

Reducing Network Bandwidth Cost on End User Resources Consumption in Cloud Environment

Buchanagandi Enock Nyamajeje and Huiqun Yu

Department of Computer Science and Engineering East, University of Science and Technology, 200237, China

Article history

Received: 25-09-2015

Revised: 19-11-2015

Accepted: 21-11-2015

Corresponding Author:

Buchanagandi Enock

Nyamajeje

Department of Computer
Science and Engineering East,
University of Science and
Technology, 200237, China
E-mail: buchana2011@hotmail.com

Abstract: Cloud computing has been envisioned as the next generation and attributed to the increasing growth of mobile devices. Rapid increment, increase demands and bandwidth cost of access cloud resources became essential user perceive incur higher cost for utilizing cloud services. Since researchers have proposed new methods, service provider need to collaborate to ensure reasonable level of QoS. In various methods, bandwidth cost of service execution and delivery schemes have suggested service level agreement as a formal contract enforces resource level quality of service against the fee. However, not sufficient for the user in dynamic wireless domains in mobile cloud. This work is dedicated to the study of impact against ensure quality of cloud based application outsourcing that satisfies the bandwidth requirements for user. A key problem in application outsourcing in the cloud-based server is the problem of bandwidth consumption, which is critical to the bandwidth cost for utilizing service infrastructure. Using mathematics expression, methodology and algorithm we formulate the bandwidth consumption problem, taking into consideration of various metrics such as service level agreement, bandwidth allocation for user and bandwidth allocation threshold limit, trustworthy security for data storage. To employ user perceived performance in mobile application outsourcing for cloud-based server, which has always been an important aspect of bandwidth cost and quality of service.

Keywords: Aware Bandwidth Cost, Access Control, Mobile Application Outsourcing, On-Demand Users, Optimistic Users, Video Files Streaming

Introduction

Recent dramatic growth demand of computational intensive application like video traffic challenges the resource demanded of mobile devices due to a large number of video streams deliver to the user. Mobile devices, such as smartphones are attributed with features supports like quality graphics, multimodal connectivity, customized user applications support and both computing and communication capabilities. These increase features capabilities of both computing and communication devices are due to the latest developments in mobile computing technology (Muhammad *et al.*, 2013). The latest computing power of computational clouds are focus on employing on demand basis for mitigating resource constrained in mobile devices, such as low bandwidth, computing power, storage and battery lifetime. Mobile devices incorporate the capabilities of both computing and communication devices provide support for accessing

communication network and performing computation by leverage cloud computing services and resources (Muhammad *et al.*, 2014). Mobile devices equipped with application processor which is a multicore general purpose processor, provide useful user-interface and running applications while the application system is located in cloud based server. The mobile cloud computing and cloud computing are focused on employing the intrinsic limitations in wireless access medium, but the mobile nature of mobile devices complicated and ubiquitous employment of intensive mobile application (Hoang *et al.*, 2013). The recent trend of augmenting cloud computing with bandwidth guarantees technology is a new paradigm in IT industry and research areas. It offers an excellent return on investment for education and training services. The emergence of cloud computing will enable mobile device relies on access sharing computing resources, storage and bandwidth, according to end-user preferences and application requirements. Cloud computing evolution

technology has applied to various computing services and applications and utilizing the cloud to augment the computing potentials of mobile devices. Cloud resources created an opportunity to mitigate the shortcomings of utilizing powerful computing in augmenting mobile devices. Cloud being one of the different types of distributed system. It consists of powerful computer clusters connected through wireless local area network and wireless Internet. Therefore, a unified computing resource(s) via bilateral service level agreement between service consumer and provider is needed to enforce certain level of quality against the fee (Abolfazli *et al.*, 2013). Cloud-based Internet applications are modern internet applications designed using the virtualization technology in the cloud computing environment that are deployed on the Virtual Machines (VMs).

End-users repeatedly access information items from the cloud space which are hosted by cloud service providers (Chonho *et al.*, 2013). When data owner requests the cloud service or requests certain number of the virtual machine in order to outsource or depots applications to the cloud based server. Data owner should negotiate with cloud providers for pricing usage of resource bandwidth that is satisfied with a performance guarantee, in order to determine the optimal policy for reducing bandwidth cost. Different from all these free application resources that is now rapidly growing intensive data application. Utilizing cloud resource such as mobile computation augmentation, bandwidth etc. That involve communication between the end users and the cloud provider does not come for free. Bandwidth cost could significantly increase due to data-intensive applications. Network bandwidth is an important factor in determining the user-perceived performance of the mobile cloud computations application and wireless communication (Morford and Purvy, 2013) and resource execution. Through end-user has to pay for resource consumption over different types of wireless networks such as 3G, Wi-Fi, WiMAX, which have different features and bandwidths when their utilizing cloud resource/services e.g., CPU, storage and bandwidth. Mobile cloud augmentation has gained tremendous ground and significant efforts have devoted. Researchers have designed and implement systems that provide accurate delivering augmentation environment, but bandwidth cost would potential impend the improvement of the quality requirement of service that are important in the offloading performance. The clouds service provider should be able to serve end-users with the quality of service guarantee to ensure accurate forecast end user's bandwidth cost to determine the true cost of using cloud resources.

The mobile device has recent rapidly increased used in several different communities. Since, there are improvements in mobile computing capabilities still several intrinsic the shortage of the mobile device

impedes the feasibility of intensive mobile computing, that carries out data-intensive mobile computing in resource-poor mobile devices that use higher consumption power (Shiraz *et al.*, 2013). The most major cause's factor to perform mobile computation augmentation to utilize cloud-based computing that meet various computing requirements of mobile devices, migrating computation of resource-poor mobile devices into resource-rich cloud based resources. Empowered by mobile cloud augmentation, has led to researchers adopt technology in cloud based mobile augmentation. Addressing questions on cloud-based outsourcing application process decision making. For example: (1) How to determine mobile application outsourcing is worth to improving user-perceived performance in mobile cloud computing environment such as, problem of bandwidth cost provision to enhance Quality of Service, (2) How user must need to forecast their bandwidth cost to determine the true cost of using the cloud. To demonstrates realize accurate of making decision factor to determine augmentation feasibility, to specify augmentation requirement and to enhance quality of user experience (Abolfazli *et al.*, 2013). In order to analyze these vital factors, it requires highly efficient monitoring mechanisms to develop optimal resource allocator to analysis and determine appropriate resources based on the end- users preferences and requirements. So that to provide to guarantee quality of service for the bandwidth cost to support quality of service requirements. Therefore, the cloud service provider must supply component responsible to monitor, store and supply information on the resource in the network bandwidth and cloud environment so that end-users can make proper reservation and budgeting.

