of GPRS versus Wi-Fi is even more stark, with Wi-Fi using just one third of the energy of GPRS.

2.2.7. ***Cloud application feasibility matrix***

An application fit for a certain mobile cloud infrastructure can be gauged, based on application requirements against the cloud infrastructure characteristics along the computing, network bandwidth and latency vectors.

	Cloud infrastructure attributes		
Applications	Compute intensity (*High* – required for compute-intensive apps)	Network bandwidth (*High* – required for content-heavy, large data transfer apps)	Network latency (*Low* – required for high interactivity
Web-mail (Yahoo!, gmail)	Low	Low	High
Social networking (Facebook)	Low	Medium	Medium
Web browsing	Low	Low	High
Online gaming	High	Medium	Low
Augmented reality	High	Medium	Low
Face recognition	High	Medium	Low
HD video streaming	High	High	Low
Language translation	High	Medium	Low

Figure 3. Cloud infrastructure and application correspondence

For example, loosely coupled, low-content applications like web search would likely work fine on a 3G network with relatively low compute servers at a 'distant' data center. In contrast, a hugely immersive and content-rich application like real-time face recognition would likely require a high-bandwidth/low-latency network like Long Term Evolution (LTE) to transfer large image content quickly between, and seamlessly interact with, the servers running the face recognition algorithm and the user-facing devices. This type of high-demand application will require 'nearby' data centers to minimize transmission and latency delays. For a highly immersive application that requires very low latency, the mobile cloud infrastructure may even call for Wi-Fi offload to minimize latency further.

3. Current strategies

Given the demands of mobile cloud computing, the following factors are essential to delivering a 'good' cloud service:

1. Optimal partitioning of application functions
2. Low network latency
3. High network bandwidth for faster data transfer between cloud and mobile devices.
4. Dynamic network monitoring

3.1. *Optimal partitioning of application functions*

Partitioning applications statically does not pro-vide optimal user experience as more and more applications are used in diverse environments and inputs. That is, there is no single partitioning that fits all due to environment heterogeneity (device, network, and cloud) and workload. Furthermore, there are many partitioning choices. For example,for an application that runs both on an Android phone and on an Android net book, the application may run better in each device by using different partitioning between device and cloud. An Android phone application may run better in different network types by using different partitioning methodologies.

3.2. *Low network latency*

Low network latency is needed in order to meet application and code offload interactivity. Cloud service providers can reduce network latency and slow downloads by moving applications closer to the user. Distributing applications can help the fact that clouds today do not have carrier-grade features and Infrastructure as a Service is already a commodity.

Additionally, while desktop applications such as email and remote desktop are moving into the Web browser, mobile platform apps will move away from the browser. The browser will disappear on tablets and we will just have a store of apps. Mobile apps will communicate directly to the cloud service itself, as opposed to needing the user to launch a Web browser and navigate through the mobile Web.

Latency increases with distance, and the number of network nodes that the data needs to pass. As a result, moving applications as close to the user as possible decreases latency effects. There are examples of providers taking steps to address this. Ericsson, for example, made a strategic partnership with another company Akamai, earlier this year which will enable service providers that run on Ericsson infrastructure to route internet traffic intelligently based on user location and add caching capabilities to a mobile network. This technology is expected to increase user experience and advance mobile e-commerce and banking. Dynamically moving the data towards the mobile user is clearly the best way to minimize latency issues and save bandwidth.

3.3. *High network bandwidth for faster data transfer between cloud and mobile devices*

More and more mobile service providers have started offering 4G/LTE mobile services within restricted areas. One of the greatest advantages of LTE is capacity. Each LTE cell supports up to four times the data and voice capacity when compared to HSPA (UMTS High-Speed-Packet-Access). Other advantages include low latency, plug and play, and support for both frequency division multiplexing (FDD) and time division duplexing (TDD) in the same platform. In theory, LTE is capable of downlink peak rates of 100 Mbps and an uplink of at least 50 Mbps. Similar to GSM and UMTS, LTE operates at different frequency bands and can be deployed in clear spectrum with bandwidth as wide as 20 MHz of paired spectrum (20 MHz Uplink, 20 MHz Downlink).

3.4. *Dynamic network monitoring*

Several new technologies promise a more intelligent deployment of network resources and may minimize latency. For example, HTML5 offers data caching , allowing users to experience fewer problems due to intermittent network performance or network congestion. When it comes to the mobile cloud, network performance management becomes increasingly important. Better mobile network monitoring systems enable dynamic traffic re-routing and swapping, or handover, between cells based on traffic load patterns and user location. This is an important factor that will help to improve the mobile cloud user experience and make it more viable for corporations that are interested in providing mobile access to many of their core applications.

4. *Proposed methodologies*

Despite the intrinsic challenges to delivering a reliable service — the resource-poor nature of mobile devices and the relatively longer network latency and lower bandwidth of mobile broadband networks — service providers can nonetheless address these four key issues with four related strategies:

Network bandwidth strategy: Bring content closer to mobile broadband through regional data centers or other means.
Network latency strategy: Move application processor nodes to the edge of mobile broadband, and/or deploy application bandwidth optimization.
Battery-saving strategy: Cloning the device in the network for compute- and energy-intensive management tasks such as automatic virus scanning of mobile devices.
Mobile cloud application elasticity: The dynamic optimization of application delivery and execution between the device and the network.

There are various solutions to the issues of delivering guaranteed Quality of Experience (QoE) using mobile cloud computing. The technical feasibility and business viability of individual solutions will, of course, depend on the individual service provider’s current network architecture, business model and commercial strategy.

5. Application areas

Various application areas are describe here,

5.1 *Cloud e-mail*

Currently most of the mobile users are accessing Gmail (free Email service from Google) through its feature applications for various Mobile operating systems; this is the best and live example of Mobile Cloud Computing.

5.2 *Cloud music*

Revolutionary technology “Music Anywhere” which allows customers to have access to their music collections from anywhere in the world using their mobile device is a biggest example of where Mobile Cloud Computing is heading.

5.3 *Cloud mobile desktop*

It tends to be a universal Storage device which can be accessed via Desktop,Laptop, Pads & Even mobile phones. Many companies offer this services wherein they allocate fixed space (Obviously expandable by paying additional amount) to a user in cloud and provides access to it via internet irrespective of the Users instruments.

5.4 *Cloud print*

Primary goal of this service offered by google is “to build a printing experience that enables any app (web, desktop, or mobile) on any device to print to any printer anywhere in the world.” This service is offered as a beta version with Google Chrome 9 at present.

6. Conclusion

This paper has mainly been focused on complications with mobile cloud computing and various strategies in order to achieve efficiency in cloud computing through mobile devices. It is still undecided that what the future truly holds for Cloud Computing and Mobile Cloud Computing, but experts foresee that within 2-3 Years, all technologically superior countries will be using Mobile Cloud Computing as their primary method of accessing data through their Mobile Phones and In fact India will Lead the show due to its higher Mobile Subscribers rate than any other country in the world. The future for Cloud Computing is surely bright, but the end users will have to wait until Cloud Computing reaches its best possible potential stage in the Mobile Industry to have access to innumerous advantages and benefits it have for all the users.

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