CONFERENCE PROCEEDINGS

20-22 September 2017, Moscow, Russia

www.aict.info/2017

CONFERENCE PROCEEDINGS

2017 IEEE 11th International Conference on Application of Information and Communication Technologies (AICT)

IEEE Catalog Number: CFP1756H-PRT
ISBN: 978-1-5386-0500-4

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IEEE Catalog Number: CFP1756H-PRT
ISBN: 978-1-5386-0500-4

2017 IEEE 11th International Conference on Application of Information and Communication Technologies (AICT) is financially supported by the Russian Foundation for the Basic Research, proiect #17-08-20518.

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EFFECTIVE USE METHOD OF CLOUDLET RESOURCES BY MOBILE USERS
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Effective Use Method of Cloudlet Resources by Mobile Users

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***Abstract* - The paper presents the solution of the linking problem of cloudlets located in the proximity of base stations of wireless metropolitan area networks (WMAN). The study also determines the number of communication channels among cloudlets for the purpose of effective utilization of cloudlet resources. The issue of uploading necessary program extensions to a corresponding cloudlet by using the possible number specifying the importance of cloudlets was investigated and a method was proposed.**

Key words: mobile computation clouds, mobile devices, computation and memory resources, cloudlet, computation clouds, communication channel, cloud services

I. INTRODUCTION

At present, comprehensive research is being carried out on the efficient use of computing and memory resources of data processing centers by the means of Cloud Computing technologies in the world. Such systems executing large computations and possessing memory resources are created on the basis of computer networks with high-speed communication channels. Cloud Computing technology enables the more efficient use of computing and memory resources of processing centers of organizations. User information is stored in servers of computing clouds, processed and the view of results is provided via browser concomitantly by the means of such technologies [1,2]. Cloud Computing service enables the widespread use of clustering and virtualization of computing and memory resources of processing. Recently, mobile users have started to use the services of cloud computing technologies broadly [3]. ?

The paper studies the issues of more efficient use of resources of computing clouds by employing mobile Cloud Computing technologies widely used in recent period. The rapid expansion of the use of mobile devices (laptops, tablets, smartphones etc.) and connection to the internet via corresponding telecommunication technologies (GPS, 3G/4G, Wi-Fi, etc.) has given an impetus to the development of mobile Cloud Computing technology. It is known that, the capabilities of any mobile device (computation and memory resources) are limited. However, users apply these devices during the solution of problems requiring large computing and memory resources. For this purpose, cloud computing technologies are used broadly. Hence, limitations of computing and memory resources in mobile user devices can be eliminated by employing cloud technologies.

II. PROBLEM STATEMENT

As mentioned above, the number of mobile users using cloud technologies, as well as game users increases rapidly. It is to denoted that, the interest for intellectual games is related to specific intellectual needs of users and serves to the improvement of their intellectual capacity [4]. Works affecting such games are being rapidly carried out in recent periods [5, 6]. As other software tools operating in online regime (translation, navigation software, etc.), games require the presence of an interface with high speed as well. The solution of such problems necessitates the application of cloudlets. In recent period, the majority of conducted research works is devoted to the solution of the issue of cloudlets use [7]. The life cycle of cloudlets was analyzed and some necessary quantitative features were investigated [8, 9]. While working with software tools interactively used in online regime, the issue of development of time diagrams of realization of requests are solved [10]. Some authors have considered the migration problem of services in mobile clouds and some disadvantages of this method have been indicated [11]. In order to carry out this process, a simple algorithm can be constructed by considering the frequency of requests to software tools [12]. Any software tools stored in such a way can be deleted from memory resources of cloudlets when there emerges a need for storing software tools with higher priority.

Each cloudlet can play a role of a mobile user for some other cloudlets which can be connected via mobile communication. It can carry out the solution of problems in cloudlet for which it plays a role of a mobile user or can connect the mobile with the required cloudlet when necessary. This situation creates new opportunities for solving the issue of uploading and storing above-mentioned Online software tools in cloudlet. It is possible that, software tool to be uploaded is already uploaded to one of the neighboring cloudlets and available for use or this software tool can be uploaded to another cloudlet and used.

The article presents the investigation of some characteristics of the solution of this problem and the maintenance of effective use of cloudlets.

III. PROBLEM SOLUTION

Denote the network infrastructure, the cloudlet storing Online software tool or software tools and other cloudlets that the cloudlet can easily connect with mobile tools as network of cloudlets. It is assumed that, each of the cloudlets on the network is capable to communicating with each other. Let's assume that, N is the number of cloudlets in the network. Each cloudlet can directly communicate with N-1 number of other cloudlets.

Denote the software extension required for use by mobile users as PA_s. Assume that, a mobile user connected to i^{th} cloudlet will use this software tool. Denote existing vacant memory space for storing new tools in i^{th} cloudlet as $V_e(i)$ and the memory space required for a software tool (PAs) to be used as $V(PA_s)$. It is clear that, in a simple case, if

$$V(PA_s) < V_e(i) \quad (1)$$

is satisfied, a new software tool can be stored in i^{th} cloudlet. If (1) condition is not met, PA_s software tool required to be stored can be stored in one of the cloudlets located at the same network as i^{th} cloudlet.

