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An Analysis of Optimizing of floating Strategies in Mobile Cloud Computing

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ABSTRACT

Together with an explosive growth of the mobile applications and emerging of cloud computing concept, mobile cloud computing (MCC) has been introduced to be a potential technology for mobile services. Mobile Cloud Computing at its simplest refers to an infrastructure where both the data storage and the data processing happen outside of the mobile device. Mobile cloud applications move the computing power and data storage away from mobile phones and into the cloud, bringing applications and mobile computing to not just smart phone users but a much broader range of mobile subscribers.

Keywords: Cloud, Mobile, Devices, Scalability, Load, Storage, Network.

1. INTRODUCTION

Together with an explosive growth of the mobile applications and emerging of cloud computing concept, mobile cloud computing (MCC) has been introduced to be a potential technology for mobile services. MCC integrates the cloud computing into the mobile environment and overcomes obstacles related to the performance (e.g., battery life, storage, and bandwidth), environment (e.g., heterogeneity, scalability, and availability), and security (e.g., reliability and privacy) discussed in mobile computing. This paper gives a survey of MCC, which helps general readers have an overview of the MCC including the definition, architecture, and applications. The issues, existing solutions and approaches are presented. In addition, the future research directions of MCC are discussed.

Mobile devices (e.g., smart phone, tablet pcs, etc) are increasingly becoming an essential part of human life as the most effective and convenient communication tools not bounded by time and place. Mobile users accumulate rich experience of various services from mobile applications e.g., iPhone apps, Google apps, etc, which run on the devices and/or on remote servers via wireless networks. The rapid progress of mobile computing (MC) (M. Satyanarayanan et al., 2010) becomes a powerful trend in the development of IT technology as well as commerce and industry fields. However, the mobile devices are facing many challenges in their resources (e.g., battery life, storage, and bandwidth) and communications e.g., mobility and security (M. Satyanarayanan et al., 2011). The limited resources significantly impede the improvement of service qualities. Cloud computing (CC) has been widely recognized as the next generation's computing infrastructure.CC offers some advantages by allowing users to use infrastructure (e.g., servers, networks, and storages), platforms (e.g., middleware services and operating systems), and softwares (e.g., application programs) provided by cloud providers (e.g., Google, Amazon, and Sales force) at low cost. In addition, CC enables users to elastically utilize resources in an on-demand fashion. As a result, mobile applications can be rapidly provisioned and released with the minimal management efforts or service provider's interactions. With the explosion of mobile applications and the support of CC for a variety of services for mobile users, mobile cloud computing (MCC) is introduced as an integration of cloud computing into the mobile environment. Mobile cloud computing brings new types of services and facilities for mobile users to take full advantages of cloud computing. This paper presents a comprehensive survey on mobile cloud computing. (M. R. Prasad, J. Gyani and P. R. K. Murti et al., 2012) The emergence of Cloud Computing, and its extension into the mobile domain, has brought a new dimension to Network as a Service: the vision of a global, interconnected "Mobile Cloud" where application providers and enterprises will be able to access valuable network and billing capabilities across multiple networks, making it easy for them to enrich their services whether these applications run on a mobile device, in the web, in a SaaS Cloud, on the desktop or an enterprise server.(S. Singh, R. Bagga, D. Singh and T. Jangwal et al., 2012) cloud computing provides a brand new opportunity for the development of mobile applications since it allows the mobile devices to maintain a very thin layer for user applications and shift the computation and processing overhead to the virtual environment. A cloud application needs a constant connection that might prove to be an Achilles heel for the cloud computing movement.

The term "mobile cloud computing" was introduced not long after the concept of "cloud computing" launched in mid-2007. It has been attracting the attentions of entrepreneurs as a profitable business option that reduces the development

and running cost of mobile applications, of mobile users as a new technology to achieve rich experience of a variety of mobile services at low cost, and of researchers as a promising solution for green it (M. Ali, et al., 2009).
MCC incorporates cloud computing properties with the mobile computing environment. Due to its attractive business model and the increased number of mobile phone (smart-phone, tablet pc etc) users in the world, the MCC is proving to be a potential future technology. It has also attracted the attention of many businessmen and entrepreneurs as a prospective and lucrative business opportunity. In [6] MCC has defined as that in MCC all the data, its storage and its processing takes place at the cloud infrastructure instead of mobile device. The mobile cloud applications running on the mobile use the computational power and data storage capabilities of the cloud. Therefore, MCC brings mobile computing services to a wide range of mobile users in addition to the smart phone users.

