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Problem over Upstream Channel in the TCP Connections of HFC/ATM Networks

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ABSTRACT

we discuss simulation results concerning the performance of the TCP protocol when running over high-speed HFC networks. Hybrid Fiber Coaxial are likely to provide fast and cost effective sup-port to a variety of applications including Video on demand , interactive computer games, and internet-type applications such as Webbrowsing, ftp, and telephony. Since most of these applications, use TCP as the transport layer protocol, the key to their success largely depends on the effectiveness of the TCP protocol. In all simulation scenarios the TCP traffic is mixed with some background traffic whose level is taken as a variable parameter. Both the background traffic and TCP traffic are either unshaped, or shaped according to the GCRA algorithm. The effect of the background traffic on the TCP protocol performance is discussed varying the buffering capacity with nodes as well as the peak bit rate that each TCP connection is allowed to use.

1. Introduction

The emergence of the HFC technology has a significant impact on already deployed Cable TV networks. An HFC network(see Figure 1) utilizes the in-phase residential broadcast cable system. [1,2,3,4,5]

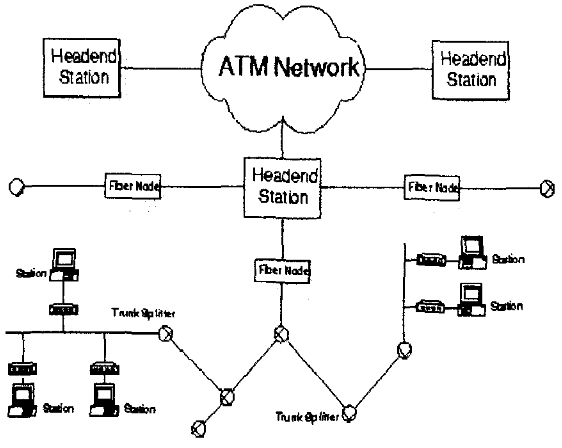

Figure 1. HFC Network connected to an ATM Network

As a return path from the stations to the headend becomes available, Cable network operators are able to add more services to television broadcast. A Medium Access Control(MAC) layer protocol is implemented at the root(or headend) and at each of the cable network nodes(or stations) to allow various nodes to share resources in a multiaccess environment. It also controls the upstream(from the stations to the headend) and the downstream(from the headend to the stations) link transmissions. MAC protocol specifications are being drafted by the IEEE802.14 working group to accomodate the needs of current and future network applications. The IEEE802.14 Draft document contains various MAC defining characteristics such as: frame format, station addressing, timing and synchronization procedures, and the ternary-tree mechanism to resolve collisions resulting from two or more stations transmitting at the same time. The MAC draft also provides the necessary "hooks" to support higher layer services such as CBR, VBR and ABR services for ATM. Numerous performance evaluation studies have been conducted on MAC protocol elements such as contention resolution and bandwidth allocation. Also, some preliminary work has been presented on improving the ABR service over HFC. But so far, little work has been done in studying the details and evaluating the performance of the TCP protocol in an HFC network environment.

TCP is now the de facto standard transport protocol for data applications in the LAN, MAN and WAN areas. Many experts believe that TCP for a long time to come will also be the most frequently used tranport protocol in the HFC enviroment, even if it has been recognized that TCP is not specifically tailored to high-speed applications. Our work concentrates on the effect that the heterogeneous traffic present in the network, that we call background traffic, may have on the TCP performance.[6,7]

To obtain a model for the TCP protocol, we adapted the officially distributed C code of the BSD 4.3-reno release, without considering the delayed and selective ACK otpions.

The paper is organized as follows. Section 2 is initially devoted to the HFC Network structure. [2,3,8,9]Section 3 is devoted to the description of the considered network topologies and performances analysis. We present a set of simulation results obtained considering TCP

ATM link in a two-node ATM network. Finally, Section 4 concludes the paper.

