

Cloud-based Mobile IPTV Terminal for Video Surveillance

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Abstract—Surveillance video streams monitoring is an important task that the surveillance operators usually carry out. The distribution of video surveillance facilities over multiple premises and the mobility of surveillance users requires that they are able to view surveillance video seamlessly from their mobile devices. In order to satisfy this requirement, we propose a cloud-based IPTV (Internet Protocol Television) solution that leverages the power of cloud infrastructure and the benefits of IPTV technology to seamlessly deliver surveillance video content on different client devices anytime and anywhere. The proposed mechanism also supports user-controlled frame rate adjustment of video streams and sharing of these streams with other users. In this paper, we describe the overall approach of this idea, address and identify key technical challenges for its practical implementation. In addition, initial experimental results were presented to justify the viability of the proposed cloud-based IPTV surveillance framework over the traditional IPTV surveillance approach.

Keywords—Video surveillance, IPTV, cloud computing, mobile terminal

I. INTRODUCTION

Video surveillance systems [1], [2] nowadays utilize a large number of cameras distributed over multiple sites. They record and process surveillance video to identify events of interest and keep the digital evidences of event occurrences as video or image feeds. The surveillance operators view these feeds in real-time or in offline fashion to ensure safety and security of people and resources.

The current video surveillance systems use different mechanisms to allow viewing the video streams from PC or handheld devices. In the case of CCTV systems, the video content is stored in centralized servers that can later be viewed from client devices through wired or wireless networks. The third generation is the modern day digital surveillance systems [3], often equipped with distributed IP-based cameras, which enable users to access the video content over the Internet in real-time. These systems also require centralized or decentralized storage servers to preserve, process, and deliver video content to the users' device even when they are on the move. Although the IP-based surveillance provide much flexibility compared to CCTV systems, the users still face challenge in camera feeds scheduling, interactive control of video stream, video sharing and alert setup.

In the context of mobile surveillance, the delivery of video content to the client's mobile terminal requires that

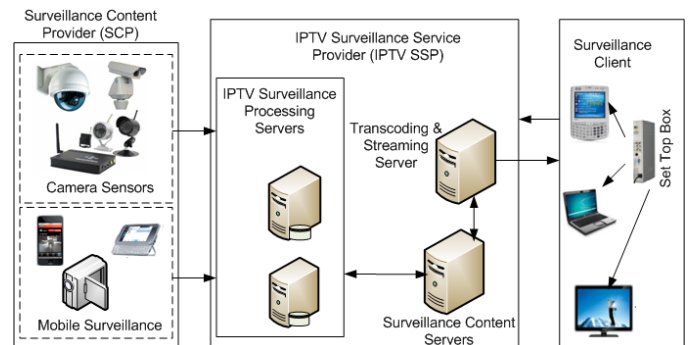


Fig. 1. Traditional IPTV framework for video surveillance

the video should be viewed from any device, anywhere and anytime [4], [5]. This requirement is particularly important for police and public security officers who are on the move while patrolling different premises such as airport, shopping malls, and schools. However, since mobile terminals have different screen sizes, computation powers, battery amounts, and available network bandwidths, it is difficult to stream/distribute live surveillance video to those diverse mobile terminals efficiently in terms of providers and users benefits. Due to the heterogeneity of mobile terminals, it is also required that each mobile terminal receives streamed surveillance video feeds with the best quality within its capability and with proper video format to easily search and play back the video [6].

In recent years, IPTV has emerged as a successful technology for real-time distribution and delivery of multimedia contents such as transmission of live TV programming and video-on-demand through IP-based wired/wireless networks with support for Quality of Service/Quality of Experience (QoS/QoE), security, mobility, and interactive control of digital content [7], [6]. Due to its immense advantage in content distribution and management, video surveillance domain can benefit from the IPTV technology. As a result, some researchers have started to investigate the use of IPTV-based solutions for distributing surveillance video feeds [8], [9]. Figure 1 shows a traditional IPTV framework for video surveillance, where the IPTV providers maintain the infrastructure for processing, content storage, streaming and transcoding services, while the set-top box at the client acts as IPTV receiver.

