A Service Platform for Subscription-Based Live Video Streaming

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Abstract – The development and expansion of broadband technologies has stimulated the multimedia streaming market for the delivery of live streaming services which can be used for a variety of applications. The design of a generic audio and video streaming platform that can be employed for a wide range of applications is presented in this paper. A key feature of the platform is the ‘subscription framework’ which enables the service users to subscribe to a set of live feeds with their application specific requirements. The platform is capable of adjusting its service functionalities and the extent to which the media streams are secured for a particular user based on the requirements given at the service subscription. The platform is designed based on a layered architecture and a prototype implementation is carried out within the University network.

I. INTRODUCTION

Live Streaming of audio and video is becoming rapidly popular among the internet users with the growth and expansion of broadband internet. A streaming service has plenty of applications such as surveillance, coverage of entertainment events, video conferencing [1]. Various streaming solutions providing platforms for delivering above services are available. Most commercial streaming solutions offer functionalities and features such as remote camera pan/tilt control, recording of media, integration to charging mechanisms, web based access and securing streamed content [2-4]. However a particular solution doesn’t contain all the above features as each of them is meant to be used for a particular application. A more generic platform would enable the service provider to attract a larger customer base by covering different types of applications.

Much research has been carried out on the subject of designing service platforms for multimedia streaming services. Pavlovski and Staes-Polet propose an architecture to deliver different types of multimedia services through fixed and mobile broadband network [5]. In the architecture, the common services such as presentation services, security services, registration and subscription services, integration with billing systems and network channels which are required for any application, are implemented at a lower level. Eoun-seuk-u and Yoo have developed a large scale live multimedia streaming framework for implementing ubiquitous city (U-city) [6]. The research covers several issues related to developing middleware that handles large number of cameras installed at different places of the city which can be used for applications such as traffic control, tourist route information, video surveillance and disaster evacuation. The framework called as ‘SLiM’ handles the two major components, camera management network and media distribution network. It uses the concept of employing different servers for performing different tasks in order to provide scalability to handle larger load. China has launched a project called ‘CERNET2’ connecting country’s education and research institutes through next generation ipv6 networks. Chen and Shen propose a multimedia service framework based on Session Initiation Protocol (SIP) for CERNET2 to provide the users with high quality, real-time and non-real time multimedia [7]. It is a 3 layer model consisting of a transport network layer, session control layer and application service layer.

The most important feature of a generic streaming platform is the flexibility for different types of applications. By offering different types of subscriptions for the service users (customers), a single service platform can adapt its functionality based on the application requirements given by each customer. In this paper, we propose a design of a generic live streaming platform which is capable of delivering subscription based services. A set of channels or live audio/video feeds captured from a number of IP cameras are provided by the platform and the users need to subscribe to each of the channel they want to view.

II. SUBSCRIPTION FRAMEWORK

To elaborate the need for providing different subscriptions based on application context, a set of example application scenarios for a live media streaming service is considered below:

• Police department may use the service for a surveillance process to monitor activities at several high security zones and to arrest suspects. The video feeds captured by the surveillance cameras need to be well protected to prevent possible unauthorized access. To analyze past incidents, live streams have to be recorded.

• The traffic police may monitor any possible traffic jams on the highways in order to identify places to assist traffic. The users or operators of the service must be
given full controllability of the traffic monitoring cameras to pan and tilt them as needed.

- Factory owners may monitor the daily activities of their factories through the internet from anywhere. They should be given full control over the system at their factory premises including the provision for adding and removing surveillance cameras. Security of the streamed data is a concern because they are available through the public internet and the owners don’t want their factories to be watched by unauthorized people.

- A service may be given for the general public to watch ongoing sports tournaments live. Only the service provider is given the ability to control cameras here. As the content streamed in this application is not confidential, higher security measures for streamed media are not required.

According to the above scenarios, a Service Subscription represents a set of 'service parameters' that are determined based on the application specific requirements of the respective user. The platform defines two main service parameters.

- First the functionalities provided by the service to the users such as camera pan/tilt, adding cameras, media recording must be authorized based on subscription. This is referred to as ‘Service functionality’.

- Secondly the streamed content must be protected based on subscriber’s security requirement which is called ‘grade of content protection’.

A set of “requirement parameters” that are provided at the subscription are defined and a “subscription framework” determines the service parameters based on those requirement parameters as illustrated in Figure 1.

\[
\text{ServiceFunctionality} = A*2^3 + B*2^2 + C*2^1 + D*2^0
\]  

(1)

The grade of content protection depends on the security requirement of the subscribers that must be fed to the system as a numerical parameter.

\[
\text{GradeOfSecurity} = \text{Required security level}
\]  

(2)

III. ARCHITECTURE OF GENERIC STREAMING SERVICE PLATFORM

The total system consists of three main entities: Media Streaming System (MSS), network of IP cameras, and a number of web based clients. The MSS is the core system component which basically receives audio and video feeds from cameras and streams them to the subscribed users. MSS is designed as a modularized system functioning at six different layers as shown in Figure 2. All the functions of the framework will totally depend on the network transport protocols which functions at the base of the architecture to carry out all the communications. The media streaming layer is responsible for capture of media, delivering to the clients and recording of media. Camera control and management governs the function of the underlying media streaming layer. The subscription and authentication layer implements the subscription framework. The topmost layer is the user interaction layer which provides an interface for the subscribers to send requests to the underlying system and receive the services as required. The session management layer which is right below that maintains a session for each occasion that a subscriber watches a particular channel. It is possible to customize the system by only changing the user interaction layer.

