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Performance Analysis of DBA Algorithms for EPON with Differentiated Classes of services

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Abstract*: A network consisting of a number of subscribers connected to a central office by using optical fibers through a passive splitter is called an access network. The access network traffic is growing day by day with the increase in number of applications. Downstream transmission of data happens through broadcast whereas, for upstream transmission, bandwidth scheduling algorithms are required to prevent collision of data during transmission. These scheduling algorithms follow Multi Point Control Protocol as specified by IEEE. A number of bandwidth allocation algorithms exist in the literature. The objective of this paper is to compare the existing algorithms like the Min's DBA, Russian Doll Model, and our algorithms- the two variants of Modified Russian Doll Model namely MRDM1 and MRDM2 and the User Prioritized Constraint Free Model proposed earlier in terms of the bandwidth utilization factor and average delay of packets. The algorithms are simulated using a Discrete Event Simulator modeled in C++ and designed by us specifically for Ethernet PON Networks having Differentiated classes of services in each Optical Networking Unit.

Index Terms*: Discrete Event Simulator Access Networks, Dynamic Bandwidth Allocation Algorithms,, Ethernet Passive Optical Network, Multi Point Control Protocol, Scheduling Algorithm

I. INTRODUCTION

The access network that uses only passive devices is called as a Passive Optical Network (PON). It is a Point to Multi Point Network. The Optical Line Terminal (OLT) in the Central Office is connected through a Passive splitter to a number of Optical Networking Units (ONU) by an Optical Fiber. A single fiber of length 'L' runs between the Central Office and the passive splitter and a number of smaller length fibers connect the passive splitter to the subscribing units called the Optical Networking Units (ONU) [1].

Data transmission from OLT to ONU and the data transmission from ONU to OLT are called the downstream and upstream transmission respectively. Data transmission in the downstream direction is broadcast in nature. All the ONUs receive all the information pertaining to all other ONUs and discard all the irrelevant information not specific to them. Whereas, the data transmission in the upstream direction cannot happen at the same time. If transmission happens at the same time, it will result in data collision. To prevent collision of data, scheduling algorithms are required which can allocate specific time period for the different ONUs to transmit in their time slot.

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These PON networks are called the EPON networks which use Time Division Multiplexing to prevent collision of data while transmitting in the upstream direction. There are other PON Access networks like the Wavelength Division Multiplexing PON (WDM PON) and the Hybrid PON. A WDM PON allocates different wavelengths to different subscriber units. The complexity at the receiving units and hence the cost increase. Also, they do not completely utilize the available bandwidth [2]. A combination of EPON and WDM PON came into existence called the Hybrid PON in which several wavelengths are used between the Central Office and the subscribers and many subscribers share a single wavelength. This proves to be advantageous as the wavelength is shared, it brings down the cost and it also completely uses the bandwidth. These Hybrid networks will play a key role in the next Generation networks [3]. For these hybrid networks also, since wavelength is shared between multiple ONUs bandwidth scheduling algorithms becomes very much essential.

EPON Standard (IEEE802.3ah) [4] was developed by the Ethernet in the First Mile (EFM) Alliance. This standard specifies that the bandwidth allocation algorithm should follow Multi Point Control Protocol (MPCP). The bandwidth allocation algorithms are left to the user to be developed and the standard do not specify the algorithms. A number of scheduling algorithms have evolved following the MPCP protocol for EPON networks. Discrete Event Simulator developed by Kramer et. al has a single Queue in its Subscriber Unit. A subscriber unit may have multiple classes of service. To support differentiated classes of services, the DES developed by Kramer et.al was modified to meet our requirements and the algorithms were tested in the developed DES.

Section 2 describes the Structure of EPON with Differentiated classes of services. Section 3 briefly describes the developed Discrete Event Simulator (DES) for EPON with differentiated services. Section 4 describes the existing algorithms in literature and the algorithms proposed. Section 5 describes compares Min's DBA, Russian Doll Model(RDM) and the two variants of Modified Russian Doll Model (MRDM), User Prioritized Constraint Free (UPCF) algorithms using the developed DES. Section 6 concludes the paper.

II. STRUCTURE OF EPON WITH DIFFERENTIATED CLASSES OF SERVICES

In an EPON Network 'N' subscribers are connected to the Central Office (CO) by means of an Optical fiber through a passive splitter. In each of the 'N' subscribers, there can be a number of applications like Voice, Video and Data with different priorities.

The ONU receives the data and buffers them in its queues as the data arrives from the subscriber and it transmits all the data stored in its buffer in their allocated fixed or variable time slots at full channel speed.

