

Mobile Cloud Computing

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Abstract—Together with rapid growth in mobile applications and cloud computing technology, mobile cloud computing has been introduced to be a potential technology for mobile services. As mobile cloud computing is still in an early stage of development, it is necessary to have a thorough understanding of the technology in order to point to the direction of future research. With this aim, this paper presents a review on the background and principles of mobile cloud computing- principle, architecture and challenges along with the possible solutions. It also gives brief account about mobile and cloud computing. Applications like M-commerce, M-healthcare and M-gaming have been presented to discuss the possible applications of mobile cloud computing. The paper concludes with the authors view about the future of this technology.

Index Terms—Cloud computing, Mobile cloud computing, Mobile computing.

I. INTRODUCTION

The IT industry is ever buzzing with revolutionary inventions since the very first computer came into the picture. The purpose of the computer to perform different tasks and applications hasn't changed over the last six decades. The only difference is that now these tasks are performed in a cheaper, faster and portable manner. A group of computers or servers are tied together to form a system called as Cloud Computing. Cloud Computing is the new form of application mode in the era of the Internet and it has become the hot topic of research in industrial and scientific communities. It provides the consumers the resources and computing infrastructure as per their requirements. The consumers can use the services and applications available on the cloud through their Internet connection. Cloud computing is not just limited to personal computers; it has a major impact even on the mobile technology. Mobility and ubiquity are the key features of the next generation network. Thus, a combination of Electronic devices like smartphones, PDA's, tablets, ubiquitous mobile network and cloud computing, resources are converging together to emerge as a new field of Mobile Cloud Computing.

II. WHAT IS MOBILE COMPUTING?

The word 'mobility' has become very popular in the world of computing. There has also been a rise in development and sales of mobile devices like smartphones, tablets etc. supporting different kinds of mobile computing and networking technologies. People are choosing these devices as their first preference for work and entertainment activities.

This brings us to the question of what is mobile computing? It is an information management platform that is independent of location and time-based constraints. Autonomy of this platform allows the users to access data from anywhere in space and at any time. Thus, whatever be the state of the user stationary or mobile, it does not affect the working ability of the platform. Thus, an impression is created that the available resources and computing power is available on the spot, whereas in reality it is far from that location.

III. WHAT IS CLOUD COMPUTING?

Cloud Computing is similar to distributed computing. In the latter, the resources are distributed over the network, the computing of this data is done in bits and pieces and the results are integrated to get the final result. By doing this we reduce the problem of huge computations being done only one site. The concept of distributed computing work is applied to cloud computing.

Cloud computing has become a well-known expression since 2007. There is no single consensual meaning for cloud computing because different developers and organizations describe it in different ways. That is said, cloud computing is commonly described as a variety of facilities which are provided by a group of low-cost servers or personal computers, generally called a cluster, via the Internet. The main part of the cloud computing system is this cluster system, called the Cloud.

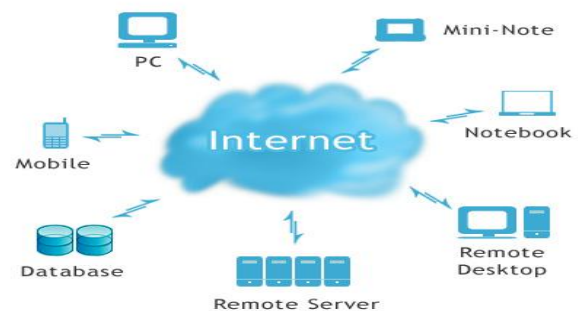


Fig. 1 Cloud Computing Technology [1]

Cloud organizes the various resources of the computers according to a certain management plan and offers safe, reliable, quick, convenient and transparent services such as data storage, retrieval and computing to clients. This liberates the client of the mentioned duties.