Limited to computing potentials of mobile devices, the computing power of clouds is tapped to alleviate the computing limitation of mobile devices for application outsourcing in mobile cloud computing. As larger amount of outsourced application and data by data owners may shared to different of cloud user types i.e., on-demand user and optimistic user. Moreover, the resources provided based on demands of the application, each end-user pay the specified cost per bandwidth rate for using the bandwidth between the cloud and the devices. In this study we proposed the model for outsourcing application/data of resources constrained mobile device to the cloud based server. The focus of this paper is on the outsourcing application's bandwidth transfer to the cloud server back to mobile devices. The aim of propose solution is to provide the cost of bandwidth transfer for the end-users bandwidth consumption. Moreover, to provide user with aware forecasting of their bandwidth cost applied according to their requirements and preferences. Considering capabilities and cellular network access functionalities of mobile devices, mobile devices leverage the cloud resources via wireless networking to access the services of computational cloud in mobile environment. For limited

resource on end-user's devices elastic application is partitioned and heavy computational tasks are outsourced and heavy partitions of the tasks are migrated by moving away from mobile device to the remote cloud based server. The objective of this paper is the realization of the architecture and algorithm to validate the feasibility of the proposed method. According to the architecture and algorithm, the method could provide efficient self-adaptability to optimize availability and performance for the user and minimize the cost of bandwidth of content/data file services for varying bandwidth environments. The main focus is bandwidth cost reduction and some of the issues it tries to address, related to the study, methods and systems directed to bandwidth cost available today. The contributions in this study are as follows:

- We design the system and implement a key authentication and access control framework with private key for the end-user to access on the cloud services
- We demonstrate the system design and methodology with case study and theoretically prove with the algorithm and mathematic expression, the algorithm implementation significantly can proximity predict bandwidth cost utilization
- We implemented fully client/server running system of the proposed methodology on the bandwidth allocation for the end-user. Based on method and running system, we provided detailed description of system model and problem formulation. We implemented application on client and the experiment results validated the proposed method. We evaluated our results in terms of end-user cloud types (on-demand user and optimistic user) requests access for the cloud service, on-demand-user fraud analysis, bandwidth cost analysis, bandwidth cost analysis and file size analysis

Section 2 described ideals for related work. Section 3 discusses the architecture and visions of this work. Section 4 outlines the methodology of the study. Section 5 present set of experimental work. Section 6 summarizes and concludes.

Related Work

The smartphones are a portable device that encapsulates computing capabilities and cellular network access functionalities in a single integrated multicore processor (Muhammad *et al.*, 2013) Mobile cloud computing pertaining of integrates three technologies, namely, mobile computing, wireless technologies and the cloud, to augment the capabilities of the mobile device. The mobile devices leverage cellular networks to access the services in the mobile cloud computing environment (Muhammad *et al.*, 2014; Ejaz *et al.*, 2014). This paper, considered mobile devices leverage data

network to access the services of the cloud resources in mobile cloud environment. Mobile computation augmentation is a not a new concept in empowering computation capabilities of mobile devices. Since it increasing, enhances and optimizes computation capabilities. Previously different several approaches have proposed regarding this issue such as load sharing, computation offloading (Abolfazli *et al.*, 2013), a virtual cloud computing such as ad hoc mobile device, Virtual Machine (VM) migration and so on (Muhammad *et al.*, 2012; O'Sullivan and Grigoras, 2013). These approaches were devoted and exploit several different techniques to augment mobile devices resources constraints based on resources available within the cloud environment (Muhammad *et al.*, 2012; Ejaz *et al.*, 2014). This dedicated to optimizing computational capabilities of resource constrained smart devices against bandwidth cost. (Abhinav *et al.*, 2011) proposed pay as you go service model, an economical basic to access cloud computing provider's resources, storage and bandwidth. That provides cloud computing environment to end users requirements and preferences which are changing needs, for utilizing the cloud's scalable and elastic computational capabilities. However, considering parameter in particular data transfer cost (i.e., bandwidth transfer) as the main factor when trying to minimize cost (Muhammad *et al.*, 2013). Also, authors, (Muhammad *et al.*, 2012) presented their work that accessing the cloud computing providers associated with two costs, mainly named, the cost of networking and the cost of using the provider's resources.

Application partitioning and remote execution have been extensively studied in mobile computing research such as (Muhammad *et al.*, 2013). Authors applied automatic offloading to applications approaches in a Smartphone application that can automatically offloaded to a remote server. Authors considered various factors such as the amount of computation, the size of offloading states and the available network bandwidth against the cost and benefit of offloading removable component on-the-fly. In our work, we do considering those various factors. The challenge is how end-users can aware forecast their bandwidth cost of mobile application outsourcing. Therefore, quality of the service requirements is being a driven force to deliver better services to end users (Muhammad *et al.*, 2013). Analysis virtual machine deployment in datacenters they simulated some of datacenters and each of the datacenters defined with Cost per Bandwidth = 0.1(cost of using bandwidth), 1000000 bytes storage, 10000 MB bandwidth and datacenter broker. Each virtual machine within the datacenter is composed of RAM 512 MB (VM memory). Datacenter broker being responsible for negotiations between the application and cloud provider, such negotiations are

driven by Quality of Service (QoS) requirements to meet application's QoS needs. Jiangtao *et al.* (2014) Proposed a novel algorithm automatically can decide whether a generated dataset should be stored in the current cloud, deleted and regenerated whenever reused or transferred to cheaper cloud service for storage.

The algorithm finds the trade-off among computation, storage and bandwidth costs in the cloud, however, the proposed algorithm show that is highly cost-effective utilized in the cloud. Our work focus on the bandwidth cost minimization for end users access mobile application outsourcing in cloud server. That is either totally or partially moved to the cloud server for storage or execution. Addressing the SLA aware cost efficient VMs placement problem is discussed in (Di *et al.*, 2012). Authors pointed out that considering the random property of VMs resource requirement, the resource must be kept overflow at a low probability. The quality of service will not be deteriorated by compacting of VMs and thus service-level agreement is ensured. All in this authors' work do not consider aware bandwidth cost forecasting for end-users that are negotiated based on service-level agreement to access to the service in the cloud space, (Meng *et al.*, 2010) only systematically discussed the bandwidth cost in their work, they highlighted the bandwidth cost but do not specifically consider on mobile cloud application requirements and cloud computing.

As shown in Table 1, it clearly mentions that comparison of different approach shows that there is very less work done previously in the cost of the bandwidth for bandwidth consumption to access the cloud. The features proposed in each approaches differently distinguished, but all the approaches are not working for usage of bandwidth resource except a two-step method. The nature of the capability of the proposed approaches in the case of trade-off between cost and quality of service are highlighted and

distinguishes here and gives as the results suggest that each approach is capable for either cost minimization or guarantee the quality of service.

Eyal *et al.* (2014) presented an end-to-end traffic redundancy elimination system based on predictive Acknowledgement (ACKs). There was so that to the bandwidth cost combined with traffic redundancy elimination system of computational additional cost and the storage would be optimized. Compared to the proposed methods and the system design in this paper, storage and any addition cost of computational should be a prior negotiated between the end-user (data owner) and the service provider based on service level agreement. In this paper, we present bandwidth cost reduction implementation, benefits for the end-users using bandwidth allocation from various sources [end-users nodes] for each corresponding end-user.

Methods and Proposed System

The architecture for cloud server storage is illustrated in Fig. 1. The system involve three different network parties can be identifies as follows.

