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Content-Based Video Streaming Using NS2-Design and Simulation

[1]P. Sankar and [2]C. Chellamuthu
[1]Department of ECE, Jerusalem College of Engineering, Chennai, India
[2]Department of EEE, RMK Engineering College, Chennai, India

Abstract: Multimedia Content Delivery Networks (CDN) have been essential for the unprecedented growth of the Internet video and entertainment popularity in recent years. Intelligent multimedia content delivery technologies have enabled a wide range of innovative services and applications, including Peer to Peer (P2P) video streaming, Internet Protocol Television (IPTV), interactive online games, cloud computing and resource sharing, over the top videos, live video consuming on mobile devices, etc. While the CDN plays an important role in the current digital revolution, many challenges also arise. In this study, researchers present a simulation program for content based video streaming in NS2 where there is no interface for analyzing such content based applications. It is based on the publish and subscribe system. This feature has been used to move the video tags from the publisher to the subscriber through the network and the video is streamed based on the content in the routing process. Simulations for different test cases are carried out to evaluate the performance metrics for video streaming.

Key words: Content based, content characterization, tag, NS2, video streaming, MOS

INTRODUCTION

A lot of existing and newly-emerging applications require processing of high-volume, real-time streaming data. Such applications include video conferencing, network monitoring, large-scale environmental monitoring and real-time financial services and enterprises. The video stream applications involve data sources and destinations that are highly dispersed. As a result, there is a need for video streams to be routed based on their contents from their sources to the destinations where they are consumed. Content-based video streaming differs from traditional IP-based video streaming schemes in their routing pattern. It is based on the video being transmitted rather than any routing information attached to it. The publisher generates video streams according to the video it holds with no subscriber associated with them. The subscribers are independent of the publishers of the video and are identified by the subscribers interests. The subscribers express their interests using declarative specifications called tags. The goal of the content-based video streaming infrastructure is to efficiently identify and route the relevant video to each receiver. If video streaming has to be carried out over the publish/subscribe network the substrings or tags associated with the videos are to be matched for the proper retrieval of the video content through the network. Several researches have been carried out in this area but according to the researchers knowledge, no research has been carried out for content based video streaming in NS2. In this study an enhancement to the NS2 is considered to study content-based video streaming.

LITERATURE REVIEW

As critical applications are deployed over the Internet, it becomes necessary for the service or content routers to ensure that the clients receive their service or content at a satisfactory level. This issue has prompted a series of activities in the area of the publish subscribe system. One emerging technology in this area is content-aware networking where new generations of routers are specifically designed to address the unique requirements of Web traffic. These content-based routers can route traffic flows based on some attributes of the content being requested such as the URL or cookie values. Content-based routers provide flexibility in defining policies for prioritizing traffic and for balancing the load and content among servers, so that service level agreements can be met. One way of deploying content networking technologies is to interpose a content router between a client and the web server or server cluster. The content router is used as a load balancer for the back-end servers and is capable of making optimal decisions (Pai *et al*., 1998). This has the disadvantage of the lack of scalability and a single point of failure. The servers select the most appropriate server site depending on the geographical locations of the clients, servers and network and server load status (Tang *et al*., 2000). The

Corresponding Author: P. Sankar, Department of ECE, Jerusalem College of Engineering, Chennai, India

problem of the lack of scalability and expressiveness can be solved by using an event notification service. Content based networking can also be implemented by using the event notification service.

