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Design And Implementation For Generating White Space In A Wi-Fi Like Connectivity

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Abstract

In Time division multiple accessing scheme, all nodes are allotted particular fixed duration time slot in which they must transmit or receive the packets related to their messages. Some nodes may have a real time stream or urgent-delivery packets to transmit. In such situation, nodes transmitting urgent-delivery or emergency messages may have to wait for their respective time slot to arrive in order to transmit. To overcome this problem, in this paper, an idea has been proposed to provide free time slot or to generate White Space in Time domain. These White Spaces can be provided to the nodes which have urgent – delivery or high priority messages to transmit. This work may find its application in military wireless nodes communication, wireless sensor networks and wireless body area networks in e-healthcare, top priority government organisation's intranet which employs Wi-Fi connectivity etc... This paper proposes design and implementation for generating White Space in Wi-Fi connectivity.

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1. Introduction

Time division multiple accessing scheme proves to be an energy efficient channel accessing scheme. Wireless communication systems which have to follow strict limited frequency usage can utilize the advantage of TDMA. In any wireless communication systems employing TDMA, all communicating nodes are allotted particular fixed duration time slots in which they must transmit the packets related to their messages. These messages can be of high priority or low priority type. Sometimes, situation may arise where some of the nodes may have packets related to a higher priority message for transmission. But then these nodes will have to wait for their respective time slot to arrive in order to transmit those packets. For example, consider a scenario like health-monitoring wireless sensor nodes communication system where some nodes may be transmitting critical data sensed by their underlying sensors. In such a case, waiting for time slots to initiate transmission by these nodes may result in a hazardous situation. Even in military wireless sensor nodes communication system based on TDMA scheme, waiting for respective time slot to arrive in order to transmit real time data stream may prove disastrous.

This problem, in any wireless fidelity i.e. Wi-Fi connectivity which employs TDMA based accessing scheme, gave an idea to generate White Space in time domain. These White Spaces can be used to transmit urgent – delivery or high priority messages. This work may also find its application in Wi-Fi connectivity within an intranet of any top priority government organisation. In any emergency situation, when the network jams, the urgent-delivery messages can be transmitted by using generated White Space.

Scope of this paper is limited with the design and implementation for generating White Space in Wi-Fi connectivity and is not extended to the contention problem and time delay constraints that are related particularly with a TDMA based system. Here the term Wi-Fi relates to wireless fidelity so the scope of this paper assumes wireless fidelity connectivity and the main concentration is on to generate the white space.

The contents in the following sections are as follows. Section II discusses about the proposed idea behind generation of White space. Section III presents the VHDL design and implementation. Section IV shows the simulation results. Section V gives the conclusion and future work to be carried out.

2. Proposed Idea

The main objective in this paper is to generate white space and to provide this generated white space to the node having highest priority message's packet. The TDMA frame format for this proposed work is illustrated in section II-A. Algorithm for generating

White Space in illustrated in section II-B. For the design and implementation purpose a network topology in which a set of distributed nodes communicate with the centralized node or access point AP is assumed. Ways to generate white space are as follows:

- Increase the number of time slots so vacant time slots are made available.
- Delay the transmission of the nodes having lower priority message's packet.
- Change the frequency if employing FDMA along with TDMA.

As the work is related considering only single channel, the first two methods are used.

2.1. TDMA Frame Format

The TDMA frame is divided into two sub-frames: a beacon frame and packet traffic frame as shown in Fig 1. Both the sub-frames are separated by a special Sync packet to indicate the end of beacon frame and start of packet traffic frame.

- Beacon frame further consists of synchronizing character (SYN), Packet Traffic Frame Length (PTFL), Time Slot Allocation Table (TSAT) and Control Delay (CD). The beacon frame is transmitted by a centralized node/Access point AP. PTFL gives the information about the length of packet traffic sub-frame. TSAT allows the client nodes to know about the timing of slots assigned to them. So on receiving this table the client nodes adjust their transmission or reception of packets corresponding to them. Control delay CD consists of a byte indicating the address of a particular client node whose transmission is to be delayed. This information is received by all the nodes but only those respond to it whose address matches to the byte transmitted in the duration of CD.
- Packet Traffic frame consists of M number of time slots were M is a variable. These time slots are allocated to the client nodes by the access point. A client node can be assigned two or more number of time slots.