- User: users can outsource parts of resource application to the cloud, to leverage the diversity of cloud resources that enables user to store, request (gather) and rely on the cloud to execute data for mobile devices. Consist of both individual consumers (on-demand users and optimistic users) and organizations (data owner)
- The cloud admin: admin is trusted expert provide assistance on behalf of the user upon request for any exposed risk of cloud storage services

Cloud server (Cloud Service Provider): who are running simultaneous set of cloud servers and managing distributed physical storage of cloud computing systems

Table 1. Comparison trade-off between cost and quality of service

Author	Approach	Features	Cost	Quality of service	Optimization
Jiangtao <i>et al.</i> (2014)	An offline and an online algorithms	Tree-like data center topology	Cost for VMs and Physical Machines (PMs)	Good (guaranteeing the quality of Services).	Optimizes the cost a data center
Di <i>et al.</i> (2012)	Guaranteed portion (guaranteed cloud service model)	Fine granularity	Cost for bandwidth reservations heterogeneously for tenants based on their workload statistics such as burstiness and correlation	Good (Guaranteed services)	Uniform usage pricing model under demand uncertain
Yu and Shen (2014)	Stochastic Virtual Cluster (SVC)	A network sharing framework and efficient VM allocation algorithms	The bandwidth occupancy cost on link	Not guaranteed	Achieve good locality but also minimize the maximum of bandwidth occupancy ratio
Yichao <i>et al.</i> (2013)	A two-step method	A logarithmic relationship between the mean hop distance from users to contents	Cost associated with the usage of storage, bandwidth and computation resources	Not guaranteed	To minimize the monetary cost associated with the usage of storage, bandwidth and computation resources
Yuan <i>et al.</i> (2013)	Trade-off among computation, storage and bandwidth	Storing large volume of generated scientific datasets with multiple cloud service provides in the cloud	Towards achieving the cost-effectiveness	Very effective in reducing cost for cloud storage	Minimum cost storage strategy for datasets of linear a data Dependency Graph (DDG)

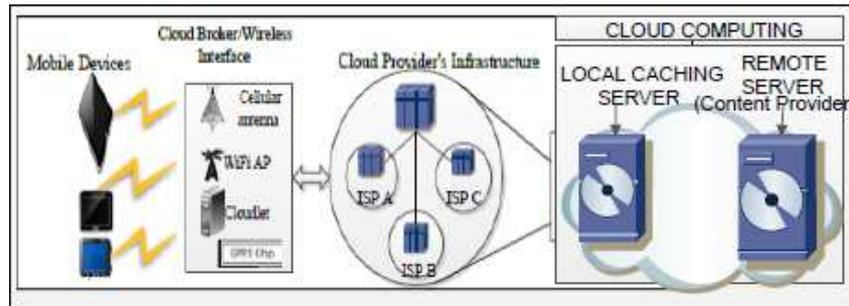


Fig.1. The client/cloud model system architecture

Mobile cloud computing advantages make its diverse environment potential for mobile cloud applications to leveraging the cloud services. Mobile devices are connected to and the end-user interacts with the cloud servers via cloud service provider to retrieve his/her data. Unlike a mobile device that has limited resource such as network connectivity; a cloud provider delivers a powerful agent in network connectivity improvement from a large platform of web servers hosted in cloud providers infrastructure belonging to thousands ISPs and multi-carriers. With high speed links, routers and other networking infrastructure and can access internet resource (such as web content) deliver them to the end user easily. Instead of application executed locally and direct demand for data streaming from data content providers. The mobile devices user can outsource parts of their application to the cloud server leveraging diversity of the cloud resources. By storing data into the cloud server, the data owners can be relieved from the burden of storage and processing. The individual users can on request (gather) certain data files of interest during a period of time mostly such as playing music, watching movie or performing a light weight application. Figure 2 illustrate the user interaction flow with their mobile device for the cloud storage services. Additionally the system model to which a user belongs is used as an access control decision for certain user types.

End-Users Request) and Data Access Module

Content Delivery Network (CND) is a network constructed from a group of strategically placed and geographically distributed catching servers. Content delivery is one of the most efficient solutions for Content Providers (CPs) in serving a large number of end-user devices, for reduction in content download time and network traffic. The focus of CDN is for the content provider to make sure they deliver the content to the end-user when they (end-user) requests for it in their mobile devices. During the request, the CDN helps end-user to receive that information (video data) as faster as possible and reducing the network traffic load that is going to run over the internet. In our model, a content provider is cloud and the content request and delivery route with Content delivery network. The content provider will send information to the end-user directly, the request will go and

come back and the information will deliver directly to the end-user. Because there is going to be large number of mobile users across the internet, this way may trigger a tedious work to the content provider to deliver the information to all this end-user. Therefore, there are should be efficient way to deliver this content (e.g., movies, big data files) to the end-users; hence, the CDN is the only way efficient to use. As shown in Fig. 3 end-user will gather and try to search some of this data file on the cloud (local caching server) and this caching server will connect/contact with content provider receiving the information in advance some of the popular one, then if the request made it will deliver direct to the end-user and the end-user will access the data file. Now what happens is that, the information need to be predicated, which information and which type of data file will be needed and moved to the caching server(in the cloud) in advance. The effect will be is that when end-user request to the data file then a local caching server (in the cloud e.g., MNOs and Cloudlets) will deliver to the end-user much faster than direct from content provider to all user in that local territory in much less time. Moreover, the amount of traffic load that generate in the internet is reducing and it made very effective and efficient. The caching server (in the cloud) stores popular data file in advance.

The mobile application *c* runs in the end user's device. Remembering the user associate with the mobile device, that is sending request to the cloud server to get access to the video data. Abundant chunk of uploaded data files to the cloud considered in this study due to its on-demand popularity. For the end users access uploaded data files (outsourced application *c*) that always have been stored in the web pages. The bandwidth for corresponding user analyzed immediately after data files have uploaded to the cloud. The list of mobile application *c* which stored in web pages can accessed via web services. Figure 3 describes the end-user interaction with the cloud servers via cloud service provider to access or retrieve his data files (media streaming services). The user can retrieve certain specific by keyword $w = \{w_1, w_2, \dots, w_d\}$ search for outsourced application *c*, the cloud content server provider delivered over the web service to mobile devices. The Web supports access to content stored on a cloud e.g. YouTube; the information in web is encoded and

formatted. As shown in Fig. 3 where dotted line (1) - send the request to the server to get access to the video data, dotted line (3)-sent message back for response to grant user access to the video data and bolded line (2) data streaming transmit ion.