2. Objectives

The present work is undertaken to optimizing offloading strategies in mobile cloud computing with the following objectives:

- Identify existing mobile cloud computing optimization challenges and their solutions from literature.
- Identify the offloading that have with improvement strategies defined.
- Collect solutions, guidelines and practices from organizations, for a challenge with more references but no mitigation strategies proposed.
- List out solutions, practices and guidelines to the mobile cloud computing offloading challenge that has no mitigation strategies identified.
- To check load balance optimization techniques with algorithm.

3. Mobile Cloud Computing

Mobile Cloud Computing at its simplest refers to an infrastructure where both the data storage and the data processing happen outside of the mobile device. Mobile cloud applications move the computing power and data storage away from mobile phones and into the cloud, bringing applications and mobile computing to not just smart phone users but a much broader range of mobile subscribers. (Aepona et al., 2010) describes MCC as a new paradigm for mobile applications whereby the data processing and storage are moved from the mobile device to powerful and centralized computing platforms located in clouds. These centralized applications are then accessed over the wireless connection based on a thin native client or web browser on the mobile devices. Alternatively, MCC can be defined as a combination of mobile web and cloud computing (Jacson H. Christensen et al., 2009), (L. Liu, R. Moulic, and D. Shea et al., 2011), which is the most popular tool for mobile users to access applications and services on the Internet. Briefly, MCC provides mobile users with the data processing and storage services in clouds. The mobile devices do not need a powerful configuration (e.g., CPU speed and memory capacity) since all the complicated computing modules can be processed in the clouds.
In the cloud, cloud controllers process the requests to provide mobile users with the corresponding cloud services. These services are developed with the concepts of utility computing, virtualization, and service-oriented architecture e.g., web, application, and database servers. The details of cloud architecture could be different in different contexts.
For example, four-layer architecture is explained in (I. Foster, Y. Zhao, I. Raicu, and S. Lu et al 2009) to compare cloud computing with grid computing. Alternatively, service oriented architecture, called Aneka, is introduced to enable developers to build .NET applications with the supports of application programming interfaces (APIs) and multiple programming models (I. Foster, Y. Zhao, I. Raicu, and S. Lu et al 2009). (R. Buyya, C. S. Yeo, S. Venugopal, J. Broberg, and I. Brandic et al., 2009) Presents architecture for creating market-oriented clouds, and (Y. Huang, H. Su, W. Sun et al., 2010) proposes an architecture for web delivered business services. In this paper, we focus on a layered architecture of cloud computing. This architecture is commonly used to demonstrate the effectiveness of the cloud computing model in terms of meeting the user’s requirements (W. Tsai, X. Sun, and J. Balasooriya et al., 2010).
(Abid Shah zad, Mureed Hussain et al., 2013) Mobile cloud computing (MCC) is an emerging and futuristic technology because of variety of advantages and applications it offers to mobile subscribers. MCC offers data storage and processing capabilities to the resource limited mobile users which makes it very potential technology in near future. **(D. Popa, M. Cremene et al., 2013)** Cloud resources and services for mobile devices. It also brings several advantages to mobile devices and to the applications developed for them. However, it increases the security risks and privacy invasion due to the fact that it combines mobile devices with Cloud services and because there is not a well-defined application model. The security issues are treated independently and the existing security solutions are supplied separately by various providers

4. Optimizing Offloading Technique

Computation offloading technique is proposed with the objective to migrate the large computations and complex processing from resource-limited devices i.e., mobile devices to resourceful machines i.e., servers in clouds. This avoids taking a long application execution time on mobile devices which results in large amount of power consumption.

(A. Rudenko, P. Reiher et al., 2000) and (A. Smailagic and M. Ettus et al., 2002) evaluate the effectiveness of offloading techniques through several experiments. The results demonstrate that the remote application execution can save energy significantly. Especially, (A. Rudenko, P. Reiher et al., 2000) evaluates large-scale numerical computations and shows that up to 45% of energy consumption can be reduced for large matrix calculation. In addition, many mobile applications take advantages from task migration and remote processing. For example, offloading a compiler optimization for image processing (U. Kremer, J. Hicks, and J. Rehg, et al., 2001) can reduce 41% for energy consumption of a mobile device. Also, using memory arithmetic unit and interface (MAUI) to migrate mobile game components (E. Cuervo, A. Balasubramanian et al., 2010) to servers in the cloud can save 27% of energy consumption for computer games and 45% for the chess game.