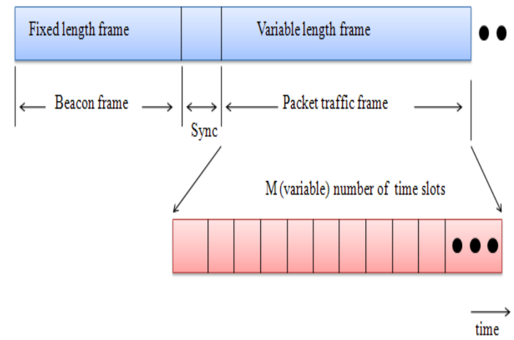

Fig 1. TDMA Frame format for proposed idea

2.2. White space generation

The main task is to identify the higher priority nodes i.e., the client nodes which have higher priority or urgent delivery message's packet. This is possible if the nodes transmit their first byte as a priority byte P_j^m before transmitting their message's packets in slots assigned in PTF. Here m is the m^{th} time slot used by j^{th} client node. The priority byte P_j^m can be assigned dynamically by application software at upper layer or can be allocated at the time of hardware installation. In the MAC layer of the Access point, logic is implemented which compares the priority byte. If the comparison is found to be true, then the access point modifies its time slot allocation table and increases the frame length which results in generation of White Space. This information is transmitted on beacon frame. On receiving the beacon frame, the client nodes adjust their transmit/receive timings.

The above method may seem to be very attractive but when number of client nodes having same priority byte is increased beyond a certain limit, then the simultaneously increasing frame size may result in end-to-end delay problems. To avoid this situation instead of generating white space by frame enlargement in above case, the white space is created by delaying the client nodes having lower priority message's packet. For this, a White Space generating logic (WSL) in MAC shown in Fig. 2 can be designed. Delaying the node is achieved by transmitting the address of that particular node in CD i.e. control Delay sub frame.

2.3. White space degeneration

After transmission of high priority message's packet, that particular transmitting node can change its priority byte P_j^m in order to reflect that the next packets are of ordinary priority. On receiving this byte, the Access Point will update the Time Slot Allocation Table, modifies Packet Traffic Frame Length in order to inform the other nodes to resize the frame and time slot duration back to normal size. Nodes transmitting nearly higher priority message can use auction game method to generate white space for transmission of their packets as described in [13].

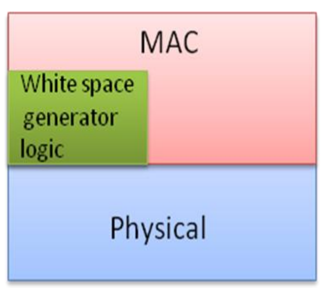

Fig 2. A White Space Generator Logic design in MAC Layer

3. VHDL Implementation

The VHDL design for generating White Space is composed of three modules namely message generator and control module, a TDM module and FIFO shift register. For simulation purpose, a message ROM consisting of certain data sets is designed. There are four such message ROMs to realize four different transmitting nodes. The LI_and_compare block is designed to perform two tasks i.e. to increment location to access new packet data from message ROMs and as well as to compare the priority byte contained within the data packet. This is the block that keeps track of beacon frame as well as packet traffic frame. But here for implementation purpose the LI_and_compare block handles only data packets along with their priority byte given by the transmitting nodes. To continuously provide data packets from the nodes, the locations of ROMs are incremented depending upon the comparison result i.e. when the priority byte is detected; the location is incremented to access next higher priority data packets and when priority byte is not present then the location is incremented depending upon the TDM frequency. The Time division multiplexing module is designed using a MUX whose select lines are controlled by a counter. The MUX module selects one data packet of all nodes and outputs them sequentially. The output of LI_and_compare is applied to the input of TDM block. The output of TDM block is passed through a parallel to serial out block that outputs the bits serially. Fig.3 shows the block diagram of the design

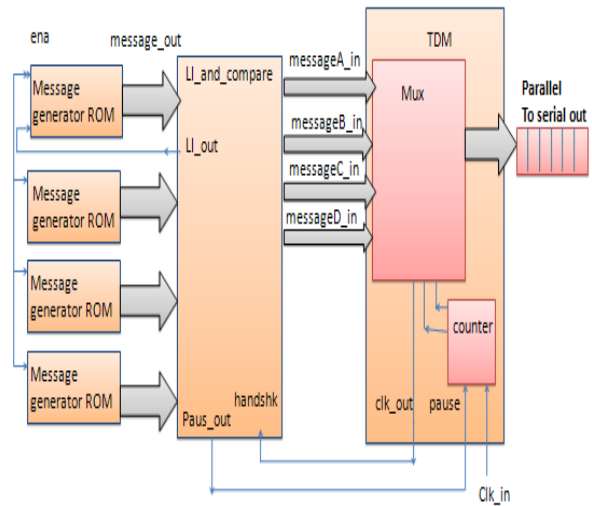

Fig 3. Block Diagram for VHDL implementation

4. Simulation Results

The Fig. 4 and Fig.5 shows different simulation results. From simulation results it is found that to implement white space generator logic module within an access point requires less device hardware utilization even if the work implemented in this paper considers only four nodes. This also gives an opportunity to reduce the size of the devices' hardware in a communication system.

