Reducing Overall Delay in Multi-Radio WOBAN

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***Abstract*—Wireless-Optical Broadband Access Network (WOBAN) is a hybrid network technology. The back-End of the WOBAN being optical, has very high performance both in terms of speed and bandwidth. There has been lot of research and numbers of protocols were designed and numerous algorithms have been proposed to bring the performance of the Front-End at par with that of the optical part. So in this paper too, we propose a technique to upgrade the performance of the wireless part so that there may be lesser processing on the actual data packet and may move smoothly across the nodes in the wireless part of WOBAN. Also when the data packet reaches the Optical Network Unit (ONU), it may be forwarded as soon as it reaches the ONU without having to wait for the designated time slot.**

***Index Terms*—Protocol, network technology, wireless-optical broadband network, delay, ONU.**

I. Introduction

There has always been an increased in the demand of the bandwidth. Also there is a tremendous increase in the access network traffic and particularly with the introduction of services like high definition TV, Video Conferencing, telemedicine and other bandwidth hungry applications, the need for such a network that support enormous data and that has high capacity and bandwidth is apparent. Also optical network provides high data rate, low transmission loss, and low bit error rate, Ultra-high bandwidth to meet the growing demand, improved performance, and increased transmission rate. On the other hand, wireless network has also greatly influenced our lives. They provide number of advantages like mobility, flexibility, lesser cost. So Wireless Optical Broadband Access network (WOBAN) combines the best feature of the wireless and optical networks. WOBAN is the hybrid of the Wireless and optical networks. WOBAN was proposed so that there may be a flexible solution to the increased demand of access network. Not only to overcome the demand but also to have cost-effective deployment of a WMN while having higher performance due to the optical network. Though the communication scenarios, of both are totally different from each other [1]. Optical network are used for high bandwidth and for long-haul communication and wireless to provide flexible connectivity. So in WOBAN we combine both in an efficient and cost-effective manner in order to take the advantages of the best features of both.

Rest of the paper is organized as follows. Section II highlights the Architecture of WOBAN, section III shows the a typical scenario for data communication in WOBAN, section IV is about the related work on the problem, section V will be on our proposed scheme, section VI consists of a scenario for our proposed scheme and we'll draw conclusion in section VII. Section VIII will be about the future work and than acknowledgement.

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II. Architecture of WOBAN

WOBAN is an optimal combination of an optical back-end and a wireless front-end for an efficient access network [1]. Architecture of a WOBAN consists of wireless part- The Front-End and the optical Part-The Back-End. At the back end, there is a Central office (CO) the Optical Line Terminal (OLT) resides in CO. The CO and the wireless part is connected through a trunk fiber. At the wireless part, first of all there are gateway routers called ONUs. The rest of the wireless nodes are connected to these ONUs. The distance between the ONU and the CO is almost 20Kms. However, this distance can be decreased or increased depending upon the requirement and the number of ONUs to be supported. End-users whether stationary or mobile, are connected to the network through the wireless nodes. There is an optical splitter between the OLT and the ONUs. The optical splitter, being passive device, so overall the architecture is more robust.

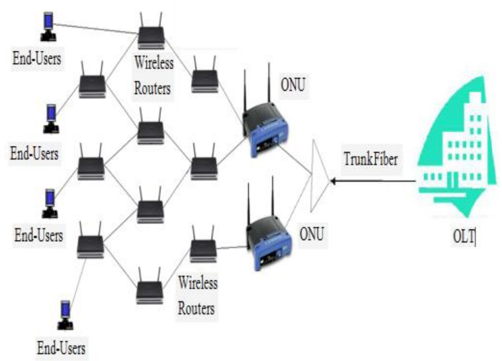

Fig. 1. Architecture of WOBAN

III. Data Communication in WOBAN

For communication in downward direction, that is, from CO towards ONU, the packet is broadcast. The optical splitter split the signal equally among the entire ONUs. The entire ONUs rejects the packet except the one for which the packet is aimed. In upward direction, when end users want to send data packets, it does so by passing the packet to the nearby nodes. That nearby node passes the data packet to its other neighboring node nearer to the ONU. In This way, packet pass hop by hop to different nodes to reach the ONU and then from ONU, through splitter, ultimately to the OLT. From OLT, the data packet is sent in the similar fashion discussed above, that is, the packet after reaching the OLT is sent back over the same fiber trunk. The optical splitter splits the signal equally among the ONUs. The entire ONUs will reject the packet except the ONU in which there is the targeted user of the packet. If this packet is meant for a node out side this WOBAN, it is routed by the CO outside the network. So in wireless part when the data packet is passed hop by hop, doing various kinds of processing and making routing decision at each hop, there comes a significant delay. Since optical part has high speed, high bandwidth, and high capacity, thus having high performance. The performance of the wireless part must be brought at par with that of the optical part. So first all this delay must be reduced, in order to match with the speed of the optical part, up to some extent.