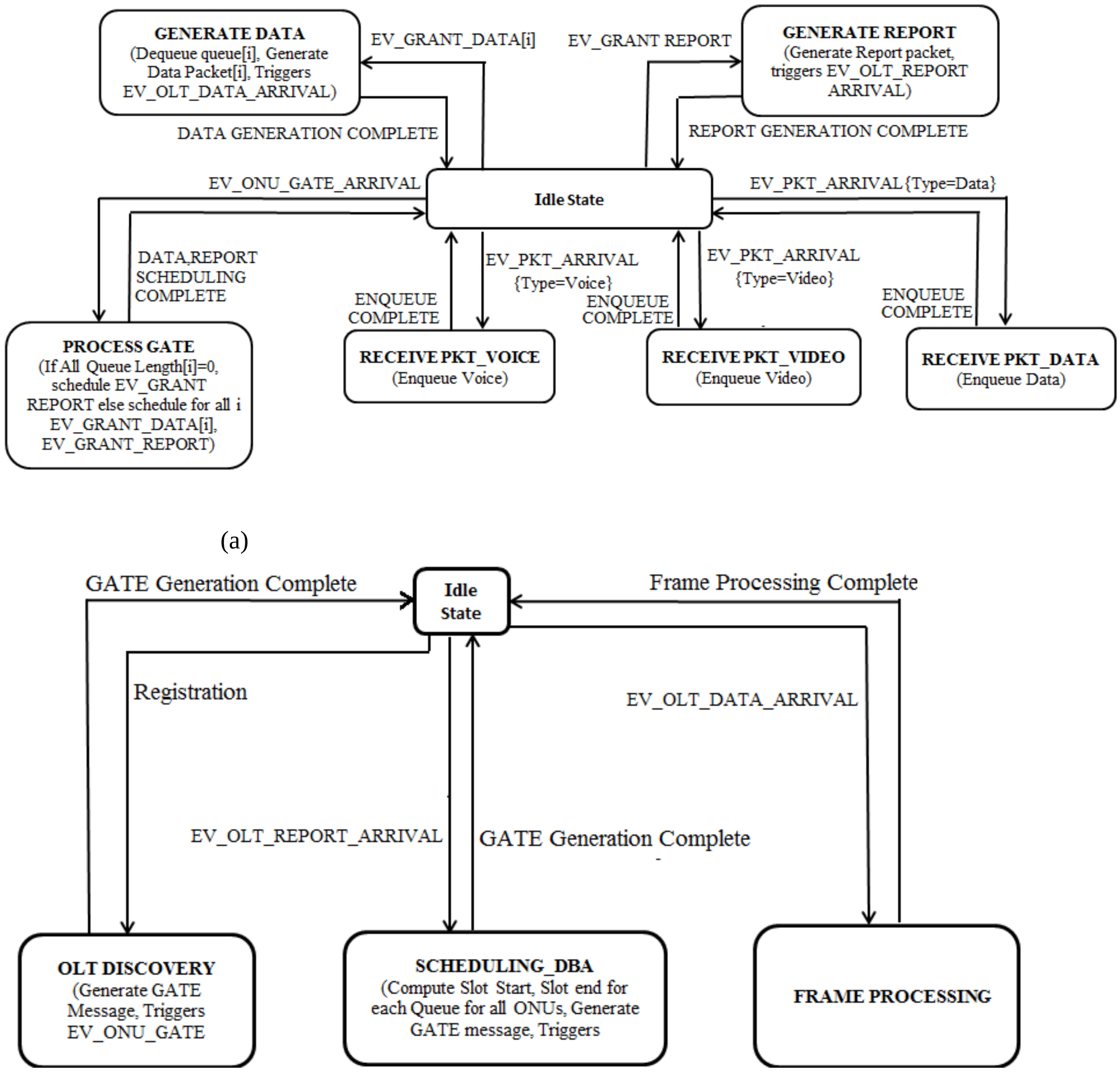

Figure.1 Simulator model: (a) Functionality of ONU and (b) Functionality of OLT

Fixed time slots if allocated do not result in the efficient utilization of bandwidth and hence a variable time slot is used which is computed and provided by the Dynamic Bandwidth Algorithms (DBA) or Scheduling algorithms. These algorithms follow Multi Point Control Protocol (MPCP) as specified by the standard. Two control messages-GATE and REPORT are used by the MPCP Protocol. Every ONU sends a REPORT message to OLT which carries information on how much data is available in its queue for transmission during the next slot. All the REPORT messages are received by the OLT which computes the slot start and slot end times and communicates the specific corresponding time slots in which ONUs can do upstream transmission through the GATE message to each ONU. The GATE message contains information on the transmission start time and the number of bytes that an ONU can transfer. The ONU starts its transmission exactly at the transmission start time specified by the OLT, and data is transmitted to OLT without collision. At the end of the data transmission, the queue status is also reported by the ONU [5], [6].

A number of applications are supported by subscribers these days and so the subscriber's network traffic can be classified into a number of classes (Voice, Video and Data) and to each class, a differentiated service is provided. A bandwidth is allocated to each ONU by INTER ONU Scheduling and the Bandwidth allocated to each user is further divided between the different classes of each subscriber, based on the Service Level Agreement (SLA) between the subscriber and the service provider which is called the Intra ONU Scheduling. Voice being very sensitive to delay is given the highest priority followed by Video and Data.

III. DES FOR DIFFERENTIATED SERVICES

IEEE802.3ah standard specifies only the MPCP protocol to enable communication between the OLT and ONU. It does not specify the scheduling algorithm. The algorithms are left out of the standard for the vendors to develop them. There are a number of algorithms in the literature. Some of them are hierarchical. The detailed literature survey on the existing algorithms used for comparison is presented in the next section.

The developed DES is hierarchical and has 3 Queues per ONU, each for Voice, Video and Data. Each queue is designed to receive a different type of traffic and can buffer up to a size of 10MB. The REPORT message contains the request from all the three queues of an ONU. GATE message from OLT contains the Start time & length of bytes that can be transmitted by each ONU from each queue.