An Application Technical Description Example

Mobile communication networks have been stronger need for both reduced traffic load and data file/content delivery time compared to broadband backbone network (the internet link of this broadband) is abundant and traffic reduction may not be as much as of critical issue. Since, into mobile communication network that serves mobile users, the area network called radio access network delivery information to all mobile users' traffic reduction is going to be a big burden. So we introduced CDN in our proposed system design structure, because especially for mobile communication CDN technology is very important. To provide the above technical description more instances we provide a scenario that reflects the movie rental company is running a mobile application in a data center such as Amazon (Fig. 4). An existing end-user wishes to outsource or gather his application/service in the cloud server storage consist two different types of end-user and services usually provides in different ways. These two different types of users are on-demand user and optimistic user. End-user always login and authenticates into the cloud space to request the services by providing her/his own types of user group (by select user type in a comb box), username and password. The cloud's admin identities and authenticates himself to the system using username and password. The cloud's admin on behalf of the end-user upon demand assign permission for any end-user requested to access the cloud services. When data owner successfully upload data file in the cloud based server for storage, all legitimate every end-user has the right to access data owner's content. If optimistic user only searches the data file and send the request to the cloud's admin server, the related videos should always already partially has retrieved and no need cloud's admin involve. But, for on-demand-user these services served in different way and need cloud's admin involved. If the cloud admin get any request demand submitted form on-demand user, this means cloud admin can decide either to grant/provide on-demand-user permission to access the service. When on-demand user searches and issues by submitting a request to the cloud's admin server to access the service, cloud's admin knows and provide access right is assigned to the on-demand user (i.e. accept or reject) access the service. If access to the service is accept, the data file request permission will send back to on-demand user only and if on-demand user authenticate from cloud's admin based server upon end-user demand. The data file request is accompanied by secrete key, admin sent to the end-user's personal email which is obtained during the registration process. To the service is launched it issue a request to enter the data file's name (video name) and

secrete key, on-demand user must provide the requested data file's name (video name) and secrete key, then submitted requests are ready for on-demand user to access the data file (video). However, for optimistic user can just login and access the application over the cloud space. The access rights granted to them do not depend on any request demand of the services. When the service launched session-out is finish both end-user (on-demand user and optimistic user) can view the status data files by clicking on "session out button" to view the status of the data files (view graph), which it include bandwidth cost, video file size etc, as shown in Fig. 5 the scenarios of this screen shot models describing the typical cost for bandwidth utilization as follows:

- Within the system interface, three sections for screen browser are provided i.e. data owner login section, user login section, and cloud login section (cloud's admin)
- Data owner (new) register and login into the system. Inside the system data owner upload the data secure cloud server automatic specifying his/her user ID and data owner himself/herself has to specify the name his video (Video name) he want to upload. Data own successfully upload the data will send to the cloud
- After the data file stored in the cloud server, request approval of each end-user (i.e. on-demand users) requests will be served by cloud's admin is considered
- Cloud's admin authenticate in cloud space audit, monitor, and upon demand assign access request approval to every on-demand user requests

Bandwidth Cost System Scenario

Mobile communication networks have been stronger need for both reduced traffic load and data file/content delivery time compared to broadband backbone network (the internet link of this broadband) is abundant and traffic reduction may not be as much as of critical issue. Since, into mobile communication network that serves mobile users, the area network called radio access network delivery information to all mobile users' traffic reduction is going to be a big burden. So we introduced CDN in our proposed system design structure, because especially for mobile communication CDN technology is very important. To better explain the implementation of our bandwidth cost system framework, our work presents a general scenario of a user access during the registration, login and authenticates to the cloud space. End user want to access the application, their personal information registered with the server manage by the cloud admin. The person information includes (Identification (user type), email Id, username and password). The application displayed at screen inside mobile user interface. The end-user can retrieval the application and its data via browsers running on devices. Though the data processing and the data storage happen outside the mobile device and results displayed through the device's user interface. These stages can illustrate in Fig. 6 and 7.

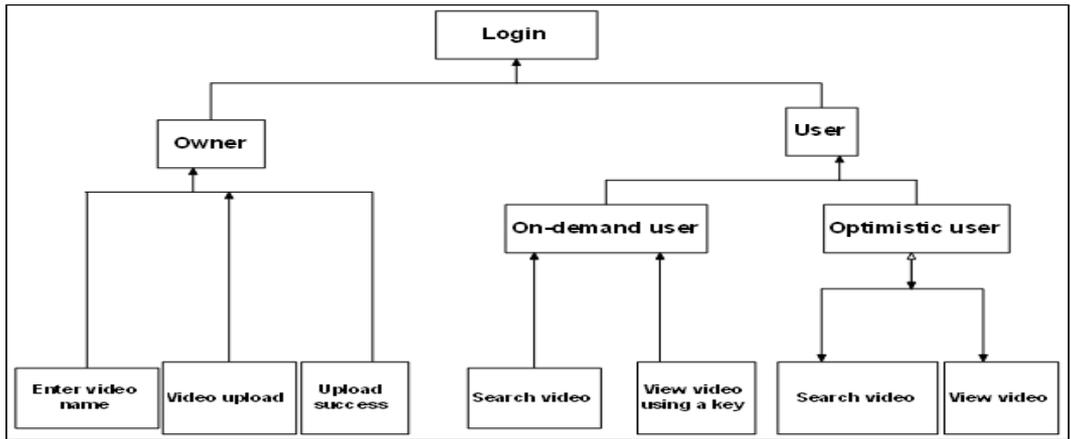


Fig. 2. User login, authenticate to outsource and to gather new application process in the system

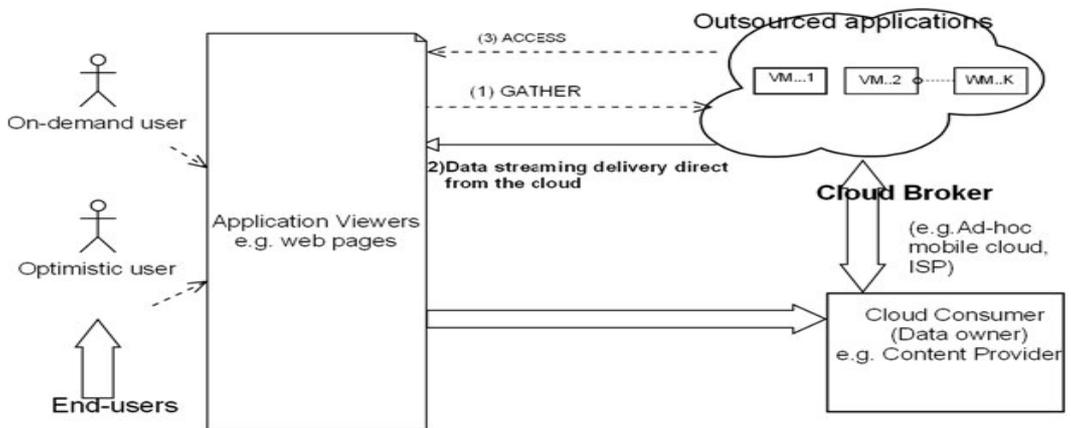


Fig. 3. The basic Structure Content service provider cloud based media streaming services

