Selection Virtual Machine in Mobile Cloud Computing

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Abstract. The article analyzes the advantages of mobile cloud technologies and problems emerging during the use of those. The network infrastructure created based on cloudlets at the second level of mobile cloud computing with hierarchical structure is analyzed. At the same time, the article explores the issues of satisfaction of demand of mobile equipment for computing and memory resources by using these technologies. The article presents one solution for the allocation of mobile user requests in virtual machines created in cloudlets located near base stations of wireless metropolitan area networks (WMAN) in a balanced way by considering the technical capacity of those. Alongside, the article considers the solution of user problem during designated time and the issue of determining virtual machines satisfying other requirements. For this purpose, different characteristics of the stated problem, virtual machines, as well as communication channels between a user and virtual machines are considered. By using possible values determining the importance of cloudlets, conditions for loading software applications of a user to a virtual machine are explored and an appropriate method is proposed.

Key words: mobile clouds computing, mobile equipment, computation and memory resources, cloudlet, virtual machines, cloud computing, communication channel, trustworthiness.

I. INTRODUCTION

Mobile users have started to use the services of cloud computing technologies broadly in recent period. The article considers the issues of more efficient use of cloud computing resources by using Mobile Cloud Computing technologies widely used recently. The rapid growth of the use of mobile equipment (notebook, tablet, smartphones, etc.) technologies in the world and connection to the Internet via corresponding telecommunication technologies (GPS, 3G, 3G, Wi-Fi, etc.) has boosted the development of new technology – mobile Cloud Computing technology. It is known that, although the capacity of any mobile device (computing and memory resources) is limited, users employ these devices for the solution of problems requiring large computational and memory resources. For this purpose, cloud computing technologies are broadly employed. Thus, it is possible to eliminate the limitations of computing and memory resources existing in mobile user devices by using cloud technologies [1].

In comparison with traditional wired network, mobile computing networks encounter several problems: the loss of signal in wireless communication channel, low transmission capacity of a channel, security, delays while connecting to network, limited resources, low computational performance, etc. Moreover, the geography, climate, etc. of the location of base stations affect the quality of services (QoS) provided by mobile cloud computing.

II. PROBLEMS IN MOBILE CLOUD COMPUTING

One of the main problems of mobile cloud computing emanates from the limitations of features of mobile software and wireless network, as well as their capacity regarding computational and memory resources. These problems challenge the development of applications and their exploitation in mobile devices. The limitations in technical capacity of mobile devices in mobile cloud computing environment, the quality of wireless communication, the variety of applications are important factors affecting the evaluation of cloud computing. In order to facilitate a specific environment for Cloud Computing in mobile applications, various stages of mobile infrastructure must be taken into consideration causing the overload of a network and transmission delays.

Mobile cloud computing is a new platform developed from the combination of mobile equipment and cloud computing and allows the users to implement the solutions of complex problems and the storage of large-volume data in memory.

By using cloud computing services, users can implement the solution of any problem. The recent decrease in the price of cloud servers facilitates the broad use of cloud computing services by mobile users. At present, numerous companies (Google, Gmail, Maps and Navigation systems for Mobile, Voice Search, Mobil Me from Apple, Live Mesh from Microsoft) develop several software add-ons for mobile device users, which allows the broad use of mobile cloud computing by users [2].

At present, users extensively utilize three types of cloud services (IaaS, Paas and SaaS services). IaaS (Infrastructure as a Service) service allows users to use computing and memory resources of cloud systems. PaaS service is a platform facilitating the use of operation systems located in virtual servers and customized program add-ons by users. The users of SaaS service can solve their problems by using the software located in cloud computing servers. There exist some studies devoted to the analysis of separate characteristics of these services [3-5]. At present, millions of mobile users broadly utilize mobile add-ons (mobile commerce, mobile education, mobile health, mobile games, etc.) by using the services mobile cloud providers [6-8]. The developed mobile applications are not dependent on the operation systems of mobile devices and the type of a device. Hence, the number of users utilizing the services of cloud technologies is rapidly growing day by day.

The provision of high quality services of cloudlets near base stations depends on the technical capacity of computer equipment used in the development of those (the intensity of processor functioning, the number of cores and virtual machines, memory volume, transmission capacity of network,

etc.). It is because the technical capabilities of cloudlets must allow the loading of software applications utilized by a user. On the other hand, it is possible to satisfy extensive computing and memory storage requirements by using traditional centralized cloud services. However, delays occur in these cloud services while obtaining results or data. Hence, it is more desirable that, software is located in cloudlets near the users utilizing them and the rapid solution of the issue is facilitated in real time regime. At the same time, while users utilize SaaS service, locating the required software in cloudlets near the users allows to provide cost-efficient, rapid and high quality services.

While using cloud technologies, the users base their judgment on following criteria [9]:

- minimization of costs required for problem solution;
- minimization of time of problem solution;
- reliability of communication channels;
- provision of the security of user information;
- rapid and reliable delivery of data and outcomes to users;
- more rapid use of online software add-ons, etc.