An event notification service is an application-independent infrastructure that supports the construction of event-based systems. The two primary services that should be provided by the infrastructure are notification selection (i.e., determining which notifications match which subscriptions) and notification delivery (i.e., routing and matching notifications from publishers to subscribers). Numerous event notification services have been developed for local-area networks, generally based on a centralized server to select and deliver event notifications. Scalable Internet Event Notification Services (SIENA) have been designed to exhibit both expressiveness and scalability (Carzaniga *et al*., 2000a). Carzaniga *et al*. (2001) explain the communication in a content based network, through the combined broadcast and content based routing scheme (Carzaniga *et al*., 2004). In content-based communication, the flow of messages from senders to receivers is driven by the content of the messages rather than by explicit addresses assigned by the senders and receivers. A routing protocol for such content-based networking was proposed by George (2008). He has explained the routing protocol with the help of a theoretical model. Another routing mechanism, realizing a content based network service over a generic point-to-point network has also been described by Carzaniga *et al*. (2001). They have also designed a principled method for mapping the core concepts and functionalities of generic a ddressing and routing schemes on to the established infrastructure of network architectures (Carzaniga *et al*., 2000b). The publish/subscribe system is an example of content based networking. A compilation of the main algorithms for routing messages in distributed content-based publish-subscribe systems has been proposed and published by Martins (2010). The discussion in this study is focused on the content-based routing problem with respect to optimality, complexity and applicability. The publish/subscribe paradigm is useful for content diffusion in the internet. The building of a distributed publish/subscribe infrastructure amounts to define a service model (or interface) and providing an implementation for it. The purpose is to reduce the size of the routing table and notification matching time Yuan *et al*. (2009). Antonio Carzinga has laid out a set of requirements for a benchmark suite for distributed publish/subscribe services and their primary components (Carzaniga and Wolf, 2002).

Video streaming refers to the real-time transmission of a stored video. There are two modes for the transmission of a stored video over the internet, the download mode and the streaming mode (i.e., video streaming). Due to its real-time nature, video streaming typically has bandwidth, delay and loss requirements which can be efficiently overcome as explained by Marchand-Maillet (2000). When the video data streams through the content based network, there are issues to be solved regarding, matching and routing. Dynamic and flexible video streaming needs to be adopted for better granularity (Zhang and Hu, 2005; Carzaniga and Wolf, 2003). Dissemination can be done by using Sem Cast a new semantic multicast approach which eliminates the need for content-based forwarding at interior brokers and facilitates fine-grained control over the construction of dissemination overlays (Papaemmanouil and Cetintemel, 2004). The researchers have developed a simulation environment using the Network Simulator (NS2), ffmpeg codec and its service utilities to study the performance of video traffic under different scheduling algorithms (Sankar and Chellamuthu, 2010). Content-based streaming is performed by examining the content carried by the traffic. The content based scheme is simulated where content is examined only once and the subsequent forwarding operations are based on the tags sent by the subscriber. Part of this study has been presented in an international conference (Sankar *et al*., 2011).

OVERALL ARCHITECTURE

The proposed content based streaming architecture is represented in Fig. 1. There are two types of nodes on the network: publishers and subscribers.

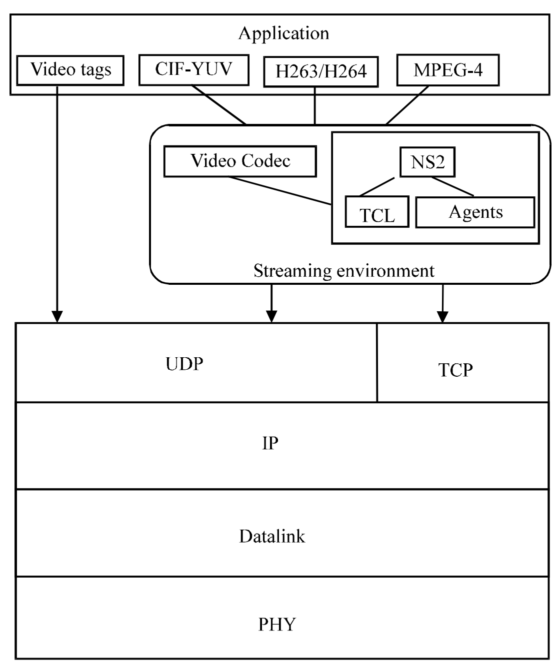

Fig. 1: The content based architecture

The following are the assumptions made in such an architecture in NS2. In the content based architecture each node is a publisher as well as a subscriber. The tagged videos reside with the publishers. The publisher advertises the content (video tags) in the network. The subscriber who is interested in the video, selects the tag and stores it. This video tag is again sent to the publisher by the subscriber. On receiving this tag, the publisher streams the video to the respective subscriber. If another subscriber joins the network it gets the list of tags from the nearest subscriber. In case multiple publishers hold the same video when the subscriptions reach them every publisher will send a chunk of that video into the network which will get assembled in the subscriber. In case multiple subscribers ask for the same video at different times, the first subscriber who becomes a new publisher will stream the video to the new subscriber.