The standard allows up to four grants in the GATE message. Each GATE message can carry the grant for the three queues of an ONU in one GATE message itself. GRANT #1 to GRANT #3 is issued for transmission of Voice, Video and Data and GRANT #4 is issued for the ONU to send the next REPORT message. The Number of Queue Sets field specifies the number of requests in the REPORT message. A REPORT frame may hold multiple sets of Queue #n as specified in the Number of Queue Sets field. Queue #n field represents the length of queue #n at time of REPORT message generation. Since we have 3 Queues in each ONU, Queue #1 to Queue #3 contains the request from each ONU for Voice, Video and Data transmission requirements.

The functionality of the OLT and the ONU is an Event Driven Process and is shown in Figure 1a, and Figure 1b. The OLT performs three main functions: OLT Discovery, Scheduling bandwidth and Frame Processing. When a new ONU joins the network, the OLT goes into OLT_Discovery State. This is the registration of a new node to the network. It then generates GATE Message which triggers the event ONU_GATE_ARRIVAL and goes back to idle state when the GATE generation is complete. On arrival of a report message, the event EV_OLT_REPORT_ARRIVAL is triggered. The OLT then starts scheduling timeslots based on Dynamic Bandwidth Allocation Algorithm. The OLT is designed such that different algorithms may be implemented for study and the required algorithm then plugged in at this point of event flow. The DBA computes the Slot Start time, Slot End Time for each queue of all ONUs and generates the GATE Message which triggers EV_ONU_GATE _ARRIVAL. When triggered by EV_OLT_DATA_ARRIVAL event, frame processing starts in OLT and the OLT returns to its idle state on completion of Frame Processing.

The functionality of the ONU is implemented in the DES as an event-driven process. The ONU receives Voice, Video and Data packets in its queues when triggered by EV_PCKT_ARRIVAL. The packets are stored in the queue of each type of packet. When packet queuing is complete, ENQUE_COMPLETE message is sent by the ONU and ONU goes back to the idle state. When EV_ONU_GATE ARRIVAL is triggered by the OLT, the ONU starts processing the GATE message. If all queue_length[i]=0, then it schedules EV_GRANT_REPORT else it schedules for all i, EV_GRANT_DATA[i] followed by triggering of EV_GRANT_REPORT. When EV_GRANT_DATA[i] is triggered, the ONU starts dequeuing queue[i], generates data_packet[i] and triggers EV_OLT_DATA_ARRIVAL and data generation is complete. The ONU when triggered by EV_GRANT_REPORT starts generating the report packets and triggers EV_OLT_REPORT_ARRIVAL event and the report generation is complete. The simulator also varies the load between the ONUs as some ONUs are to be lightly loaded and some are to be heavily loaded. Also per queue statistics are generated.

V. EXISTING AND PROPOSED DBA ALGORITHMS

IEEE802.3ah standard does not specify the scheduling algorithms. It only specifies the MPCP protocol which clearly states how the communication between the OLT and ONU should take place. The scheduling algorithms are left to the vendors to be developed [7-22]. Some of the algorithms existing in the literature are hierarchical and centralized which are presented in the following section. When the decision making capability about bandwidth allocation lies with the OLT, we call it as the centralized allocation algorithm. Some algorithms also differentiate between different classes of services while some do not. When algorithms also use multiple levels of scheduling like INTER and INTRA ONU Scheduling, we call them as hierarchical in nature.

A Hierarchical DBA algorithm was proposed by Min [14]. INTER ONU allocation is followed by an INTRA ONU allocation and bandwidth within an ONU is scheduled. To reduce delay, voice allocation is done first. Available bandwidth is then calculated and distributed among Video and Data based on their requirements Highest priority queue is granted to exhaustion, so this causes light load punishment. Since Ethernet is bursty, it also cannot utilize full excessive bandwidth, has less Bandwidth Utilization Factor and longer delay.

RDM (Russian Doll Model) algorithm proposed by Sadon et.al [15] classifies the ONUs as lightly loaded and heavily loaded ONUs. It is a hierarchical algorithm in which in Inter ONU Allocation, the excess bandwidth from the lightly loaded ONUs is shared among the heavily loaded ONUs proportional to the request in the three queues. The bandwidth allocated to an ONU is further divided between the various classes of services in Intra ONU allocation. Voice is allotted bandwidth first followed by Video and then Data. Allocation is based on the Service Level Agreements (SLA). This algorithm also does not completely utilize the bandwidth available for Video and Data.

In the Modified Russian Doll Model [16], we proposed an allocation scheme where voice allocation happens first as in RDM. Bandwidth left unutilized by voice services was used for video and the bandwidth left unutilized by video was used for data. More of the unutilized bandwidth from voice and video is allocated to data. A minimum bandwidth is assigned to the ONU, even if doesn't have packets to transmit to enable it to send the REPORT packets in the next transmission cycle. The algorithm makes full use of the available bandwidth and gives better performance. Bandwidth Utilization Factor was improved and delay was reduced. The paper discusses the algorithm and analyses the performance based on the different load scenarios given as input. We refer to this algorithm as MRDM1. User requirement of data bandwidth may be higher rather than voice bandwidth. In User Prioritized Constraint Free (UPCF) DBA Algorithm [17], bandwidth is allocated to a service proportional to the request from the user.

