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A Dynamic Cloud Based Mobile TV Using Social Network

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Abstract:

The rapidly increasing power of personal mobile devices (smartphones, tablets, etc.) is providing much richer contents and social interactions to users on the move. This trend however is throttled by the limited battery lifetime of mobile devices and unstable wireless connectivity, making the highest possible quality of service experienced by mobile users not feasible. The recent cloud computing technology, with its rich resources to compensate for the limitations of mobile devices and connections, can potentially provide an ideal platform to support the desired mobile services.

Tough challenges arise on how to effectively exploit cloud resources to facilitate mobile services, especially those with stringent interaction delay requirements. In this paper, we propose the design of a Cloud-based, novel Mobile sOcialtV system (CloudMoV). The system effectively utilizes both PaaS (Platform-as-a-Service) and IaaS (Infrastructure-asa- Service) cloud services to offer the living-room experience of video watching to a group of disparate mobile users who can interact socially while sharing the video.

To guarantee good streaming quality as experienced by the mobile users with timevarying wireless connectivity, we employ a surrogate for each user in the IaaS cloud for video downloading and social exchanges on behalf of the user. The surrogate performs efficient stream transcoding that matches the current connectivity quality of the mobile user. Given the battery life as a key performance bottleneck, we advocate the use of burst transmission from the surrogates to the mobile users, and carefully decide the burst size which can lead to high energy efficiency and streaming quality. Social interactions among the users, in terms of spontaneous textual exchanges, are effectively achieved by efficient designs of data storage with BigTable and dynamic handling of large volumes of concurrent messages in a typical PaaS cloud.

These various designs for flexible transcoding capabilities, battery efficiency of mobile devices and spontaneous social interactivity together provide an ideal platform for mobile social TV services. We have implemented CloudMoV on Amazon EC2 and Google App Engine and verified its superior performance based on realworld experiments.

Thanks to the revolutionary "reinventing the phone" campaigns initiated by Apple Inc. in 2007, smartphones nowadaysare shipped with multiple microprocessor cores and gigabyte RAMs; they possess more computation power than personalcomputers of a few years ago. On the other hand, the wide deployment of 3G broadband cellular infrastructures furtherfuels the trend.
Apart from common productivity tasks like emails and web surfing, smartphones are flexing their strengthsin more challenging scenarios such as real-time video streaming and online gaming, as well as serving as a main tool for socialexchanges. Although many mobile social or media applications have emerged, truely killer ones gaining mass acceptance are stillimpeded by the limitations of the current mobile and wireless technologies, among which battery lifetime and unstableconnection bandwidth are the most difficult ones.

It is natural to resort to cloud computing, the newly-emerged computingparadigm for low-cost, agile, scalable resource supply, to support power-efficient mobile data communication. With virtuallyinfinite hardware and software resources, the cloud can offload the computation and other tasks involved in a mobileapplication and may significantly reduce battery consumption at the mobile devices, if a proper design is in place. The bigchallenge in front of us is how to effectively exploit cloud services to facilitate mobile applications. There have been afew studies on designing mobile cloud computing systems [1][2][3], but none of them deal in particular with stringentdelay requirements for spontaneous social interactivity among mobile users.

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In this paper, we describe the design of a novel mobile social TV system, CloudMoV, which can effectively utilize the cloud computing paradigm to offer a living-room experience of video watching to disparate mobile users with spontaneous social interactions. In CloudMoV, mobile users can import a live or on-demand video to watch from any video streaming site, invite their friends to watch the video concurrently, andchat with their friends while enjoying the video.

It therefore blends viewing experience and social awareness among friendson the go. As opposed to traditional TV watching, mobile social TV is well suited to today's life style, where familyand friends may be separated geographically but hope to share a co-viewing experience. While social TV enabled by set-topboxes over the traditional TV systems is already available [4][5], it remains a challenge to achieve mobile social TV, wherethe concurrently viewing experience with friends is enabled on mobile devices. We design CloudMoV to seamlessly utilize agile resource support and rich functionalities offered by both an IaaS (Infrastructure-as-a-Service) cloud and a PaaS (Platform-asa-Service) cloud.

