PASSIVE OPTICAL NETWORK FOR SUPPORTING IOT

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Bandwidth Allocation For Multiservice Access On EPONs

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New Jersey Institute of Technology

IEEE Optical Communications , February 2005

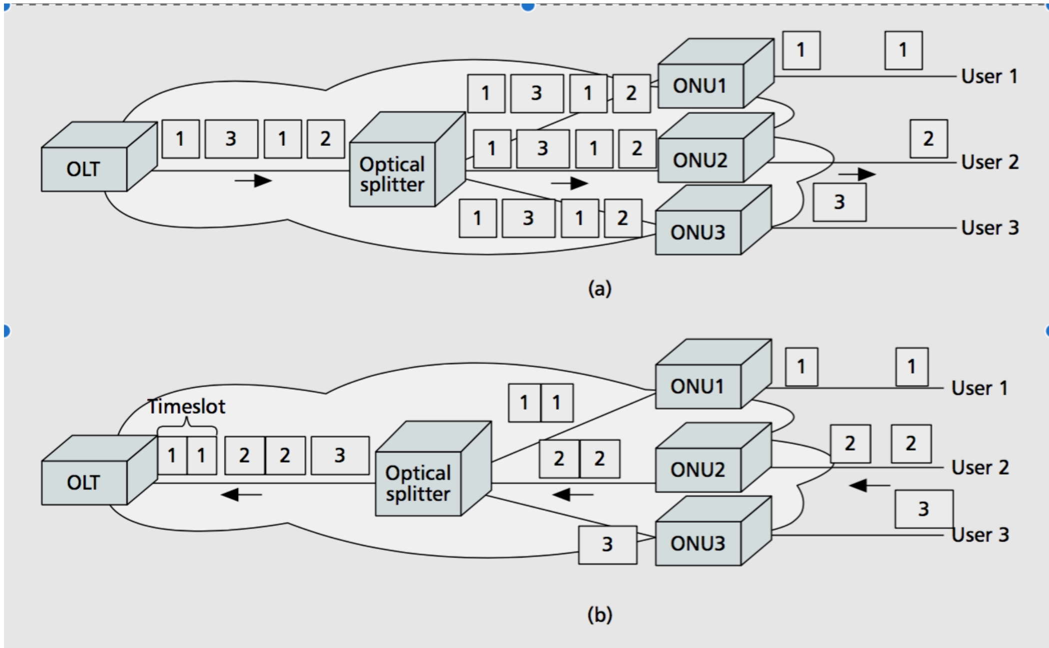
Overview

- Algorithm for dynamic bandwidth allocation with service differentiation
- Based on Multipoint control protocol (MPCP) and bursty traffic prediction techniques
- QoS metrics enhancement (average frame delay, average queue length and frame loss probability)
- Multiple service provision for single ONU using queuing,scheduling and class based bandwidth allocation

Motivation

- Minimize gap between capacity of backbone network and user requirement
- EPON : high speed , simple, inexpensive and scalable technology
- Ethernet does not support QoS directly
- Upstream shared channel
- Directional property of PON
- To maintain diverse QoS , bandwidth management is required

EPON



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Multipoint Control Protocol in EPON

- Frame based protocol
- 64 byte MAC control messages
- Facilitate efficient upstream data transmission
- Auto discovery : REGISTER_REQUEST, REGISTER and REGISTER_ACK messages
- REPORT/ GATE
- REPORT msg: timestamp & queue status of ONU
- GATE msg : timestamp, grant start time and grant length
- No packet fragmentation

Bandwidth Allocation Techniques

Fixed Bandwidth Allocation : grants each ONU a fixed time slot length

1. Ignorant of actual traffic arrival rate
2. Underutilization

Limited Bandwidth Allocation : a maximum time slot length Bmax is specified

1. Restrict aggressive competition for upstream bandwidth
2. Conservative approach

Bandwidth Allocation Techniques

Credit based Bandwidth Allocation : allocates credit for the wait time traffic between REPORT message and sending frames

1. $$B_{grant} = B_{queue} + C,$$

Where Bgrant= granted bandwidth, Bqueue = frames queued up in buffer, C = credit

2. Wait time frame transmitted within current slot

Excessive Bandwidth Allocation : Underexploited bandwidth of lightly loaded ONUs are redistributed among heavily loaded one. EBR: excessive bandwidth reallocation

Multi-services at an ONU

Priority Queuing : Categorizing traffic into different class.

