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WiMAX MAC PROTOCOL LAYER INSIDE

Introduction:

This article describes 802.16-2004 MAC layer protocols, its functions mainly for schedule management and resource allocation. This article also helps in the design of PHY layer as MAC layer plays very important role to determine modulation-code rate and other useful PHY parameters.

Description:

Before we start analyzing MAC layer let us summarize protocol layers at L1 and L2 of fixed WiMAX. As mentioned below MAC layer comprises of three sub layers namely convergence sub layer, MAC common part sub layer and security sub layer.

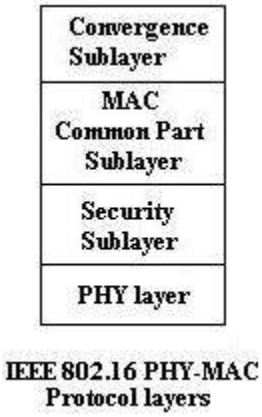

Fig.1 WiMAX Protocol layers(PHY,MAC)

The MAC comprises three sub layers:

1. Convergence sub layer: Interfaces layer above i.e. network layer and layer below i.e. MAC CPS. This includes classifying external network service data units (SDUs) and associating them to the proper MAC service flow identifier (SFID) and connection identifier (CID). Hence it takes care of delivery of CS PDU to the MAC SAP associated with the service flow for transport to the peer MAC SAP and receipt of the CS PDU from the peer MAC SAP. The optional feature supported by this layer is Payload header compression.

2. MAC common part sub layer: The core MAC functionality is performed by this sub layer. It takes care of access mechanism of SS with BS, Bandwidth allocation, connection establishment and connection maintenance. This is explained in detail in this article.

3. Security sub layer: It takes care of security aspects viz. authentication, secure key exchange and encryption.

To understand MAC CPS we need to understand WiMAX frame structure which is mentioned below. For the discussion point of view let us assume following system parameters and we will assume that number of subscriber Station (SS) is one.

Let us assume that WiMAX system BW is 3.5MHz hence we will have sampling frequency of 4MHz. Let us assume System Frame Duration of 10ms and DL/UL Ratio of 56%, hence we will have total symbols in a WiMAX Frame equal to 125, No. of symbols in DL sub frame 70 and No. of Symbols in UL sub frame 55.

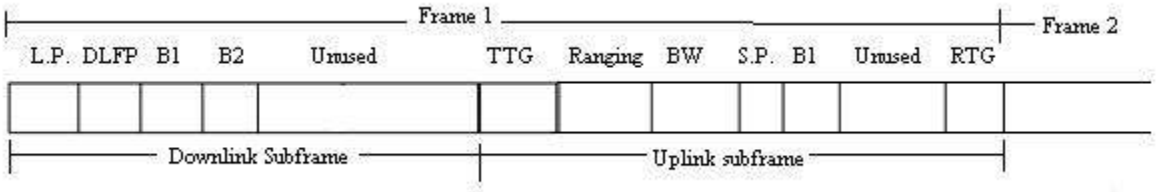

Fig.2 WiMAX TDD Frame Structure

As mentioned in the frame, downlink sub frame is transmitted by Base station (BS) to Subscriber stations (SSs) and Uplink sub frame is transmitted by SSs to BS. TTG and RTG are the turnaround times to allow electronic circuitry in Base station and Subscriber stations to settle down in switching from Tx to Rx and vice versa to avoid loss of the data.

Let us understand how the **scheduling concept** is mentioned in the standard. The standard defines DLFP which is 88 bits long and is always BPSK which is transmitted after L.P. (Long preamble) of 2 symbols. It carries Length of the Downlink Bursts and it is in unit of OFDM symbols.

DLFP= {..., Rate_ID, Length_B1, DIUC, Length_B2, DIUC, Length_B3, DIUC, Length_B4....}

DLFP is decoded by SS based on known modulation-code rate, which is always BPSK1/2. DLFP's extracted parameters are required as scrambler seed. Once SS decodes this it will come to know about Downlink B1 which carries system critical messages namely DLMAP, ULMAP, UCD and DCD as described in the 16d standard. ULMAP structure with important fields mentioned below.

ULMAP= {..., Allocation start time,...start_time_B1,...duration_B1,...Start_time_B2,...duration_B2,...}

Allocation start time field, which defines starting point of uplink sub frame which is in units of Physical slots (PS), and mentions after how many PSs starting from DL Sub frame, uplink allocation is going to start. Physical slot is the basic unit of resource allocation is fixed WiMAX and it is 4/Fs. For ranging standard defines fixed location after TTG but Bandwidth request can be sent anywhere in the uplink sub frame except region dedicated for ranging request. ULMAP which is transmitted by BS contains start_time_field by which SS will come to know when in the frame they have to initiate the transmission. SS will transmit the burst appending Short preamble (S.P.) as defined in the standard.

As modulation-code rate for SS can vary in the system, request for bandwidth is designed in units of bytes. The Bandwidth Request PDU consists of header alone, which consist of field BR, which defines number of bytes requested by SS.

Each MAC PDU starts with Generic MAC Header (GMH) which is 6 bytes long and consists of mainly following fields. As mentioned each MAC messages will have type field by which MAC layer will decide what action need to be taken with the received MAC PDU on both the sides(BS and SS)

GMH= {Header type,…, MAC msg type,..., CID, HCS}

There are two major fields UCD and DCD which is called uplink channel descriptor and downlink channel descriptor respectively. These fields in conjunction with UIUC and DIUC will decide modulation-code rates of the downlink and uplink bursts.

As in all the standards and wireless systems, before actual conversation (voice) or data transfer starts there will be exchange of messages between requesting system (Here SS) and serving system (Here BS). Similarly in WiMAX following messages are exchanged between BS and SS before internet connection is established.

MAC message flow between BS and SS before data transfer takes place:

1. Broadcast message-DLMAP,ULMAP,UCD and DCD (BS->SS)
2. RNG REQ (SS->BS),RNG RSP (BS->SS)
3. BW REQ (SS->BS),SBC REQ (SS->BS),SBC RSP(BS->SS)
4. BW REQ (SS->BS),REG REQ (SS->BS),REG RSP (BS->SS)

At this stage network entry for SS is completed and now it will establish service flow. For Service flow there are two methods, BS initiated and SS initiated. We will talk about BS initiated Service flow for both downlink and uplink connection.

5. DSA REQ for downlink (BS->SS),DSA RSP for downlink (SS->BS)
6. DSA ACK for downlink (BS->SS),DSA REQ for uplink (BS->SS)
7. DSA RSP for uplink (SS->BS),DSA ACK for uplink (BS->SS)

At this stage connection is established and both the sides can transfer the data to each other i.e. Network layer can start communicating thorough MAC-PHY.

Reference: IEEE 802.16-2004 Standard