The limitations of technical capabilities of mobile devices in mobile cloud computing environment, the quality of wireless communication, the variety of applications are important factors affecting the efficient use of cloud computing services [10].

Limitations of the capabilities of mobile devices: the limitations in the resources of mobile devices must be taken into consideration while developing software applications for users in cloud environment. By the resource scarcity of mobile devices, the restrictions in their computational and memory resources are considered. Despite the improvement of several parameters of processor and memory resources of mobile devices, such as the screen size, wireless communication, sensor technologies and operation systems, serious problems are encountered during the use of energy sources and the exploitation of complex software applications requiring large computational and memory resources. The energy capacity of mobile devices is based on the batteries with limited energy storage used by these devices and hence, there emerges a need to extend the lifecycle of the batteries of mobile devices. The larger the execution of software application in clouds, the lower the energy consumption in mobile devices will be [11].

Cloud technologies are used in order to extend the lifecycle of the batteries (energy saving). When software extensions requiring large computational and memory resources are solved in mobile devices, the processor and memory resources of mobile devices participate in the solution of indicated problems at full capacity. This causes the rapid battery discharge. Cloud technologies are used for eliminating this issue. That is, the problem solution is executed in clouds and mobile device acts as a terminal in this case. As a result, it allows for longer use of the battery of a mobile device.

Quality of wireless communication*:* unlike the wired networks employing physical connection tools providing fixed coverage, the environment of information transfer constantly changes in mobile cloud computing environment. Moreover, data processing centers of cloud computing services are usually located far from users and this creates problems while obtaining the results rapidly. Numerous delays occur due to the use of wireless connection channels and at the same time, the transmission capacity of networks decreases. In addition, interruptions often occur in wireless networks (due to weather condition, geography of location, etc.). Considering the abovementioned, cloud servers must be located in the vicinity of base stations close to users in order to avoid such problems. Several measures can be adopted in order to eliminate network delays [12]. The closer the applied software are located to users, the lower the number of delays in network will be, as the delays occur depending on the distance. The closer located the servers hosting large-volume software extensions (data), such as video and translation software requiring large computational and memory resources to mobile device, the better the coverage and less the number of delays will be. Similar situation can also be attributed to the translation software in real time and the problem of delay can be easily addressed. Thus, service providers can improve the coverage efficiently by basing on the location and cashing the capacity logically, and restructuring the internet path.

Division of applied software: Mobile devices are not capable to use software requiring large computational and memory resources or high energy consumption is needed while using this type of software due to the problem of limited resources of mobile devices. For this purpose, software tools are divided into several parts and those use the resources of mobile cloud computing. The main computational part of software is processed by cloud; mobile devices only solve some simple problems. The requirements for the characteristics of cloud infrastructure, such as mobile device, network coverage and delay vectors determine whether the software add-ons will be supported by particular mobile cloud infrastructure. The main approach to mobile cloud convergence is the division of applied software into such parts that the parts requiring larger computations would function in cloud and other parts related to user interface would operate in a mobile device [13].

So, the factors affecting the efficient use of cloud services in mobile cloud computing are as follows:

- location of data centers of cloud computing system far from user;
- overload of internet network;
- occurrence of delays in network;
- occurrence of interruptions in communication channels;
- short lifecycle of batteries of mobile devices;
- functioning of software applications (Aps) in online regime;
- use of cloudlets with various technical capacity in network;
- non-optimal location of user requests in cloudlets, etc.

The following strategies are considered to be employed for solving the above-mentioned problems:

- development of network infrastructure based on cloudlets;

- locating the cloudlets in necessary locations in network;
- locating the software applications in cloudlets close to users in order to reduce the number of delays;
- determination of computational and memory resources of cloudlets;
- selection of virtual machines in cloudlets corresponding to the requirements of users;
- utilization of minimal communication channel between user and cloudlets;
- location of software applications with high frequency of use in cloudlet network in advance;
- clustering of cloudlets in accordance with services (IaaS, PaaS, SaaS, etc.) used in those cloudlets;
- organizational issues of inter-cloudlet information migration, etc.

The article reviews balanced solution for the allocation of mobile user requests (tasks or software applications) in virtual machines placed in cloudlets located near the base stations of Wireless Metropolitan Area Networks (WMAN) taking into account their technical capacity. Section 2 reviews related works on the development of hierarchically structured network infrastructure based on cloudlets.

As the user requests demand various volume of computational and memory resources, the issue of appropriate allocation of requests in cloudlets used in network is deemed as a topical problem.

