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Mobile Cloud Computing.

*[1]Miss Priyanka J.Pursani, [2]Prof. P.L.Ramteke

Abstract:

Despite increasing usage of mobile computing, using its full potential is difficult due to its problems such as resource scarcity, frequent disconnections, and mobility. Mobile cloud computing can address these problems by executing mobile applications on resource providers external to the mobile device. Cloud computing is the latest effort in delivering computing resources as a service. It represents a shift away from computing as a product that is purchased, to computing as a service that is delivered to consumers over the internet from large-scale data centers – or "clouds".

In this paper, we provide an extensive survey of mobile cloud computing research, while highlighting the specific concerns in mobile cloud computing along with various issues to be considered and their solutions.

Keywords: Cloud Computing, Cloudlet, Cloud Server, Remote Cloud, Virtualization

1. Introduction:

1.1 Cloud computing:

''Cloud computing refers to both the applications delivered as services over the Internet and the hardware and systems software in the datacenters that provide those services'' [1]. A cluster of computer hardware and software that offer the services to the general public (probably for a price) makes up a 'public cloud'. Computing is therefore offered as a utility much like electricity, water, gas etc. where you only pay per use. For example, Amazon's Elastic cloud, Microsoft's Azure platform, Google's App Engine and Salesforce are some public clouds that are available today. However, cloud computing does not include 'private clouds' which refer to data centers internal to an organization. Therefore, cloud computing can be defined as the aggregation of computing as a utility and software as a service.

Virtualization of resources is a key requirement for a cloud provider—for it is needed by statistical multiplexing that is required for scalability of the cloud, and also to create the illusion of infinite resources to the cloud user. Ambrust et al holds the view that ''different utility computing offerings will be distinguished based on the level of abstraction presented to the programmer and the level of management of the resources''. To take an example from the existing cloud providers, an instance of Amazon's EC2 is very much like a physical machine and gives the cloud user almost full control of the software stack with a thin API. This gives the user a lot of flexibility in coding; however it also means that Amazon has little automatic scalability and failover features.

In contrast, Google's App Engine enforces an API on the user but offers impressive automatic scalability and failover options. Microsoft's Azure platform is something in between the aforementioned providers by giving the user some choice in the language and offers somewhat automatic scaling and failover functions. Each of the aforementioned providers has different options for virtualizing computation, storage and communication.

1.2. Mobile cloud computing:

There are several existing definitions of mobile cloud computing, and different research alludes to different concepts of the 'mobile cloud':

1. Commonly, the term mobile cloud computing means to run an application such as Google's Gmail for Mobile on a remote resource rich server (in this case, Google servers) as displayed in Fig. 1while the mobile device acts like a thin client connecting over to the remote server through 3G. Some other examples of this type are Facebook's location aware services, Twitter for mobile, mobile weather widgets etc.

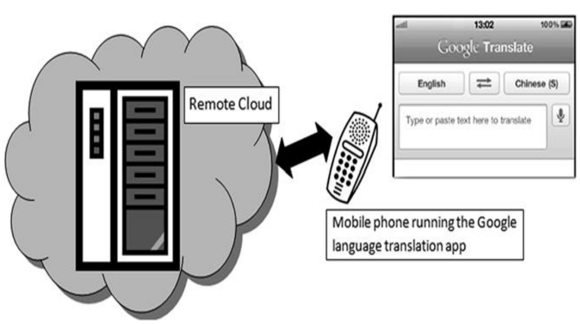

Fig 1: A remote cloud server catering to mobile devices though the internet.

2. Another approach is to consider other mobile devices themselves too as resource providers of the cloud making up a mobile peer-to-peer network as in [3]. Thus, the collective resources of the various mobile devices in the local vicinity, and other stationary devices too if available, will be utilized as shown in Fig. 2. This approach supports user mobility, and recognizes the potential of mobile clouds to do collective sensing as well. Peer to peer systems such as SATIN [4] for mobile self-organizing exist, but these are based on component model systems representing systems made up of interoperable local components rather than offloading jobs to local mobile resources. This paper focuses primarily on this latter type of work.