To avoid the use of the term packet, that may lead to confusion, throughout the paper we use the term segment to identify the TCP data unit, and the term message for the data units exchanged by the background traffic sources and destinations. TCP segments are divided into cells by the AAL 5 sublayer before accessing the ATM service, while the AAL 3/4 sublayer is used for the messages of the background traffic.

2 HFC Network Overview

In an HFC network up to two thousand stations are connected to a single tree network. All stations transmit to the headend using an upstream communications channel.
The frame format of the MAC protocol is shown in Figure 2. The upstream channel is divided into minislots. Minislots that are used to transmit requests in contention are commonly referred to as Contention Slots(CS). CSs are used to request grants for data transmission(in Data Slots).A special field in the Data Slots may be used to send piggybacked requests(not subject to contention). One or more minislots can form a Data Slot(DS) to carry data packets, such as ATM cells. The size of the CS and DS is chosen so that a DS is accomodated in an integer number of minislots. The headend(HE) allocates the number of CS and DS slots available on the upstream channel in fixed size clusters or frames.

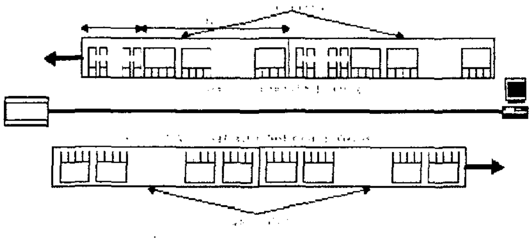

Figure 2. Frame format of 802.14 MAC protocol

At start-up, the stations are ranged or synchronized with respect to the headend in order to gain a unique time reference. Each CS is assigned a Request Queue(RQ) value by the headend. When a station has data to transmit, it waits for a CS with an RQ value equal to zero, and sends a request. The station waits for feedback information about the collision status and allocation of DS contained in downstream control messages. In case of collision(two or more requests arriving at the headend at the same time), the headend performs the ternary-tree blocking algorithm and assigns different CSs in the next cluster with RQ values greater then 0.

CATV networks are characterized by a tree and branch topoloy. At the root of the tree, a base station or headend controls the traffic, as shown in Figure 3. The bandwidth is divided into several channels. Several minislots can be concatenated in order to form a data slot while one contention slot maps into one minislot.

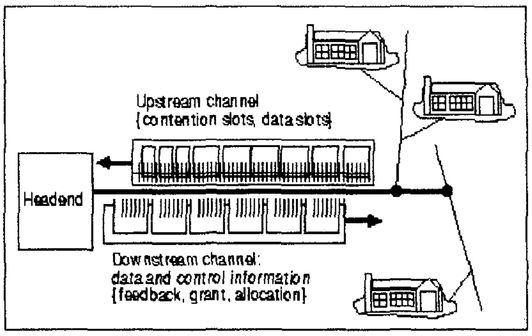

Figure 3. CATV network structure

The basic MAC operation is as follows.[4] Upon the arrival of the first data packet, a station sends a request packet in a contention slot that conforms to the First Transmission Rule(FTR). (FTR, which governs the access of newcomer stations, is discussed in greater detail in the next section.) Then the station waits for the request feedback from the headend. If more than one station sends a request in the same contention slot, a collision results. Requests are then retransmitted according to according to a collision resolution algorithm. Stations cannot monitor collisions because modem receivers and transmitters are tuned to different frequencies for the downstream and upstream channels. Feedback about collisions must be provided by the headend either explicitly or implicitly. The algorithm must also take into account the delay before a station receives the feedback information in order to insure the best utilization of the network resources. In case of a successful request transmission, the station waits for a data grant in order to sent its data. At this point if the station has additional requests for bandwidth it may choose to bypass the contention process and use the Extended Bandwidth Request field available in the MAC PDU. This is Known as "piggybacking". In order to allocate data slots, the headend uses schemes such as first come first served(FCFS) or round robin(RR); We use RR in our simulations. It is assumed that the headend can deal with priority traffic for both contention reslution and bandwidth allocation. Similarly, it is able to distingusish between different connections and provide QoS.[2,3,4]

