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An Efficient QoS Control Scheme for Smart FiWi Networks

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***Abstract*: Optical fiber offers an unprecedented bandwidth when compared to other access media. It provides comparatively longer ranges of communication without requiring any active devices. Due to difficulty and higher costs of optical fiber and spectrum limitations of wireless networks, we utilize the idea of combining the Wireless Local Area Networks(WLAN) and Passive Optical Networks(PON) which lead to the development of Fiber-Wireless (FiWi) Access networks. But there arises the problem of inefficient data transmission as we try to combine two different networking technologies. As a consequence, the Quality of Service (QoS) of real time communication degrades significantly. In this paper, this problem of QoS degradation has been addressed with a solution proposed to improve the QoS. The proposed scheme has been simulated using OMNET++ and the results prove to improve the QoS significantly.**

***Keywords*: Fiber-Wireless (FiWi), Passive Optical Networks (PON) and Quality of Service (QoS).**

1. Introduction

FIWI networks are aimed at integrating the Passive Optical Networks(PON) and Wireless Local Area Networks (WLAN) in order to provide a high capacity and wide coverage access network. It has attracted a wide range of researchers due to the growing demand for Internet access.

A FiWi access network comprises of PON and WLAN.A WLAN consists of fixed Access Points(APs) and mobile users(STAs). A number of STAs which are in the coverage area of an AP may be managed by that AP.

A PON consists of Optical Line Terminals(OLTs), Optical Network Units(ONUs) and passive splitter which are all fixed. The uplink and downlink transmissions of the ONUs are controlled by the ONU to which it is connected through the passive splitter.

A FiWi may be an attractive and fascinating solution which due to its impressive features will be able to meet the growing needs of mobile users and sensors.

A FiWi access network based on PON and WLAN also has its disadvantages. A major disadvantage of FiWi network is its transmission latency. This causes serious effects on the QoS in real time communications.

When an STA starts data transmission, the uplink between the AP and STA is controlled by IEEE 802.11e which is responsible for the QoS. Then from the AP data are carried to the OLT through the ONU. The communication between the OLT and the ONU is controlled by the Dynamic Bandwidth Allocation(DBA) algorithm. As a consequence, there arises the transmission latency which causes a degradation in the QoS.

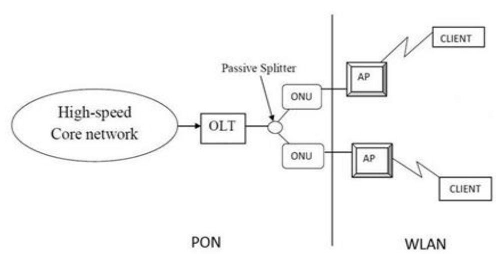

Fig. 1. FiWi Network Architecture

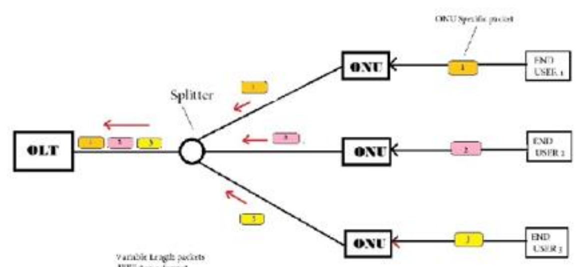

Fig. 2. Upstream Traffic flow in EPON

2. Related work

The major objective of Hybrid Fiber-Wireless access network is reducing its cost and complexity by combining the high bandwidth availability of optical networks and the ubiquity and mobility of wireless networks. [5] highlights the key enabling the integration of optical and wireless technologies and the state of art of FiWi networks. A new research area of FiWi networks opened when the challenges in the RoF and R&F based networks were analysed.

Gateways are located between the Ethernet PON(EPON) and Wireless Mesh Network(WMN). Since all of the downstream from the EPON to the WMN and all of the upstream from the WMN to the EPON must be exchanged at GWs, traffic distribution technique between GWs is necessary to achieve efficient utilization of the network resources[6].The solution includes limiting the hop count by clustering and balancing the load traffic according to the degree of network congestion at the each gateway.

Certain challenges and constraints faced by the wireless community that are not faced by their wired counterparts has been discussed in [4]. A scheme to drop the voice stations from the CFP if they are idle for a specific period of time has been developed.