Cloud computing system has a layered architecture. The three layers are-

- Infrastructure layer: It is the lowest layer and comprises of physical devices and hardware, such as servers and storage, which are virtualized as a reserve for data storage and computing purposes to users. This layer lets the users install the operating system and software applications. Thus, it is denoted as IAAS i.e. Infrastructure as a Service.
- Platform layer: It is the second layer of the architecture and is considered to be the most important layer of the

Manuscript received April, 2013.

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system. It provides the user with a computing platform that has a parallel programming environment, distributed storage and management system along with distributed file systems for mass data. It also provides platform resources such as program testing, execution and maintenance. Thus, this type of services in a platform layer is called Platform as a Service (PaaS). The typical services are Google Application Engine [4] and Azure from Microsoft [5]

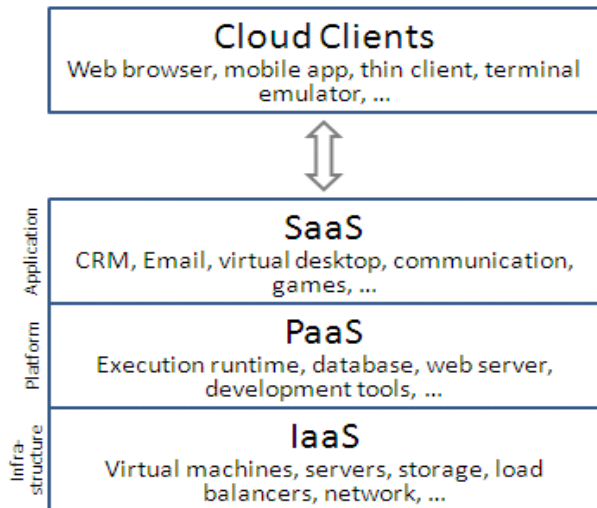


Fig. 2 Layers of Cloud computing system [2]

- c) Application layer: It provides the end users with software and applications along with the consumer GUI. It is named Software as a Service (SaaS). Any application delivered over the Internet and hosted remotely can be called as SaaS. The earliest SaaS is the Customer Relationship Management (CRM) [6]. Some other services provided by Google on-line office such as documents, spreadsheets, presentations are all SaaS. The features of a cloud computing system are:
 - a) Virtualization: The main component of cloud computing system is the Cloud, where all bottom layer resources are virtualized. Required resources are accessed through the browser and it is needless to know the actual location of the device where the resource is located. In addition to this, virtual machines are also installed to carry out the support load relocation in case of an overload.
 - b) Elasticity and scalability: Resource allocation is elastic in nature, i.e. it should have the capability to adapt with the changes and the demand. This means that the system should be elastic enough to suffice the need of the rise in demand and come back to its normal level when the demand decreases. Cloud computing has the ability to scale the resources when the need of the resources increases. Cloud is an infinite entity and users can buy as much computing power as per their need.
 - c) Autonomy: Cloud computing is an autonomic system, i.e. it allocates the resources automatically and allows the user to interact with the cloud to perform tasks like building, deploying and maintaining without any interruption of the cloud computing provider.
 - d) Wide-ranging network access: Cloud capabilities are available over the network and it can be accessed by the users' standard mechanisms, thus supporting diverse types of client platforms.

Cloud computing has to deal with security and privacy issues before large organizations start adopting it. Important data lying outside of corporate firewalls and the hacking of the cloud components raises serious issues. Furthermore, the organizations save up money on the resources but they have to spend more money on the bandwidth. Sufficient bandwidth is required for providing exhaustive and complex data on the network. Because of this, many organizations are waiting for a decline in the cost of bandwidth before switching to cloud computing systems.

IV. PRINCIPLES OF MOBILE CLOUD COMPUTING

Mobile cloud computing is a combination of mobile computing, cloud computing and mobile Internet. It can be stated as availability of cloud computing facilities in the mobile environment. It integrates the advantages of all the three technologies and can thus be called as cloud computing for mobiles.

Mobile cloud computing is a new model where the data processing and storage is moved from mobile devices to powerful and centralized computing platforms located in clouds. These platforms can then be accessed through wireless connections via web browsers on the mobile devices. This is similar to cloud computing, but the client side has changed to make it viable for mobile phones, but the main concept behind it is still cloud computing.

