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Next generation CATV networks with QoS guarantees

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ABSTRACT

This paper is a research mainly on how to build a high efficiency cable network; we will discuss the "Advanced IEEE 802.14 up" stream channel access mode along with the Collision Resolution Protocol, and then bring up a series of brand-new solutions of better efficiency, which are "Conditional Blocking Ternary Tree (CBTT) Algorithm", "Probability P-persistence Transmission Rule", and "Virtual Contention Algorithm". Furthermore, it will introduce a Multi-Priority mode to enhance the Quality of Service (QoS) for the multimedia transmission. We will utilize these techniques to improve the existing inefficiency of the cable network transmission, which greatly enhances the bandwidth utilization of cable network, and relatively drops the cost and improves economic value. In the end, this paper will show the simulation results using the NIST ATM/HFC Network Simulator to prove the high efficiency obtained from using the techniques (Advanced IEEE 802.14) proposed in this paper.

1. Introduction

Resulting from the prosperous development of the Internet, the number of online users has been rapidly increasing, which makes the current bandwidth become insufficient and the poor quality of transmission. Therefore, how to build a network with transmission of better quality has become the earnest question across all fields. This paper will base on IEEE 802.14 to set the goal of providing the Quality of Service (QoS) guarantees for cable network services. To improve the QoS for users, this paper proposed "Advanced IEEE802.14 MAC Layer" [1], to divide data transmission flow into CBR, rt-VBR, nrt-VBR, ABR and UBR modes [2–4], and introduces MAC layer protocols with priority levels suitable for two-way data flows on different priority levels to create a broadband and exceptional-quality high-speed network. The following sections are structured as follows: Section 2 is about related works; Section 3 introduces the Conditional Blocking Ternary Tree (CBTT) Algorithm and Probability P-persistence Transmission Rule; Section 4 explains the Virtual Contention Algorithm; Section 5 presents the efficiency analysis for the "Advanced IEEE 802.14 MAC Layer", and Section 6 is the conclusion of this paper.

2. Related works: IEEE802.14 Collision Resolution Protocol

In Table 1, we list QoS control protocols over cable networks. DOCSIS (Data over Cable Service Interface Specification) adopts Truncated Binary Exponential Back-off Algorithm as its Collision Resolution Protocol. In DOCSIS, "Starvation" waiting will be able to occur and the transmission quality drop quickly when the transmission loading increased. This paper proposed Advanced IEEE 802.14 including a series of efficient methods to improve the efficiency of Collision Resolution Protocol (CRP).

Due to the nature of shared media on the up stream channel of a cable network, multiple MAC users simultaneously sending out requests are inevitable. In this situation, defining a suitable CRP would be the key point to increasing transmission efficiency. There are many techniques of CRP [5,6]; for example, MCNS utilizes Binary Exponential Back-off method, or in simpler words, it halts whenever collisions occurred and waits for a time interval before resending data. On the other hand, IEEE 802.14 adopts the Blocking Ternary Tree Splitting (BTTS) Algorithm, which will be explained hereunder.

First, we will use a simpler example to illustrate the working mechanism of IEEE 802.14 CRP, and compare the advantages and disadvantages of Blocking and Non-Blocking Modes.

As shown in Fig. 1, this is a normal frame format which we can simply dissect into Contention Slots and Data Slots. This is obviously a clustered-type frame (Cluster Mode) because its Contention Slots and Data Slots are separated rather than mixed together. Each CS (Contention Slot), which is also Request MiniSlots (RMSs), is followed by a RQ (Request Queue) value. RQ value is defined in the CRP; this will be explained following. Next, we will adopt a simpler diagram (10 RMSs) to explain the Blocking Collision Resolution and Non-Blocking Collision Resolution.

As Fig. 2(a) demonstrates, B and C have a collision at the third RMS, and similarly, D and E, H and I, J and K also have Collisions at the 7th, 9th and 10th RMSs, respectively. The headend will then require a suitable resolution method. IEEE 802.14

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Table 1
QoS control protocols over cable networks.

Standard and proposed standard	DOCSIS (Data Over Cable Service Interface Specification)	IEEE 802.14	Advanced IEEE 802.14 (this paper proposed)
QoS types	1. UGS (Unsolicited Grant Service)	1. CBR	1. CBR
	2. UGS-AD (Activity Detection)	2. rt-VBR	2. rt-VBR
	3. rt-PS (real time Polling Service)	3. nrt-VBR	3. nrt-VBR
	4. nrt-PS (non real-time Polling Service)	4. ABR	4. ABR
	5. BE (Best Effort Service)	5. UBR	5. UBR
	6. CIR (Committed Information Rate Service)		
Collision Resolution Algorithms	1. Truncated Binary Exponential Back-off Algorithm	1. Ternary Tree Algorithm	1. Conditional Blocking Ternary Tree Algorithm
		2. P-persistent first transmission rule	2. Probability P-persistence Transmission Rule
			3. Virtual Contention Algorithm

utilizes Blocking Ternary Tree method, which is illustrated in Fig. 2(b), setting the maximum RQ value to the number of RMSs that have Collisions. Therefore, the maximum value of RQ is 4 in this case, and the RMSs that will have collisions are divided into three RMSs during the next round. One of the three RMSs here is randomly chosen by every MAC user generating colliding requests in the RMS. If a collision happens, the same procedure is repeated once again, until all collisions are resolved; in other words, new request is received only when the RQs of all RMSs are equal to zero. If there is not enough RMS in this Round, it will be retained till the next Round, until all collisions are resolved, as shown in Fig. 2(c) and (d). Fig. 3 shows the collision resolution of Non-Blocking Mode. Whenever there is a free RMS, a new request can make use of it at once without the need to wait till a new round. Therefore, it is one round less than Fig. 2, which in turn forces it to face a higher collision risk. As shown above, both methods bear disadvantages in terms of their own nature; thus we introduce the "CBTT Algorithm" plus "Probability P-persistence Transmission Rule" along with the "Virtual Contention Algorithm" to retain the advantages of both methods and rectify their disadvantages.

3. Conditional blocking Ternary Tree (CBTT) Algorithm and Probability P-persistence Transmission Rule

Due to the advantages and disadvantages existing in both Blocking and Non-Blocking Modes, we would like to introduce a method to combine their advantages and revise the disadvantages. Here we bring up the Conditional Blocking method: when the RMS max. {RQ} $\geqslant 2$, the Blocking Mode will be executed to stop sending new requests. When RMS max. {RQ} $\leqslant 1$ (the reason to be explained in Fig. 7), Non-Blocking mode will be adopted to receive new requests. However, in order to avoid the disadvantage of Non-Blocking Mode, we adopt the Probability P-persistence Transmission Rule, which increases efficiency when HC blocking state is aborted. Moreover, this paper also introduces Multi-Priority RMS, which is explained in the next section to show the Multi-Priority frame format. When a collision happens, the ternary tree algorithm will be used to resolve the problem in both PRMS (Priority RMS) and NRMS (Non-Priority RMS).

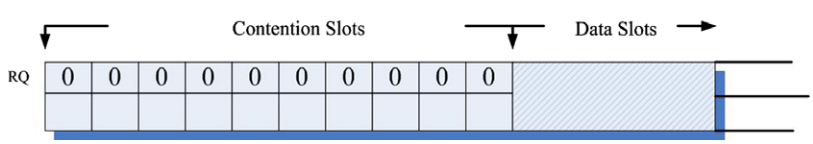

Fig. 1. Normal frame format.

Fig. 2. Blocking Collision Resolution Mode.