However, the surveillance solutions based on IPTV still face the problem in terms of large-scale storage, processing,

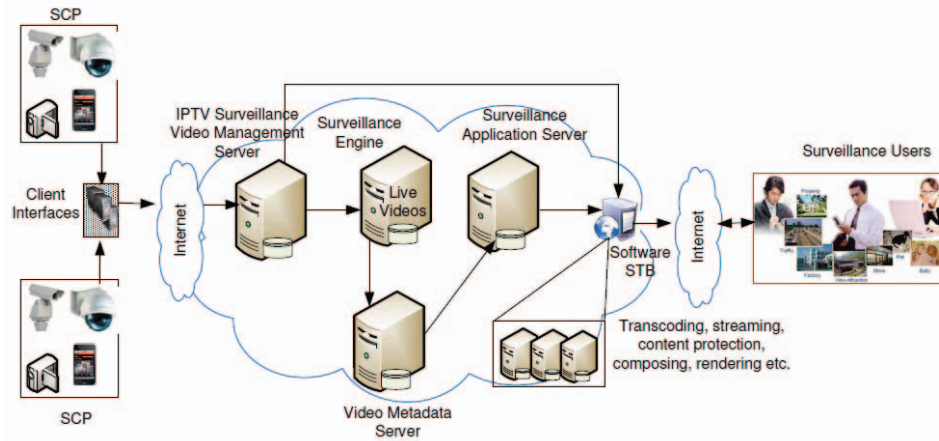


Fig. 2. Proposed cloud-based mobile IPTV framework for video surveillance

analysis, and ubiquitous delivery of video content [9]. One promising approach to address these issues is to utilize the emerging cloud computing infrastructure that can provide a flexible stack of massive computing, storage and software services in a scalable and virtualized manner [10], [11], [12]. In this paper, we propose a novel cloud-based mobile IPTV solution for video surveillance system, which not only supports broadcasting or multicasting of surveillance video content to different parties but also enables efficient monitoring, processing, storing, and analysis of surveillance video feeds.

The rest of this paper is organized as follows: our proposed approach for IPTV surveillance is presented in Section 2. Section 3 describe the implementation details of the proposed framework and Section 4 provides the initial experimental results. Finally, we conclude the paper in Section 5.

II. PROPOSED APPROACH

A high-level view of the proposed cloud-based IPTV framework for video surveillance is given in Figure 2. The framework is based on the work presented in [13] and [14]. In our approach, most of the functionalities of the video surveillance and IPTV are shifted to the cloud. The benefits of shifting most of the functionalities to a virtualized environment can be explained from two perspectives: from the IPTV surveillance operators perspective, a better manageability of customer devices and a simplification of the surveillance service and application delivery as well as respective cost reduction are made possible. On the other hand, the consumption of video surveillance content, services and applications through potentially less complex hardware in the end users domain is attractive to surveillance users. In the proposed approach, the video feed is generated from different surveillance content providers (SCP) such as fixed cameras, IP cameras and mobile devices. The video feeds from these sources are continuously captured and stored in cloud. The users are charged based on their uses of servers resources. All the servers (i.e. content, transcoding and streaming servers) capacity are aligned continuously, notably to handle peak loads and to achieve continuous, high utilization levels of servers while meeting the Service Level Agreements (SLAs) of surveillance users. The pricing of this cloud-based model is out of scope of this paper.

A. System components

In the following, the components of the proposed system is described precisely:

Client Interface: It connects to individual SCP sources such as fixed cameras, IP cameras and mobile devices to transmit video content to the cloud-based IPTV surveillance video management servers. The authorized user can configure the connected devices and control the frame rate by which the video is recorded. The client can also specify whether the video recording with be continuous or motion-enabled. In case of motion-enabled recording, as soon as the client system detects any motion (e.g. person movement) the video recording starts and it stops when there is no motion.

IPTV Surveillance Video Management Server (ISVMS): It receives all the video data from various SCPs. It is responsible for initial registration and configuration of the surveillance video devices, receiving video streams from the same devices, recording this video, proxying live video streams to surveillance clients, and streaming recorded video to clients. In an abstract way, all these functionalities form a virtual ISVMS instance for each customer and thus can control hundreds of distributed cameras or clients.

Surveillance Video Engine (SVE): The SVE engine acts as a ISVMS client and access streams of live, proxied video from the ISVMS. It has two major functions- the first is to observe digitally encoded surveillance videos and detect events happening in the video in near-real time and transmit to video meta data server; the other is to index and store detected events to support search and correlation after occurrence. All these tasks are implemented using SVE message queue [13]. The SVE message queue contains several components that performs many tasks such as object/color classification, alert detection, indexing and ingesting to video meta data server, object detection, object tracking etc.

Video Meta Data Server (VMS): It provides a massively scalable data repository that is optimized for rapid ingestion of video- associated meta data (e.g. duration, Frame rate, Keyframe position, starting points) with real-time indexing. It also preserves all event processing information, which are shared with multiple surveillance users based on subscription.