All existing hierarchical algorithms consider voice to be of higher priority and allocate more amount of bandwidth to voice traffic. But in this algorithm, user's preference is given priority. The excess bandwidth from the lightly loaded ONUs is divided between the heavily loaded ONUs based on their request. The Inter ONU allocation is same as that of MRDM1 algorithm. In Intra ONU allocation, the allocation for different services in an ONU is again based on their request in the REPORT messages. User priority is given utmost importance. The algorithm provides increase in performance by providing higher Bandwidth Utilization without any reduction in Fairness index.

In a slightly modified version of Modified Russian Doll Model-Variant2 (MRDM2), we propose an allocation scheme where the Voice is given higher priority over Video and Data. The Bandwidth left unutilized by data services is used for video and the bandwidth left unutilized by video is used for voice. More of the unutilized bandwidth from data and video is allocated to voice other than the minimum assured bandwidth for voice. A minimum bandwidth is assigned to the ONU, even if doesn't have packets to transmit to enable it to send the REPORT packets in the next transmission cycle. The algorithm makes full use of the available bandwidth and gives better performance. Bandwidth Utilization Factor was improved and delay was measured. Analysis on the performance is made based on the different load scenarios given as input. The inter ONU allocation procedure is the same as that of RDM method but Intra ONU allocation is done as shown in Eq. (1)- Eq.(4).

For each ONU,

$C_{Voice} = B_i * S_i^{Voice}$

$C_{Video} = B_i * S_i^{Video}$

$C_{Data} = B_i * S_i^{Data}$

$B_{C2\_Data} = C_{Data}$

$B_{C1\_Data\_Video} = C_{Data} + C_{Video}$

$B_{C0\_Data\_Video\_Voice} = C_{Data} + C_{Video} + C_{Voice}$ (1)

If $R_i^{Data} < C_{Data}$ then

$B_i^{Data} = R_i^{Data}$ else

$B_i^{Data} = C^{Data}$ (2)

If $R_i^{Video} < C_{Video}$ then

$B_i^{Video} = R_i^{Video}$ else

If $R_i^{Video} < B_{C1\_Data\_Video} - B_i^{Data}$ then

$B_i^{Video} = R_i^{Video}$ else

$B_i^{Video} = B_{C1\_Data\_Video} - B_i^{Data}$ (3)

If $R_i^{Voice} < C_{Voice}$ then

$B_i^{Voice} = R_i^{Voice}$ else if

$R_i^{Voice} < B_{C0\_Data\_Video\_Voice} - B_i^{Data} - B_i^{Video}$ then

$B_i^{Voice} = R_i^{Voice}$ else

$B_i^{Voice} = B_{C0\_Data\_Voice\_Video} - B_i^{Data} - B_i^{Voice}$ (4)

Where the thresholds for each class of service is given by S_i^{Voice}, S_i^{Video}, S_i^{Data} based on the agreed SLA, the aggregated bandwidth for each traffic class is given by C_{Voice}, C_{Video}, $C_{Data.}$ R_i^{Voice}, R_i^{Video} , R_i^{Data} are the requests and B_i^{Voice}, B_i^{Video}, B_i^{Data} are the allocated bandwidths in each traffic class.

VI. PERFORMANCE EVALUATION

In this section, Min's scheduling Algorithm, Russian Doll Model(RDM) Algorithm, Modified Russian Doll Model (MRDM1) Algorithm and User Prioritized Constraint Free (UPCF) Algorithms proposed earlier are compared with , the second variant of MRDM which is MRDM2 using the Discrete Event Simulator that supports differentiated classes of services and the results are presented in the following section. The parameters like Average delay, Average Queue size and the carried load are compared and illustrated.

The developed DES in C++ is hierarchical and has 3 Queues per ONU, each for Voice, Video and Data. Each queue receives a different type of traffic and can buffer up to 10MB. The REPORT message from the ONU to OLT contains the request from all the three queues of an ONU in one message. The standard allows us to send up to four grants in the same GATE message. This is utilized and each GATE message can carry the grant for the three queues of an ONU in one GATE message itself. GATE message from OLT contains the Start time and length of bytes that can be transmitted by ONU from each queue. As the algorithm requires lightly loaded and heavily loaded ONUs, the simulator also varies the load between the ONUs and maintains the target load of the system at the desired level. The performances are analyzed considering three different traffic scenarios and are shown in Table I.

Table I. Scenarios considered for simulation

Scenario	Voice Traffic	VideoTraffic	Data Traffic
1	20%	20%	60%
2	20%	60%	20%
3	60%	20%	20%

Packets generated follow Constant Bit Rate (CBR) for Voice, Pareto distribution for video and data class of packets. PON of distance up to 20 Km with 16 ONU is considered with a maximum slot size as 15500 bytes. The DES is also made to generate per queue statistics for analysis purpose.

Average Delay is the sum total of time the packet spends in the queue and the time it takes to reach the OLT from ONU. The time spent in the queue depends on how quickly the packets can be sent by the ONU which in turn depends on the allocated bandwidth. Lesser the delay, greater is the efficiency of the algorithm.