Our design achieves the following goals. Encoding flexibility. Different mobile devices have differentlysized displays, customized playback hardwares, and various codecs. Traditional solutions would adopt a few encodingformats ahead of the release of a video program. But even the most generous content providers would not be able to attendto all possible mobile platforms, if not only to the current hottest models. CloudMoV customizes the streams for differentdevices at real time, by offloading the transcoding tasks to an IaaS cloud. In particular, we novelly employ a surrogate foreach user, which is a virtual machine (VM) in the IaaS cloud. The surrogate downloads the video on behalf of the user andtranscodes it into the desired formats, while catering to the specific configurations of the mobile device as well as thecurrent connectivity quality.

Battery efficiency:

A breakdown analysis indicates that the network modules (both Wi-Fi and 3G) and the display contribute to a significant portion of the overall power consumption in a mobile device, dwarfing usages from other hardware modules including CPU, memory, etc.

We target at energy saving coming from the network module of smartphones through an efficient data transmission mechanism design. We focus on 3G wireless networking as it is getting more widely used and challenging in our design than Wi-Fi based transmissions. Based on cellular network traces from real-world 3G carriers, we investigate the key 3G configuration parameters such as the power states and the inactivity timers, and design a novel burst transmissionmechanism for streaming from the surrogates to the mobile devices. The burst transmission mechanism makes careful decisions on burst sizes and opportunistic transitions among high/low power consumption modes at the devices, in order to effectively increase the battery lifetime.

A number of mobile TV systems have sprung up in recent years, driven by both hardware and software advances in mobile devices. Some early systems [8][9] bring the "livingroom" experience to small screens on the move. But they focusmore on barrier clearance in order to realize the convergence of the television network and the mobile network, than exploringthe demand of "social" interactions among mobile users.

There is another trend in which efforts are dedicated to extendingsocial elements to television systems. Coppens et al.try to add rich social interactions to TV but their design is limited to traditional broadcast program channels. Oehllberg et al. [5] conduct a series of experiments on human social activities while watching different kinds of programs. Though inspiring, these designs are not that suitable for being applied directly in a mobile environment. Chuah et al.

extend the social experiences of viewing traditional broadcast programs to mobile devices, but have yet to deliver a well integrated framework. Schatz et al.have designed a mobile social TV system, which is customized for DVBH networks and Symbian devices as opposed to a wider audience. Compared to these prior work and systems, we target at a design for a generic, portable mobile social TV framework, featuring co-viewing experiences among friends over geographical separations through mobile devices. Our framework is open to all Internet-based video programs, either live or on-demand, and supports a wide range of devices with HTML5 compatible browsers installed, without any other mandatory component on the devices.

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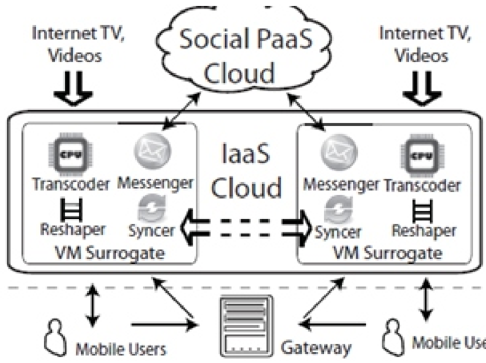
For any application targeted at mobile devices, reducing power consumption is perennially one of the major concernsand challenges. Flinn et al. exploit collaborations between the mobile OS and the mobile applications to balance theenergy conservation and application performance. Yuan et al. investigate mobile multimedia streaming, similar tomost of the other work, by adjusting the CPU power for energy saving; however, according to the recent measurement work of Carroll et al., the display and the wireless network card (including the cellular module) and not the CPU consumemore than half of the overall power consumption in smart phones nowadays. Our work is able to achieve a significant(about 30%) power saving, by opportunistically switching the device between high-power and low-power transmission3 modes during streaming.

Some existing work (e.g., Anastasi et al.) have provided valuable guidelines for energy savingover WiFi transmissions; our work focuses on 3G cellular transmissions which have significantly different power models;3G is a more practical wireless connection technology for mobile TVs on the go at the present time.

The architecture of CloudMoV:



CLOUDMOV: ARCHITECTURE AND DESIGN:

As a novel Cloud-based Mobile social TV system, CloudMoV provides two major functionalities to participating mobileusers: (1) Universal streaming. A user can stream a live or on-demand video from any video sources he chooses, suchas a TV program provider or an Internet video streaming site, with tailored encoding formats and rates for the deviceeach time. (2) Co-viewing with social exchanges. A user can invite multiple friends to watch the same video, and exchangetext messages while watching. The group of friends watching the same video is referred to as a session. The mobile userwho initiates a session is the host of the session. We present the architecture of CloudMoV and the detailed designs of thedifferent modules in the following.

