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Location-aware interest-related micro-cloud topology construction and bacteria foraging-based offloading strategy

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ABSTRACT

Micro-cloud, as one kind of mobile cloud computing modes, can reduce network delay and alleviate resource constraint of mobile devices. In this mode, mobile devices use their idle resources to provide services for others. Due to the mobility, irregularity of mobile devices, the stability problem of micro-cloud environment still remains challenging. In order to increase the stability of micro-cloud and decrease network delay, the interest-related and location-aware micro-cloud topology is proposed in this paper. The interest-related mobile device nodes are classified into the same micro-cloud which can raise the probability of resource reuse. For reducing failed requests and enhancing the scalability of micro-cloud topology, both node location and node service capacity are considered. Moreover, the bacteria foraging-based offloading algorithm for interest-related micro-cloud topology is proposed, which is an energy-efficient and response time constraint offloading approach. The experiments are conducted and the experiment results show that the location-aware interest-related micro-cloud topology has better stability and scalability, while the bacteria foraging-based offloading algorithm performs better in terms of reducing response time and energy.

1. Introduction

With the development of mobile devices, mobile applications have been used in different fields, such as mobile commerce, mobile healthcare, and mobile social networking. However, compared with fixed devices, the mobile devices are influenced by short battery life, limited processing capacity and storage capacity. When mobile devices deal with compute-intensive applications or data-intensive applications, the resource constraint problem will be particularly acute.

Mobile cloud computing [1–3] can offer an effective approach for solving resource constraint problem for mobile devices. The mobile cloud computing includes three modes [4]: the remote cloud, micro-cloud and cloudlet. At present, most mobile devices still rely on remote cloud services. The biggest downside of remote cloud is that it is located far from mobile devices, which will result in high network delay and large energy consumption. Although the cloudlet mode can reduce network delay, it still costs more on infrastructure than micro-cloud. The micro-cloud is an ad-hoc network based on mobile devices. The idle resources from part of mobile devices are used to consist a computation resource pool, which can provide services for other mobile devices. Therefore mobile devices become part of cloud service hardware which can store data and process services without accessing central servers.

The applications used in mobile cloud environment are various, such as image recognition, natural language processing, cloud gaming and augmented reality [5]. Especially when users have similar interest, similar user demands are requested among interest-based clustering. The use cases are listed as follows. Asanka [6] developed a virtual classroom system called Second Life. By using face recognition and analyzing student behaviors, those students who wants peer to peer online learning can share information in virtual classroom. Cui [7] presented a method for extracting traffic information through using natural language processing and mobile cloud computing technology. Therefore people can collect and share timely traffic information on mobile device. The searching time for interest-related users will be reduced. Zhang [8] proposed an adaptive scheduling algorithm of virtualized GPU resource in cloud gaming. Thus, users who play GPU intensive game can sharing GPU resource with each other and decrease network delay. Nor [9] provided a cloud education system by using augmented reality. Especially for students with attention deficit hyperactive disorder

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(ADHD), augmented reality enables those kind of students study within a safe environment.

However, the existing micro-cloud topologies consider either mobile device location or mobile user interaction frequency, ignoring impact of mobile users who have same interest field. The mobile users who focus on same interest field may use same applications or require same resources, this may increase the probability of resource reuse. Moreover, as mobile devices are more irregular and dynamic compared with fixed devices, the assurance of scalability and stability are crucial in designing micro-cloud topology. Meanwhile, the bacterial foraging optimization algorithm [10,11] is a widely used genetic algorithm for global optimization, which shows better convergence, robustness and precision on global searching compared with conventional global optimization algorithms. Therefore, the interest-related micro-cloud topology construction method and bacteria foraging-based offloading strategy are proposed.

The main innovations and contributions of this paper are summarized as follows.