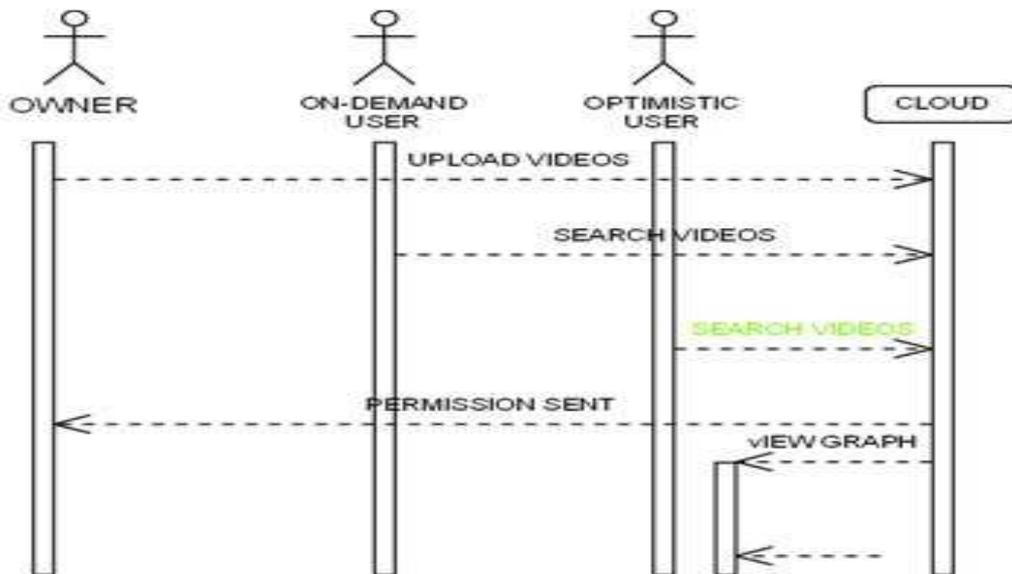


Fig. 4. An access request

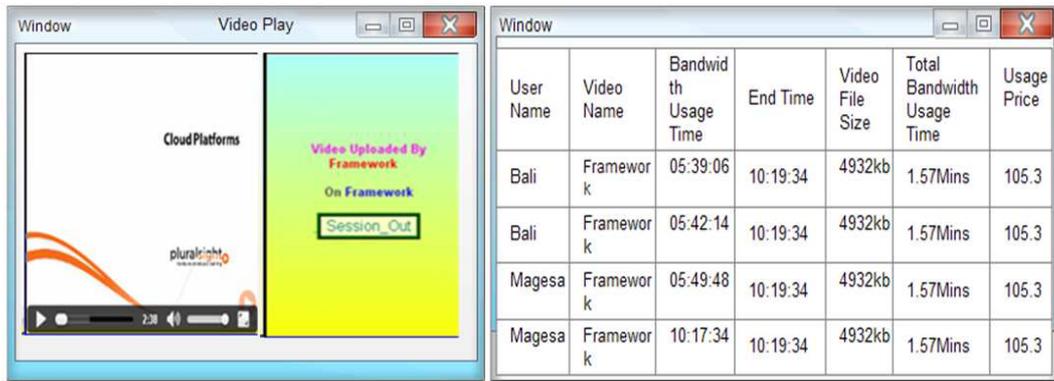


Fig. 5. Window prompt application session-out user view graph

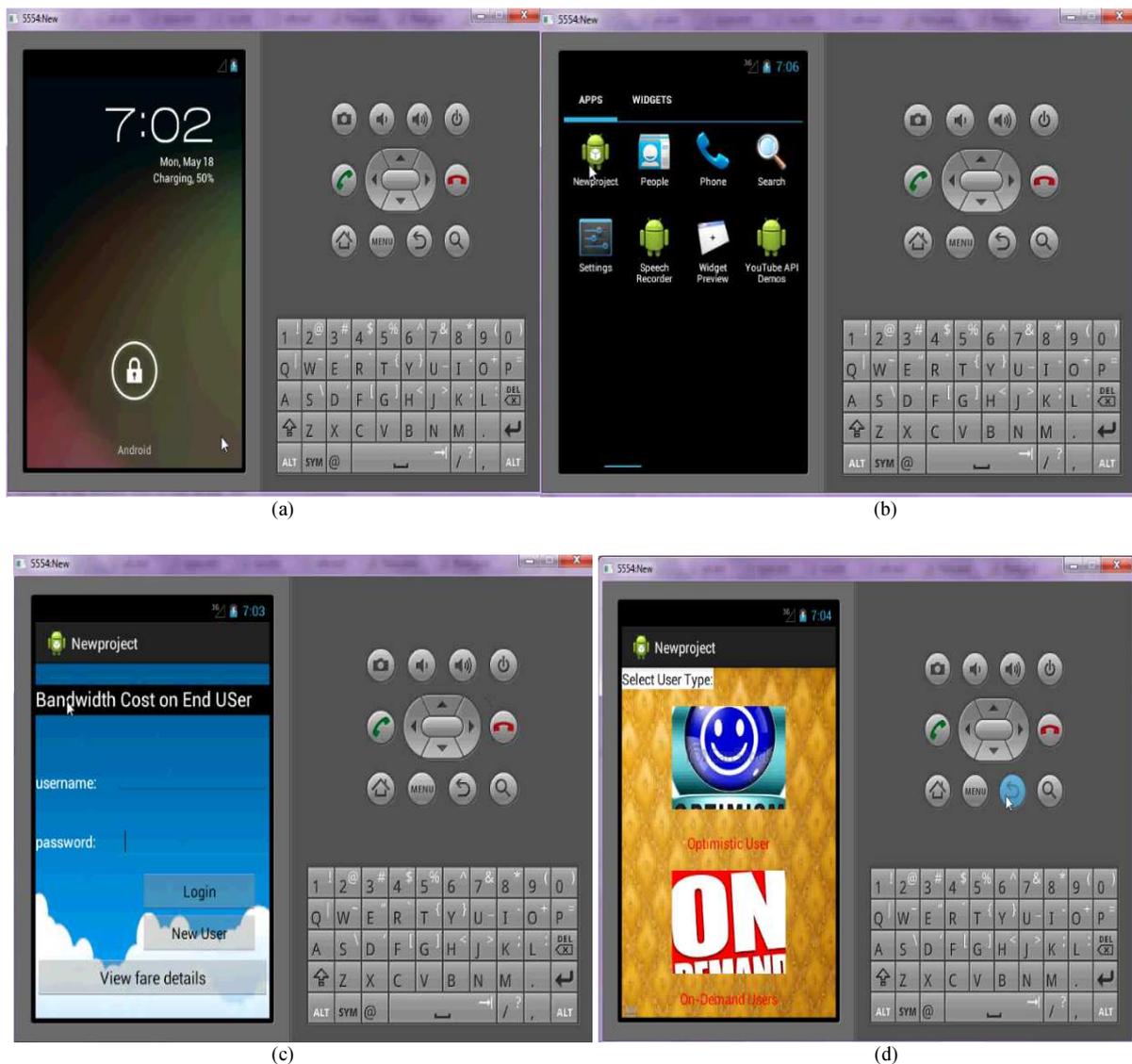


Fig. 6. Client architecture (a) Android emulator display on screen (b) Apps user interface display on screen (c) User run app and User prompted to enter password for authentication (d) user permitted access after successful



Fig. 7. Client/server architecture

Problem Formulation

For cloud provider possesses a number of cloud server/storage geographically located all over the WAN, two major objectives is (1) cloud service provider should optimizing the cost for bandwidth consumption to end users (2) cloud provider should provide users with bandwidth cost system to be aware forecasting of their bandwidth cost applied according to their application requirements and preferences. However, there is conflict between these two objectives. To minimize the cost of bandwidth, therefore cloud service provider should understand the varying bandwidth requirements from on network to another network in cloud environment, the amount of bandwidth each application uses and what is the performance Service-Level Agreement (SLA) for these applications. It is a point that makes cost of the bandwidth minimization problem a challenge. For the end users, large number of the end user may share data owner's outsourced data but the end users only access certain data files of their own interest. Data owner are data files service providers (e.g. online streaming). For different end users direct access data files from cloud server, bandwidth requirements and cost (cost for bandwidth consumption) the negotiation appropriately done between the cloud service provider and users.