IV. Related Work

Number of routing algorithms has been proposed. Traditional routing approaches like SPRA and MHRA are both based on the shortest path. They don't consider other characteristics of the network like congestion, available bandwidth, load on the link etc. Most often the shortest path is not the best path. So both SPRA and MHRA both do not overcome the delay problem in particular and also the load balancing and congestion problem. Another approach is PTRA, chooses the path with the highest throughput based on the Link State Advertisement (LSA). Again, the path with the highest throughput might not be the shortest path, as we are interested in selecting the shortest path having highest throughput and least delay.

There are some other routing algorithms proposed to overcome the delay problem. In DARA [3] and CaDAR [4] the authors have calculated the delay of each link and then for forwarding the packet, overall delay of the path is calculated. The authors have identified four types of delay.

1) Transmission delay

$$\frac{1}{\mu C_{uv}}$$

2) Slot synchronization delay

$$\frac{1}{2\mu C_{uv}}$$

3) Queuing delay

$$\frac{1}{\mu C_{uv} - \lambda_{uv}}$$

4) Propagation delay—Nodes being closer to each other. So negligible

Table I shows the comparison of various algorithms. It is obtained by studying various algorithms and their characteristics about whether they solve the delay and throughput problem or not. The table below shows that the DARA and CaDAR are almost same. However, CaDAR is better then DARA in a sense that it also assigns capacities to all the links. In both the algorithms, though they very efficiently calculate the link delay, and select the link with the least delay. However, calculating these so many types of delay for a link and for each packet and then for the whole path, is itself a delay. If a data packet has to undergo these so many processing and decision making, the reduced delay may not be significant. So in this paper we propose a mechanism in which there will be reduced processing and decision making on the actual data packet. Though the shortest path with the least delay is calculated in similar fashion as in CaDAR and DARA but however, the processing overhead will be much reduced on the actual data packet, so it will move smoothly across the nodes. Thus there will be significant reduction in the delay.

TABLE I: Comparisons of Various Algorithms

Routing algorithm	Delay handled?	Good throughput?	Load Balancing?
SPRA	Upto some extent	Not so much	no
MHRA	Not completely	No so much	no
PTRA	Not	Yes	Yes
DARA	Yes*	Yes	Yes
CaDAR	Yes*	Yes	Yes

V. Proposed Scheme

The link condition and the capacity required for a node is advertised in LSAs. LSAs are advertised periodically. So if after a LSA, link condition are changed, say for instance, flow on the link is changed, then the link will be either under-utilized or over-utilized and may lead to congestion, packet loss depending upon whether the demand of the node was increased or decreased after that particular LSA. Time-Slots for various nodes are also adjusted according to the LSA. So all the algorithm discussed above, heavily depends upon the LSA, thus in the inter-LSA period, the network condition may change dramatically, thus leading to the wrong estimation and calculations. Also the slot may be wrongly synchronized. And due to lack of network information the capacity may be wrongly assigned to the link thus leading to other offensive results like congestion, packet loss and so on. One solution to all these is to send LSA frequently but in this case a major chunk of bandwidth will be used by sending LSAs themselves. So In our proposed scheme, we will send a control packet ahead of the actual data packet. Thus there will be no need of LSAs. In this method, we will embed the sequence number and size of the data packet in the control packet. The control packet is actually the header of the data packet separated from the data packet. So for synchronization and identification purpose we use the sequence number. The control packet will contain fields for the sequence number and the size of the data. One extra field will have to be added in the data packet for the sequence number using the bits of reserved field. The control packet will travel ahead of the data packet, thus finding the shortest path with the least delay for the actual data packet. The data packet will follow the same path which was followed by the control packet. All the routing decision will be made and the shortest path with the least delay will be calculated for the control packet only. There will be no processing on the actual data. The intermediate node, just looking at the sequence number of the packet will forward it on the same path on which the control packet was forwarded. Also the control packet will tell each node exactly how much data is coming from a particular node. So in this way, capacities will also be assigned to the link according to the information of the control packet as it contains the size of the upcoming data packet. Thus not only there will be no processing on the data packet and capacities will be assigned to the links, but also the control packet will so synchronize the time slot at each node, so that the when the data reach the node, it will not have to wait for designated time slot and will be forwarded as it reaches the node. Similarly time slot will be reserved at the ONU as well, so as data reaches the ONU, it will be forwarded without waiting for the designated time slot, as the designated time slot will reach as soon as the data packet will reach the ONU.

