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Mobile Cloud Computation Offloading Switch Based on Decision Value Model

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Abstract

A method had been constructed for mobile cloud computation offloading switch based on decision value model. In this method, two important ratios had been built: one is the calculation ratio which are offloaded on a proxy server completed tasks time and at the mobile node completed tasks time. Another is the calculation ratio which is offloaded on proxy server completed tasks energy and at the mobile node completed tasks energy. And then, decision value function was produced by combining with these two ratios. Finally, consider the optimization switch problem of computing tasks between different proxy servers. Experimental results show that the proposed method has a smaller time consumption and energy consumption by comparing with random offloading switch and minimum time-based offloading switch, and battery remaining of mobile node can be used rationally.

Keywords*: mobile cloud computing, decision value function, offloading switch, time consumption, energy consumption*

1. Introduction

Mobile cloud computing refers to use mode of IT resource service through mobile network with on-demand, easy to expand the way of obtaining needed for the infrastructure, platform and software [1]. Mobile terminals via a wireless network will be a computationally intensive task offloading to operate on the private cloud that is connected with wireless network, and through the dynamic migration technique will migrate operational task in different mobile cloud services network in order to achieve the most effective mobile cloud service application [2].

Task allocation and network switch decision based on utility value, compared with the classical multiple attribute decision; more effectively reflect the needs of the user's QoS. Network switch can also be integrated network requirements with user applications. Therefore, it has relatively good applied foundation [3]. Kassar presented an overview of which a single mobile user carried out network switch decision in a mixed network. The thesis mainly states fundamental issues of many available under the environment of network carried out the single network choices decision [4]. Nguyen focus on how to help users to make the network selection decision, and he constructed a framework of a mobile terminal in the network switch, with the lowest cost for the goal of building a network selection strategy [5]. Nimmagadda described network switch policy carried in the hybrid network of heterogeneous. This strategy can make the users in the network selecting the optimal network and set up the switch to start time, the evaluation index is each network bandwidth and energy consumption performance attributes [6]. Chun presented an intelligent decision model in terms of the vertical switch, this proposed model dependent a series of utility function model and the structure of these models can take into account available network battery energy consumption and transmission completion time [7]. By using two different strategies, Papazachos carried out auctioned mechanism. At the same

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time, he proposed the concept which can choose better network switch decision at lower service cost based on a higher of user preferences on the switching decision [8]. Fernando applied user habitual choice for overhead which is constructed based on the user's utility function. This utility function is proposed based on user behavior decision theory. By using this utility function, optimization models were developed with different network source management [9]. Shi considered the heterogeneous network environment characteristics of "optimal connection", and proposed network switch decision method to take the user as the center. Through the identification of heterogeneous network, the optimal network switch can be selected for different user application needs [10].

In this paper, a decision value model was constructed in order to obtain better effect for the offloading and switch in mobile cloud computing.

2. Decision Value Model of Mobile Cloud Computing

2.1. Offloading Tasks

Before distributing the computing tasks which have been offloaded, resource information need be collected for mobile terminal itself and alternative proxy server network. These resources information can be applied for the next task division and offload distribution. Because the related information can be received from the wireless network and proxy server connected with wireless network by all kinds mobile terminals, these terminals can realize rational division of computing task and select appropriate wireless network to offload task.

To local resource and resource on proxy servers, computing validity and effectiveness of energy consumption are defined respectively as follows:

Computing validity: it is the ratio between whole time which computing task was offloaded on proxy server and computed and whole time which computing task is computed on mobile terminals.

Effectiveness of energy consumption: it is the ratio between energy consumption which computing task was offloaded on proxy server and computed and energy consumption which computing task is computed on mobile terminals.

By obtaining computing validity and effectiveness of energy consumption of every task, best order can be arranged.

A. Computing validity

Firstly, define t_i^{mobile} as complete time which computing subtask T_i is implemented on local mobile terminal. The formula is shown as (1).

$$t_i^{mobile} = \frac{C_{T_i}}{C_i^{mobile}} \tag{1}$$

Where, C_{T_i} represents computation amount to perform subtasks, and its unit is million instructions; C_i^{mobile} represents the computing power of the mobile terminal, its unit is millions of instructions per second.