The cost of bandwidth minimization problem model is. We formulate the problem of cloud bandwidth consumption as a demand proportional resource allocation strategy. Therefore, assume cloud possesses a number of server machine, denoted by $K = (1, 2, \dots, k)$, each server machine $t \in K$ may have different outgoing bandwidth capacity of B_L for the corresponding user $U =$

$(1, 2, 3, \dots, n)$ and cost C_L per unit of bandwidth (the cost of using bandwidth in this outsourced application C) of each user i . The cost C_L is the cost per MB bandwidth that the cloud service provider charges end user, the capacity B_L is the Maximum Bandwidth (in MB) that can one transmit from cloud sever in that cloud service provider and the capacity B_W is that user require a minimum level of bandwidth. User U and cloud server K have direct access with the total bandwidth B . We assume end users require a minimum level of bandwidth B_W to send the request to the server to get access to the video data and the cost C_L per unit bandwidth access the cloud server is z_1 . Same, we assume the cost C_L per unit bandwidth response from cloud server to access video data is z_2 , the total Bandwidth Cost (BC) = $BC = B_W (U * Z_1 + K * Z_2)$. For the average number of users $U = (1, 2, 3, \dots, n)$ queue to access data file, the incoming aggregate traffic intensity demand D in the time bucket t . The total cost incurred by traffic routing algorithm for the input traffic demand D is $C(I) = c * t$, where $C(I)$ is cost incurred, c is the unit cost of cloud service provider, t is traffic computed time. Assume end users and cloud service provider have negotiated, bandwidth cost is $K BC = B_W (U * Z_1 + K * Z_2)$ by cutting the cost incurred by network traffic routing algorithm. Otherwise, total bandwidth cost is $(BC = B_W (U * Z_1 + K * Z_2) + C(I) = c * t)$. This process repeats until the minimization bandwidth utilization cost is found.

Algorithm 1 Aware Bandwidth cost

1. **INPUT:**
2. Get service information;
3. Get owner name p ;
4. Allocate the bandwidth B_W for end user i ;

5. Allocate the bandwidth threshold limit B_L ;
6. Get users type (on-demand users or optimistic users) s ;
7. Get uploaded data file name v ;
8. **OUTPUT**:
9. Cost of using bandwidth in this resource
10. **WHILE** user request access to the cloud services **DO**
11. (allocate the bandwidth for the user
12. **IF** $B_w < B_L$ **THEN**
13. data owner upload data file
14. **ELSE IF** $B_L \leq B_w$ **THEN**
15. analyses the bandwidth
16. **else**
17. view stored files
18. **end if**
19. **end while**
20. **for** $i=0$ to n **do**
21. bandwidth capacity of B_L for the corresponding end users
22. **end for**
23. **repeat**
24. user request access to the cloud services
25. **until**
26. end users and cloud service provider have negotiated,
27. the cost C_L per unit of bandwidth minimization utilization is found
28. $B_C = B_w(U * Z_1 + K * Z_2)$

Methodology

We perform experiment of the proposed methodology; we implemented the project methodology in Java both in the mobile and in the cloud using cloud emulator. As discussed earlier, the proposed methodology consists of three entities, i.e., the cloud, the cloud's admin and the user. The implementation consists of android emulator software development kit, java programming and platform interface used to communicate with apache tomcat which serve as cloud server to run the application. The cloud admin implemented as the third party. User application functionality of the system implemented as client that connects with service provider (data owner) for user to access the services. The hardware characteristics are Pentium CPU@1.1GHz, 1GB RAM, storage of 20GB and windows operating system. The communication between the entities accomplished using Navicat 8 Lite for MySQL. Since Content Delivery Network (CND) is an integral part in the system implementation, the implement procedures starts when the end-user requests a data file to its nearest caching server (such as MNOs and Cloudlets) isn't in the caching server, then the caching server redirects the end-user's request to the remotely located content provider (such as public cloud). Figure 8 indicates the process of experimentation scenario.

Evaluation

This section analyzes the project characteristics of the cloud and user client for the application outsourcing. It investigates the impact of user interaction with the cloud space of the application outsourcing in experiment.

User Login and Request for the Cloud Service

Both cloud admin and user login into the application in cloud space. The application connects with data owner that required by the user to access the service. The data owner submits the data and data file's name required for generating secret key to the cloud server. Users (on-demand user and optimistic user) access to the request service, but only on-demand user authenticate from admin. Cloud admin has responsible for view on-demand user request, view upload video details, view graph for on-demand user fraud, view graph for file size and view graph for the bandwidth cost as show in Fig. 2 and 9.

On-Demand-User Fraud Analysis

The goal of fraud analysis is to protect the application and services from attacks and misbehavior. To ensure that the communication between the entities is trustworthy and a malicious cannot interfere into the application. That is the system will not lose its functionality. The graph shows user activities and interacts with the services in the cloud space as shown in Fig. 10.

Bandwidth Cost Analysis

In the bandwidth, cost based mobile application outsourcing, the available searched and requested data files are stored on the cloud. We perform the experiment with single application (video files) to analyze the cost for varying bandwidth according to different user in a point of data files size. The cost of the bandwidth varies depending with bandwidth usage time and cloud user types (on-demand user or optimistic user) regarding dynamic bandwidth allocation for corresponding user. On-demand users bandwidth usage tends to be high as well as cost compared to optimistic users as shown in Fig. 11.

File Size Usage Analysis

Network traffic that is accessed by mobile users (e.g., smart devices) is rapidly increasing. Mobile network performance is highly dependent on the content download of multimedia data and applications. Several mobile network operators have suffered from service outage or performance deterioration due to the significant increase in use of mobile devices. To consider the case for file size access process, since we only considered reducing bandwidth cost in this study. Also, we can consider the case for on-demand users authenticates from cloud admin where if there is fraud involving application request. User authenticates from admin minimizing data transmission delay (queuing for services) and to improve the bandwidth utilization rate for varying data files size. Figure 12 illustrate the line chart of number of data file buffering to different video usage.