III. PROBLEM STATEMENT

It is known that, various architectures have been proposed for the facilitation of the efficient use of clouds. MCC-based architecture has been proposed for the efficient use of cloudlet resources by using resource management center (RM-Resource Manager). As users access cloud software they connect to proposed RM initially, thereafter, that center connects them to corresponding cloud resource during a short period and a mobile user easily connects to cloud software [12]. MCC architecture is given in Figure 1. Mobile devices connect to mobile networks via base stations (for instance, base transmitter station – 3G/4G, access point Wi-Fi, etc.) establishing functional interface and connections (air connections) between network and mobile devices and managing those connections. Requests and information of mobile users (for instance, ID and location) are transferred to Resources Management Center (central processors connected to server) providing mobile network services. Here, mobile network operators can provide services to mobile users, such as home agent (HA) stored in databases and AAA (authentication, authorization, and accounting) services based on subscriber information. Thereafter, the requests of subscribers are sent to a server of Resource Manager Center of proposed model providing the connection via Internet, and a connection is established with corresponding cloud via internet here. Management center stores information regarding computer equipment (server, desktop, notebook, etc.) used during cloud development. At the same time, information is gathered on technical capabilities of cloudlets in manager centers (performance intensity of processor, number of processor cores, and number of virtual machines and their technical characteristics, memory volume, etc.) and on which cloudlets users are located close to in mobile network. Hence, it is among problematic issues to determine on which cloudlet and virtual machine a software application must be located, which satisfies the user requests based on received requests. The article is devoted to the efficient allocation of software applications in cloudlets selected in accordance with the user requests.

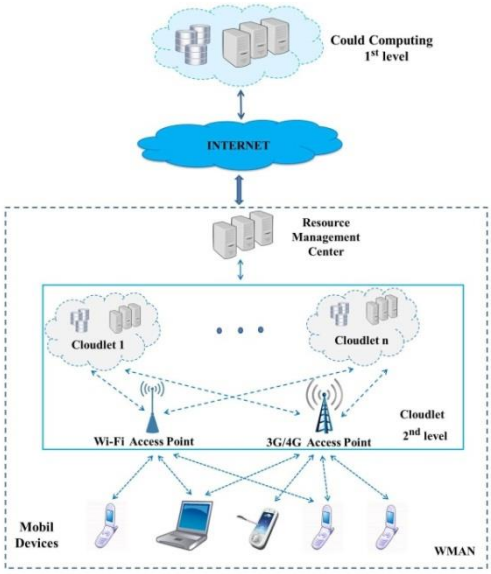

Figure 1. MCC structure scheme

Users often select the type of a virtual machine not corresponding to the resources required by a problem to be solved. The requirements for the characteristics of cloud infrastructure such as mobile device, network coverage and delay vectors determine whether software add-ons will be supported by particular mobile cloud infrastructure (Table 1).

TABLE 1.

Program applications	Computational intensity (performance)	Network transmission capacity	Network delays
Web mail	low	medium	high
Social networks (Facebook)	low	medium	medium
Use of web pages	low	low	high
Online games	high	medium	low
Face recognition	high	medium	low
HD format video data	high	high	low
Translation software	high	medium	low

Table 1 describes the requirements posed to the computational intensity of a particular type of problem, network transmission capacity and network delays. As users utilize web-mail or social networks, they do not pose particular requirements to large computational resources (low), network transmission capacity (medium) and network delays (high). However, assume that, if a user uses biometric recognition, HD video data, online games, translation and navigation software, solid requirements are posed to above-mentioned attributes of cloud infrastructure. High definition and content applications, such as face recognition in real time require the networks with large coverage area and low delays such as LTE. This, in turn, provides the transmission of

algorithms required for face recognition, large images operating in cloud servers to user devices rapidly and without problems. The environment of high transmission capacity and low number of delays for software requiring high volume of transmission can be achieved by using data centers located in the vicinity [14].

Hence, the satisfaction of multiple user requests and resource requirements with various volume and their location in optimal cloudlets and virtual machines are among topical issues. The majority of studies conducted in Mobile Cloud Computing technologies field is devoted to the issues of efficient processing of the user requests in farther located cloud servers [15-16]. The loading of internet network in centralized Cloud Computing systems is less rapid due to the increase in delays of the user requests in communication channels (in internet networks, internet providers, among base stations, etc.). For this purpose, abovementioned delays can be eliminated (reduced) by establishing cloudlet networks closely located to users. At the same time, the cloudlets process the requests rapidly and provides less energy consumption of mobile devices as well.

Delays can be reduced by providing the solution of the user requests in closely located cloudlets and decreasing the number of communication channels between in the number of inter-cloudlet connections. Energy consumption, delays and interruptions can be reduced by the appropriate allocation of auxiliary (interface) and min parts of software applications utilized by users in mobile devices and cloud servers in a corresponding manner [16].

Therefore, the article proposes a solution of the issue of selecting virtual machines capable of providing the more rapid solution of a problem in accordance with user requirements by employing technical capacity of cloudlets and virtual machines created in cloudlets.

IV. CONCLUSION

The article proposed a solution of a problem of allocation of mobile user requests in virtual machines by considering the technical capabilities of virtual machines created in cloudlets located near bases stations of wireless metropolitan area networks. The features of user problem and virtual machines were explored while solving the problem.

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