UML DIAGRAMS

The various UML diagrams describing the simulation process of content based video streaming using NS2 are described as follows:

Class diagram: The class diagram is a type of static structure diagram that describes the structure of a system by showing the system's classes and their relationship between the classes. In Fig. 2 the super class is the agent. The sub classes derived from the agent are the Tags, mvsUDPAgent, mvsSink, UDPAgent and NULL. The Flooding class is further inherited from the Tags class. In Fig. 3, the super class is the application. The sub class traffic is derived from it.

Sequence diagram: A sequence diagram is used to represent or model the flow of messages, events and actions between the objects or components of the system. The time is represented in the vertical direction showing the sequence of the interactions of the header elements which are displayed horizontally at thetop of the diagram. The sequence diagram is shown in Fig. 3.

The simulation program for content based video streaming is explained. Initially the message port is assigned a unique value, say 42. The publishers and subscribers publish and subscribe their tags through this port. The size of the packet and the maximum fragmented size of the packet are set to 1052 (IP+UDP header) and 1024, respectively. A simulator instance is set by initializing the number of nodes and the corresponding trace file and nam-trace file for the simulator. The trace file records the detail of the packet flow during simulation. The nam-trace file is a tcl-based animation tool that is used to visualize the ns simulations and real world packet.traced data. The nam-trace file contains topology information like the nodes, links, queues, node connectivity, etc. as well as packet traced information. After setting up the normal parameters a new agent has been derived. The tag agent is used for sending and receiving the message. The messages are sent to the desired nodes or to the application or to a tcl file. A 'Flooding' agent is derived from the 'tag' agent. The procedures for the 'Flooding' agent are defined.

The send 'tag' procedure performs the task of publishing the content from a node through the defined message port. The send to 'eighbours' procedure performs the task of forwarding the content to the neighbor nodes in the network.

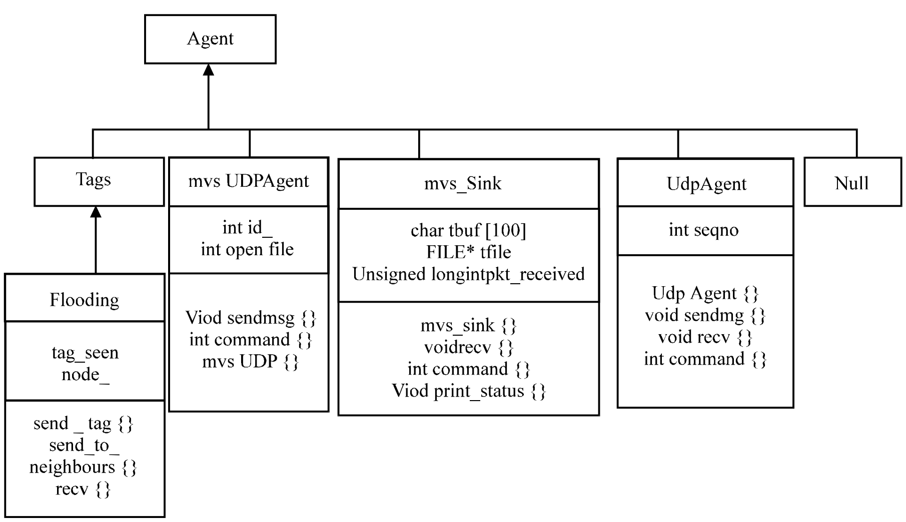

Fig. 2: The class diagram (agent)

