Wi-Fi Mac Layer Transmitter and Receiver Using VHDL

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Abstract: In this paper, we are using IEEE 802.11 standard for VHDL modeling of Wi-Fi MAC layer transmitter and receiver, for the wireless communication in the Radio frequency range. Wi-Fi wireless fidelity for LAN is designed for local area networks, which are private, local (short range), but where competing cable systems run at very high speeds. Wi-Fi MAC layer used various IEEE standards. Here WI-Fi MAC transmitter and receiver used Probe request frame, association frame, RTS frame, CTS frame, modulation, signal processing filters, match filter, demodulation and decoding. In this paper we discussed coding, modulation, pulse shaping in transmitter part and match filter, demodulation and decoding in receiver part of the module.

Keywords: WLAN, IEEE 802.11,VHDL,Wi-Fi MAC layer**.**

I. Introduction

In recent year, the popularity of WLAN (Wireless Local Area Network) has generated much interest on improvement and performance analysis of the IEEE802.11 protocol. The IEEE 802.11 protocol defines the MAC (Medium Access Control) and the physical layer functions of WLANs. The WLAN MAC protocol employs two medium access methods for packet transmission which are the DCF (Distributed Coordination Function) and the PCF (Point Coordination Function) .We focus on the MAC layer provides a CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance. The optional PCF based on the contention free service is suitable for delay sensitive traffic. Due to technology advancement in the 21St Century, wireless Communication had been most popular choices of communication. More and more people are turning to wireless due to the convenience of mobility. An 802.11 LAN is based on a cellular architecture where the system is subdivided in to cells, where each cell [called Basic Service Set or BSS] is controlled by a Base Station [called Access point, or in short AP].Even though that a wireless LAN may be formed by a single cell, with a Single Access Point[can also work without an Access Point], most installations will be formed by several cells, where the Access Points are connected through some kind of back bone[called Distribution System or DS],typically Ethernet, and in some cases wireless itself.

II. WI-FI MAC Layer Transmitter and Receiver

Overview of MAC Layer

The layer of MAC specifies two different mechanisms: distributed coordination function (DCF) with contention scheme and point coordination function (PCF) with contention free or polling scheme to perform real-time applications. At present DCF is the dominant MAC mechanism implemented by IEEE 802.11 compliant products. The 802.11 protocol covers the MAC and physical layer, the standard currently defines a single MAC which interacts with three physical layers.

MAC layer acts as an intermediate stage between Data link layer and physical layer. Its primary responsibility is to provide a reliable mechanism for exchanging transacting packets [data, control and management] on the communication channel through physical layer. MAC layer performs the following functions:

(i) Generation of various MAC frames.

(ii) 32-bit CRC for payload data.

(iii) FIFO buffer interface for receiver.

(iv) Parallelizing data by bit to byte converter.

MAC receiver controller state machine implementation. MAC architecture Medium access control layer performs function like:

(i) On transmission, assemble data into a frame.

(ii) On reception, disassemble frame and perform address recognition and error detection.

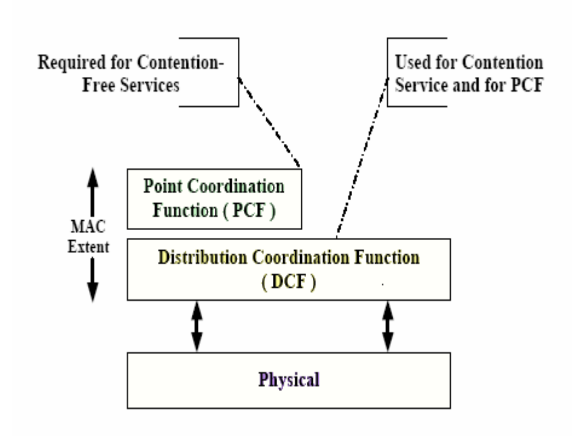

Fig 1: Architecture of MAC Layer MAC Layer Frame Format

The basic format for all packets sent by the MAC layer. Some actual packets do not actually contain all of the fields. However, all fields are present in all data packets. Up to four addresses are needed because it is sometimes necessary to identify the address of the access point used by the transmitter or receiver. Thus, if two wireless LAN users are sending packets to one another but each is using a different access point, the 802.11 MAC addresses of both access points and both clients will be present in the four address fields.Fig.2 represent the MAC frame format. Table 1 and table 2 define and describe the 802.11 packet format[1,3].