![Figure 2 – Layered architecture for the MSS](image)

A. Media Streaming Layer

The media streaming layer handles three basic functions:

1) Acquisition of live audio and video feeds to MSS from IP cameras

2) Delivering the media streams to required subscribers
3) Recording the live streams at MSS whenever needed

To capture media streams from cameras, RTP/RTCP based unicasting on UDP is used. This is because the streaming service platform needs to facilitate live media delivery with minimum possible latency [8]. To deliver streams from multiple IP cameras to a large number of service subscribers, existing streaming server software is used. An important requirement for the streaming server is the ability to feed media streams coming through the IP network. Apple’s open source streaming platform, Darwin Streaming Server (DSS) is used, as it is possible to feed streams of RTP packets from IP cameras using RTSP ANNOUNCE method [9]. A module called ‘Media Receiver’ is developed within the MSS to capture audio and video streams and feed them to the DSS. The ‘Media Receiver’ uses the RTSP based streaming session control as illustrated in Figure 3. The subscribers are served with requested channels through DSS. The media delivery to the subscribers is done also using RTSP [10].

Media streams captured live from IP cameras are recorded at the MSS in two ways:

1) On-demand recording – recording is initiated whenever the subscriber gives a command.
2) Schedule based recording – A schedule for recording is setup and archives are created automatically.

Each stream is recorded by connecting to the DSS through the VLC API [11]. Once the recording process has been completed by VLC, the file is stored in a server which is made available for access by authorized subscribers through the user interface.

![Figure 3 – Use of RTSP for media streaming](image)

### B. Camera Management and Control Layer

This layer controls the media feeds from all the IP cameras connected to MSS. Subscribers who have the privileges can either start or stop audio and video feeds from the cameras. This layer enables the subscribers to add a new camera to the service and receive audio/video feeds from it instantly. Controlling the pan and tilt (P/T) of the cameras based on subscriber requests is another vital function. In general, P/T cameras allow the users to control pan/tilt through web (HTTP) requests. A particular brand of IP cameras has a specific format of HTTP requests where user can specify the parameters such as direction of rotation (up/down for tilt and left/right for pan) and number of degrees to turn. The camera control and management layer provides a common interface for controlling P/T of most brands of IP cameras.

### C. Subscription and Authentication Layer

Provision of subscriptions based on user requirements through a subscription framework is the major task of this layer. As discussed in section II, the service parameters are determined by obtaining the requirement parameters through the user interface.

Authentication of subscribers to the system is also handled by this layer. In addition, the subscription and authentication layer controls the access to different functions provided by the service. Once a particular function is
requested by the subscriber, his ‘ServiceFunctionality’ setting is checked in order to decide whether that request can be authorized or not.

D. Session Management Layer

The purpose of the session management layer is to setup, maintain and terminate a session for each occasion that a subscriber watches a particular channel and aid billing of the subscribers based on the time. A Voice over IP (VOIP) based mechanism on Session Initiation Protocol (SIP) is applied with the use of the SIP proxy server ‘Asterisk’ [12, 13]. Each time a subscriber requests a certain media channel, a SIP call is generated at MSS on his behalf. The generated SIP call is answered by a SIP UA (expand) which is also residing within the MSS. On receipt of a request to watch a certain channel, a SIP call initiated to the SIP UA by communicating with the Asterisk server. Once the SIP UA receives the call request along with the channel requested by the user, the user’s subscription is checked to see whether he has access to the particular channel. If the channel has been subscribed by the user, the call is accepted and the media stream is setup from the streaming server to the client (subscriber) through the Asterisk server. Provisions are made available to charge the subscribers for usage with the generation of call data records (CDR) in the Asterisk server for each SIP session. These CDRs can be fed to a service provider’s existing VOIP billing system.

E. User Interaction Layer

A web based user interface is provided for the subscribers to access the service. User’s requests are initially handled by a set of server side scripts running on an HTTP server. Then they are forwarded through a module called ‘Web Gateway’ to the core of the MSS. The interaction between the Web Gateway and the Media Streaming System is done through TCP messages with a simple application level protocol. This also enables the customization of the user interface conveniently while keeping the core functionality unchanged.

IV. IMPLEMENTATION AND RESULTS

The subscription based generic streaming service platform which is designed as explained in the previous section is implemented on a Linux platform mainly using C++. PHP is used to implement the web interface. Figure 4 illustrates the physical arrangement of the implementation.

Figure 4 – Physical arrangement of the implemented system

The operation of the system was tested by applying the system to a small scale surveillance service within the University. Two IP cameras: an Axis 207 fixed camera and a UNC-9711 wireless P/T camera were deployed at two different locations and connected to the MSS through the University LAN. The users can access the service through Internet Explorer (IE) and watch the subscribed streams using Apple QuickTime. Figure 5 shows the interface for a user who has subscribed both of the above cameras.

Figure 5 – Subscriber interface
The requirement parameters of a user can be provided at the service subscription from the interface shown in Figure 6. The system provides 6 grades of protection (0 to 5) and subscriber can select one of them. The grade 0 refers to no protection at all and grade 5 provides maximum security.

![Service Subscription Interface](image)

Figure 6 – Service Subscription Interface

V. CONCLUSION AND FUTURE WORK

A live streaming service platform was designed having an architecture that is flexible enough to be used for a wide range of media streaming applications. The platform is capable of providing features such as recording of live media, remote control of camera pan/tilt, provision for time based subscriber billing and securing the streamed content. A subscription framework is developed together with the platform in order to deliver the service based on the application context and the subscriber’s requirements. The designed platform was successfully implemented to provide a small scale surveillance service.

The platform can be further improved by enhancing the subscription framework to facilitate the requirement parameters related to the quality of the video delivered to the subscriber such as frame rate and resolution that are not considered in this paper.

VI. ACKNOWLEDGEMENT

This work has been carried out with the support of Dialog Telekom PLC. Their contributions are gratefully acknowledged.

VII. REFERENCES