In the first scenario, the traffic is in the ratio, 20%: 20%:60%, i.e. it is a data-intensive load. UPCF provides a higher voice delay in this scenario since the voice proportion in the overall traffic is lower hence there is minimal bandwidth allocation for voice as shown in Figure 2 and this queues up packets at higher loads and causes greater delay. For both RDM and MRDM2, we see that delay is minimal at low loads, increases gradually as the load increases. The reason that delay doesn't continue to rise at very high loads can be attributed to the input queue size limit and the packet dropping that happens therein as shown in Figure 3. In MRDM1, where the voice allocation happens first as in RDM, at mid and high loads, the delay is greater when compared to RDM and MRDM2. The reason is that the unused voice bandwidth is allocated to video and data. More Data traffic is allocated and hence the carried load increases as shown in Figure 6, but that ultimately results in more delay for the voice packets. It is also found that the average voice delay of MRDM2 is much lower than other algorithms, including RDM. This is because, MRDM2 is a voice favoring algorithm and directs any extra bandwidth to it.

We also see from Figure 3 that the number of voice packets dropped starts to increase at a much lower load for UPCF, Min, RDM and MRDM1 than MRDM2 as lesser voice bandwidth gets allocated at these loads. The video load is also similar to voice and the same conclusions apply to video delay as shown in Figure 4. For data as shown in Figure 5, we find that UPCF and MRDM1 are superior in this case because of larger bandwidths being assigned to data. Considering that data is a best effort, and voice delay is the most important metric, we can conclude that, for data-intensive loads, MRDM2 is better suited.

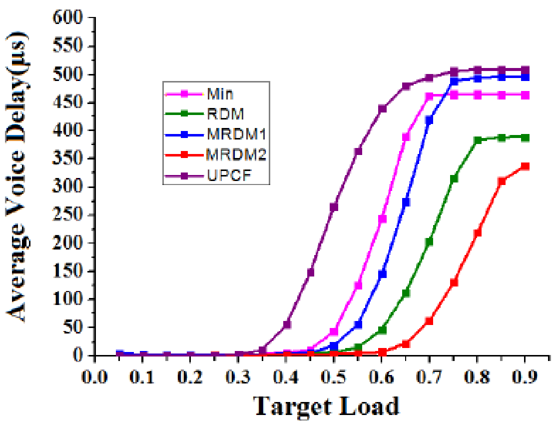

Figure.2 Average Voice delay in Scenario1 (20%, 20%, 60%)

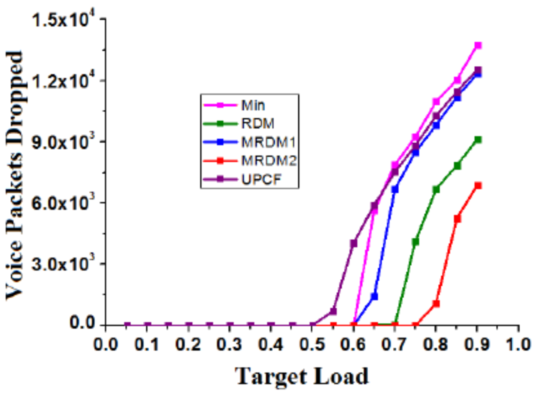

Figure. 3 Voice packets dropped in Scenario1

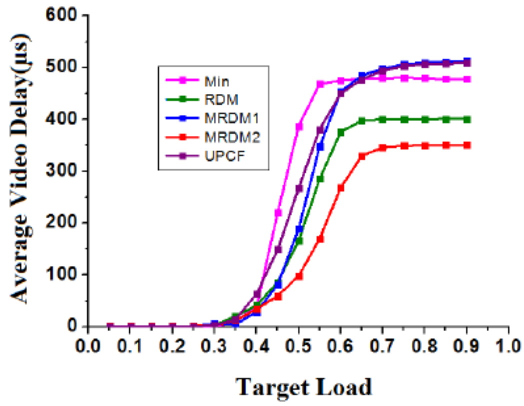

Figure. 4 Average Video Delay in Scenario1

The bandwidth utilization for all the algorithms is shown in Figure 6. Here we see that min DBA fares much poorer than UPCF/RDM/MRDM2 at higher loads. In Min's algorithm, Voice is allocated first as in RDM. But the unused voice or video bandwidth is not allocated to any other type of traffic. Hence, as shown in Figure 6, the carried load is less at lower loads, increases with increase in load and becomes a constant at higher loads. Bandwidth utilization increases with load for UPCF/RDM/MRDM2/MRDM1 which is expected. At mid loads, UPCF is seen to be marginally better than RDM/MRDM2 since available bandwidth to an ONU is better distributed amongst its various queues, whereas in MRDM2, the excess bandwidth from data to be used by voice and video may not fully get utilized because of low video and voice traffic. In MRDM1 as discussed before, as voice allocation is performed first and because of the sliding threshold, the excess from the voice bandwidth is allocated to video and the data traffic, the utilization is higher at all loads. And in the case of RDM, though voice allocation happens first as in MRDM1, since the unused bandwidth from voice is allocated to both video and data based on SLAs, it provides lower utilization at mid loads as compared to MRDM1. Also at higher loads, the unused voice bandwidth itself will be negligible. Hence no advantage is seen here. Hence we can conclude that considering the average delay for the delay sensitive traffic and the bandwidth utilization factor, MRDM2 fares better when compared to other algorithms in this scenario.