5. Improving data storage capacity and processing power

Storage capacity is also a constraint for mobile devices. MCC is developed to enable mobile users to store/access the large data on the cloud through wireless networks. First example is the Amazon Simple Storage Service (Amazon S3) which supports file storage service. Another example is Image Exchange which utilizes the large storage space in clouds for mobile users (E. Vartiainen, and K. V. -V. Mattila et al., 2010).This mobile photo sharing service enables mobile users to upload images to the clouds immediately after capturing. Users may access all images from any devices. With cloud, the users can save considerable amount of energy and storage space on their mobile devices since all images are sent and processed on the clouds. (Flickr and Sho Zu) is also the successful mobile photo sharing applications based on MCC. Face book is the most successful social network application today, and it is also a typical example of using cloud in sharing images.

MCC also helps reducing the running cost for compute-intensive applications that take long time and large amount of energy when performed on the limited-resource devices. Cloud computing can efficiently support various tasks for data warehousing, managing and synchronizing multiple documents online. For example, clouds can be used for trans coding (A. Garcia and H. Kalva et al., 2011) playing chess (E. Cuervo, A. Balasubramanian, Dae-ki Cho et al., 2010), (K. Kumar and Y. Lu et at., 2010) or broadcasting multimedia services (L. Li, X. Li, S. Youxia, and L. Wen et al., 2010) to mobile devices. In these cases, all the complex calculations for trans coding or offering an optimal chess move that take a long time when perform on mobile devices will be processed quickly on the cloud. Mobile applications also are not constrained by storage capacity on the devices because their data now is stored on the cloud.

6. Improving reliability

Storing data or running applications on clouds is an effective way to improve the reliability since the data and application are stored and backed up on a number of computers. This reduces the chance of data and application lost on the mobile devices. In addition, MCC can be designed as a comprehensive data security model for both service providers and users. For example, the cloud can be used to protect copyrighted digital contents (e.g., video, clip, and music) from being abused and unauthorized distribution (P. Zou, C. Wang, Z. Liu, and D. Bao et al., 2010). Also, the cloud can remotely provide to mobile users with security services such as virus scanning, malicious code detection, and authentication (J. Oberheide, K. Veeraraghavan, E. Cooke, J. Flinn, and F. Jahanian et al., 2008). Also, such cloud-based security services can make efficient use of the collected record from different users to improve the effectiveness of the services.

7. Applications of Mobile Cloud Computing

Mobile applications gain increasing share in a global mobile market. Various mobile applications have taken the advantages of MCC. In this section, some typical MCC applications are introduced.

Mobile Commerce

Mobile commerce (m-commerce) is a business model for commerce using mobile devices. The m-commerce applications generally fulfill some tasks that require mobility e.g., mobile transactions and payments, mobile messaging, and mobile ticketing. The m-commerce applications can be classified into a few classes including finance, advertising and shopping.

The m-commerce applications have to face various challenges e.g., low network bandwidth, high complexity of mobile device configurations, and security. Therefore, m-commerce applications are integrated into cloud computing environment to address these issues. (X. Yang, T. Pan, and J. Shen et al., 2010)) proposes a 3G E-commerce platform based on cloud computing. This paradigm combines the advantages of both 3G network and cloud computing to increase data processing speed and security level (J. Dai, and Q. Zhou et al., 2010) based on public key infrastructure (PKI). The PKI mechanism uses an encryption-based access control and an over-encryption to ensure privacy of user's access to the outsourced data. In (Z. Leina, P. Tiejun, and Y. Guoqing et al., 2011) a 4PL-AVE trading platform utilizes cloud computing technology to enhance the security for users and improve the customer satisfaction, customer intimacy, and cost competitiveness.

Mobile Learning

Mobile learning (m-learning) is designed based on electronic learning (e-learning) and mobility. However, traditional m-learning applications have limitations in terms of high cost of devices and network, low network transmission rate, and limited educational resources (X. Chen, J. Liu et al., 2010), (H. Gao and Y. Zhai et al., 2010) , (Jian Li et al., 2010). Cloud-based m-learning applications are introduced to solve these limitations. For example, utilizing a cloud with the large storage capacity and powerful processing ability, the applications provide learners with much richer services in terms of data (information) size, faster processing speed, and longer battery life. (W. Zhao, Y. Sun, and L. Dai et al., 2010). Presents benefits of combining m-learning and cloud computing to enhance the communication quality between students and teachers. In this case, smart phone software based on the open source Java ME UI framework and Jaber for clients is used. Through a web site built on Google Apps Engine, students communicate with their teachers at anytime. In addition, a contextual m-learning system based on IMERA platform (C. Yin, B. David, and R. Chalon et al., 2009) shows that a cloud-based m-learning system helps learners access learning resources remotely.