Clouds TV was just what the market ordered and this is apparent by the overwhelming response it has received since launching in 2010. In just its broadcast infancy of three years,Clouds TV is already one of the highest rated stations in Tanzania and is leading the pack in the youth segment. As a visual expression of Clouds FM, Clouds TV is very much the People's TV station and has continuously been a market leader in content creation including the launch of Tanzania's first locally produced soap opera and domestic tourism shows. Clouds TV was also the first station to fully integrate social media interaction and engagement into every broadcast. If it is cool, hot, and happening, you will find it on Clouds TV.

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Components of Cloud-Mov:

Transcoder:

It resides in each surrogate, and is responsible for dynamically deciding how to encode the videostream from the video source in the appropriate format,dimension, and bit rate. Before delivery to the user,the video stream is further encapsulated into a propertransport stream. In our implementation, each video is exported as MPEG-2 transport streams, which is the defacto standard nowadays to deliver digital video and audiostreams over lossy medium.

Reshaper:

The reshaper in each surrogate receives the encoded transport stream from the transcoder, chops itinto segments, and then sends each segment in a burst tothe mobile device upon its request (i.e., a burst transmissionmechanism), to achieve the best power efficiency of the device. The burst size, i.e., the amount of datain each burst, is carefully decided according to the 3G technologies implemented by the corresponding carrier.

Social Cloud:

The social cloud is built on top of any general PaaS cloud services with BigTable-like data storeto yield better economies of scale without being locked down to any specific proprietary platforms. Despite itsimplementation on Google App Engine (GAE) as a proof of concept, our prototype can be readily ported to otherplatforms. It stores all the social data in the system, including the online statuses of all users, records ofthe existing sessions, and messages (invitations and chat histories) in each session. The social data are categorizedinto different kinds and split into different entities (in analogy to tables and rows in traditional relational database, respectively) [23]. The social cloud is queried from time to time by the VM surrogates.

Messenger:

It is the client side of the social cloud, residing in each surrogate in the IaaS cloud. The Messengerperiodically queries the social cloud for the social data on behalf of the mobile user and pre-processes the datainto a light-weighted format (plain text files), at a much lower frequency. The plain text files (in XML formats) areasynchronously delivered from the surrogate to the user in a traffic-friendly manner, i.e., little traffic isincurred.In the reverse direction, the messenger disseminates this user's messages (invitations and chat messages) to otherusers via the data store of the social cloud.

Syncer:

The syncer on a surrogate guarantees that viewing progress of this user is within a time window ofother users in the same session (if the user chooses to synchronize with others). To achieve this, the syncerperiodically retrieves the current playback progress of the session host and instructs its mobile user to adjustits playback position. In this way, friends can enjoy the "sitting together" viewing experience. Different from thedesign of communication among messagers, syncers on different VM surrogates communicate directly with eachother as only limited amounts of traffic are involved.

Mobile Client:

The mobile client is not required to install any specific client software in order to use CloudMoV,as long as it has an HTML5 compatible browser (e.g., Mobile Safari, Chrome, etc.) and supports the HTTP LiveStreaming protocol [24]. Both are widely supported on most state-of-the-art smartphones.

Gateway:

The gateway provides authentication services for users to log in to the CloudMoV system, and storesusers' credentials in a permanent table of a MySQL database it has installed. It also stores information ofthe pool of currently available VMs in the IaaS cloud in another inmemory table. After a user successfullylogs in to the system, a VM surrogate will be assigned from the pool to the user. The in-memory table is usedto guarantee small query latencies, since the VM pool is updated frequently as the gateway reserves and destroysVM instances according to the current workload. In addition, the gateway also stores each user's friend list ina plain text file (in XML formats), which is immediately uploaded to the surrogate after it is assigned to the user.

