Chapter 1

Introduction

In recent years, multimedia transmission has become a hot topic in communication areas. The networks, regardless of the wired or wireless ones, play the role to support a wide range of multimedia services (e.g., voice, data and video). No matter which kind of the network is considered, the system bandwidth is unavoidably bounded by a certain amount. In order to satisfy the huge service demands and fulfill the multimedia requirements with a limited bandwidth, an efficient Multiple Access Channel (MAC) protocol is required. Its development, hence, is the first step towards the realization of multimedia traffic transmission.

In the literature, there are many different kinds of MAC protocols being proposed and examined for various types of networks [1-5, 7-15]. In order to evaluate their performances, one often needs to write a specific program for each protocol, according to its individual features. We, however, find that these MAC protocols in fact are composed of many common Building Blocks, and can be formed by re-organization of these Building Blocks.

In this chapter we present the literature review of those articles upon which our research is based. We then specify the main contributions of this thesis. Finally, we outline the general flow of the thesis.

1.1 Literature Review

We first concentrate on the protocols over hybrid fiber-coaxial network.

It is widely recognized that HFC networks are designed to provide economical service access for residential subscribers. A number of protocols were proposed to the HFC plant [1-5]. We will summarize these protocols in the sequel.

Centralized Priority Reservation (CPR) [1] employs contention minislots with simple *p*-persistence to send requests to the head-end (H/E). The H/E then makes the reservations according to a centralized policy, and informs the stations by means of explicit grant minislots in the downstream channel.

UniLINK [2] superimposes a frame structure on fixed-length slots. It also supports the transmission of variable-length message by suing concatenation. In other words, a station is allowed to transmit in several consecutive slots. Each frame is divided into three regions: a periodic region (for synchronous traffic), a reservation region and a contention region. The boundaries of these regions are dynamically changed by the system controller according to system load. The station tries to seize one or more slots in the contention region using CSMA with collision detection. After successfully transmitting, the station moves its follow-up transmissions to reservation region.

ADAPt [3] proposes a frame structure which is divided into two regions: an STM (Synchronous Transfer Mode) region for the transmission of voice traffic, and an ATM (Asynchronous Transfer Mode) region for ATM cells. The slots in the ATM region can either operate in a contention mode or be reserved for data. The boundary that divides the two regions is periodically adjusted according to system load.

MLAP [4] relies on a fixed frame structure of length longer than a round-trip delay. Contention slots are spread over the frame. Transmission in contention slots is arbitrated by a tree-based algorithm, START-n [6]. Each contention slot within a round-trip time is controlled by different replica of the START-n algorithm.

XDQRAP [5] is a distributed scheme in which the head-end simply acts as a reflecting node. The stations control the access to the media by means of a distributed queue in the data channel and a tree-based contention resolution algorithm in the contention channel.

The feathers of these protocols are summarized in Table.1.

		CPR	UniLINK	ADAPt	MLAP	XDQRAP
Frame Structure	Dynamic regions		Three regions	Two regions		
	Fixed frame scheme	✓			✓	✓
	CMS	CMS			us.reg	CMS
	DMS	DMS			RB	
Access Method (Collision Resolution)	CSMA/CD		✓	✓		
	p-persistent	✓				
	START-n				✓	
	tree-based					✓
Head-end Schedule	ACK	ACK			ds.ack	
	Grant (allocate)	Grant	✓	MAP	ds.alloc	
	Label slot		Reservation region Contention region	Reservation Contention		
	Reflection node1					✓

Table 1

Next we concentrate on the protocols over local wireless communications.

Wireless communication has become an important field in communications. A number of protocols were proposed to the wireless communications [7-15]. They are summarized in the following.

In PRMA [7,8], the time scale is divided into slots, which in turn are grouped into frames. A slot in a frame is either available or reserved by a voice user. Both voice and data users can contend for the available slots, according to the voice and data transmission permission probabilities P_t and P_r. If a voice user succeeds in contention, this slot will be labeled as "reserved" and the voice user can use the corresponding slot in the subsequent frames until the end of the current talkspurt. If a data user succeeds in the contention, this slot is still labeled as "available" and the data user can only use this slot in the current frame and no reservation is allowed. Any contention is detected after transmission of the whole packet.

In D-TDMA [9,10], the time scale on the channel is divided into a contiguous sequence of TDMA frames, which are subdivided into reservation slots, voice slots and data slots. The reservation slots are located at the beginning of each frame. A short reservation packet transmitted in the reservation slot is used for reservations. The base station keeps track of the information slots, which are either reserved or available. At the end of the reservation period, the successful reservations will be identified and broadcasted by the Base Station (BS). The successful voice user will be assigned one of the available voice slots and will keep using it in subsequent frames until the end of the talkspurt. After the assignment of voice traffic, the data user can contend for the remaining slots, but cannot reserve them. The unsuccessful voice users, either due to collisions in channel access or due to the shortage of available information slots, can retry in the next frame. The retransmission of data packets is however distributedly controlled by data retransmission probability. The ratio between the reserved voice and the contended data bandwidth must be dynamically adjusted to achieve the best performance.

