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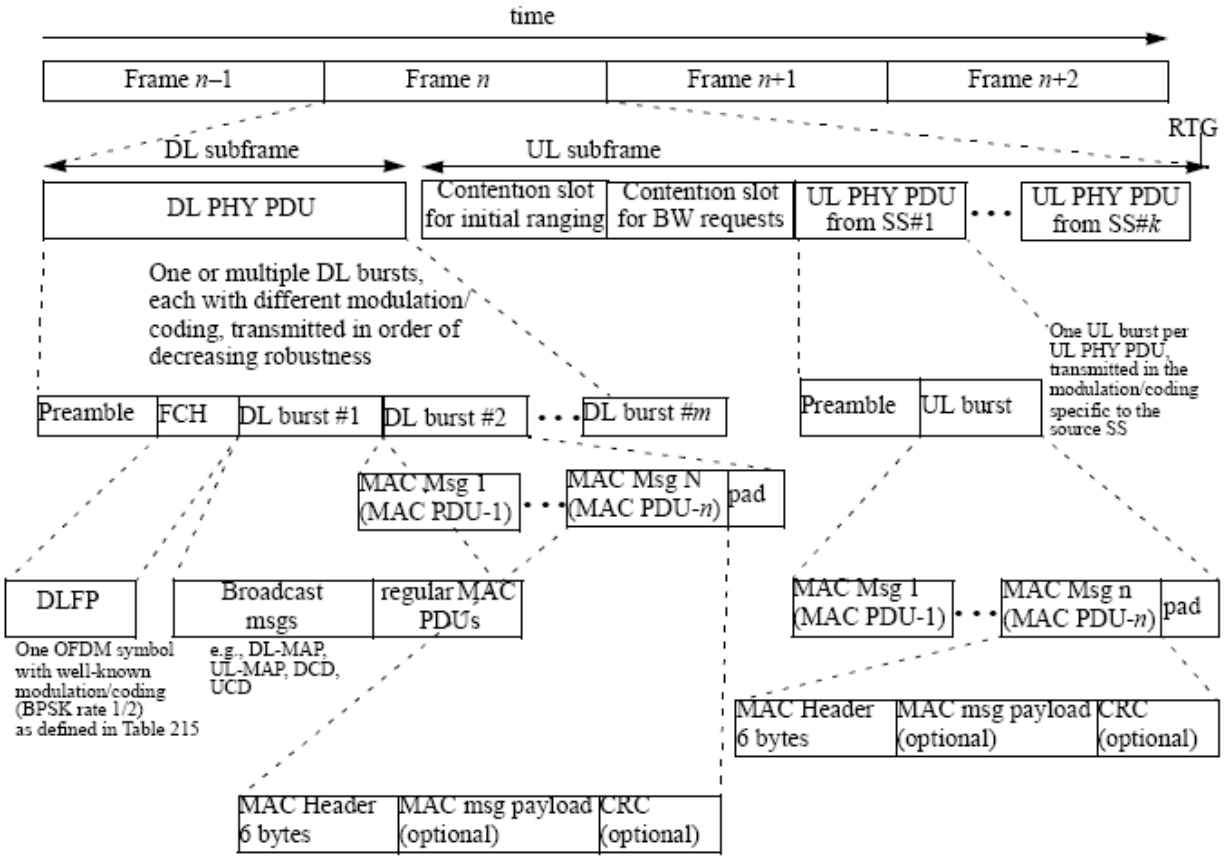
WiMAX Physical layer

Introduction:

This paper covers wimax frame and symbol structure and describes Physical layer modules and functions of each in brief as per IEEE 802.16-2004. IEEE 802.16-2004 defines five physical layers namely SC, SCa, OFDM, OFDMA and WirelessHuman. OFDM Physical layer is used in the broadband technology namely 'fixed wimax' and OFDMA is used in Mobile wimax.

Description:

Following figure describes wimax TDD frame, which is adopted by wimax forum.



DL-subframe is transmitted by Base station and received by Subscriber station, while UL subframe is transmitted by more than one SSs and received by Base Station.

DL subframe comprise of Preamble, FCH followed by Downlink Bursts.

Preamble consists of two symbols for the case of DL-subframe and one symbol for the case of UL-subframe with the exception in Ranging Request frame. Preamble is the known pattern and is as defined

in the standard in section 8.3.3.6 and is mainly used in the receiver for synchronization purpose (time, frequency and channel).