Then, define $t_{i\to j}^{unload}$ as complete time which computing subtask T_i is offloaded and computed on proxy server N_j. Calculation formula is shown as (2):

$$t_{i\to j}^{unload} = \frac{T_i^{up}}{B_j} + \frac{C_{T_i}}{C_{N_j}} + \frac{T_i^{down}}{B_j} \tag{2}$$

Where, $\frac{T_i^{up}}{B_j}$ represents the time which a task is uploaded to the network, $\frac{C_{T_i}}{C_{N_j}}$ represents the time which the task T_i is uploaded and computed in proxy server network, $\frac{T_i^{down}}{B_j}$ represents the time which the task is downloaded from the network.

At this point, average time can be computed that sub-tasks T_i is downloaded and computed on all proxy servers networks. The formula is shown as (3):

$$\bar{t}_{i\to j}^{unload} = \frac{1}{n}\sum_{j=1}^{n}\left(\frac{T_i^{up}}{B_j} + \frac{C_{T_i}}{C_{N_j}} + \frac{T_i^{down}}{B_j}\right) \tag{3}$$

Now, we can obtain a ratio which is computed by t_i^{mobile} and $\bar{t}_{i\to j}^{unload}$. The formula is shown as (4):

$$\lambda = \frac{\bar{t}_{i\to j}^{unload}}{t_i^{mobile}} \tag{4}$$

If $\lambda > 1$, it shows that the time is less when computation is executing on mobile terminal; If $\lambda < 1$, it shows that the time is less when computation is executing on proxy servers.

B. Effectiveness of energy consumption

Let E_i^{mobile} represents power consumption that T_i is completed on mobile terminal. Calculation formula is shown as follows:

$$E_i^{mobile} = e_{mobile} \times C_{T_i} \tag{5}$$

Where, e_{mobile} represents energy consumption that millions of instructions implemented on the mobile terminal.

When computing tasks T_i is offloaded on the proxy server network N_j, power consumption is $E_{i\to j}^{unload}$. Calutation formula is shown as(6):

$$E_{i\to j}^{unload} = (T_i^{up} + T_i^{down})e_j \tag{6}$$

Where e_j represents energy consumption when unit data changes between N_j and mobile terminal.

At this point, average energy consumption can be computed that sub-tasks T_i is downloaded and computed on all proxy servers networks. The formula is shown as (7):

$$\bar{E}_{i\to j}^{unload} = \frac{1}{n}\sum_{j=1}^{n}\{(T_i^{up} + T_i^{down})e_j\} \tag{7}$$

Now, we can obtain a ratio which is computed by E_i^{mobile} and $\bar{E}_{i\to j}^{unload}$. The formula is shown as (8):

$$\varepsilon = \frac{\bar{E}_{i\to j}^{unload}}{E_i^{mobile}} \tag{8}$$

If $\varepsilon > 1$, it shows that energy consumption is less when computation is executing on mobile terminal; If $\varepsilon < 1$, it shows that energy consumption is less when computation is executing on proxy servers.

C. Decision value function

At this point, for each of computing tasks $\{T_i\}$ which implemented on the mobile terminal, we can obtain a time value function and an energy consumption value function such as formula (9) and formula (10).

$$v_{\lambda_i} = \frac{\lambda_i^{\min} - \lambda_i}{\lambda_i} \tag{9}$$

Where, $\lambda_i^{\min}$ represents minimum computation time ratio of all the computing tasks.

$$v_{\varepsilon_i} = \frac{\varepsilon_i^{\min} - \varepsilon_i}{\varepsilon_i} \tag{10}$$

Where, $\varepsilon_i^{\min}$ represents minimum energy consumption ratio of all the computing tasks.

So, we can construct a total decision value function in order to judge priority whether subtask should be offload on proxy server. This function is shown as formula (11).

$$v = \theta v_{\lambda_i} + (1-\theta) v_{\varepsilon_i} \tag{11}$$

Where, θ represents the weight of the time value which can be computed according to importance degree of time and energy consumption. In this paper, we take time and energy as the same. So θ is set to 0.5.

2.2. Optimization Switch

When offloading tasks running on proxy server, mobile user need consider whether this task should be switch better network.

Similar with forced switch, let tasks T_i run on the original proxy server network N_k, then let $\tilde{S}_{i\to k}$ express whole consumption which is shown as formula (12).

$$\tilde{S}_{i\to k} = \overline{C}_{T_i} M_k + \overline{T}_i^{down} N_k \tag{12}$$

Where, M_k and N_k are economic consumption that millions of instruction implemented on the proxy server network N_k or mobile terminal.