In RAMA (Resource Auction Multiple Access) [11], the frame structure is composed of the auction slots, voice slots and data slots. The difference between D-TDMA and RAMA is the channel access strategy. In D-TDMA, slotted ALOHA is employed, while in RAMA, an auction strategy is implemented to achieve higher success probability. In each auction slot, the available resource will be auctioned to requesting users, and then assigned to the winner. From the system performance viewpoint, RAMA can be considered as an extreme case of D-TDMA, with no contention failure owing to collision in the channel access.

In DRMA [12], as in PRMA, no bandwidth is dedicated to reservations. Each slot is used either for information transmission or channel reservation depending on its necessity. Each slot is marked as either "reserved" or "available". There are two kinds of reserved slots in a frame: those reserved by voice users for the duration of the respective talkspurt, and those reserved by data users for the current data packet. The latter have to be released immediately after the data transmissions. Each available slot can serve as a set of reservation slots, as in D-TDMA. The contention in the available slot is controlled by the voice transmission permission probability P_t and the data transmission permission probability P_r as in PRMA. The number of reservation slots and their positions in a frame changes dynamically according to the traffic condition.

C-PRMA [13] adopts some of the concepts used in PRMA, but presents more centralized functions. The basic feature that characterizes C-PRMA is its ability to grant transmissions at each slot to the Mobile Station (MS), among those reserved that has more urgent need. Each MS packet transmission takes place in the command/response way. The BS transmits slot-by-slot *commands*, which allow managing a random-access polling scheme among the MS's. The polling commands, generated by a scheduling algorithm, specify whether a slot of the uplink channel is available or reserved, and identify the MS that is enabled to transmit. The random access is used for transmission reservation in available slots, in which the polling mechanism provides the transmission coordination, in the reserved slots, among the active MS's.

Idle-signal multiple access for integrated service (I-ISMA) [14], derived from PRMA, combines a contention mechanism with a time-reservation technique. All data packets and the first packet of voice talkspurts contend to access the channel. The successful transmission of the first packet of the talkspurt acts as a reservation, and the BS will periodically poll the MS for the transmission of the whole talkspurt. The BS broadcasts a signal (idle signal) to declare the idle state of any free slot on the channel.

R-ISMA [15] is a combination of ISMA [16] and time-reservation technology. Since a terminal transmits a very short reservation packet before the transmission of the full message, the collision period is shortened so that the channel utilizing efficiency can be improved. After a terminal succeeds in transmitting a reservation packet, the message, no matter how long it is and when the packet was generated, will be transmitted by the polling scheme. Moreover, the user of a polling scheme gives rise to the flexibility needed to introduce an ARQ (Auto Repeat reQuest) scheme [17] if we must deal with an erroneous channel environment.

The feathers of these protocols are summarized in Table.2.

	PRMA	D-TDMA	RAMA	DRMA	C-PRMA	I-ISMA	R-ISMA
fixed reservation overhead		✓	✓				
fixed frame scheme	✓	✓	✓	✓			
Minislot		✓	✓	✓			
Dynamic					✓	✓	✓
Reserved S-ALOHA	✓	✓		✓	✓		
auction strategy			✓				
Others						p-persistent	p-persistent
Label	Reservation Available	reservation available	reservation available	reservation available			
Polling Strategy					HRP	Periodical (for scheduled packet)	
ACK					Ack for reservation	ISA	ISA
Grant					Command for MS	Psi (for scheduled packet)	PS
Command					Command reservation	ISU	IS

Table 2

1.2 Contribution

After surveying a variety of MAC protocols over networks, we find that these MAC protocols are composed of common Building Blocks. The contribution of this thesis is therefore listed as follows:

- Defining a set of common Building Blocks for various existing MAC protocols;
- Defining a systematic flow for connecting these Building Blocks so that different MAC protocols can be formed by simply re-organizing the flow of some of these Building Blocks;
- Simulate these MAC protocols and compare their performance under the same environment;
- Implement (some of) these Building Blocks through Visual C++ for feasibility test and create a simulation test-bed for MAC protocols with Graphic-User Interface.

1.3 Thesis Overview

This thesis is organized in the following manner.

Chapter 2 is devoted to the basic Building Block finding. These Basic Building Blocks can be used to form different MAC protocols.

Chapter 3 presents examples to illustrate the usage of Building Blocks to form some existing MAC protocol. Also covered is the detailed description of each Building Block.

Chapter 4 summarizes our finding and points to future work.