Another example of MCC applications in learning is “Cornucopia” implemented for researches of undergraduate genetics students and “Plantations Pathfinder” designed to supply information and provide a collaboration space for visitors when they visit the gardens (R. Rieger and G. Gay et al., 2012). The purpose of the deployment of these applications is to help the students enhance their understanding about the appropriate design of mobile cloud computing in supporting field experiences. In (R. Ferzli and I. Khalife et al., 2011) an education tool is developed based on cloud computing to create a course about image/video processing. Through mobile phones, learners can understand and compare different algorithms used in mobile applications e.g., de-blurring, de-noising, face detection, and image enhancement.

Mobile Gaming

Mobile game (m-game) is a potential market generating revenues for service providers. M-game can completely offload game engine requiring large computing resource e.g., graphic rendering to the server in the cloud, and gamers only interact with the screen interface on their devices.(Z. Li, C. Wang, and R. Xu et al., 2001) Demonstrates that offloading multimedia code can save energy for mobile devices, thereby increasing game playing time on mobile devices. (E. Cuervo, A. Balasubramanian, Dae-ki Cho, A. Wolman, S. Saroiu et al., 2010) Proposes MAUI (memory arithmetic unit and interface), a system that enables fine-grained energy-aware offloading of mobile codes to a cloud. Also, a number of experiments are conducted to evaluate the energy used for game applications with 3G network and WiFi network. It is found that instead of offloading all codes to the cloud for processing, MAUI partitions the application codes at a runtime based on the costs of network communication and CPU on the mobile device to maximize energy savings given network connectivity. The results demonstrate that MAUI not only helps energy reduction significantly for mobile devices i.e., MAUI saves 27% of energy usage for the video game and 45% for chess, but also improves the performance of mobile applications i.e., the game’s refresh rate increases from 6 to 13 frames per second.

(S. Wang and S. Dey et al., 2011) Presents a new cloud-based m-game using a rendering adaptation technique to dynamically adjust the game rendering parameters according to communication constraints and gamers’ demands. The rendering adaptation technique mainly bases on the idea to reduce the number of objects in the display list since not all objects in the display list created by game engine are necessary for playing the game and scale the complexity of rendering operations. The objective is to maximize the user experience given the communications and computing costs.

8. Issues and Approaches of Mobile Cloud Computing

As discussed in the previous section, MCC has many advantages for mobile users and service providers. However, because of the integration of two different fields, i.e., cloud computing and mobile networks, MCC has to face many technical challenges. This section lists several research issues in MCC, which are related to the mobile communication and cloud computing. Then, the available solutions to address these issues are reviewed.

A. Issues in Mobile Communication

Low Bandwidth: Bandwidth is one of the big issues in MCC since the radio resource for wireless networks is much scarce as compared with the traditional wired networks.

(X. Jin and Y. K. Kwok et al., 2011) proposes a solution to share the limited bandwidth among mobile users who are located in the same area e.g., a workplace, a station, and a stadium and involved in the same content e.g., a video file. The authors model the interaction among the users as a coalitional game. For example, the users form a coalition where each member is responsible for a part of video files e.g., sounds, images, and captions and transmits/exchanges it to other coalition members. This results in the improvement of the video quality. However, the proposed solution is only applied in the case when the users in a certain area are interested in the same contents. Also, it does not consider a distribution policy e.g., who receives how much and which part of contents which leads to a lack of fairness about each user's contribution to a coalition.

(E. Jung, Y. Wang, I. Prilepov, F. Maker, et al., 2010) considers the data distribution policy which determines when and how much portions of available bandwidth are shared among users from which networks e.g., WiFi and WiMAX. It collects user profiles e.g., calling profile, signal strength profile, and power profile periodically and creates decision tables by using Markov Decision Process (MDP) algorithm. Based on the tables, the users decide whether or not to help other users download some contents that they cannot receive by themselves due to the bandwidth limitation, and how much it should help e.g., 10% of contents. The authors build a framework, named RACE (Resource-Aware Collaborative Execution), on the cloud to take advantages of the computing resources for maintaining the user profiles. This approach is suitable for users who share the limited bandwidth, to balance the trade-off between benefits of the assistance and energy costs.

