ISSN No. 0976-5697
Volume 2, No. 3, May-June 2011
International Journal of Advanced Research in Computer Science
RESEARCH PAPER
Available Online at www.ijarcs.info

Challenges in Mobile Cloud Computing

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Abstract: Mobile Computing is a generic term describing the application of small, portable, and wireless computing and communication devices. This includes devices like Laptops with Wireless LAN technology, Mobile phones, and Personal Digital Assistants (PDAs) with Bluetooth or IRDA interfaces.Cloud computing describes a service model that combines a general organizing principle for IT delivery, infrastructure components, an architectural approach and an economic model – basically, a confluence of grid computing, virtualization, utility computing, hosting and software as a service (SaaS). Paper is to study challenges when we combine mobile computing with cloud computing in order to improve efficiency.

Keywords: cloud computing, cloud infrastructure, cloud services, high bandwidth, immersive applications, immersive communications,smart phones.

I. INTRODUCTION

Application usage on mobile devices has exploded due to the increasing popularity of smart phones and tablet devices like the iPod, along with ubiquitous network connectivity. The corresponding growth in data centers has elevated interest in cloud computing in our industry.
According to Gartner research the global cloud computing services market could reach $150 billion by 2014. [1]However accurate this prediction turns out to be, the growth in data center build-outs and the proliferation of 'smart 'devices are real and happening now. Consequently, what are the issues raised by mobile versus general cloud computing, and what is the likely impact on service provider networks delivering cloud services to mobile devices.

II. KEY FACTORS IN USER-PERCEIVED PERFORMANCE OF CLOUD COMPUTING

In cloud computing, resource-intensive computing is offloaded to the cloud to leverage the cost advantages of massive data centers. In this paradigm, user perception of cloud computing performance relies on minimizing the overall delay response of these applications. The main contributing factors are[6]:

- Processing time at the data center
- Processing time on the device
- Network latency
- Data transport time

The last two network-dependent factors are significant drivers of user-perceived performance of mobile cloud computing for most mobile applications today.

III. INHERENT CHALLENGES /DRIVERS OF MOBILE COMPUTING

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[19].

IV. 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[20].

V. 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 smartphone[2]; 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.

VI. 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 phones 4 and iPod, 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

While mobile device performance will continue to improve in absolute terms (Figure 1)[14], 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.

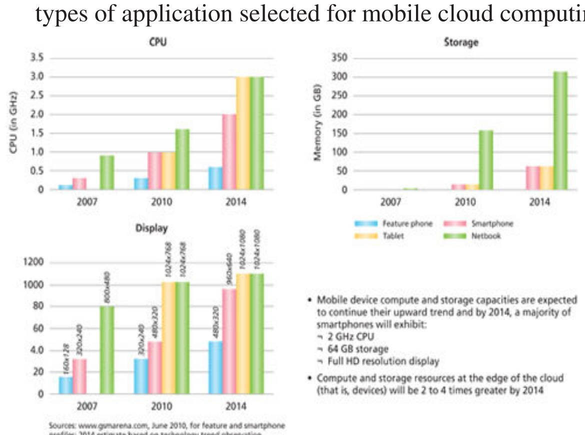

Figure 1. Mobile device computing, storage and display trends.

VII. SPECIAL CONSIDERATIONS FOR MOBILE CLOUD COMPUTING

The offloading of computer-intensive applications onto ubiquitous, (theoretically) unlimited computing resources in the 'cloud, 'requires special considerations in network design and application deployment[22].

1. What are immersive applications?

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. Cloud service 'distance' matters (especially for immersive applications)

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[21].

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.

3. Conserve battery life

Another significant barrier in mobile cloud computing is the limited battery life of mobile devices. 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 (Figure 1) 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 maintaining the GPRS connection 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 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.

4. 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 compute, network bandwidth and latency vectors (Figure 2)[14].

	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

Figure2. Application and cloud infrastructure mapping

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.

VIII. CONCLUSION

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

- Optimal partitioning of application functions across cloud and device
- Low network latency to meet application and code offload interactivity
- High network bandwidth for faster data transfer between cloud and devices
- Adaptive monitoring of network conditions to optimize network and device costs against user-perceived performance of the cloud application.

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:

1. Network bandwidth strategy: Bring content closer to mobile broadband through regional data centers or other means.
2. Network latency strategy: Move application processor nodes to the edge of mobile broadband, and/or deploy application bandwidth optimization.
3. Battery-saving strategy: Cloning the device in the network for compute- and energy-intensive management tasks such as automatic virus scanning of mobile devices.
4. 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.

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