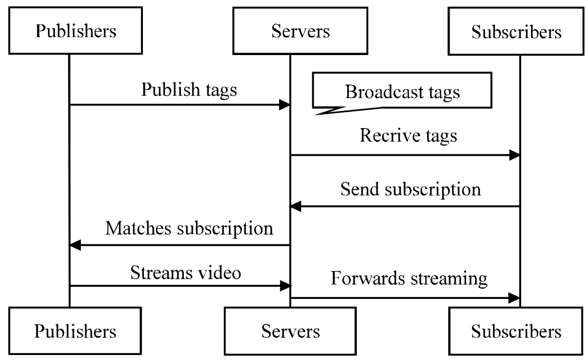

Fig. 3: The sequence diagram

The 'recv' procedure is defined for receiving the content from the nodes in the network through the defined port. A small snippet of the code that is used inside the 'tcl' program is shown:

```
Class Agent/Tags/Flooding -superclass Agent/Tags
Agent/Tags/Flooding instproc send_message {size msgid msg} {
$self instvar messages_seen node_
global ns MESSAGE_PORT
$ns trace-annotate Node [$node_ node-addr] is sending {$msgid:$msg}
lappend messages_seen $msgid
$self send_to_neighbors -1 $MESSAGE_PORT $size "$msgid:$msg"
}
```

SIMULATION OF CONTENT BASED VIDEO STREAMING

To study the performance of the video traffic, the simulation is carried out using an enhanced video streaming environment. It consists of a dumbbell topology network with 9 nodes. The nodes are labeled as Pblisher (PUB), Sbscriber (SUB) and server. There are 3 publisher nodes, 3 subscriber nodes and 3 server nodes. They are shown in Fig. 4. The simulation parameters are shown in Table 1.

The publisher nodes publish the tags corresponding to their videos. The tags are broadcast over the network through the routers which in turn reach the subscribers. The subscriber nodes subscribe for the videos using the corresponding tags that were published. The publishers verify the tag from the subscriber and if it matches with the tags of the videos published the required video is streamed to the subscriber node. The content in the publish/subscribe system can be of different types. The various types of video content and the relationship between the publish/subscribe system provide us with various cases that are described. The simulation is carried out for the streaming of two different videos 'akiyo' and 'water'. The network Quality of service (Qos) parameters such as delay, jitter and PSNR are

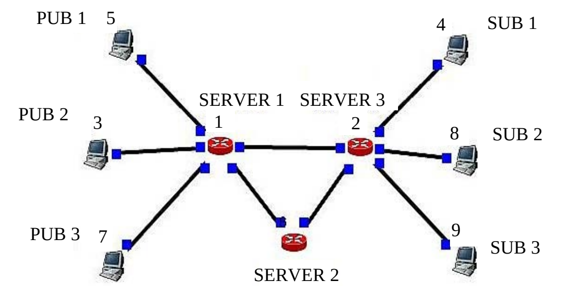

Fig. 4: Simulation environment

Table 1: Average PSNR for the video

Videos	Average PSNR
Water	27.72556
Akiyo	33.65320

evaluated and the results have been plotted. The Publisher (PUB2) and Subscriber (SUB2) are kept in idle state.

Case 1: Multiple subscribers may subscribe for the same video from a single publisher. The subscribers SUB1 and SUB3 subscribe for the 'akiyo' video from publisher PUB1. The delay and jitter experienced in this case by the subscriber are shown in Fig. 5a, b, respectively. In Fig. 5a the average delay values are marked on the graph. It indicates that for the video the average value of delay is to be maintained in the network, so that the subscribers will not experience any jitter as shown in Fig. 5b.

Case 2: A single subscriber may subscribe for multiple videos from different publishers. The various subscriptions are made to different publishers depending on the need for and availability of videos. The subscriber SUB1 subscribes for 'akiyo' from publisher PUB1 and 'water' from publisher PUB3. The delay experienced by both videos is shown. The average values of delay are shown in Fig. 6a. The jitter experienced by the videos when they travel through the network is shown in Fig. 6b. The delay shown in the two cases is the network delay. The average network delay is calculated using the equation:

$$\text{Average network delay} = \frac{(\text{Receiving time} - \text{Sending time})}{\text{SequenceNo.}}$$

The performance of content based video streaming depends on the network average latency. In both cases, the network latency can still be brought down, by providing proper caching policies and algorithms.