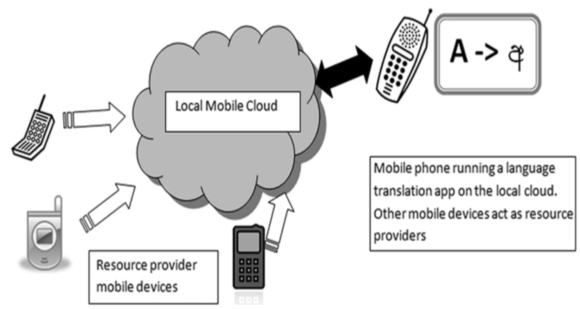

Fig 2: A virtual resource cloud made up of mobile devices in the vicinity.

3. The cloudlet concept proposed by Satyanarayanan [2] is another approach to mobile cloud computing. Fig. 3 illustrates this approach where the mobile device offloads its workload to a local 'cloudlet' comprised of several multi-core computers with connectivity to the remote cloud servers. Plug Computers can be considered good candidates for cloudlet servers because of their form factor, diversity and

low power consumption. They have the same general architecture as a normal computer, but are less powerful, smaller, and less expensive, making them ideal for role small scale servers installed in the public infrastructure. These cloudlets would be situated in common areas such as coffee shops so that mobile devices can connect and function as a thin client to the cloudlet as opposed to a remote cloud server which would present latency and bandwidth issue

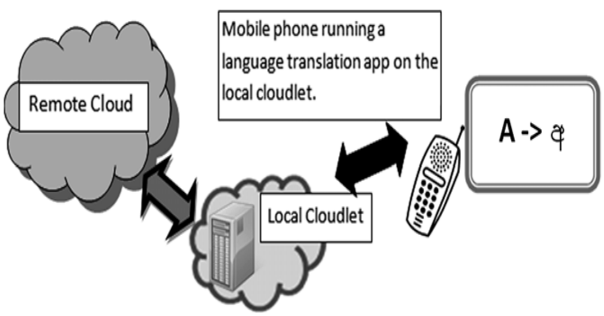

Fig 3: A cloudlet enabling mobile devices to bypass latency and bandwidth issues while benefitting from its resources.

2. Scenario for using Mobile Clouds:

2.1. Example: Using mobile cloud with distributed computation ,and collective sensing Now let us consider the following detailed scenario:

In the aftermath of a natural disaster such as the Indian Ocean tsunami in 2004, the immediate provisioning of emergency services becomes of great importance. Among these services, searching for missing persons is one of the most critical yet excruciating tasks. In this kind of chaotic situation, infrastructure is destroyed, limiting access to computers and data, making such a search even more difficult. Often, missing person reports are filed, but the persons in question may be injured with no means of communication, or even deceased. One way of dealing with this is to photograph every person found, gather all images to a central location, and perform search and match operations with images of missing persons. However, this approach is not very realistic considering the limited human and machine resources in such a situation.

Several questions exist in this scenario:

1. How and who would capture the images necessary?

2. How would the captured images be collected?

3. How would the collected images be processed?

The first question is easily answered. Anyone with a camera phone of decent quality could contribute to this. However, the second and third questions—data collection and processing, are more tricky. Acquired data could be uploaded to a remote server, but as is often the case in such disaster sites, connectivity would be a problem. Also this method could take a while, especially if a centralized server node is not already set up. Images could be processed locally, but mobile devices are typically not equipped with enough resources to carry out such operations (individually). Let us now consider the possibility of employing a local mobile cloud for the aforementioned scenario. In this case, photographs taken by various individuals would constitute the data against which the missing persons will be matched. Relief workers and communities working together at the disaster site could collaboratively 'lend' their mobile devices' storage and processing resources to a ‘local mobile cloud, that could effectively carry out the image processing needed to identify the missing persons. A key challenge here is the fact that the number of, and the type of available resources cannot be known or predicted beforehand. How then, can the work be efficiently distributed and load balanced? Furthermore, in such situations it most likely that devices will encounter other unknown nodes, rather than familiar devices. Therefore, it is important that the mobile cloud be able to give a performance gain even without prior information. The aforementioned scenario is only one example demonstrating the need for a mobile cloud computing framework. In wearable computing, two major challenges are to reduce the bulkiness of systems for everyday use and not having enough battery power [5]. This could be solved by offloading/sharing the computational jobs to the local ‘mobile cloud’, while sensors and peripherals facilitate the pervasive experience for the user. In the area of augmented reality, it has been suggested that using cloud resources [6] can solve similar problems. In biomedical engineering, wearable medical devices forming Body Area Networks (BANs) can enable real time collection and analysis of patients’ medical data [7].