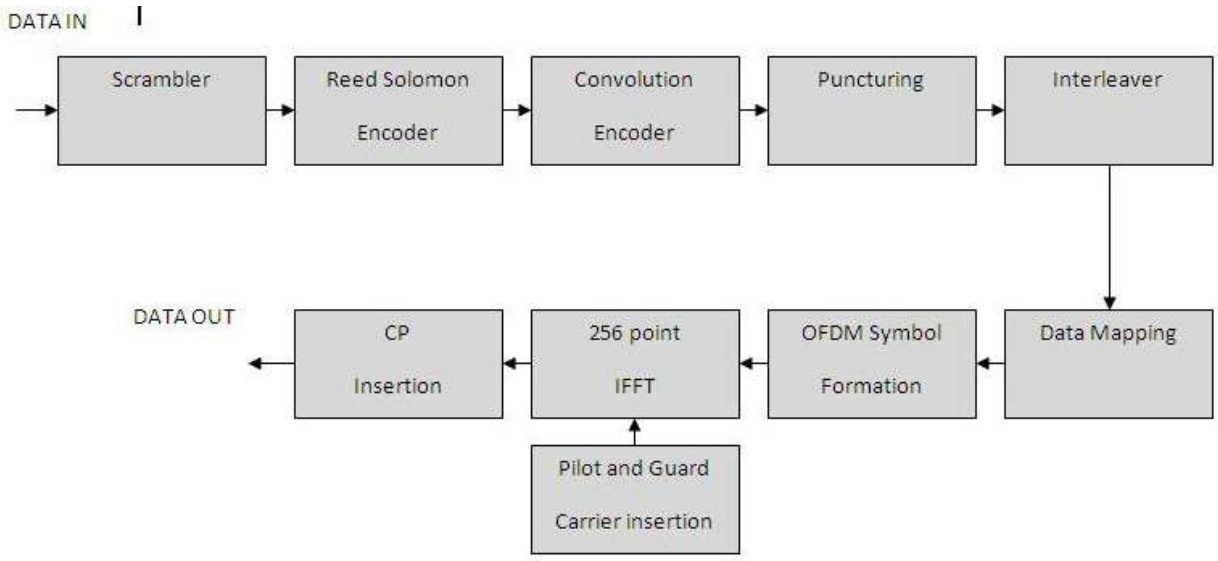
FCH is Frame Control Header (DLFP-Downlink Frame Prefix) and consists of 88 bits which carries mainly lengths (in unit of symbols) and modulation-code rates of Downlink bursts. Other than this it has BSID and Frame Numbers which is used in seed calculation. It is always BPSK ½, as the mod-code rate is known it can be easily demodulated-decoded on subscriber side and data can be derived and the same is consecutively used for demodulation-decoding of the Downlink Bursts.

All the Downlink and Uplink Bursts carried MAC PDU comprise of GMH, payload and CRC.

GMH and CRC are defined in the standard under section 6.

UL subframe consist many uplink bursts. Each Burst is transmitted by Subscriber station (SS), which comprise of Preamble followed by burst, which carries MAC PDU.

Following figure describes wimax Physical layer modules used to convert raw data of MAC layer into complex data. These modules are used for forming one OFDM symbol. If the Burst is more than one symbol long the same modules are used repeatedly. This complex data passes through DAC and RF Frequency converter before transmission by Antenna. The reverse will take place in reception.



Let us analyze what happens to the MAC layer PDU as it is passes through these modules.

IEEE standard defines modulation-code rate table as below.

Modulation	Uncoded block size (bytes)	Coded block size (bytes)	Overall coding rate	RS code	CC code rate
BPSK	12	24	1/2	(12,12,0)	1/2
QPSK	24	48	1/2	(32,24,4)	2/3
QPSK	36	48	3/4	(40,36,2)	5/6
16-QAM	48	96	1/2	(64,48,8)	2/3
16-QAM	72	96	3/4	(80,72,4)	5/6
64-QAM	96	144	2/3	(108,96,6)	3/4
64-QAM	108	144	3/4	(120,108,6)	5/6

For example if the PDU has 20 bytes and modulation-code rate is BPSK1/2 then PDU is fragmented into 12 and 8 bytes to be carried over 2 OFDM symbols over the air. In the second symbol necessary padding will be incorporated.

We will take example of QPSK ¾ to understand the modules.

Step 1: 35 bytes will be fed to the input of scrambler which is a generic linear feedback shift register with EX-OR gate. The output is randomized data of 35 bytes to which hex byte of zero is added.

Step 2: The 36 bytes will be fed as input to the RS encoder which will give 40 bytes of data with redundancy added for error correction at the receiver on the other side. RS Encoder is bypassed for BPSK1/2.

Step 3: The Convolution Encoder will double this input bytes and will produce 80 bytes of data as the rate is ½ of this encoder.

Step 4: Puncturing will remove bits as per order mentioned in the standard hence the data rate will increase. For QPSK3/4 puncturing configuration is 5/6, which produces total of 48 bytes as mentioned in the block Diagram.

Step 5: The Interleaver consists of permutation equations which help in error correction as it spreads the data over distributed carriers in bunch of 192 data carriers of OFDM symbol of total 256 carriers.

Step 6: This 48bytes (i.e. 384bits) will be fed to QPSK data mapping which will produce 192 complex data which will be carried over 192 data carriers. In QPSK 2 bits are converted to one complex data as per the constellation diagram.

Step 7: The symbol is formed after embedding pilot, DC and guard carriers. WiMAX consists of OFDM symbol of 256 carriers in total consisting of 192 data, 8 pilots, 1 DC and rest of the carriers as guard carriers.

Step 8: These 256 values are fed to the IFFT module which will produce time domain complex data.

Step 9: Cyclic prefix is added which helps to overcome effect of the delay spread is added to OFDM symbol.

Step 10: After CP is added to each symbol, packet formation take place. For the Downlink subframe, Preamble and FCH is appended to the Downlink bursts after they have passed through all above physical layer modules. For the Uplink Burst, only preamble is appended to the uplink burst after burst is formed by concatenating all the symbols.

The reverse process takes place in the receiver with the exception that time, frequency and channel estimation and equalization modules are incorporated before it passes through the FFT, de mapping, de-interleaving, decoding and descrambling blocks.

REFERENCES: IEEE 802.16-2004 Standard Section 8.3 OFDM Physical layer