3. Performance results

In the simulation scenarios that we considered, TCP connections are supposed to operate in sustained overload, performing a very long file transfer: segments are always ready at the transmitter when an ACK is received. The size of the buffers at the TCP transmitters is set to a value that avoid any loss at the source during the fragmentation process of a TCP segment into ATM cells. The TCP receivers are assumed to be fast enough and to have enough buffer space so as to avoid losses. The maximum window size is set to a value that allows a single TCP transmitter to obtain the full available bandwidth on the link.

The background traffic messages are generated according to a Poisson process, with a truncated geometric message length distribution. The burstiness of both the TCP connections and the background traffic can be controlled with a shaping device that operates according to an adaptation of the GCRA(Generic Cell Rate Algorithm) recommended by ITU-T for traffic policing in ATM network.

A GCRA shaper is based on the control of the cell interdeparture time by delaying cells that are scheduled for transmission too early. The basic parameters of the GCRA shaper are the bandwidth allocation factor β, which is the amount of bandwidth allocated to the connection relative to its mean bandwidth, and the cell delay variation tolerance τ which is the amount of time that a cell is allowed to "accelerate" with respect to its expected arrival time. When the background traffic is shaped, we assign to each connection $\beta = 1.2$ and $\tau = 0$ in the case of the simple network.

In this paper, We analysis with amount of cells which receiver arrives. Both the background traffic load and the TCP traffic are expressed in Mbit/s of user data.

Simulations were run until the receiver throughput reached a 98% precision with 95% confidence, or stopped after 17s of simulated time.

We consider a simple network, sketched in Fig. 4, comprising only two ATM switches. The data Rate on each channel is 150 Mbit/s, and channel L, linking the two ATM switch, is the system bottleneck. In this simulation model, two ATM Switch and one HFC Network is consisted.

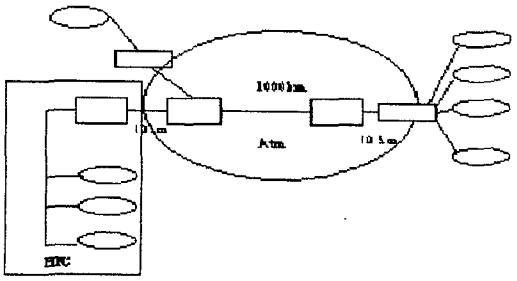

Figure 4. Simulation Model

One background traffic in ATM network and seventy TCP traffic in HFC network is consisted. This simulation results is acquired with gcc and script languang over linux platform.

In ATM network, Transmission length between Two ATM switches is 1000 Km. Transmission length between HFC network and ATM switch is 10 Km. In Figure 5, seventy TCP/VBR sources with each 2Mbit/s about Upstream channel over HFC network are transmitted. and unshaped background traffic/VBR is transmitted about 20Mbit/s, 50Mbit/s, 100Mbit/s respectively.

Cell structure in the simulation model is followed.

```
Typedef   struct_Cell {
Struct_Cell   cell_next; /pointer for use by the queue the cells will be stored in */
VPI vpi;
PTI pti;
Struct cell_payload{
Packet *tcp_ip_info;
AAL5_Trailer len;
RM rm;
}u;
}Cell
```

In Figure 6, unshaped background traffic/VBR is transmitted 50Mbit/s and seventy TCP/VBR sources with 2Mbit/s, 10Mbit/s respectively about Upstream channel over HFC network are transmitted.

In Figure 7, seventy TCP/VBR sources with each 2Mbit/s about Upstream channel over HFC network are transmitted. and shaped background traffic/VBR is transmitted about 20Mbit/s, 50Mbit/s, 100Mbit/s respectively.

4. Conculsion

In this paper, We analysis performance about upstream channel of TCP/VBR traffics over HFC/ATM network in order to service various bi-direct transmission. Upstream channel data over HFC network is clearly degraded.