When the overall upstream TCP traffic exceeds the optical link capacity, the contemporary dynamic bandwidth allocation techniques (e.g., IPACT) present a serious challenge to the fair sharing of the bottleneck bandwidth amongst competing TCP flows. A probabilistic packet marking based TCP rate control mechanism known as PPM-TRC has been proposed in order to deal with this issue [9].

The ability to provide different priority to different applications, users, or data flows, or to guarantee a certain level of performance to a data flow is called QoS. A novel decentralized bandwidth intra-ONU scheduler (M-DWRR) that allows for a unique ONU-gripping to QoS traffic by adaptively setting weights for the different CoS has been presented in [1].

MPCP provides a means of communication between the OLT and the different ONUs. Each ONU periodically reports its buffer occupancy status to the OLT and requests slot allocation. Upon receiving the message, the OLT passes this information to the DBA module. The DBA module in turn performs the bandwidth allocation computation and generates grant messages. Once the grant table is generated, the OLT transmits to the ONUs this information through MPCP GATE messages. The grant allocation table is updated by the output of the DBA algorithm. limited bandwidth allocation algorithm has been discussed and then improved by allocating the excess bandwidth to the heavily loaded ONUs referred to as DBA1. Then the DBA2 algorithm has been proposed [3]. This modified grant table generation algorithm employ some early allocation mechanism in which an ONU requesting bandwidth less than minimum guaranteed bandwidth can be scheduled instantaneously without waiting. Whereas those who are requesting above the minimum guaranteed bandwidth will have to wait until all REPORT messages have been received and the DBA algorithm has computed their bandwidth allocation.

A hybrid coordination scheme has been proposed to enhance performance of an infrastructure WLAN which utilizes centralized early back off-timer announcement, acknowledgment piggybacking, and prioritized scheduling mechanisms [10].

The IEEE 802.11 has been extensively discussed in [8]. Then the enhancements in the MAC layer has been mentioned which includes the Enhanced Distributed Channel Access (EDCA) and HCF controlled channel access (HCCA). With 802.11e, there may still be the two phases of operation within a super frame (i.e., CP and CFP). The EDCA is used in the CP only, while the HCCA is used in both phases.

A new method has been proposed in [2] for the calculation of the service interval by using the send rates of different traffic streams and suggest an advanced way to determine which one of the functions for which kind of streams to deploy. Despite its simplicity the proposed methods decrease packet delay and loss rates significantly and increases the number of streams having acceptable QoS levels.

With the proposed data rate estimation algorithm [7], the QAP can provide guaranteed parameters such as delay, packet loss rate, and throughput for both the real-time VBR and CBR traffics.

The concept of packet bursting for CSMA/CA based networks was proposed as a packet frame grouping scheme to improve the system performance when small packets are transmitted in [11]. This suggestion is included as an optional mode in the draft of IEEE 802.11e and is referred as TXOP Bursting mechanism. The principle of TXOP bursting is to allow, for the station that won the channel access, the transmission of multiple packets.

3. Existing QOS control scheme in PON

Dynamic Bandwidth Allocation is executed by the OLT which is of two methods that is, Status Reporting(SR-DBA) and Traffic Monitoring(TM-DBA).

In SR-DBA, the upstream traffic is initially buffered by the ONU and the required bandwidth is recorded in a REPORT frame and sent to the OLT which upon reception of REPORT message starts the calculation of bandwidth to be allocated. The OLT then records the calculated bandwidth in a GATE message and sends it back to the ONU. Then the ONU starts the data transmission from the buffered traffic in accordance with the GATE message received.

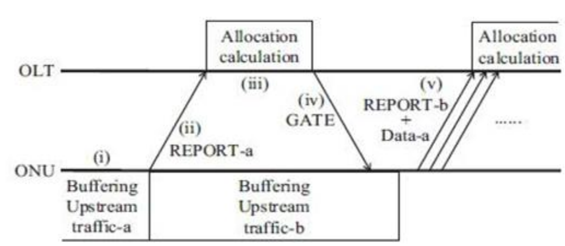

Fig. 3. Concept of SR-DBA

TM-DBA allocates bandwidth based on the amount of traffic required by the ONU. It always allocates some additional bandwidth to each ONU and the ONU sends idle frames during that period. When the OLT does not receive idle frames, it identifies that the traffic requirement of ONU has increased and recalculates the bandwidth allocation.