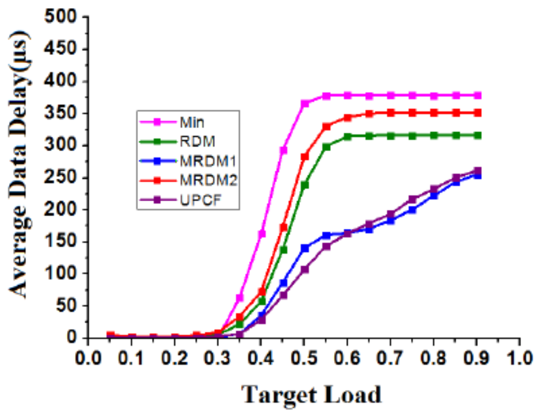

Figure. 5 Average data delay in Scenario1

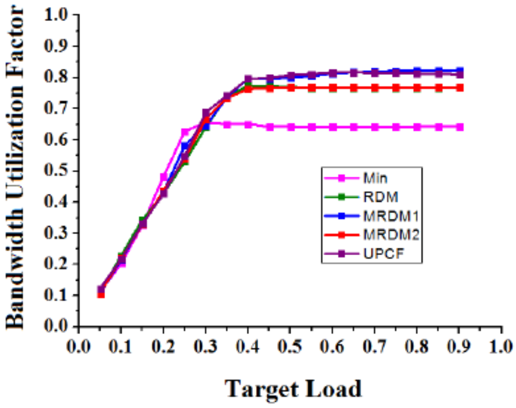

Figure. 6 Bandwidth Utilization Factor in Scenario1

In scenario 2, the traffic is in the ratio, 20%: 60%:20%, i.e. it is a video intensive load. We find in this scenario that the average voice delay of MRDM1 is much lower than other algorithms as shown in Figure 7. For MRDM1, we see that delay is minimal at low loads, increases gradually as the load increases. Here, the unused voice traffic is used up by video in entirety and since the video traffic is high in this scenario, additional bandwidth is not provided to data. As a result, the average voice delay is reduced for MRDM1. UPCF provides a higher voice delay in this scenario since the voice proportion in the overall traffic is lower hence there is minimal bandwidth allocation for voice as in scenario1. The Voice delay in MRDM2 is slightly on the higher side when compared to MRDM1. This is because, in MRDM2, the unused bandwidth from data is available to video in entirety. This brings down the video delay. As the video traffic is higher, unused traffic from video will not be available to voice at higher loads. This increases the voice delay at higher loads.

UPCF allocates more bandwidth to video, as this being the video sensitive traffic as in Figure 8. MRDM 2 and MRDM1 provides the next best lower average video delay as the bandwidth unused by voice and data respectively is being utilized here. However, the average delay for video is high in the case of Min and RDM.

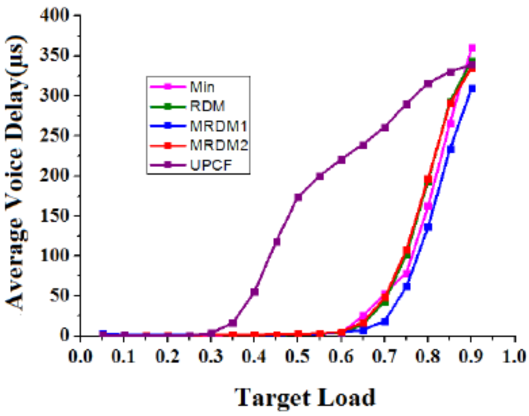

Figure. 7 Average Voice delay in Scenario2

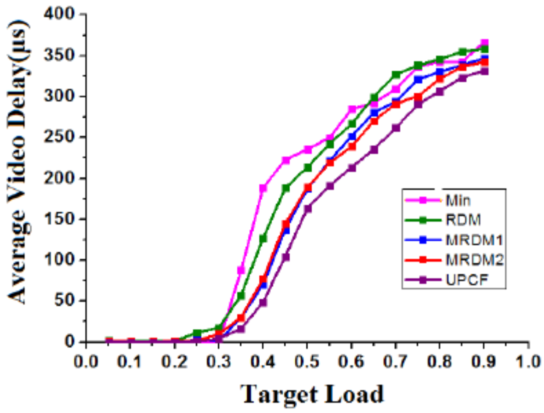

Figure. 8 Average Video Delay in Scenario2

Considering that data is a best effort, and voice delays are the more important metric, we can conclude that, for Video intensive loads, MRDM1 is better suited in terms of the average delay for Voice and for Video packets. In the bandwidth utilization for all the algorithms, as shown in Figure 9, we see that RDM/Min fares much poorer than other algorithms at higher loads. Bandwidth utilization increases with load for other algorithms which is expected. At mid loads and higher loads, UPCF/MRDM1 is seen to be marginally better than other algorithms. MRDM2 also has almost the same utilization factor as that of MRDM1 but considering the average delay for the delay sensitive traffic and the bandwidth utilization factor, MRDM1 is found to be more suitable when compared to other algorithms in this scenario.

In scenario 3, the traffic is in the ratio, 60%: 20%:20%, i.e. it is a voice intensive load. We find that as the traffic is voice intensive, UPCF provides the lowest voice delay in this scenario since the voice proportion in the overall traffic is higher and hence more bandwidth is allocated for voice as in Figure 10. UPCF is followed by MRDM2 with lower average delay for Voice. All other algorithms provide a higher average delay for voice. The Voice delay in MRDM2 is slightly on the higher side when compared to UPCF at mid loads. This is because, the advantage of MRDM2 lies in utilizing unused data and video bandwidth towards voice traffic but at high loads even if data and video traffic are comparatively at lower proportion, still they do not contribute any significant unused bandwidth that can be exploited for voice.