1. High priority- expedited forwarding (EF)
2. Medium priority-assured forwarding(AF)
3. Low priority-Best effort (BE)
4. Higher priority replaces others in the buffer when full.

Priority Scheduling : strict priority scheduling serves buffered high priority frames first. Replaces in the buffer too.

1. Uncontrolled increasing delay of low priority frames
2. Unfair drop

Priority-based Scheduling : strict priority scheduling in one time interval.

Multi-services at an ONU

Class Based Bandwidth Allocation(D1) :

1. Fixed BW to EF traffic
2. Sum of the AF request <= residual BW (granted all)
3. Otherwise, BW divided equally
4. Leftover from EF,AF request -> BE
5. Long report collection time (waits for all ONU's)
6. Unfair to AF,BE request

Multi-services at an ONU

Class Based Bandwidth Allocation(D2) :

1. Estimates EF traffic in waiting time by previous cycle
2. Reported EF frame = buffered EF + estimation of EF
3. AF & BE is buffered frame
4. EBR is used
5. Lightly loaded queues receiving instantaneous grant
6. Heavily loaded queue deferred until arrival of all reports
7. Delay due to collection of all reports
8. Estimation of EF impaired due to changing waiting time

Dynamic Bandwidth Allocation with Multiple Services (DBAM)

1. REPORT/GATE mechanism + class based BW allocation
2. Priority queuing to overcome delay of D1
3. Priority based scheduling for buffer frame
4. Limited bandwidth allocation(SLA)
5. Class based traffic prediction of arriving traffic within wait time
6. OLT serves ONUs in a fixed round robin order

Dynamic Bandwidth Allocation with Multiple Services (DBAM)

1. Maximum Bandwidth parameter of each ONU_i ,

$$S_i = S_i^{EF} + S_i^{AF} + S_i^{BE}$$

2. OLT serves the ONUs alternatively

3. The interval of an ONU = time between sending REPORT msgs (ONU_1 t1-t6)

4.ONUs piggybacks REPORT msg at the end of its timeslot

5. t1-t4 = RTT between ONU_1 & OLT + REPORT processing delay

6. t2-t6 = waiting time of UNO_1

7. t6 – t8 due to REPORT msg at t2

Dynamic Bandwidth Allocation with Multiple Services (DBAM)