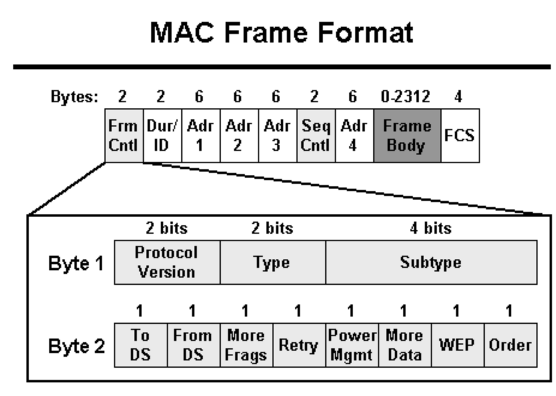

Fig 2: MAC Frame Format

Table 1. 802.11 packet format

Frame Control	Duration ID	Address1 (source)	Address2 (destination)	Address3 (rx node)	Sequence Control	Address4 (tx node)	Data	FCS
2	2	6	6	6	2	6	0 - 2,312	4

Values:
NOTE: Bits are numbered right to left (i.e. bit number is same as 2**n)
Table 2.Description of an 802.11 packet

Field	Bits	Notes/Description
Frame Control	15 - 14	Protocol version. Currently 0
	13 - 12	Type
	11 - 8	Subtype
	7	To DS. 1 = to the distribution system.
	6	From DS. 1 = exit from the Distribution System.
	5	More Frag. 1 = more fragment frames to follow (last or unregimented frame = 0)
	4	Retry. 1 = this is a re-transmission.
	3	Power Mgt. 1 = station in power save mode, 1 = active mode.
	2	More Data. 1 = additional frames buffered for the destination address (address x).
	1	WEP. 1 = data processed with WEP algorithm. 0 = no WEP.
	0	Order. 1 = frames must be strictly ordered.
Duration ID	15 - 0	For data frames = duration of frame. For Control Frames the associated identity of the transmitting station.
Address 1	47 – 0	Source addresses (6 bytes).
Address 2	47 – 0	Destination addresses (6 bytes).
Address 3	47 – 0	Receiving station address (destination wireless station)
Sequence Control	15 – 0	
Address 4	47 – 0	Transmitting wireless station.
Frame Body		0 - 2312 octets (bytes).
FCS	31 – 0	Frame Check Sequence (32 bit CRC). Defined in P802.11.

III. WI-FI Features

Wi-Fi wireless fidelity for LAN is designed for local area networks, which are private, local (short range), but where competing cable systems run at very high speeds. Wi-Fi achieves greater than 10MB/sec throughput for a user many circumstances. Currently Wi-Fi carries more user data than any other wireless technology. Evolution is to go further, faster and at lower power consumption. Upstart wireless LAN technologies under the 802.11 umbrella have leapfrogged towards cellular and other efforts edging towards broad band wireless such as 802.16/WiMax and have led to the first wide spread, commercially successful broadband wireless access technology. In fact, Wi-Fi is a runway success around the globe.

Transmitter and Receiver Block Diagram

The first block of the transmitter is input generator which is used to generate random input. This random input is given to the coding block. For coding we are using ECC (Error Control Correction) it takes the input and generates an output which contains an input and some modified form of input [7]. For modulation we are using PSK (Phase Shift Keying) at output modulator we will get the single bit PSK[1]. The next block is pulse shaping which results zero when there is input of 0, L, Z, X, U and results one when their input is H. last block is Signal Processing Filter will converts input into packet form. The packet is of 16 bits in which first four bit is of packet serial number next 8 bits are for Data and remaining four bits is CRC (Cyclic Redundancy Check). And the output of the signal processing filter is given to receiver block at the output we get transmitted input.

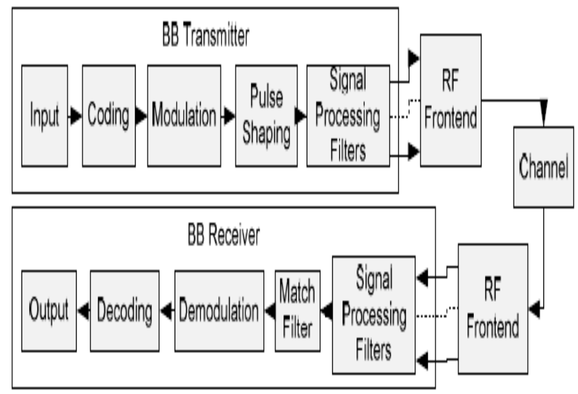

Fig 3: Block Diagram of MAC Layer Transmitter and receiver

IV. VHDL Modeling of Wi-Fi MAC layer For Transmitter and receiver

There are two types of widely used hardware description languages i.e. Verilog HDL with c-language like syntax, easy to learn and another is VHDL which follows the structure of ADA programming language. VHDL is acronym for VHSIC i.e. very large scale integrated circuit hardware description language [10, 11, 12]. It was standardized by IEEE.VHDL is used for synthesis construct and implement a design on silicon. VHDL is used for simulation to imitate real world scenario for verification. Due to high computational complexity of WLAN system and the capability of microprocessors, an implementation based solely in VHDL. In microprocessors would require a large number of components and would be cost inefficient FPGAs with their spatial/parallel computation style can significantly accelerates complex parts of WLAN and improve the efficiency of discrete components implementations.