Min/MRDM1 and RDM have higher delays when compared to UPCF and MRDM2. In these algorithms, the bandwidth allocated for voice is limited by a certain threshold. At Mid and higher loads, though the proportion of voice is high, voice traffic do not get any additional bandwidth. But as video and data traffic also increases more of those packets are also transmitted which increases the delay for voice traffic transmission.

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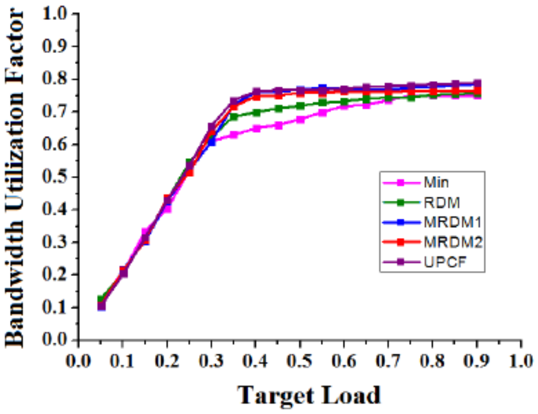

Figure. 9 Bandwidth Utilization Factor in Scenario2

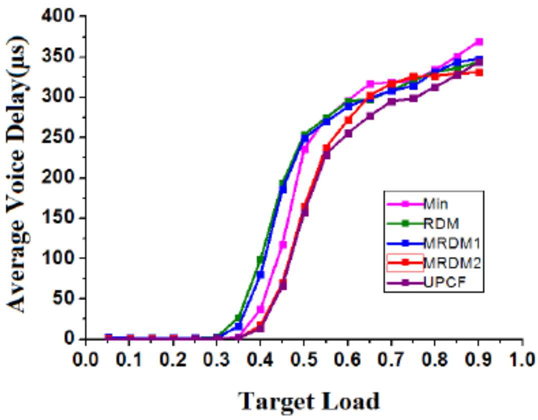

Figure. 10 Average Voice delay in Scenario3

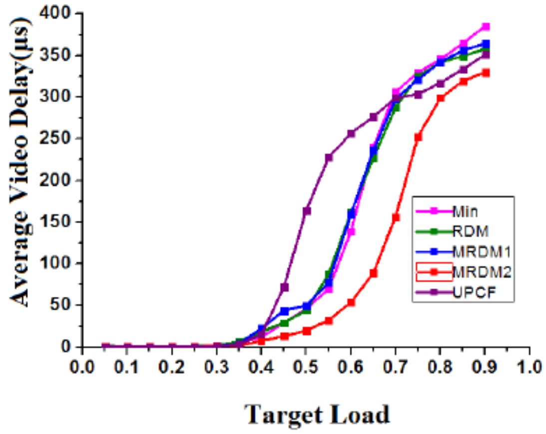

Figure. 11 Average Video Delay in Scenario3

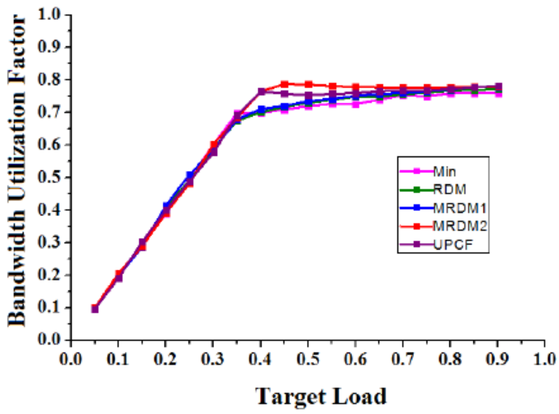

Figure. 12 Bandwidth utilization in scenario3

Video delay reduces for MRDM2 as the unused bandwidth from data is utilized for video as shown in Figure 11. Hence MRDM2 allocates more bandwidth to video. However, the average delay for video is high in the case of other algorithms. The un-utilized bandwidth from voice available to video is negligible and hence average delay for video is more.

Bandwidth utilization for all the algorithms is shown in Figure. 12. Here we see that RDM fares much poorer than other algorithms at mid and higher loads. Bandwidth utilization increases with load for UPCF/RDM/MRDM2 which is expected. At mid loads and higher loads, MRDM2 is seen to be marginally better than UPCF, as the excess bandwidth robbed from data and video traffic is utilized for voice at higher loads. In other algorithms, the utilization is slightly on the lower end since voice allocation is done first here and the algorithms limits on the maximum bandwidth available for voice. Hence carried load is less. Hence we can conclude that considering the average delay for the delay sensitive traffic and the bandwidth utilization factor, MRDM 2 fares better when compared to other algorithms in this scenario.

VII. CONCLUSION AND FUTURE WORK

This paper specifies and uses a hierarchical Discrete Event Simulator that can be used to compare the algorithms developed for dynamic bandwidth allocation in EPON. The DES can also be used to evaluate many such hierarchical algorithms in future. It can also be extended to algorithms of 10GE PON. The research work also compares the existing and proposed algorithms under three scenarios where the network is voice-centric, video-centric or data-centric. It is observed that for the data-centric and voice-centric network the proposed MRDM2 algorithm is favorable. Also for the video-centric network, MRDM1 proposed earlier is favorable. The network can be made to be an adaptive network to utilize any of the MRDM algorithms based on the demand from the user.