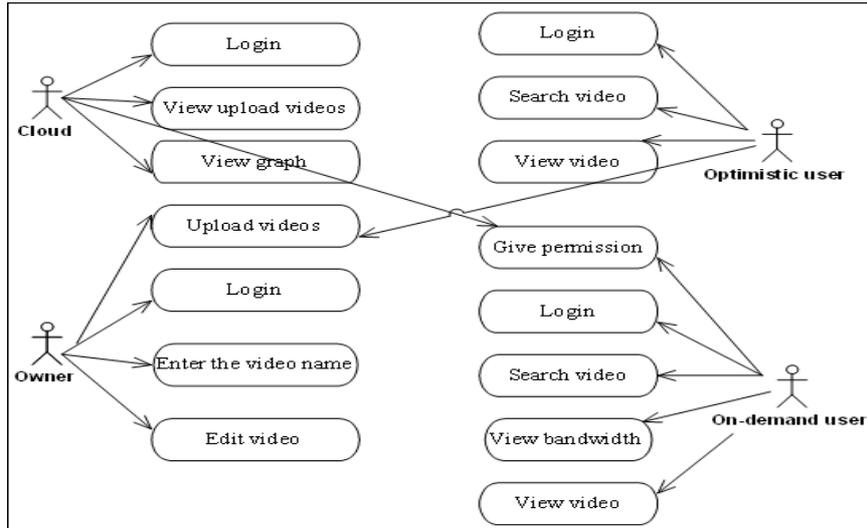
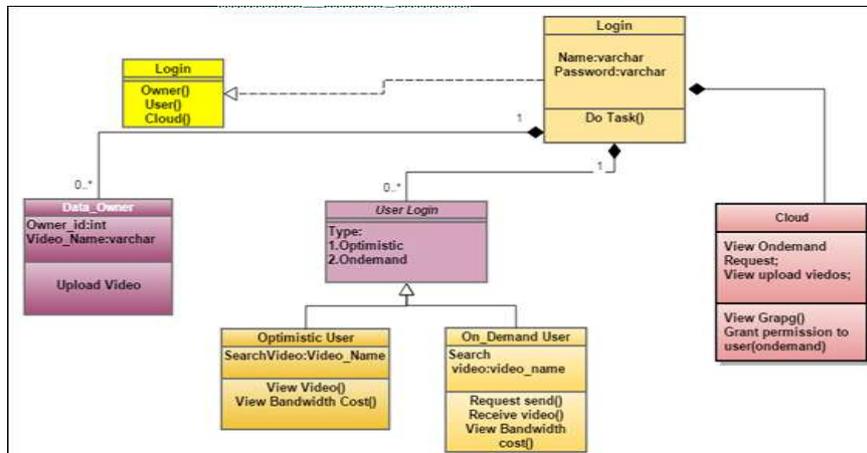
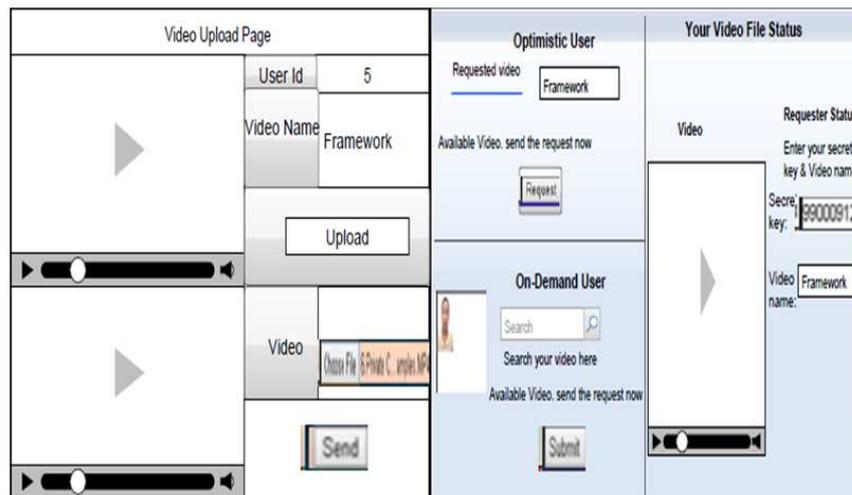


Fig. 8. Experiment taxonomy for system development in content delivery



(a)



(b)

Fig. 9. User login and request for the service (a) case-diagram (b) On left-Data owner upload the data file and send to cloud, on right-Optimistic user, only on-demand user authenticate from admin to access the data

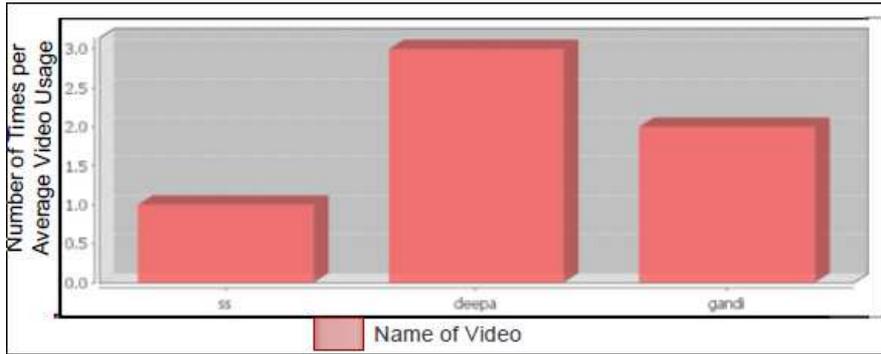


Fig. 10. User fraud analysis

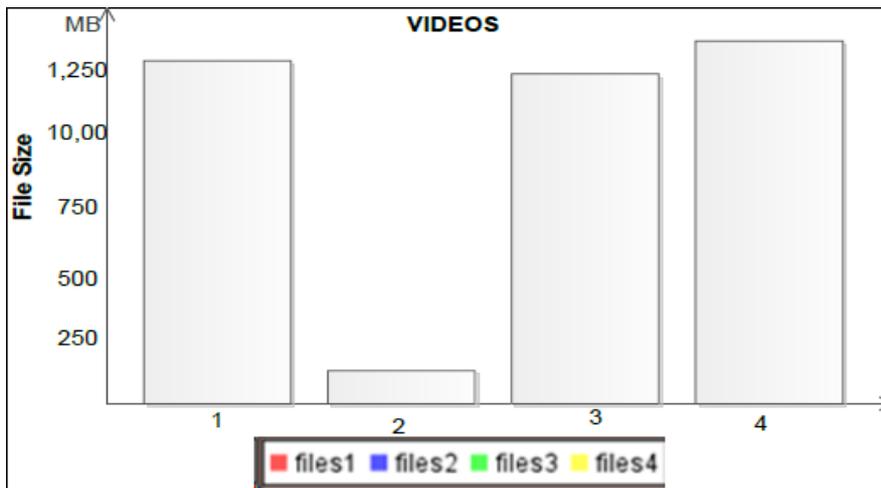


Fig. 11. Bandwidth cost analysis

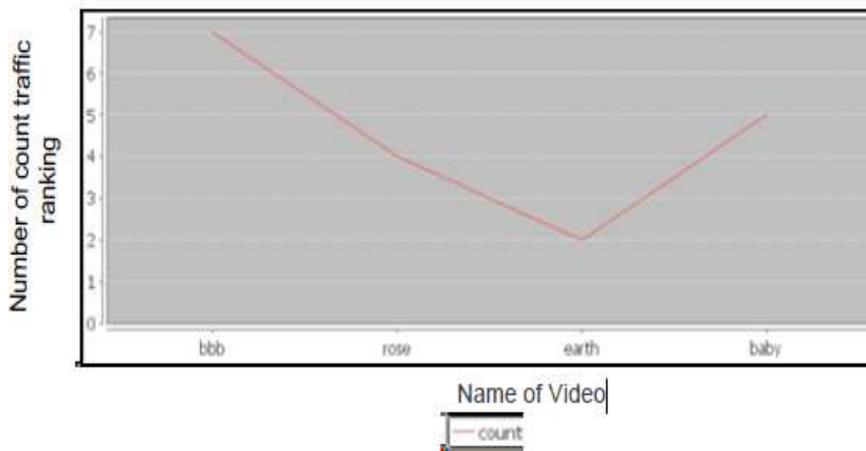


Fig. 12. File size cost analysis

Conclusion

In this study, we propose a theoretic framework model to study the Cost-Bandwidth consumption tradeoff for mobile application outsourcing in the cloud-

based server and consider a realistic scenario with a video's files streaming bandwidth cost system. We formulate the bandwidth cost system of virtual machine instances, under bandwidth allocation as a constrained bandwidth analysis for bandwidth optimization problem.