3. Various Issues Related to Mobile Cloud Computing and their Solutions:

The mobile usage of cloud computing services is still in the early stages of development and several open issues need to be addressed. With the mobility of users and their devices, several problems arise that need to be taken into account, when making use of cloud computing services on mobile devices.

1. Mobility and resource discovery

The first being, that cloud computing resources are widely spread around the globe and offer a lot of different services to their users. Mobile devices that want to make use of those resources should be able to automatically discover cloud computing resources that preferably are nearby their current location.

2. Mobility and cloud session connectivity

Another problem to face is the fact that mobile devices are not always connected to a network because of dead spots or other influences, resulting in unreachable cloud computing resources [8]. Related to that is the fact that connectivity with remote cloud computing resources can suddenly disappear [8].

Furthermore, network addresses of mobile devices can change over time, due to different regional address assignments, resulting in a need for topology-agnostic identification of connections.

3. Program-technical characteristics

Offloading of computation to remote resources is a technique that requires additional effort and skills of application developers, as applications possibly need to be adjusted accordingly [8]. To make full use of remote resources, it might for example be necessary that parts designed for remote execution need to be different from their local complements, as they need to make use of parallelization, which also demands additional skills from developers.

4. Overhead due to use of cloud

Along with the remote execution of application parts comes the problem that those parts need to be transferred to the cloud resource first, before an execution can take place. The overhead produced by this transfer also needs to be taken into account, when dealing with computation offloading and possibly related time and energy savings.

5. Reliability

The ability of the cloud computing system to perform and maintain providing its resources under unexpected failures, of e.g., storage, network connectivity and computing power, for a supported predefined amount of time. This ability can be by

e.g., (1) supporting replication of objects and services, (2) using redundant communication (more than one communication paths used for the dissemination of the same information), (3) using redundant processing (more than one processing entities used to process the same action).

6. Scalability

The ability of the cloud computing system to expand the amount of resources and services to large scales to satisfy rapid increases in service demand. This ability can be satisfied by e.g., (1) support for massive sharing of content, (2) flexible, fault-tolerant and distributed data bases, (3) fast and consistent content replication support.

7. High availability

The ability of the cloud computing system to provide and support a large amount of different resources that are easily accessible and that are operating in optimal performance conditions for a predefined agreed amount of time.

8. Security and privacy

The ability of the cloud computing system to protect itself and its provided resources from security and privacy attacks. Different security and privacy aspects need to be considered when running foreign code on remote resources that maybe also used by several users at the same time [8]. The main security solutions are e.g., related to (1) data integrity, where the unauthorized modification of information incoming and outgoing the cloud should be detected, (2) confidentiality to secure the data access and transfer. The main privacy solutions should ensure that the identity of the cloud computing clients should not be revealed to unauthorized entities.

5. Conclusion:

Mobile cloud computing aims to empower the mobile user by providing a seamless and rich functionality, regardless of the resource limitations of mobile devices. Although still in its infancy, mobile cloud computing could become the dominant model for mobile applications in the future. Thus we have given an extensive survey of current mobile cloud computing research in this paper. Highlighting the motivation for mobile cloud computing, we have also presented different definitions of mobile cloud computing in the literature.

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