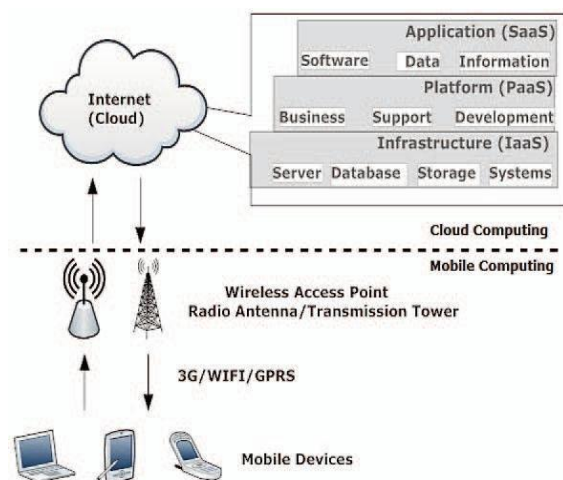


Fig. 3 Mobile cloud computing architecture [7]

As shown in the Fig. 3, mobile cloud computing can be simply divided into mobile computing and cloud computing. The mobile devices can be smartphones, laptops or PDA's, that are connected to a network through 3G, WIFI or GPRS. Mobile users can send requests to the cloud through web browser and the resources are allocated to the established connection. After the web application is started, the monitoring and calculating functions of the system will be implemented to guarantee that the QoS is maintained until the connection is completed. This includes accomplishing tasks like sending response rapidly, synchronizing and load balancing to ensure that the resources are allocated to the appropriate clients.

V. CHALLENGES AND ITS SOLUTIONS

The main goal of mobile cloud computing is to provide users a convenient and quick way to access the data from the

cloud on the go by using their mobile devices. While enhancing the user's convenience, a lot of problems still remain in the realization of mobile cloud computing.

A. Limitations of the hand-held devices:

While talking about mobile devices using cloud computing, the first thing that has to be looked upon is the resource constraints. Although mobile devices have improved in all aspects- storage, size of the screen, capability of CPU, wireless communication, operating systems, there are serious limitations in computing capability and energy resource to set up complex applications. As compared to PCs and laptops, the modern mobile devices like the iPhone 5 or the Android or Window mobile phones, reduce the processing capability by 3 times, memory by 5-6 times and bandwidth by around 10 times. Although these intelligent phones are improving consistently, the vast disparities still pose a limitation to mobile cloud computing.

B. Limitations of the loss of the battery and network flow:

If an application needs a lot of battery and network flow, it will become difficult to deploy that application on the mobile device. To overcome this problem, there will need to be a reduction in the data exchange rate and the amount of data exchanged between the mobile device and the cloud end, by optimizing the cloud end.

C. Problem of individualization of mobile devices:

At present, there are various handheld operating systems and to develop an application based on the handheld device, we must make the client end of the application software simple. Simple client end means that a large amount of data computing can be put in the cloud end and the client side be made standard so that it can run on any mobile device, without making much modification.

D. Quality of service:

The data transfer rate in mobile cloud computing environment is ever-changing and the connection is discontinuous since the Internet service provider is normally far away from the mobile device users. The latency delay period in a wireless network may be 200 milliseconds compared to 50 milliseconds in wired network. Some other issues such as dynamic alteration of application throughput, mobility of users and even weather will lead to variations in bandwidth and network overlap. Therefore, the handover delay in mobile network is higher than in wired network.

VI. APPLICATIONS

With the rise in sales of mobile devices and increasing development in the field of mobile cloud computing, mobile applications have gained a growing share in the global mobile market. Some of the applications of mobile computing are as follows:

A. Mobile commerce

M-Commerce is a business model for commerce through mobile devices. It was developed to provide the capabilities of commerce by means of wireless technology. The m-commerce applications are divided into three categories- finance, purchase and advertising.