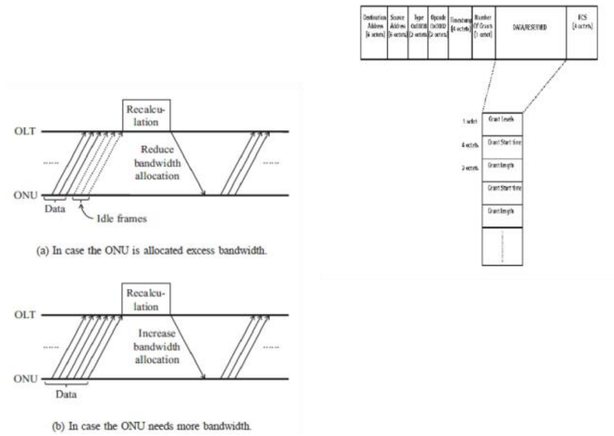

Fig. 4. Concept of TM-DBA, MPCP GATE message format

4. Proposed work

DBA2 algorithm [3] has reported a throughput of 95%. Here the OLT employs some early allocation mechanisms in which an ONU requesting bandwidth less than a minimum bandwidth can be scheduled immediately with no waiting time.

Whereas those requesting above that minimum bandwidth have to wait till the bandwidth computation is performed. The DBA2 algorithm helps in improving the QoS of our PON thereby improving the QoS of the FiWi network.

DBA2 algorithm works with the MPCP arbitration scheme. MPCP supports OLT for time slot allocation. The protocol relies on two Ethernet control messages that is, GATE and the REPORT message in its regular(non-discovery) operation.

The GATE message consists of two information: starting time of transmission and the length of transmission. REPORT messages are sent by the ONU along with the data frames in the allocated time slot. Based on the buffer occupancy, ONU may request for the bandwidth in the GATE message. Once a GATE message is received the OLT forwards it to the DBA module which takes the bandwidth decision.

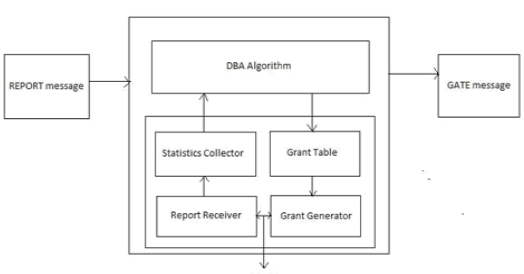

Fig. 5. Concept of MPCP with DBA2

This scheme will reduce the waiting time of ONUs by early allocation of lightly loaded ONUs thereby increasing the throughput and decreasing the delay caused by the waiting time of the ONUs. By implementing this algorithm in the PON side, the throughput of our FiWi network is also bound to be increased considerably.

5. Simulation results

A. Simulation Environment

For the performance evaluation of FiWi network, we need an event driven packet based simulation model developed using C++. This support for simulation is provided by OMNET 4.1.

B. Results

A FiWi network has been simulated with 4 ONUs and the bandwidth allocation has been shown when an access point tries to transmit its data upstream. The proposed work has been implemented and the following FiWi network has been designed.

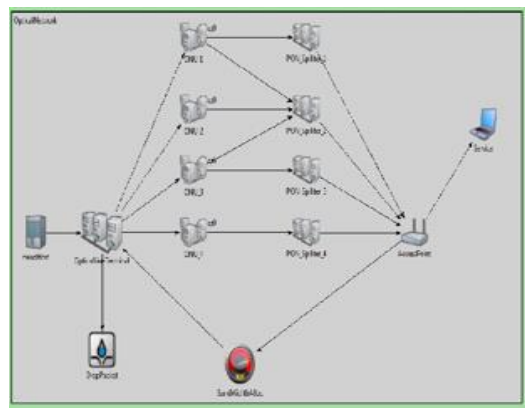

Fig. 6. Design of FiWi network in OMNET++

6. Conclusion

A FiWi network was designed with the DBA2 allocation scheme. The FiWi network consists of 4 ONUs and how an Access Point communicates with the OLT has been shown. The performance of the network designed is yet to be studied and the final results will be the future work.

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