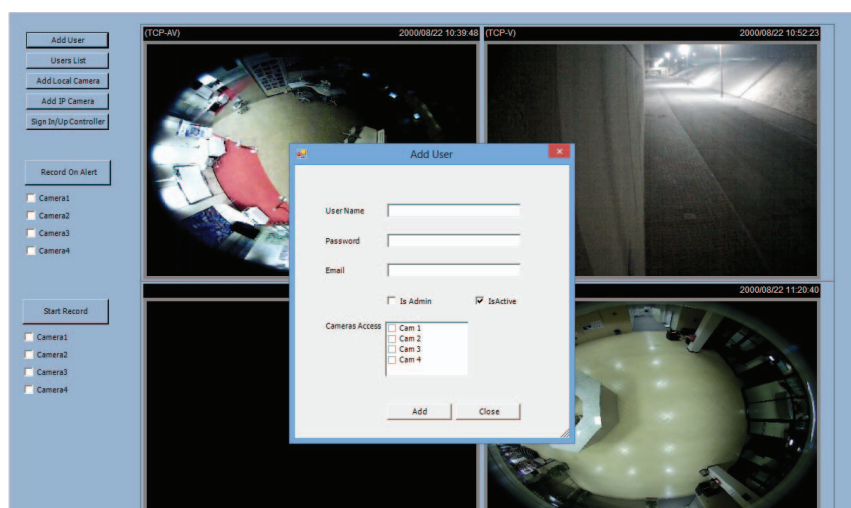


Fig. 3. Snapshot of the implemented prototype.

Thus it supports extremely efficient searches of the aggregated metadata from hundreds or thousands of video sources.

Surveillance Application Server (SAS): It contains various surveillance applications that access the live or recorded video based on users subscription.

Software STB: This resides in the cloud and acts as IPTV receiver and controller of the video channels, that are scheduled by the surveillance users. It delivers surveillance videos (live or recorded) from the Cloud to all possible IPTV terminals or devices owned by surveillance users. It is responsible for encoding and decoding of H.264/MPEG-2 content streams and processing content transcoding, EPG and other metadata. In addition, it execute Web applications as TV portal pages, EPG or other TV- related applications and manages the service composition (composing User Interface, video and applications). Moreover, it performs UI rendering (cloud-rendered UI) and handles content protection mechanism.

Surveillance clients: They are the consumers of the surveillance feeds. The clients subscribe to the video feeds as per their interest and accordingly the content is streamed to their devices or the notification of matching video feeds is sent to the client.

III. IMPLEMENTATION

The proposed framework is implemented using various technologies and deployed it in the public cloud infrastructure. Figure 3 shows a snapshot of the implemented prototype. The current implementation has three main parts, which are as follows:

- The server part consists of Amazon Web Service (AWS) instance, Red5 media server, SQL DB server and IIS web server. The SQL DB stores video data, metadata, camera information and user information. The Red5 Media Server which help in streaming and encoding.
- The web services acts as middleware for managing camera and user data, send alerts and maintain these data via SQL DB. Figure 4 shows a snapshot of

the alert management system. The web services are developed using C# to communicate with both client side view and server side application. These web services give the system ability to communicate with any kind of client applications independent of operating systems.

- A web-based client application is developed to control cameras through web browser and give the user ability to record videos, playback videos, capture images, and share videos clips with one or more users through their IPTV terminals.

A. Key Implementation Issues

There are many issues related to the implementation of the proposed framework. For ISVMS we need to consider greater flexibility to adapt the video surveillance system to heterogeneous SCPs and support federated users who can access to multiple ISVMS instances potentially dislocated on different virtual machines and geographically distributed. In case of SVE, we need to mitigate the potential problems when multiple clients saturate the network bandwidth or the camera streaming capacity by simultaneously accessing live videos or events of interest. The SVE message queue also need to consider appropriate video analytic components for event-detection and delivery. The VMS requires as much as accurate information in order to speed up the retrieval process.