With the help of m-commerce, banks and other financial institutions allow their users to access their account information and carry out transactions like buying of stocks, paying money etc. Stock market services allow people to

respond to the stock market changes at any time irrespective of their location.

Mobile vouchers, coupons, tickets etc. can be sent to the users via their mobile phones. The users are then able to use these vouchers or tickets by showing their mobile phone at the ticket counter thus making the whole process a lot quicker and simpler.

Mobile advertising is the advertisements that are sent to mobile phones. Companies have reported that a better response is received through mobile marketing campaigns than traditional campaigns. Thus, this promises to be a big area of advertising in the future.

B. Mobile gaming

Mobile gaming (m-game) is a burgeoning market that is generating revenues for service providers. M-game can completely free game engines requiring large computing resources (e.g., graphic rendering) to the server in the cloud allowing gamers to only interact with the screen interface on their mobile devices.

Techniques are being developed to reduce the energy consumption of the mobile devices and thus to increase the gaming time on the mobile devices along with the performance of the mobile application. The main goal is to maximize the user experience.

C. Mobile healthcare

In healthcare environments, mobile computing devices help in faster and simpler access of data, thus resulting in better care of the patients. Mobile healthcare (m-healthcare) enables patients to be monitored at any time, any place through wireless technology. Also, health-aware mobile devices can detect pulse rate, blood pressure to alert the emergency system. Furthermore, m-healthcare allows patients or other health-care organizations to access the current and past medical data at the tip of their fingers.

Mobile computing devices create more free space, less clutter and lower costs, while delivering more services more efficiently, with a lower error rate through linking with electronic health systems.

D. Other Uses

Mobile cloud computing also helps mobile users to share photos and videos with people on popular social networking websites like Facebook and twitter. Mobile users are also provided with cloud services such as- map and other applications that provide location-based services like finding the local whether, road traffic or nearby restaurants.

VII. FUTURE DEVELOPMENTS

Research work has contributed immensely to the success of mobile cloud computing. But there are still some issues, which need to be addressed to take this technology to the next level and make sure that it is used by a majority of the population.

A. Low Bandwidth

Although researchers are proposing optimal and efficient way of allocating bandwidth, limited bandwidth still poses a huge concern because the number of mobile and cloud users are increasing radically. Therefore, further studies should try to incorporate technologies like 4G to overcome this issue.

B. Standard interface

The current interface between mobile devices and cloud is based on web interfaces. These interfaces are not designed for the mobile devices and thus carry huge overheads. Also, compatibility among mobile devices may be an issue. To overcome this flaw, a standard protocol and interface needs to be designed.

C. Quality of service

The original goal of mobile cloud computing is to provide PC-like services on the mobile devices. Since, there are a diverse features existing between PCs and mobile devices, we cannot directly shift the services from the computer’s platform to mobile devices. In addition, mobile users may face delay in communication with the cloud because of congestion due to bandwidth limitation, network disconnection and signal attenuation.

D. Service convergence

In future, there may be cases where a single cloud cannot suffice the needs of the mobile users. Hence, a new model is needed where the users can make use of services from multiple clouds in a unified manner. One of the possible solutions of this issue is ‘Sky Computing’, which is a level above cloud computing. To put sky computing in simple terms, it just means leveraging resources from multiple clouds to create a distributed framework. Similarly, the mobile sky computing will enable users to support cross-cloud communication and deploy other mobile applications and services. For all these requirements to be met, service convergence needs to be explored.

VIII. CONCLUSION

Mobile cloud computing as a development and extension of mobile computing and cloud computing has inherited mobility and scalability. Due to the large-scale response, it has become the hot topic of research in recent years. Within a year, it is expected to observe a fierce competition among PaaS players to become the market leader in mobile cloud computing. In the next 2-3 years, customers in technologically and progressive countries will be sensing a major change in mobile application technology. 2014-15 is estimated to be the year when mobile cloud computing will really start to dominate the industry.

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