International Journal of Wireless Networks and Broadband Technologies
Volume 10 • Issue 1 • January-June 2021

Strategy for Reducing Delays and Energy Consumption in Cloudlet-Based Mobile Cloud Computing:

Problems on Mobile Devices, Problem Solution, Selection of Cloudlets According to User Requirements

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ABSTRACT

In the paper, the problem of using cloudlet-based mobile cloud computing to solve the issues (resource deficiency and limited energy) that require large computing and memory resources on mobile devices has been studied. Energy-saving of mobile devices, resource limitations in mobile devices, and elimination of network delays are analyzed. It is shown that the solution of mobile users' tasks in the cloud leads to the increased battery life of mobile devices and reduces network delays, which is shown by mathematical calculations. The article considers the balanced distribution of the tasks in the cloudlet network. The paper also deals with the selection of cloudlets according to user requirements. The cases for which a cloud application can be loaded by the user were evaluated and a model was proposed using the possible values that determine the importance of cloudlets (user proximity, high reliability, etc.).

KEYWORDS

Cloudlet, Connection Channel, Energy Consumption, Mobile Cloud Computing, Mobile Devices

INTRODUCTION

Reducing of computing and memory resources of mobile devices, and the short period of autonomous operation of a battery life creates problems which require large computing and memory resources. Mobile cloud computing has been used to overcome these problems (Pang et al., 2015; Dinh et al., 2013; Fernando et al., 2013). Cloud technology eliminates resource restrictions offering virtual resources such as SaaS (Software as a Service), PaaS (Platform as a Service), and IaaS (Infrastructure as a Server) for mobile devices. User's tasks are performed on cloud servers and the results are sent to the mobile device. When using this technology, the mobile device acts as a terminal, which allows saving energy. Thus, mobile cloud computing is a new paradigm created by the integration of mobile network and cloud computing, which

DOI: 10.4018/IJWNBT.2021010102

provides overcoming the computing and memory resources limitations on mobile devices and reducing energy consumption (Abolfazli, 2014; Sarddar, & Bose, 2014).

Moreover, solution of mobile users' tasks on remote cloud servers creates great problems. Mobile users are loaded on remote cloud servers via the Internet, and it may cause the occurrence of delays due to the overload of network and increase the energy consumption of the mobile device. The quality of the service (QoS) is low if the network is loaded. Mobile devices have become the main computing platform for many users. Recent software applications require great computing and memory sources. Limited computing and memory resources of mobile devices, low battery life cannot provide rapid solutions for these problems. Thus, the energy consumption of mobile devices, reducing resource limitations on mobile devices and network changes are of the main problems. When using a cloudlet-based network, numerous cloudlets appear around the user. More loading of one cloudlet and less loading of others will cause delays in the system. Balanced placement of the user's tasks on these cloudlets is the main problem. If a user loads and solves a task in a nearby cloud, there will be less delays and less energy consumption. The delays and energy consumption will increase with the growing number of communication channels if cloudlets are far away from mobile devices. Therefore, solution for selecting a cloudlet that satisfies the user's requirements in the cloudlet network is studied.

The article analyzes the issues of energy saving and resource limitations in mobile devices and the elimination of network delays. The introduction emphasizes that saving energy consumption of mobile devices, eliminating resource constraints and network delays in mobile devices are of great importance. Section 2 provides an overview of the studies in this field. Section 3 examines the factors that affect the time of task processing in mobile cloud computing and its delivery to the user, and suggests the use of hierarchically structured cloudlet-based mobile cloud computing to solve abovementioned problems. Section 4 compares energy saving when solving the tasks in cloudlets through the mathematical way and the delays that occur in cloudlets or cloud servers, and shows the advantages of cloudlets. Section 5 discusses the selection of cloudlets according to the user's request.

RELATED WORK

In some studies, energy consumption can also be reduced by placing the main and extra parts of the software applications that users use on their mobile devices and cloud servers (Huerta-Canepa & Lee, (2017). The article (Jia et al., 2016) shows that the delays in data sharing are long-term as the cloud servers are physically far away from users. The proximity of cloud servers to the users significantly reduces the delays in data sharing (Shi et al., 2012). In the article (Alakbarov R, & Alakbarov O, 2019) a method is developed to ensure the efficient use of cloud sources by mobile users. In the paper, the issue of how to properly use cloudlets located on the mobile user's route in wireless metropolitan area networks (WMAN) is described. Some investigations (Li & Wang, 2013) propose the use of cloudlets to reduce computing load on mobile devices. In (Gelenbe, Lent & Douratsos, 2012) the problem of reducing energy consumption by the optimal distribution of a user-solved problem between a cloud server and a remote cloud server is described. In (Mukherjee et al., 2014; Ahmed et al., 2015; Beloglazov et al., 2012) the issues of software application delays and the development of mobile computing systems that reduce energy consumption are discussed. The paper (Garrison, Wakefield, & Kim, 2015) considers saving energy consumption on mobile devices using cloudlets. The usage of cloudlets to avoid delays on the Internet while solving mobile users' problems in remote clouds is studied (Satyanarayanan et al., 2009). The paper (Tawalbeh, Jararweh & Dosari 2015) studies the selection of cloudlets that serve more efficiently for mobile devices. It is shown that security issues when using the cloudlet network are higher than using the cloud servers (Quwaider & Jararweh, 2015). The article (Verbelen et al., 2014) shows the use of cloudlets as a way of solution in the reduction of delays and energy consumption. In (Bohez et al., 2015), a method for the efficient use of cloudlet sources by mobile users is proposed. The balanced distribution and management of issues in a cloudlet-based mobile computing network is investigated (Singh & Chana, 2015; Li, 2012;

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