The performance of the TCP protocol when runnig over a simple HFC/ATM network was studied through simulation, in simple network scenario. We took as performance parameter the background traffic load and TCP/VBR traffic load.

Numerical results showed that shaping the traffic on the TCP connections over HFC/ATM networks improves the TCP performance.

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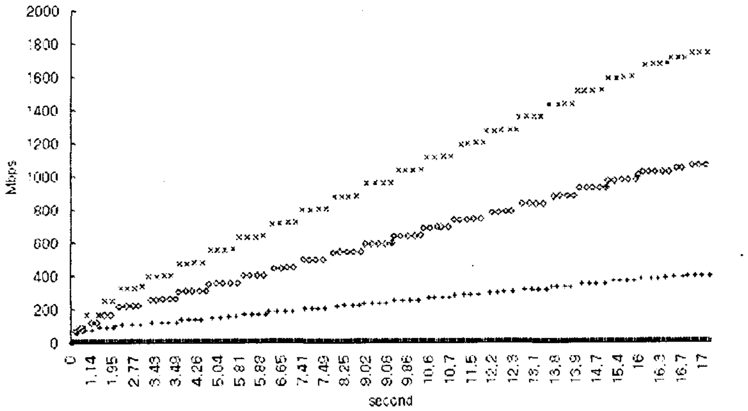

Figure 5. ×××(20Mbit/s),◇◇◇(50Mbit/s),+++(100Mbits) unshaped background traffic respectively

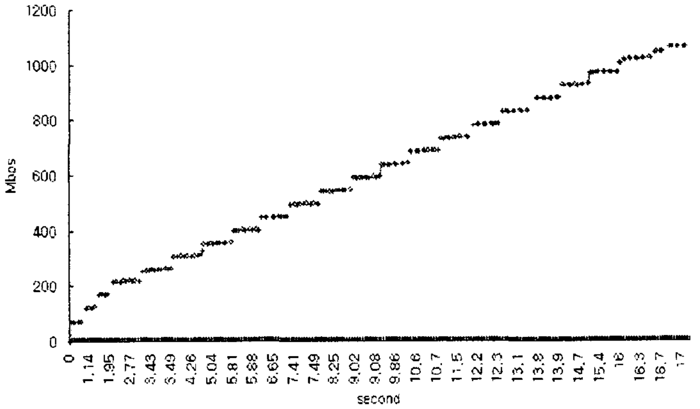

Figure 6. ◇◇◇(2Mbit/s),+++(10Mbits) traffic respectively over HFC Network

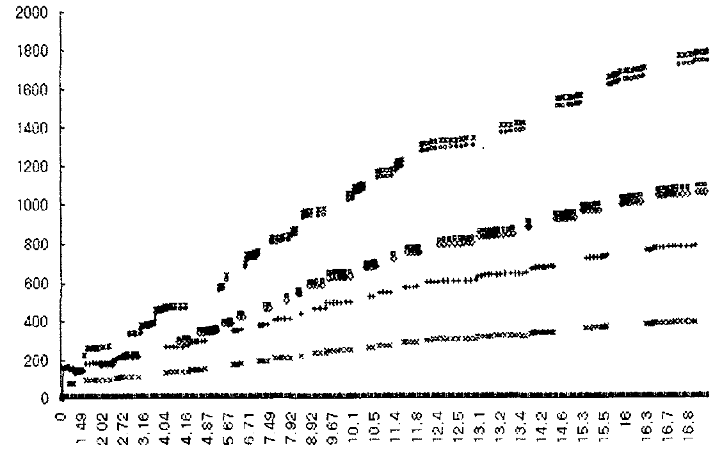

Figure 7. o o o (20Mbit/s) ◇◇◇(50Mbit/s) ××× (100Mbit/s) unshaped background traffic ***(20Mbit/s) □ □ □ (50Mbit/s) +++(100Mbit/s) shaped background traffic