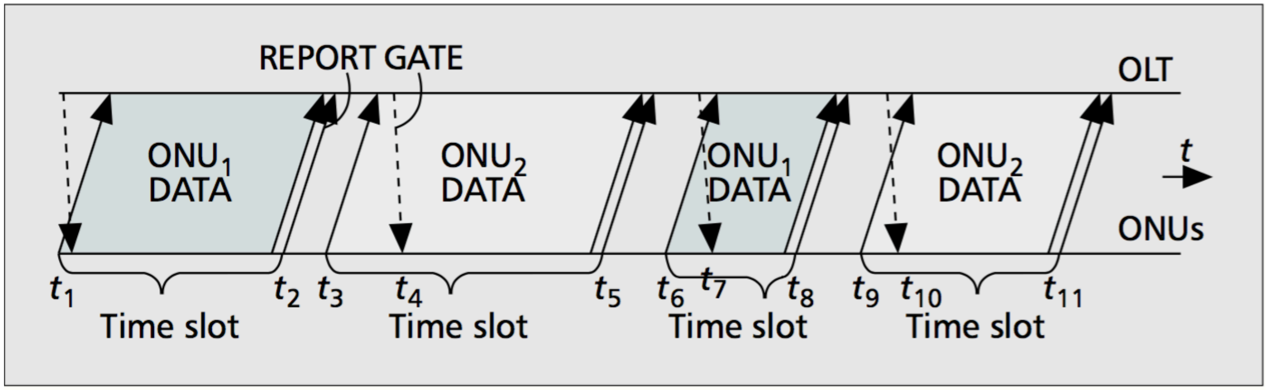


Fig 3. Upstream transmission in DBAM

Dynamic Bandwidth Allocation with Multiple Services (DBAM)

8. Requested Bandwidth for each class c

$$R_{i,n+1}^{c} = (1 + \propto) B_{i,n}^{c}, c \in \{EF, AF, BE\}$$

where $R_{i,n+1}^{c}$ = requested BW

$B_{i,n}^{c}$ =queued up class C traffic in buffer during interval n

$\propto$ = estimated credit

$$\propto = \frac{T_{i,n}^{w}}{T_{i,n}}$$

where $T_{i,n}^{w}$ =waiting time(frames arrival) of ONU in interval n

$T_{i,n}$ = length of interval n

Dynamic Bandwidth Allocation with Multiple Services (DBAM)

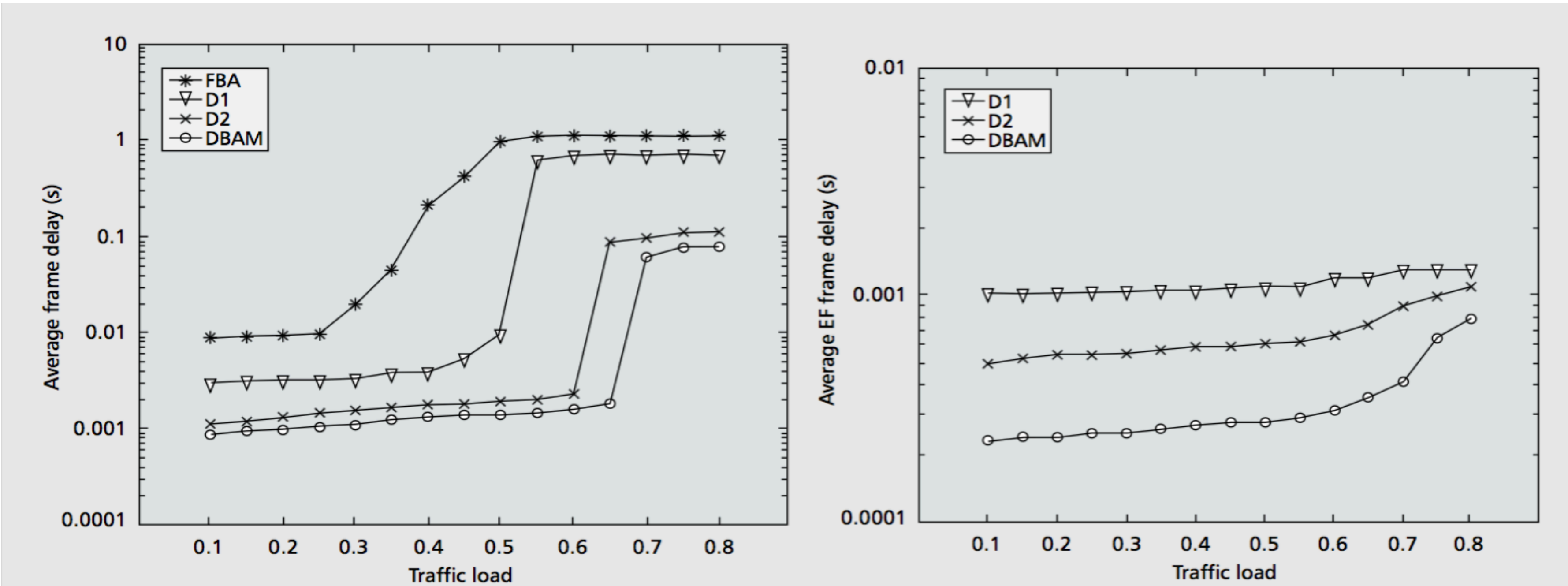
9. Granted Bandwidth for interval (n+1)