(1) Aiming at mobile device resource constraint, mobile user service personalization and micro-cloud service scope limitation, the interest-related and location-aware micro-cloud topology construction algorithm is proposed. Moreover, in order to improve user QoS, reduce application response time and mobile device energy consumption, the bacteria foraging-based offloading algorithm is presented in the proposed micro-cloud environment.
(2) Since the interest-related topology can reduce time of searching interested resources and improve efficiency of resource sharing, the mobile device nodes are classified by using interest set classification algorithm in our proposed topology. Then according to mobile device location and node service capacity, node interaction model is constructed. Compared to other benchmark topologies, our proposed micro-cloud topology can reduce searching delay and enhance stability.
(3) For bacterial foraging optimization shows better convergence, robustness and precision on global searching, the bacteria foraging-based offloading strategy is presented which can reduce waiting time for users. Compared to other benchmark algorithms, our proposed offloading strategy shows better performs in terms of decreasing response time and energy consumption.

The rest of this paper is organized as follows: Section 2 reviews some related work. Section 3 describes the interest-related micro-cloud topology construction and offloading strategy. Section 4 presents the algorithms used in micro-cloud topology construction and offloading strategy and Section 5 shows the experiment of micro-cloud topology construction and offloading strategy. Finally, Section 6 is the conclusion of the paper.

2. Related work

Since the interest-related and location-aware topology construction and offloading strategy for micro-cloud include user interest model construction, micro-cloud topology construction and optimal offloading selection, we have reviewed references from these three aspects. The related references are described as follows.

2.1. The user interest model

As the interest model establishment includes feature extraction, feature weight calculation and vector space model establishment, we review the references as follows. Yamaguchi et al. [12] proposed a method for discovering interested topic for Twitter users by analyzing tags of user lists. According to the features of tags and the relevance between users and tags, the interested topics were extracted. Gautam et al. [13] proposed a Map Reduce based vector space model (MR-VSM) for user profiling. The term vector of user's interested news item was created through TF-IDF algorithm. Then the set of terms were profiled by MR-VSM, which increases the computational efficiency. Shi et al. [14] proposed a semi-supervised classification algorithm based on the rough set and ensemble learning. Tolerance rough set theory was used to approximate concepts existed in documents and extract an initial set of negative examples. Then, SVM, Rocchio and Naive Bayes algorithms were used as base classifiers to construct an ensemble classifier, which ran iteratively and exploited margins between positive and negative data to progressively improve the approximation of negative data. Thus, the class boundary eventually converged to the true boundary of the positive class in the feature space. Li et al. [15] proposed a two-level hierarchical algorithm that systematically combined the strength of support vector machine (SVM) and k nearest neighbor (KNN) techniques based on variable precision rough sets (VPRS) to improve the precision of text classification.

The above-mentioned classification methods have only considered word co-occurrence. However, our proposed feature extraction algorithm has considered both word co-occurrence and each singe word's weight, which can increase the accuracy of feature selection.

2.2. The micro-cloud topology construction

The micro-cloud topology construction includes interest set classification, node interaction model and topology construction. The related references are shown as follows. Sotiriadis et al. [16] proposed an interoperable micro-cloud model that enabled a full network of usable IoT objects, and at the same time maintained the required quality of service from an end-user's perspective. Schembra et al. [17] proposed a business model for processing the delay-constrained multimedia streaming applications in mobile cloud. In this model, mobile users were divided into two classes according to the way they intend to pay for the services. With combination of micro-clouds and remote clouds, the proposed model can decrease network delay and energy consumption. Srirama et al. [18] proposed a mobile cloud model which is combined with social network. The model used cloud facial recognition service to recognize users. Moreover, the user interest was extracted from the information and images shared in social network. Mascitti et al. [19] proposed a mobile cloud model based on opportunity model. Their mobile cloud model can evaluate the service portfolio execution time to select services and it does not need send requests to remote cloud. However, though the model had considered the interaction problems between mobile devices, the micro-cloud connection requirements only relied on execution time. Sciancalepore et al. [20] proposed an adaptive algorithm based on opportunistic communication for mobile devices. The peer connection depended on network environment. Asimakopoulou et al. [21] proposed a dynamic micro-cloud based on mobile device sharing mechanism. Huang et al. [22] proposed an improved mobile cloud framework named MobiCloud. The MobiCloud can both provide traditional computing services and enhance the function of ad hoc network.

The above-mentioned methods mainly focus on execution time of application in mobile cloud. But our proposed micro-cloud topology has considered user interest and mobile device location. The nodes with similar service capacity and location are connected, which can improve the efficiency of obtaining resources. The structure of our proposed topology can optimize stability and scalability.