Availability: Service availability becomes more important issue in MCC than that in the cloud computing with wired networks. Mobile users may not be able to connect to the cloud to obtain service due to traffic congestion, network failures, and the out-of-signal.

(G. Huerta-Canepa and D. Lee et al., 2010) and (L. Zhang, X. Ding, Z. Wan, M. Gu, et al., 2010) propose solutions to help mobile users in the case of the disconnection from clouds. In (G. Huerta-Canepa and D. Lee et al., 2010), the authors describe a discovery mechanism to find the nodes in the vicinity of a user whose link to cloud is unavailable. After detecting nearby nodes that are in a stable mode, the target provider for the application is changed. In this way, instead of having a link directly to the cloud, mobile user can connect to the cloud through neighboring nodes in an ad hoc manner. However, it does not consider the mobility, capability of devices, and privacy of neighboring nodes.

Heterogeneity: MCC will be used in the highly heterogeneous networks in terms of wireless network interfaces. Different mobile nodes access to the cloud through different radio access technologies such as WCDMA, GPRS, WiMAX, CDMA2000, and WLAN. As a result, an issue of how to handle the wireless connectivity while satisfying MCC's requirements arises e.g., always-on connectivity, on-demand scalability of wireless connectivity, and the energy efficiency of mobile devices. (A. Klein, C. Mannweiler, J. Schneider et al., 2010) Proposes architecture to provide an intelligent network access strategy for mobile users to meet the application requirements. This architecture is built based on a concept of Intelligent Radio Network or IRNA Access (A. Klein, C. Mannweiler, and H. D. Schottenet al, 2009). IRNA is an effective model to deal with the dynamics and heterogeneity of available access networks. To apply IRNA in MCC environment, the authors propose context management architecture (CMA) with the purpose to acquire, manage, and distribute context information.

B. Issues in Mobile Computing

Computing Offloading: As explained in the previous section, offloading is one of the main features of MCC to improve the battery lifetime for the mobile devices and to increase the performance of applications. However, there are many related issues including efficient and dynamic offloading under environment changes.

Offloading in the static environment: Experiments in (A. Rudenko, P. Reiher, G. J. Popek, G. H. Kuenning et al., 1998) show that offloading is not always the effective way to save energy. For a code compilation, offloading might consume more energy than that of local processing when the size of codes is small. For example, when the size of altered codes after compilation is 500KB, offloading consumes about 5% of a device's battery for its communication while the local processing consumes about 10% of the battery for its computation. In this case, the offloading can save the battery up to 50%. However, when the size of altered codes is 250KB, the efficiency reduces to 30%. When the size of altered codes is small, the offloading consumes more battery than that of local processing.

Offloading in the Dynamic Environment: This subsection introduces a few approaches to deal with offloading in a dynamic network environment e.g., changing connection status and bandwidth. The environment changes can cause additional problems. For example, the transmitted data may not reach the destination, or the data executed on the server will be lost when it has to be returned to the sender. (S. Ou, K. Yang, A. Liotta, and L. Hu et al., 2007) analyzes the performance of offloading systems operating in wireless environments. In this work, the authors take into account three circumstances of executing an application, thereby estimating the efficiency of offloading. They are the cases when the application is performed locally without offloading the application is performed in ideal offloading systems without failures and the application is performed with the presence of offloading and failure recoveries. In the last case, when a failure occurs, the application will be re-offloaded. This approach only re-offloads the failed sub-tasks, thereby improving the execution time. However, this solution has some limitations. That is, the mobile environment is considered as a wireless ad hoc local area network i.e., broadband connectivity is not supported. Also, during offloading execution, a disconnection of a mobile device is treated as a failure.

(E. Cuervo, A. Balasubramanian, Dae-ki Cho, A. Wolman, et al., 2010) introduces architecture to dynamically partition an application at a runtime in three steps. First, MAUI uses code portability to create two versions of a mobile application, one for the local execution on devices and the other for the remote execution in cloud.

9. Securing Data on Mobile Cloud Computing

Although both mobile users and application developers benefit from storing a large amount of data/applications on a cloud, they should be careful of dealing with the data/applications in terms of their integrity, authentication, and digital rights. The data-related issues in MCC are as follows.