$$B_{i,n+1} = \min\{\sum_c R^c_{i,n+1}, S_i\}, c \in \{EF, AF, BE\}.$$

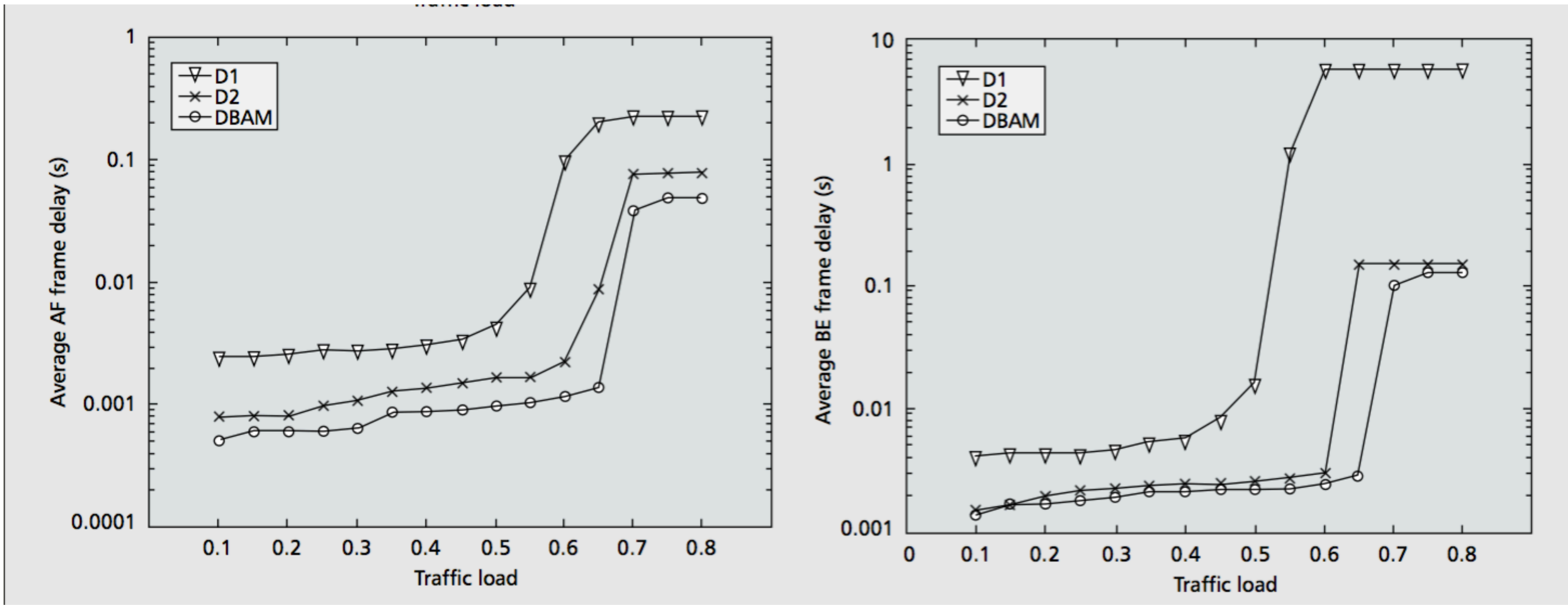
$$B^c_{i,n+1} = \min\{R^c_{i,n+1}, S^c_i\}, c \in \{EF, AF\},$$