VI. Scenario

Consider the Fig. 2, below. Consider that End-User 2 generated data, suppose the sequence number of the data be 500. Now this sequence number and the size of the data packet will be embedded in the control packet. The only thing which will be included in the data packet will be a field for sequence number, so that the intermediate node recognizes this sequence number. Now suppose the control packet after reaching node A (since End-User is connected to the network via node A), finds out the shortest path with the least delay link to node B, at B it find the shortest with least delay link to node C and then to ONU. Based on the control packet, capacities will also be assigned to the links {AB} and {BC}. Also the intermediate node B and C will adjust the time slot according to the arrival of the data packet and then will not make any processing on the actual data packet, the only things which the intermediate node will do is to check the sequence number.

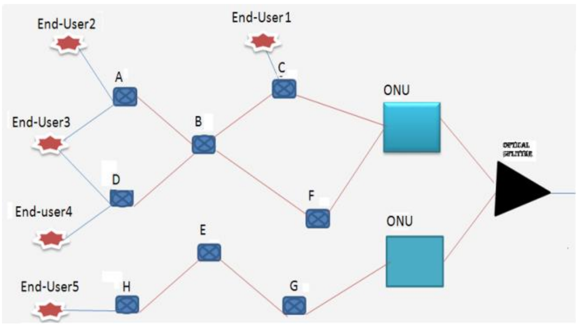

Fig. 2. Back-end of WOBAN

Thus recognizing the sequence number, they will forward the data packet on the path on which the control packet was followed. Another advantage of the control packet is that, when the control packet reaches the node B and C, it will also so synchronize the time slots at the B and C, that as soon as the data packet arrive these nodes, its time slot also come. So the data packet will be forwarded as soon as it reaches the node without having to wait for designated time slot and thus there will be no queuing delay and time slot synchronization delay as well. Similarly at ONU too, the control packet will reserve the time slot for the data packet and will also reserve the bandwidth for the data packet to be forwarded on the fiber trunk. So again as soon as the data packet reaches the ONU, its designated time slot will also come, so it will be forwarded without having to wait for designated time slot. In this way three types of delays namely, processing over head delay on the data packet, queuing delay and time slot synchronization delay, significantly impacting the overall performance of the wireless part are reduced. Fig. 3 below shows data packet of various End-Users and their time slots. Packet will be forwarded in the time slots one by one. Since we know that time slots are synchronized on the basis of the LSAs. The control packet of a particular data packet will so synchronize the time slot that as soon as its data packets reaches the node's queue, its time slot will also come, so it will be forwarded without having to wait for it designated time slot. Again, the only thing which the intermediate node has to check is the sequence number of the data packet. The packet will be forwarded in similar fashion at ONU as well.

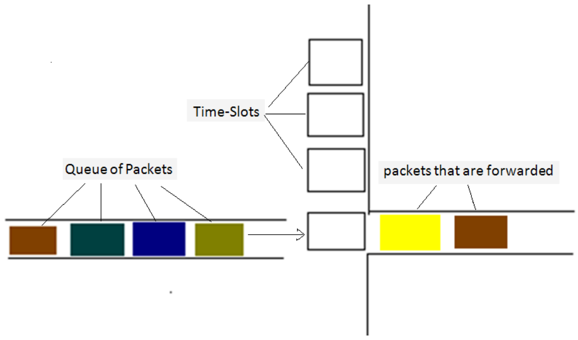

Fig. 3. Queue of packets and their time-slots.

VII. Conclusion

We have shown a fine technique to reduce the overall delay and efficiently use the network resources. With DARA and CaDAR, delay will have to be calculated for all the links and ultimately for the entire path, for each packet sent and then decision will have to be made regarding the shortest path with the least delay for every data packet. Also both the algorithm depends upon the LSA, since network condition may change even before next link state advertisement. So in this paper, we have shown an efficient mechanism in assigning capacities to the link and synchronizing the time slots of the nodes and a mechanism in which there will be no processing or routing decision on the data packet. Since there is no other processing on the data packet and also the control packet will also reserve the time for the data packet at intermediate nodes and ONU, so the packet does not have to wait in the queue for its designated time slot. Thus there will be significant reduction in the overall delay. Overall all the three types of delays will be eliminated, namely, queuing delay, time slot synchronization delay and processing delay. The need for LSAs is also eliminated. So since there are no LSAs, thus there will be an efficient utilization of resources. Table II shows the comparison of various algorithms with our proposed scheme.

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