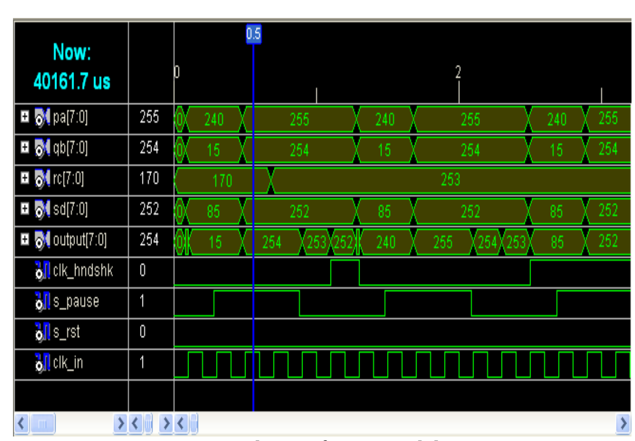

Fig 4. Simulation of TDM module

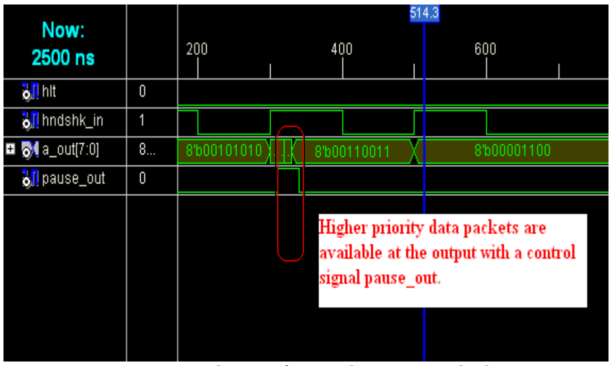

Fig 5. Simulation of LI_and_compare Block

Device Utilization Summary (estimated values)			
Logic Utilization	**Used**	**Available**	**Utilization**
Number of Slices	12	1920	0%
Number of Slice Flip Flops	3	3840	0%
Number of 4 input LUTs	21	3840	0%
Number of bonded IOBs	21	63	33%
Number of GCLKs	1	8	12%

Fig 6. Design Summary of LI_and_compare

Device Utilization Summary (estimated values)			
Logic Utilization	**Used**	**Available**	**Utilization**
Number of Slices	10	1920	0%
Number of Slice Flip Flops	2	3840	0%
Number of 4 input LUTs	19	3840	0%
Number of bonded IOBs	44	63	69%
Number of GCLKs	1	8	12%

Fig 7. Design Summary of MOD_TDM

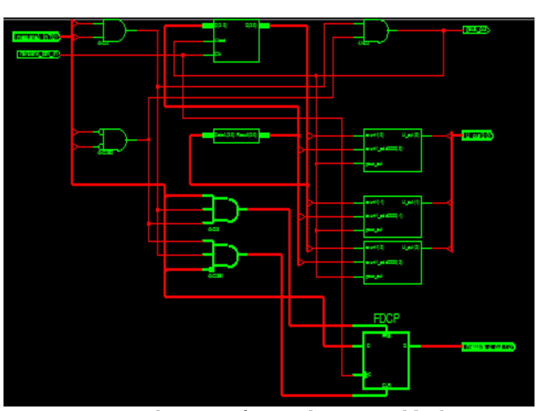

Fig.8 RTL Schematic of LI_and_compare block

5. Conclusion and Future Work

In this paper, a method for generating white space in time domain has been discussed using a simple algorithm i.e. increasing the TDMA Frame thus providing free time slots to the higher priority node and delaying the other nodes which have lower priority message's packets to be transmitted. This scheme might find it difficult to tackle situations when two or more transmitting nodes have nearly equal priority. In such case priority resolution can be done on the basis of game based auction method [13]. This approach can be extended to various other wireless channel accessing schemes such as OFDM by designing suitable algorithms. The future work to be carried out will be the implementation of receiver for this proposed work and demonstration for generating and utilizing white space in a Wi-Fi like connectivity.

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