And design online bandwidth cost system to approach the optimal aware forecasting of the cost of using bandwidth in mobile application outsourcing to end users. In the existing system, the growth of Internet online services has grown very rapidly in last decades. The drawback can see when implementing the system, disadvantage being computability in design and implementing the system. More and more Internet applications move their platform to cloud providers and number of such applications that provide an online streaming service does not have any quantitative guarantee. Moreover, this scenarios can contribute to slow down or impend the adopting the designing of upfront bandwidth cost system fully utilized to satisfy the baseline user demand. This will minimize the consumption of the cloud resources due to users will not interested using mobile cloud environment access or outsource their data files in the Cloud servers. We have implemented application on client and applied it to a full system (i.e., Client/Server). Our experiment confirm that with outsourced video steaming plays, system and the algorithm can automatically generate bandwidth cost for each end user that makes correct for bandwidth cost prediction decisions for future online streaming applications under varying bandwidth allocated and application type. In future, we believe to extend the system significant towards developing future "aware bandwidth cost" mobile applications to leverage cloud computing resource.

Acknowledgement

This work was partially supported by the NSF of China under grants No. 61173048 and No. 61300041, Specialized Research Fund for the Doctoral Program of Higher Education under grant No. 20130074110015 and the Fundamental Research Funds for the Central Universities under Grant No. WH1314038.

Author's Contributions

Buchanagandi Enock Nyamajeje: Make considerable contributions to conception and design and/or acquisition of data and/or Analysis and interpretation of data.

Huiqun Yu: Give final approval of the version to be submitted and any revised version.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and no ethical issues involved.

References

- Abhinav, P., Y.H. Charlie, Z. Ming, B. Paramvir and W. Yi-Min, 2011. Enabling automatic offloading of resource-intensive smartphone applications. Technical Reports.
- Abolfazli, S., Z. Sanaei, E. Ahmed, A. Gani and R. Buyya, 2013. Cloud-based augmentation for mobile devices: Motivation, taxonomies. IEEE Commun. Surveys Tutorials, 16: 337-368
- Chonho, L., W. Ping and N. Dusit, 2013. A real-time group auction system for efficient allocation of cloud internet applications. IEEE Trans. Services Computing, 8: 251-268
- Di, N., C. Feng and B. Li, 2012. Pricing cloud bandwidth reservations under demand uncertainty. Proceedings of the International Conference on Sigmetrics/Performance Joint Measurement and Modeling of Computer Systems, Jun. 11-15, New York, pp: 151-162. DOI: 10.1145/2254756.2254776
- Ejaz, A., A. Akhuzada, M.D. Whaiduzzaman, G. Abdullah and H. Siti *et al.*, 2014. Network-centric performance analysis of runtime application migration in mobile cloud computing. J. Simulation Modeling Practice Theory, 50: 42-56.
- Eyal, Z., C. Israel and M. Osnat, 2014. PACK: Prediction-based cloud bandwidth and cost reduction system. IEEE/ACM Trans. Netw., 22: 39-51. DOI: 10.1109/TNET.2013.2240010
- Hoang, T.D., L. Chonho, N. Dusit and W. Ping, 2013. Survey of mobile cloud computing: Architecture, application and approaches. Wirel Commun. Mob. Comput., 13: 1587-1611.
- Jiangtao, Z., H. Zhixiang, H. Hejiao, W. Xuan and G. Chonglin *et al.*, 2014. SLA aware cost efficient virtual machines placement in cloud computing. Proceedings of the IEEE International Performance Computing and Communications Conference, Dec. 5-7, IEEE Xplore Press, Austin, pp: 1-8.
DOI: 10.1109/PCCC.2014.7017101
- Meng, X., V. Pappas and L. Zhang, 2010. Improving the scalability of data center networks with traffic-aware virtual machine placement. Proceedings of the IEEE Infocom, Mar. 14-19, IEEE Xplore Press, San Diego, pp: 1-9. DOI: 10.1109/INFCOM.2010.5461930
- Morford, M. and R. Purvy, 2013. Cost-aware, bandwidth management systems adaptive to network conditions. Blue Coat Syst. Inc.
- Muhammad, S., A. Ejaz, G.I. Abdullah and H. Qi, 2014. Investigation on runtime partitioning of elastic mobile applications for mobile cloud computing. J. Supercomputing, 67: 88-103.
DOI: 10.1007/s11227-013-0988-6

- Muhammad, S., A. Saeid, S. Zohreh and G. Abdullah, 2012. Virtual machine migration: A resource intensive outsourcing mechanism for mobile cloud computing. *Archives Des. Sci. J.*
- Muhammad, S., MD., Whaiduzzaman and G. Abdullah, 2013. A study on anatomy of smartphone. *J. Comput. Commun. Collaboration*, 1: 24-31.
- Muhammad, S., S. Abolfazli, Z. Sanaei and A. Gani, 2013. A study on virtual machine deployment for application outsourcing in mobile cloud computing. *J. Supercomputing*, 63: 946-964.
DOI: 10.1007/s11227-012-0846-y
- O'Sullivan, M.J. and D. Grigoras, 2013. Cloud application models facilitated by the CPA. *Proceedings of the International Conference on MOBILE Wireless Middle Ware, Operating Systems and Applications*, Nov. 11-13, IEEE Xplore Press, Bologna, pp: 120-128.
DOI: 10.1109/Mobilware.2013.14
- Shiraz, M., A. Gani, R.H. Khokhar and R. Buyya, 2013. A review on distributed application processing frameworks in smart mobile devices for mobile cloud computing. *IEEE Commun. Surveys Tutorials*, 15: 1294-1313.
- Yichao, J., W. Yonggang, G. Kyle, K. Daniel and X. Haiyong, 2013. Toward monetary cost effective content placement in cloud centric media network. *Proceedings of the IEEE International Conference on Multimedia and Expo*, Jul. 15-19, IEEE Xplore Press, San Jose, pp: 1-6. DOI: 10.1109/ICME.2013.6607582
- Yu, L. and H. Shen, 2014. Bandwidth guarantee under demand uncertainty in multi-tenant clouds. *Proceedings of the IEEE 34th International Conference on Distributed Computing Systems*, Jun. 30-Jul. 3, IEEE Xplore Press, Madrid, pp: 258-267.
DOI: 10.1109/ICDCS.2014.34
- Yuan, D., X. Liu, L. Cui, T. Zhang and W. Li *et al.*, 2013. An algorithm for cost-effectively storing scientific datasets with multiple service providers in the cloud. *Proceedings of the IEEE 9th International Conference on Science*, Oct. 22-25, IEEE Xplore Press, Beijing, pp: 285-292. DOI: 10.1109/eScience.2013.34