Assume that, a set of software tools stored in i^{th} cloudlet is $PA(i) = \{PA_{i1}, PA_{i2}, \dots, PA_{i,i_k}\}$ set. This set can be corrected as software tools that are added or removed and transmitted to other cloudlets at the same network. Hence, a set of software tools located at the same network can be expressed as

$$PA = \bigcup_{i=1}^{N} PA(i) \quad (2)$$

If a cloudlet is found to satisfy

$$PA_s \in PA = \bigcup_{i=1}^{N} PA(i) \quad (3)$$

then, a mobile user intending to use with PA_s software tool can be connected with those cloudlets. A problem can have such a technical solution that, a mobile user would not notice the realization of this procedure.

If (3) condition is not satisfied, the following algorithms can be applied.

The practical number of routes connecting two cloudlets can be calculated directly and by taking the number of intermediate cloudlets maximum as 2 as below [13]:

$$M = A_{N-2}^0 + A_{N-2}^1 + A_{N-2}^2 = \frac{(N-2)!}{(N-2)!} + \frac{(N-2)!}{(N-3)!} + \frac{(N-2)!}{(N-4)!}$$

$$M = N^2\text{-}4\text{N}+5 \quad (4)$$

In order to apply this formula, $N \geq 3$.

While the length of routes is corresponding to the number of connections included in routes, the length can be taken as equal to the number of connections for simplicity. Given that, we have taken the maximum number of intermediate cloudlets as 2 in formula (4), the minimum and maximum number of connections in routes linking two cloudlets can be 1 and 3, respectively. Hence, the maximum number of intermediate cloudlets can be 2 for practical purposes. That is:

It's denote the number of connection channels at $m^{th}(m \in [1, M])\ route\ as\ r_m$. In this case, $1 \leq r_m \leq 3$. Routes connecting ith cloudlet to j[th] cloudlet can be denoted as $m^{ij}(m^{ij} \in [1, M])$ and the number of connections in these routes as r_m^{ij}. The probability of transmission of connections included in each of these routes are selected from p_l ($l \in [1, L]$) and can be specified as $p_m^{ij}(k), (k = 1, \dots r_m^{ij})$. While calculating the probability of connection linking i[th] and j[th] cloudlet, the following must be considered:

Each route of connection ij is the sequential link of communications. Hence, transmission probability of $m^{ij}(m^{ij} \in [1, M])$ route can be calculated as $p_m^{ij} = \prod_{k=1}^{r_m^{ij}} p_m^{ij}(k)$;

It is assumed that, routes in connection ij connect i^{th} cloudlet and j[th] cloudlet in parallel. So, the final probability of transmission is:

$$p^{ij} = 1 - \prod_{m=1}^{M}\left(1 - p_m^{ij}\right),\ i \neq j. \quad (5)$$

While solving the issue of locating software tool to any cloudlet, potential cloudlets must be evaluated by i^{th} cloudlet. During evaluation, quantitative and qualitative features of a cloudlet must be taken into consideration. For this purpose, fuzzy and other methods can be applied. We do not consider the evaluation problem mentioned above. However, it is clear that, such evaluation can be conducted intuitively. Hence, this value can be considered as integral value of a cloudlet and denoted as $IC(j)$ for each cloudlet.

While determining the significance of any cloudlet on this network for problem solution, $IC(j)$ must be multiplied to p^{ij} probability of transmission of ij connection. This product will consider the significance of cloudlet, as well as the quality of connection. A cloudlet with large $p^{ij} * IC(j)$ product and satisfying condition (1) can be selected.

So, PA_s software tool can be located in j[th] cloudlet co-located with i[th] cloudlet on the same network and satisfying the following conditions:

$$\begin{cases} p^{ij} * IC(j) = max\{p^{iz} * IC(z)\}, z \neq i, j \neq i \\ V(PA_s) < V_e(z), z \neq i \end{cases} \quad (6)$$

So, the requested software tool can be uploaded to j[th] cloudlet satisfying condition (6) and mobile users requiring to work with this software tools can be connected to that cloudlet. Thereafter, a set of software tools of j[th] cloudlet can be corrected and sent to other cloudlets. As a result, cloudlets located at one place can process the request of mobile users more effectively.

IV. CONCLUSION

The article presents a method for maintaining the effective realization of requests of mobile users utilizing the cloudlets. In this case, the cloudlets in networks are defined and the set of such cloudlets are specified. A solution is proposed for the

problem of uploading online software tools frequently used by mobile users to one of the cloudlets located on the network and the connection of mobile user with specific cloudlet. For this purpose, the practical number of routes are specified creating a link between two cloudlets on one place. The probability of routes and the whole connection is determined by using transmission probabilities between two cloudlets. The conditions for uploading necessary software tools to a specific cloudlet is determined by using these probabilities and possible values specifying the importance of cloudlets.

The method and obtained results in the article can be used for the solution of similar problems in local networks.

ACKNOWLEDGMENT

This work was supported by the Science Development Foundation under the President of the Republic of Azerbaijan – Grant № EİF-2014-9(24)-KETPL-14/02/1

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