Peak signal to noise ratio: The Peak Signal To Noise Ratio (PSNR) is the ratio between the maximum power of the original signal (data from the original video) and the

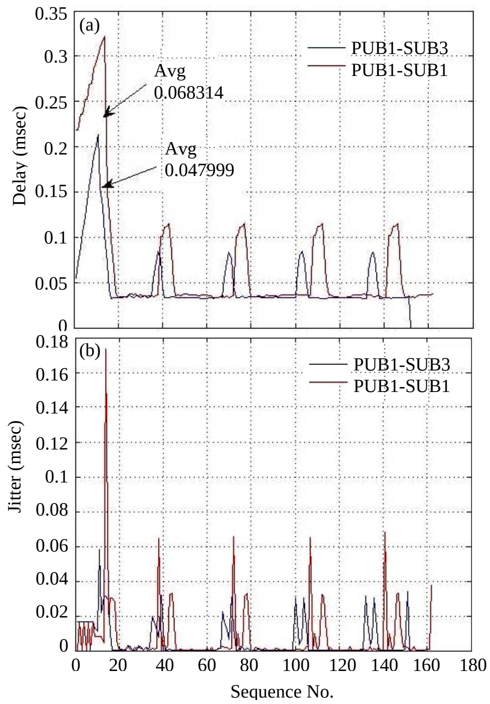

Fig. 5: Multiple subscribers' single publisher. a) Delay; b) Jitter

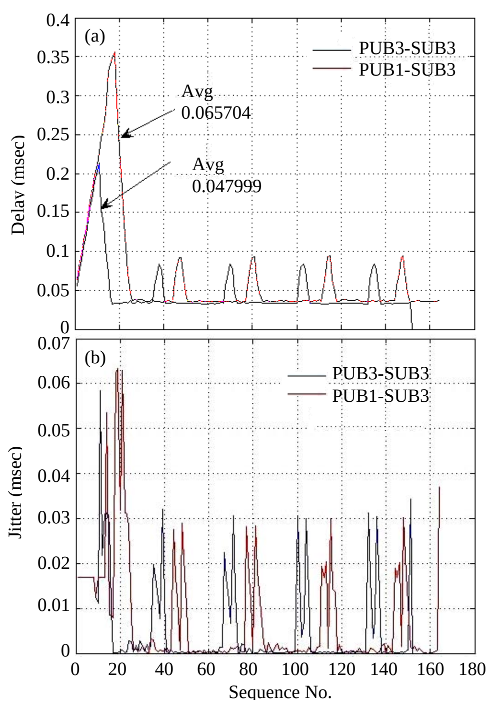

Fig. 6: Single subscriber' different publishers. a) Delay; b) Jitter

power of the interfering noise that is introduced in the process. As the signal quality can vary over a dynamic range, the PSNR values are normally given on a decibel scale. The average PSNR values for all the two videos under consideration are shown in Table 2.

Table 2: Mean opinion score

PSNR (db)	MOS
>37	5 (Excellent)
31-37	4 (Good)
25-31	3 (Fair)
20-25	2 (Poor)
<20	1 (Bad)

Table 3: Simulation parameters

Parameters	Values
Bandwidth	1 Mb
Propagation delay	10 msec
Scenarios	1PUB 2 SUB, 2 PUB 1 SUB
Algorithms	Drop tail
Simulation time	8 sec
Topology	Dumbbell (standard) for NS2
Traffic	Videos

Having calculated the PSNR value, another metric MOS (Mean Opinion Score) can also be calculated. This clearly shows the distortion caused by the network. The MOS can be determined from the Table 3. The 'akiyo' video that is streamed in the network is good where as the video 'water' is streamed fair enough only.

CONCLUSION

In this study, researchers have presented a simulation program for content based video streaming in NS2 where there is no interface for analyzing such content based applications. This program was designed for MPEG4 and h264 videos. The concept of a Publish/ subscribe system was used. The tag class and flooding class were designed using the Agent class of NS2 for developing the interface. This feature has been used to move the video tags from the publisher to the subscriber through the network. To study the effectiveness of the interface developed, the 'akiyo' and 'water' videos were streamed in a dumbbell topology, consisting of 3 publishers, 3 subscribers and 3 servers. The performance metrics such as delay, jitter, PSNR and MOS were evaluated. The PSNR values obtained from the simulation show that the quality of the video received at the subscriber end is reasonably good. The results prove that the interface developed in NS2 is a useful enhancement for content based applications.

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