IV. EXPERIMENTS

We conducted experiments by deploying the system in local and cloud infrastructure. The results obtained based on the local infrastructure is considered as traditional IPTV case, whereas the cloud-based implementation and deployment reflects the performance of the proposed approach. Overall, the goal of our experiments was to obtain the lost frame statistics while recording and storing video segments onto the surveillance content servers. Under normal mode (motion detection is set to null), we recorded video for 1 hour. Figure 5 shows the result of our experiment. We observed that when the camera setting was adjusted to 30 frames/sec, the average

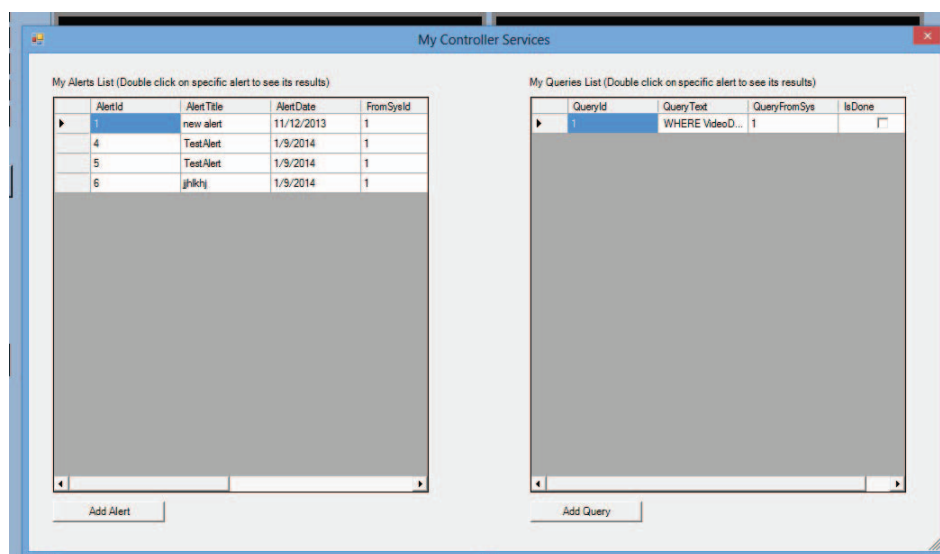


Fig. 4. Snapshot of the alert management.

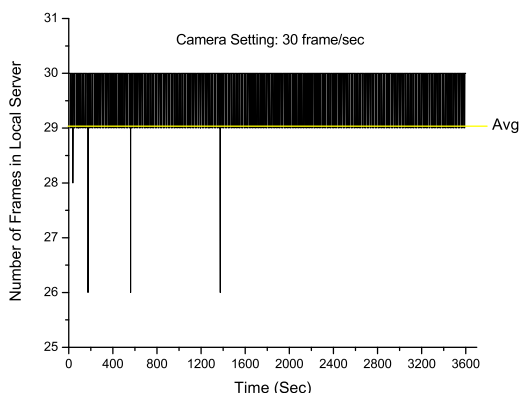


Fig. 5. Frame loss statistics when capturing and storing video in local infrastructure.

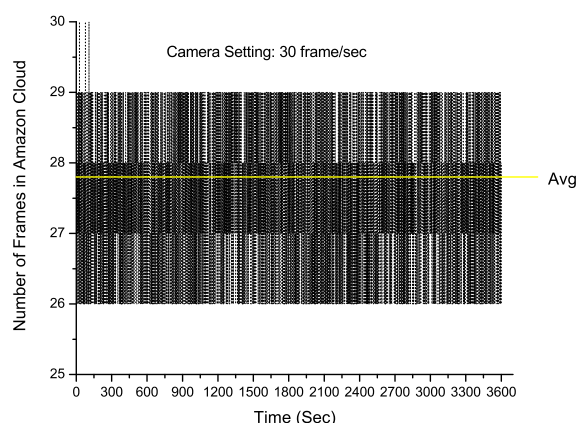


Fig. 6. Frame loss statistics when capturing and storing video in cloud infrastructure.

frame loss was 3-5%, while on the cloud implementation (Figure 6) it was 5-7%.

Our preliminary experiments indicate that the results ob-

tained in terms of frame loss of IPTV-based Cloud surveillance is comparable to that of local IPTV surveillance environment; although this result could vary depending on the network conditions, number of concurrent users and other factors.

V. CONCLUSION

In this paper, we introduced a cloud-based IPTV surveillance framework and demonstrated its viability by real implementation of a prototype surveillance system. We compared the results with respect to frame loss between a cloud-based IPTV surveillance and a local server-based surveillance and found slight deviations between them. Further studies are needed to derive a benchmark for the results. Nevertheless, our preliminary results enable us to verify whether surveillance video streaming over the cloud-based IPTV framework is a viable solution compared to traditional IPTV approach. Although cost is one of the important factors when considering cloud, the current work ignored this aspect to focus on the core framework first. In future we will investigate the cost issues relevant to our proposed framework along with vigorous experiments in real life for longer period.

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