V. Simulation Result: The simulation results of Various individual input module for MAC Layer transmitter and individual output module of MAC Layer receiver part are given in fig.4 to fig.11 respectively.

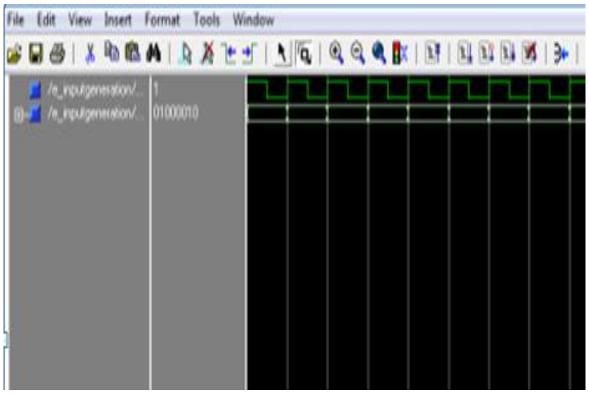

Fig.4 Input Generation

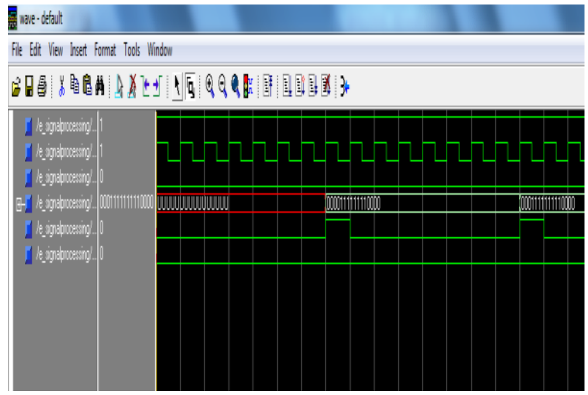

Fig.7 Signal processing filters Transmitter

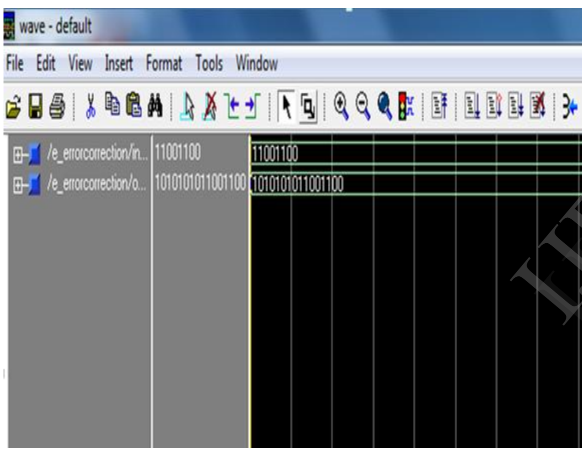

Fig.5 Error correction

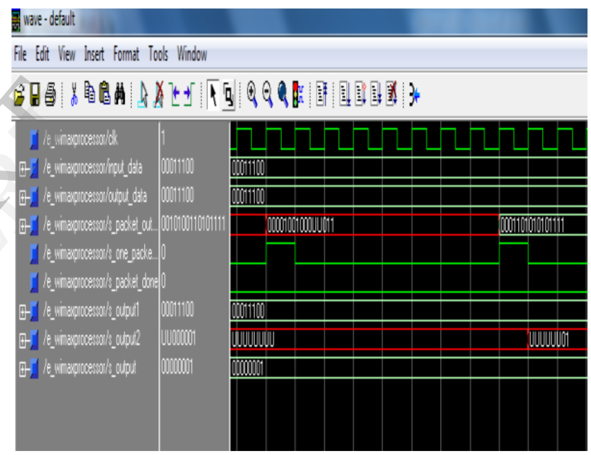

Fig.8 WiMax processor

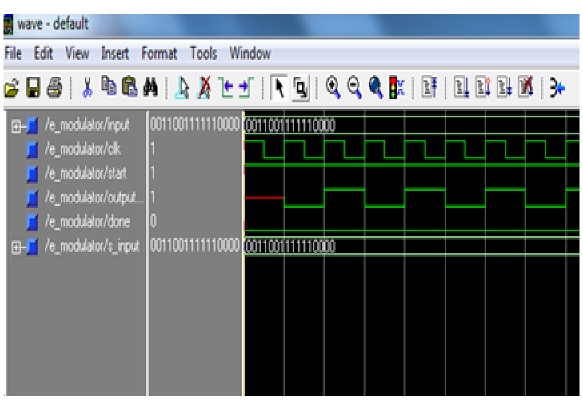

Fig.6 Modulator output

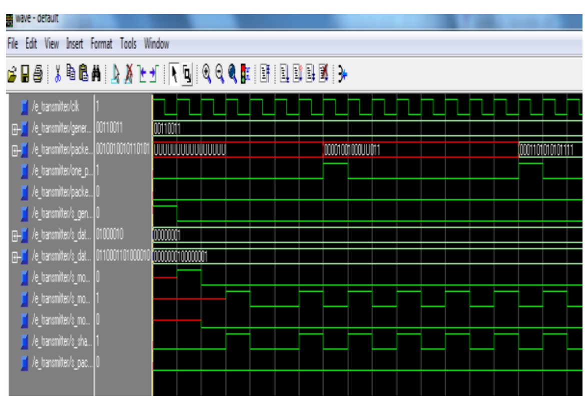

Fig.9 Transmitter output

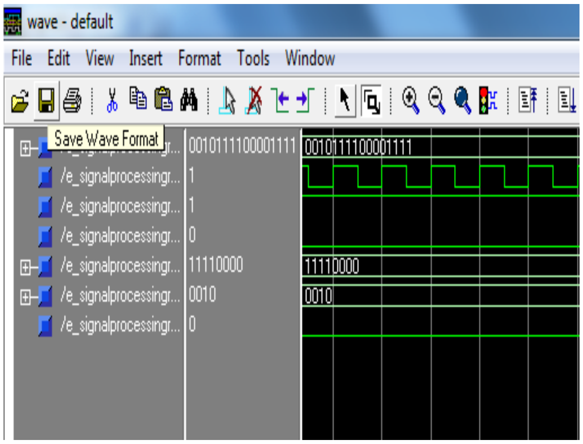

Fig.10 Signal processing filter receiver

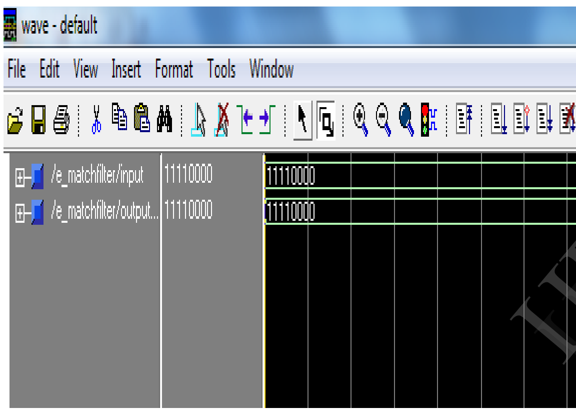

Fig.11 Output of Match Filter

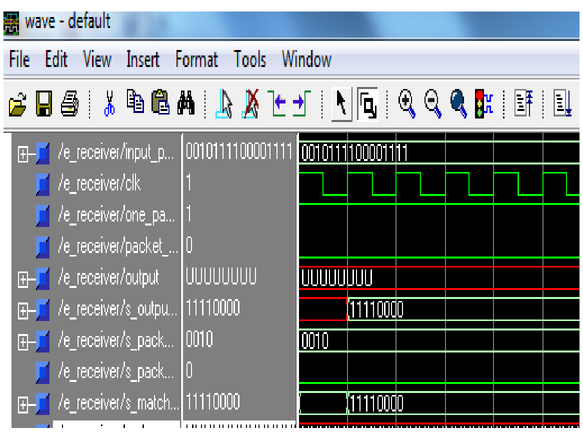

Fig.11 Receiver Output

VI. Conclusion:

We implement various individual modules of Wi-Fi Mac Layer Transmitter and Receiver with VHDL language in this paper and base on IEEE 802.b/g specification. This design of the Wi-Fi transmitter and receiver is capable of transmitting and receiving the frame formats. For the architecture, it can realize the DCF function of receiver part and ensure those functions are workable. We can use these modules and Implement in other vendor's FPGA. For fulfilled that cost down and customize requirement or other similar application. VHDL is managing large designs better than Verilog. VHDL is a very strongly typed language models must be coded precisely with defined and matching data types. When we combine many people's modules of one design for FPGA. We can reduce compatible issue and development time. The formats include all 802.11 frames i.e. MAC frame, RTS frame , CTS frame and ACK frame. The transmitter is also capable of generating error-checking codes like HEC and CRC. It can handle variable data transfer.

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