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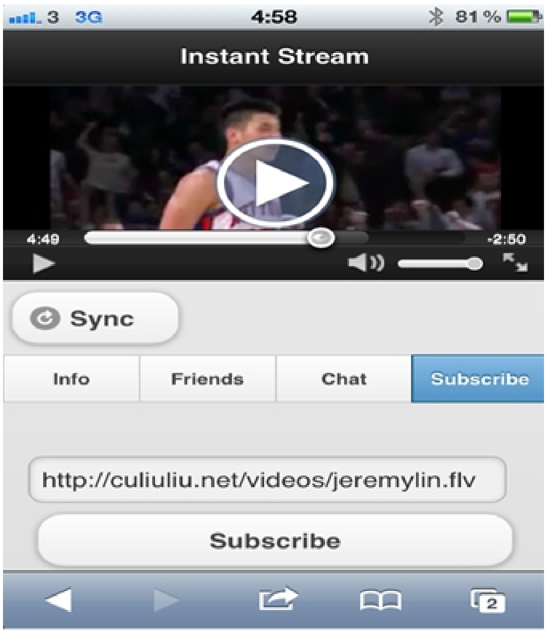
Screen Samples:



we propose to implement all the video processing related tasks using ANSI C, to guarantee the performance.In particular, we install FFmpeg together with libavcodec as the groundsill library to develop the transcoding,segmentation and reshaping modules on the VM surrogates. We have also installed a Tomcat web server (version 6.5) toserve as a Servlet container and a file server on each surrogate.

Both FFmpeg and Tomcat are open source projects. Oncea VM surrogate receives a video subscription request from the user, it downloads the video from the source URL, andprocesses the video stream by transcoding and segmentation, based on the collected device configurations by the portal.For example, in our experiments, the downloaded stream is transcoded into a high-quality stream and a low-quality streamin real time with H264/AAC codecs.

The high-quality stream has a “480x272” resolution with 24 frames per second, whilethe low-quality one has a “240x136” resolution with 10 frames per second. A mobile user dynamically requests segments ofthese two different video streams, according to his current network connection speed. The transcoded stream is furtherexported to an MPEG-2 transporting stream (.ts), which is segmented for burst transmission to the user.

CloudMoV deployed on Amazon EC2 and Google App Engine, using a number of iPhone 4S smart phones (iOS5.01) as the mobile clients, which have been registered on the Apple developer site. The gateway is implemented on aVirtual Private Server (VPS) hosted by Bluehost. Unless stated otherwise, the experiments are conducted over the 3Gcellular network of 3HK , which is one of the largest Telecom operators in Hong Kong.

Conclusion:

Trend for mobile TV, i.e., mobile social TV based on agile resource supports and rich functionalities of cloud computingservices. We introduce a generic and portable mobile social TV framework, CloudMoV, that makes use of both an IaaScloud and a PaaS cloud. The framework provides efficient transcoding services for most platforms under various networktimely chat exchanges among the viewing users.

By employing one surrogate VM for each mobile user, we achieve ultimatescalability of the system. Through an in-depth investigation of the power states in commercial 3G cellular networks, we thenpropose an energy-efficient burst transmission mechanism that can effectively increase the battery lifetime of user devices.We have implemented a realistic prototype of CloudMoV, deployed on Amazon EC2 and Google App Engine, whereEC2 instances serve as the mobile users' surrogates and GAE as the social cloud to handle the large volumes ofsocial message exchanges. We conducted carefully designed experiments on iPhone 4S platforms.

The experimental resultsprove the superior performance of CloudMoV, in terms of transcoding efficiency, power saving, timely social interaction,and scalability. The experiments also highlight the drawbacks of the current HTTP Live Streaming protocol implementationon mobile devices [24] as compared to our proposed burst transmission mechanism which achieves a 29.1 % increase ofbattery lifetime Much more, however, can be done to enhance CloudMoV to have product-level performance.

In the current prototype, we do not enable sharing of encoded streams (in the same format/bit rate) among surrogates of different users.

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In ourfuture work, such sharing can be enabled and carried out in a peer-to-peer fashion, e.g., the surrogate of a newly joineduser may fetch the transcoded streams directly from other surrogates, if they are encoded in the format/bit rate that the new user wants.For implementing social interactions, most BigTable-like data stores (including GAE) support memcache [34] which is a highly efficient secondary storage on the data stores. We seek to integrate memcache support into CloudMoV, bypossibly memcaching the data (e.g., chat histories) of sessions where friends chat actively, so as to further improve the queryperformance. To sustain the portability of the system, we will stick to standard API interfaces, i.e., JCache (JSR 107), in oursystem.

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