$$B^{BE}_{i,n+1} = B_{i,n+1} - B^{BE}_{i,n+1} - B^{AF}_{i,n+1}.$$

Performance Evaluation of DBAM



Performance Evaluation of DBAM



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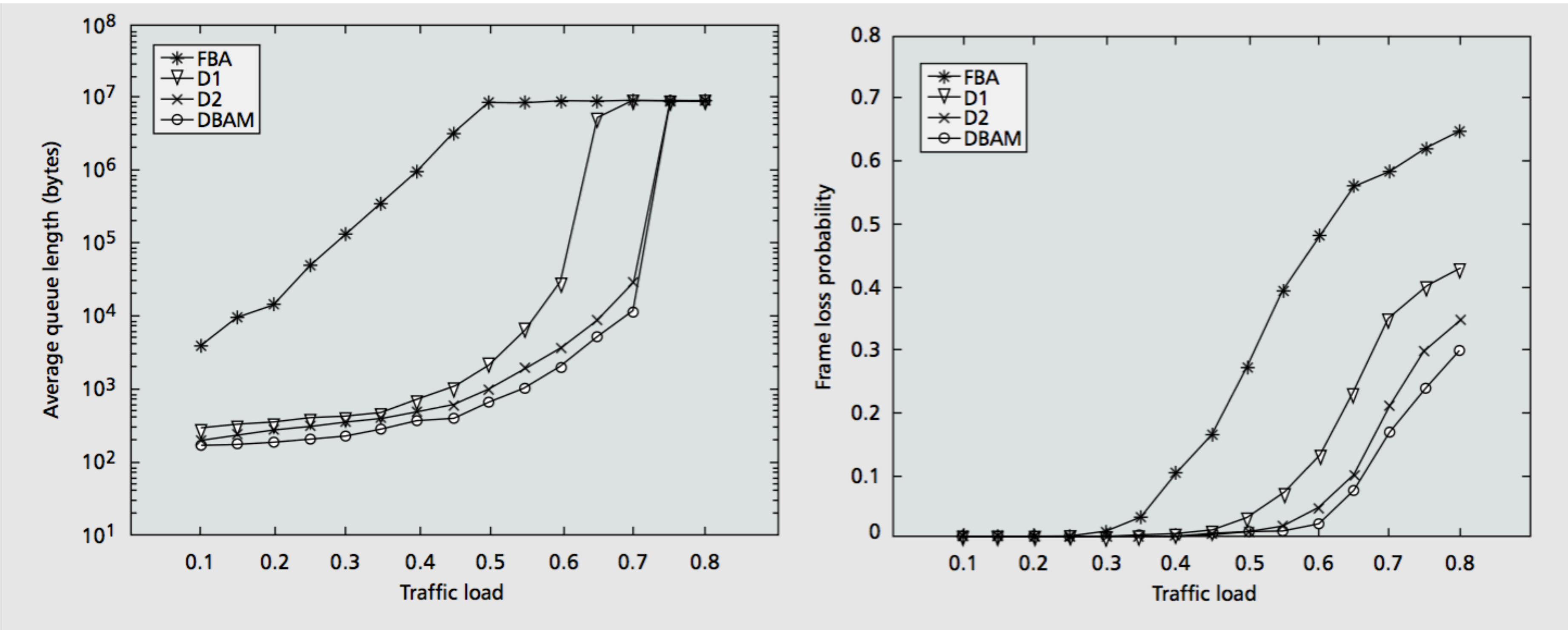
Performance Evaluation of DBAM



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Conclusion

IOT

Making IoT a reality depends on many things, including reliable, high bandwidth wireless communications. But for every wireless access point, you need a backhaul network to collect and funnel all that data. It's been suggested that passive optical networks (PONs) will play an important role in consumer networks, and you'll certainly hear more about that during OFC. But we'll also need more optical fiber with active switches and routers, and an expansion of the core network architecture. Like an iceberg which only shows a small fraction of its bulk above the surface, the IoT will drive a massive build-out of supporting optical infrastructure.

http://www.ofcconference.org/en-us/home/about/ofc-blog/2014/august-2014/getting-ready-for-the-internet-of-things/


Thank You