REFERENCES

1. G. Kramer, Ethernet Passive Optical Networks: McGraw-Hill, March 2005
2. A. Banerjee, Y. Park, F. Clarke, H. Song, S. Yang, G. Kramer, K. Kim, and B. Mukherjee, "Wavelength-Division Multiplexed Passive Optical Network (WDM-PON) Technologies for Broadband Access: A Review [Invited]", OSA Journal of Optical Networking, Vol. 4, No. 11, pp. 737-758, Nov 2005.
3. Eugene Dai. IEEE plenary meeting, http://www.ieee802.org/3/ad_hoc/ngepon/public/15mar/ngepon_0315_dai_01.pdf (March 2015).

4. IEEE Standard for Information technology-- Local and metropolitan area networks-- Specific requirements-- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment 1: Physical Layer Specifications and Management Parameters for 10 Gb/s Passive Optical Networks IEEE Std 802.3av-2009 (Amendment to IEEE Std 802.3-2008), 2009
5. F. Effenberger, D. Cleary, O. Haran, G. Kramer, R. D. Li, M. Oron, and T. Pfeiffer, "An Introduction to PON technologies", IEEE Communications Magazine, Vol. 45, No. 3, pp. S17-S25, Mar 2007.
6. F. Effenberger, H. Mukai, S. Park, and T. Pfeiffer," Next-Generation PON-Part II: Candidate Systems for Next-Generation PON", IEEE Communications Magazine, Vol. 47, No. 11, pp. 50-57, Nov 2009.
7. Ahmad R. Dhaini, Chadi M. Assi, Martin Maier, and Abdallah Shami," Dynamic Wavelength and Bandwidth Allocation in Hybrid TDM/WDM EPON Networks", Journal of Lightwave Technology, Vol. 25, No. 1, pp. 277-286, January 2007
8. Michael P.Mc Garry," Ethernet Passive Optical network architectures and Dynamic Bandwidth Allocation Algorithms", IEEE Communications Surveys & Tutorials, Vol.10, No. 3, pp.46-60, July 2008.
9. Kramer G et.al "Interleaved polling with adaptive cycle time (IPACT): a dynamic bandwidth distribution scheme in an optical access network", Photonic Network Communications, pp. 89–107, 2002.
10. Y. Zhu, M. Ma," IPACT with grant estimation (IPACT-GE) scheme for Ethernet passive optical networks", IEEE/OSA Journal of Lightwave Technology, Vol. 26, No.14, pp. 2055-2063, 2008.
11. H. Naser, H. Mouftah," A joint-ONU interval-based dynamic scheduling algorithm for Ethernet passive optical networks", IEEE/ACM Transactions on Networking, Vol. 14, No.4, pp.889-899, 2006.
12. A. Shami, X. Bai, C. Assi, N. Ghani, "Jitter performance in Ethernet passive optical networks", IEEE/OSA Journal of Lightwave Technology, Vol.23, No.4, pp. 1745-1753, 2005.
13. C.M. Assi, Y. Ye, S. Dixit, M.A. Ali," Dynamic bandwidth allocation for quality-of-service over Ethernet PONs", IEEE Journal on Selected Areas in Communications, Vol.21, No.9, pp.1467-1477, 2003.
14. Li Min et al, "New dynamic bandwidth allocation algorithm for Ethernet PON", The Eighth International Conference on Electronic Measurement and Instruments, IEEE, pp.3-224-3-227, 2007.
15. S.K. Sadon, N.M. Din, M.H. Al-Mansoori, N.A. Radzi, I.S. Mustafa, M.Yaacob, M.S.A. Majid, "Dynamic hierarchical bandwidth allocation using Russian Doll Model in EPON", Elsevier Computers and Electrical Engineering, pp.1480-1489, 2012
16. N.Subhashini, Dr.A.Brintha Therese, "Modified Russian Doll Model for efficient Dynamic Bandwidth Allocation in EPON", International Journal of Applied Engineering Research, Vol. 9, No.19, pp. 5611-5622, 2014
17. N.Subhashini, Dr.A.Brintha Therese, "User Prioritized Constraint Free Dynamic Bandwidth Allocation Algorithm for EPON Networks", Indian Journal of Science and Technology, Vol. 8, No.33, December 2015
18. Bai X, Shami A, Assi C., "On the fairness of dynamic bandwidth allocation schemes in Ethernet passive optical networks", Computer Communications, Vol. 29, No. 11, pp.2123–35, July 2006.
19. Lai, J.-R., Chen, W.-P.," High utilization dynamic bandwidth allocation algorithm based on sorting report messages with additive-polling thresholds in EPONs", Optical Switching and Networking, Vol. 18, Part1, pp.81-85, November 2015
20. Lai, J.-R., Huang, H.-Y., Chen, W.-P., Wang, L.K., Cho, M.-Y., "Design and Analytical Analysis of a Novel DBA Algorithm with Dual-Polling Tables in EPON", Mathematical Problems in Engineering, Vol.2015, 2015.
21. Mercian, A., McGarry, M.P., Reisslein, M., " Impact of report message scheduling (RMS) in 1G/10G EPON and GPON", Optical Switching and Networking, Vol.12, pp. 1-13, April 2014.
22. Bontozoglou, A., Yang, K., Guild, K., "A midterm DBA algorithm for quality of service on aggregation layer EPON networks", Photonic Network Communications, Vol. 25, No.2, pp. 120-134, April 2013

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