Then, compute economic consumption $\tilde{S}_{ik\to j}$ which computing task switches from N_k to N_j. The formula is shown as (13):

$$\tilde{S}_{ik\to j} = \overline{T}_i^{up} S_{kj}^{migrate} + \overline{C}_{T_i} M_j + \overline{T}_i^{down} N_j \tag{13}$$

Define ρ as migration gains of the optimal migration and σ as migration consumption:

$$\rho = \tilde{S}_{i\to k} - (\overline{C}_i M_j + \overline{T}_i^{down} N_j) \tag{14}$$

$$\sigma = \overline{T}_i S_{kj}^{migrate} \tag{15}$$

If $\rho \le \sigma$, it is show that migration is invalid.

If $\rho > \sigma$, it is show that migration should be carried out.

3. Experiment and Analysis

In order to verify the validity of the method in this paper, we carried out the following experiment study. First, set scene of simulation experiment as shown in figure 1.

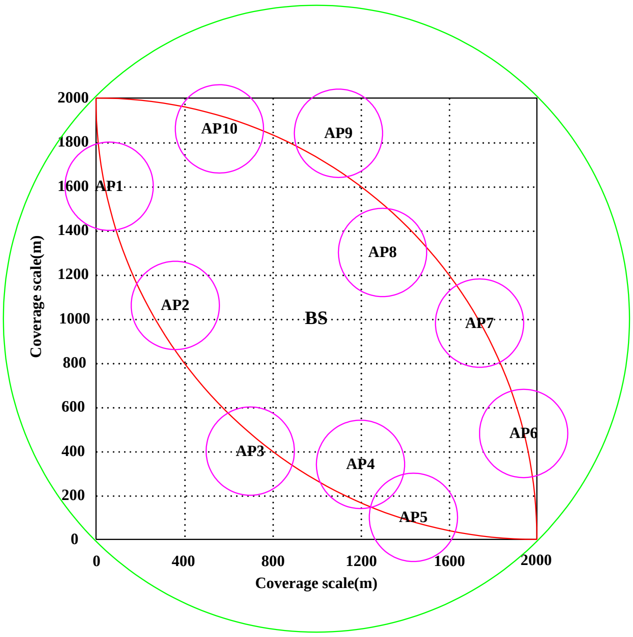

Figure 1. Scene of Simulation Experiment

In the figure 1, the base station BS is located in the central position of scene, and its coverage radius of circular area is 2000 m. Besides, 10 AP hotspots is random configuration and they are distributed in the two connecting arc near of the rectangle diagonal point. Coverage area of each hotspots AP is a 200m radius of circular area is.

Select Samsung's Note3 as mobile terminal platform. This phone supports 3G network and WLAN's hotspots AP meanwhile.

In order to verify the validity of this method, we chose two comparison methods: one is random selection method, and another is time-minimized consumption method.

In the process of experiment, three contents had been compared. First, time consumption is compared along with increasing of sub-tasks; Second, time consumption is compared along with increasing of proxy serve; Third, energy consumption is compared along with changing of battery remaining of mobile terminal. Three experiments are shown in figure2, figure3, and figure4.

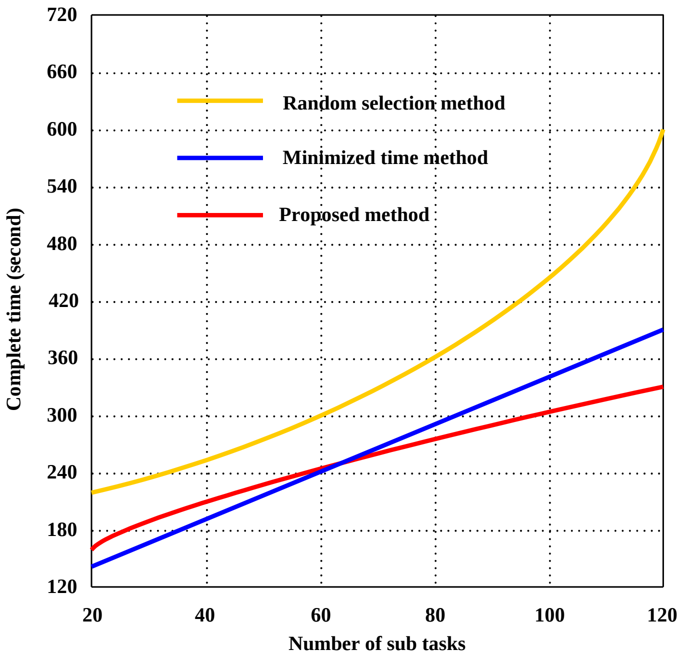

Figure 2. Time Consumption with the Change of Number of Subtasks

From. figure 2, time consumption of three subtasks rise with increasing of subtasks. The rise is most obvious for random selection method.