Integrity: Mobile users often concern about their data integrity on the cloud. Several solutions are proposed to address this issue(A. Tanenbaum and M. Van Steen et al., 2007) , (W. Wang, Z. Li, R. Owens, and B. Bhargava et al., 2209).. However, such solutions do not take the energy consumption of mobile users into account. (W. Itani, A. Kayssi, and A. Chehab et al., 2011) Considers the energy consumption issue. This scheme consists of three main components: a mobile client, a cloud storage service, and a trusted third party.

Authentication: (R. Chow, M. Jakobsson, R. Masuoka, J. Molina et al., 2010) presents an authentication method using cloud computing to secure the data access suitable for mobile environments. This scheme combines TrustCube (Z. Song, J. Molina, S. Lee, S. Kotani, R. Masuoka et al., 2009) and implicit authentication (M. Jakobsson, E. Shi, P. Golle, and R.Chow et al., 2009) , (E. Shi, Y. Niu, M. Jakobsson, and R. Chow et al., 2010) to authenticate the mobile clients. Trust Cube is a policy-based cloud authentication platform using the open standards, and it supports the integration of various authentication methods. The authors build an implicit authentication system using mobile data e.g., calling logs, SMS messages, website accesses, and location for existing mobile environment. The system requires input constraints that make it difficult for mobile users to use complex passwords. As a result, this often leads to the use of simple and short passwords or PINs.

Digital rights management: The unstructured digital contents e.g., video, image, audio, and e-book have often been pirated and illegally distributed. Protecting these contents from illegal access is of crucial importance to the content providers in MCC like traditional cloud computing and peer-to-peer networks. (P. Zou, C. Wang, Z. Liu, and D. Bao, et al 2010) proposes Phosphor, a cloud based mobile digital rights management (DRM) scheme with a sim card in mobile phone to improve the flexibility and reduce the vulnerability of its security at a low cost.

Enhancing the Efficiency of Data Access: With an increasing number of cloud services, the demand of accessing data resources e.g., image, files, and documents on the cloud increases. As a result, a method to deal with i.e., store, manage, and access data resources on clouds becomes a significant challenge.(Y. J. Nam, Y. K. Park, J. T. Lee, and F. Ishengoma et al., 2011) Proposes an algorithm in which I/O operations are executed at a block-level. The algorithm uses log-structured I/O transaction (M. Rosenblum and J. K. Ousterhout et al., 2012) to minimize the number of the block-level I/O operations. The main idea here is to perform onto the cloud storage log-structure writes with the optimal number of data blocks that adaptively changes with I/O and cloud storage pricing policy.

Another solution to increase the efficiency of accessing data on the cloud is using a local storage cache. (E. Koukoumidis, D. Lymberopoulos, K. Strauss et al., 2011) presents a solution which utilizes a memory capacity of mobile devices to increase the speed of data access, reduce latency and improve energy efficiency for the mobile devices. The idea of this solution is to build a Pocket Cloudlet based on non-volatile memory to store the specific parts or even full cloud services in the mobile devices.

Context-aware mobile cloud services: It is important for the service provider to fulfill mobile users' satisfaction by monitoring their preferences and providing appropriate services to each of the users. A lot of research work try to utilize the local contexts e.g., data types, network status, device environments, and user preferences to improve the quality of service (QoS). (F. A. Samimi, P. K. Mckinley, and S. M. Sadjadi et al., 2006) builds a model, called Mobile Service Clouds (MSCs), which is extended from Service Clouds paradigm(P. K. McKinley, F. A. Samimi, J. K. Shapiro, and C. Tang et al., 2006). In this model, when a customer uses a service on the cloud, the user's request firstly goes to a service gateway. The gateway will choose an appropriate primary proxy to meet the requirements e.g., the shortest way and minimum round-trip time and then sends the result to the user. In the case of disconnection, MSCs will establish transient proxies (F. A. Samimi, P. K. McKinley, S. M. Sadjadi, and P. Ge et al., 2004) for mobile devices to monitor the service path, and support dynamic reconfiguration (with minimum interruption). The advantages of this model are that the model addresses the disconnection issue and can maintain the QoS at an acceptable level. (H. H. La and S. D. Kim, et al., 2010) proposes a framework for providing context-aware mobile services based on the algorithm to choose a context-aware adapter. The authors consider several contexts such as device environments, user preferences, and situational contexts.

Unlike (H. H. La and S. D. Kim, et al., 2010), (P. Papakos, L. Capra, and D. S. Rosenblum et al., 2010) builds a middleware module, called VOLARE, embedded on mobile device, which monitors the resources and contexts of the mobile device, thereby dynamically adjusting requirements of users at a runtime.

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