When the number of subtasks is less than 60, minimized time method is better.

With the number of subtasks increasing, the proposed method is becoming least time consumption method

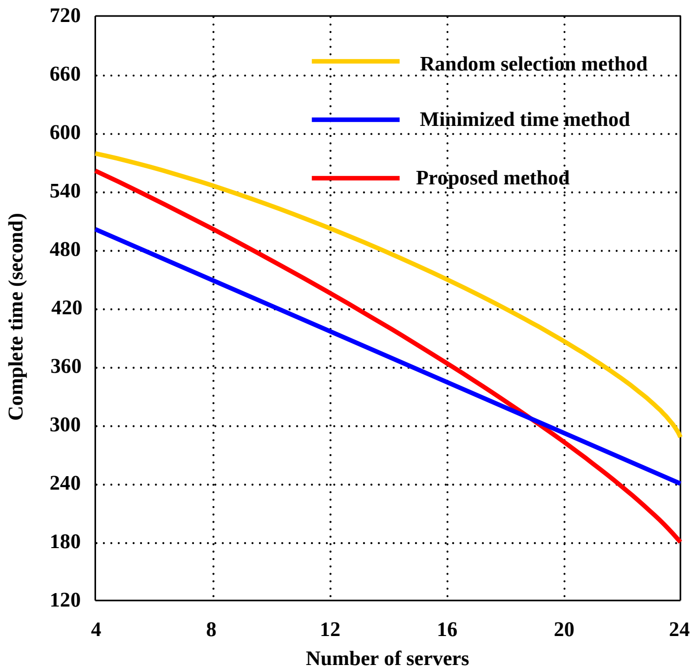

Figure 3. Time Consumption with the Change of Number of Proxy Server

From figure 3, time consumption of three subtasks drop with increasing of proxy server. The rise is most obvious for random selection method. With the number of subtasks increasing, the proposed method has an obvious dropping trend.

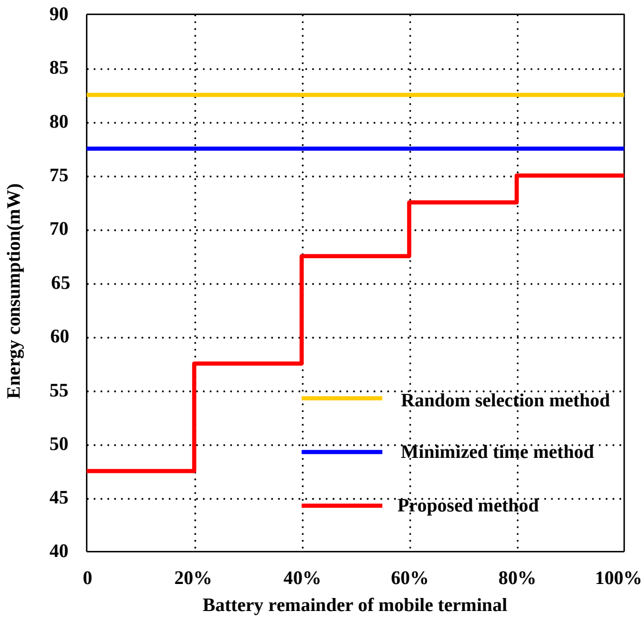

Figure 4. Energy Consumption with the Change of Battery Remain of Mobile Terminal

From figure 4, we can see that energy consumption of random selection method and minimized time method does not drop with battery power reducing in mobile terminal. The proposed method can decide energy consumption for task according to change of battery remaining. When battery remaining is lower, mobile terminal will try to reduce energy consumption as possible.

4. Conclusions

Mobile cloud computing has been becoming an important field of intelligent phone platform. In this paper , the core issue focus on how to enjoy lowest-cost, minimum energy, and fastest service on mobile terminal. A new offload and switch method had been proposed for mobile cloud computing based on decision value function. In this method, time and energy consumption is fully considered to judge whether computing task should offload on proxy server. Experimental results show that the proposed method has better performance than random selection method and minimized time method.

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