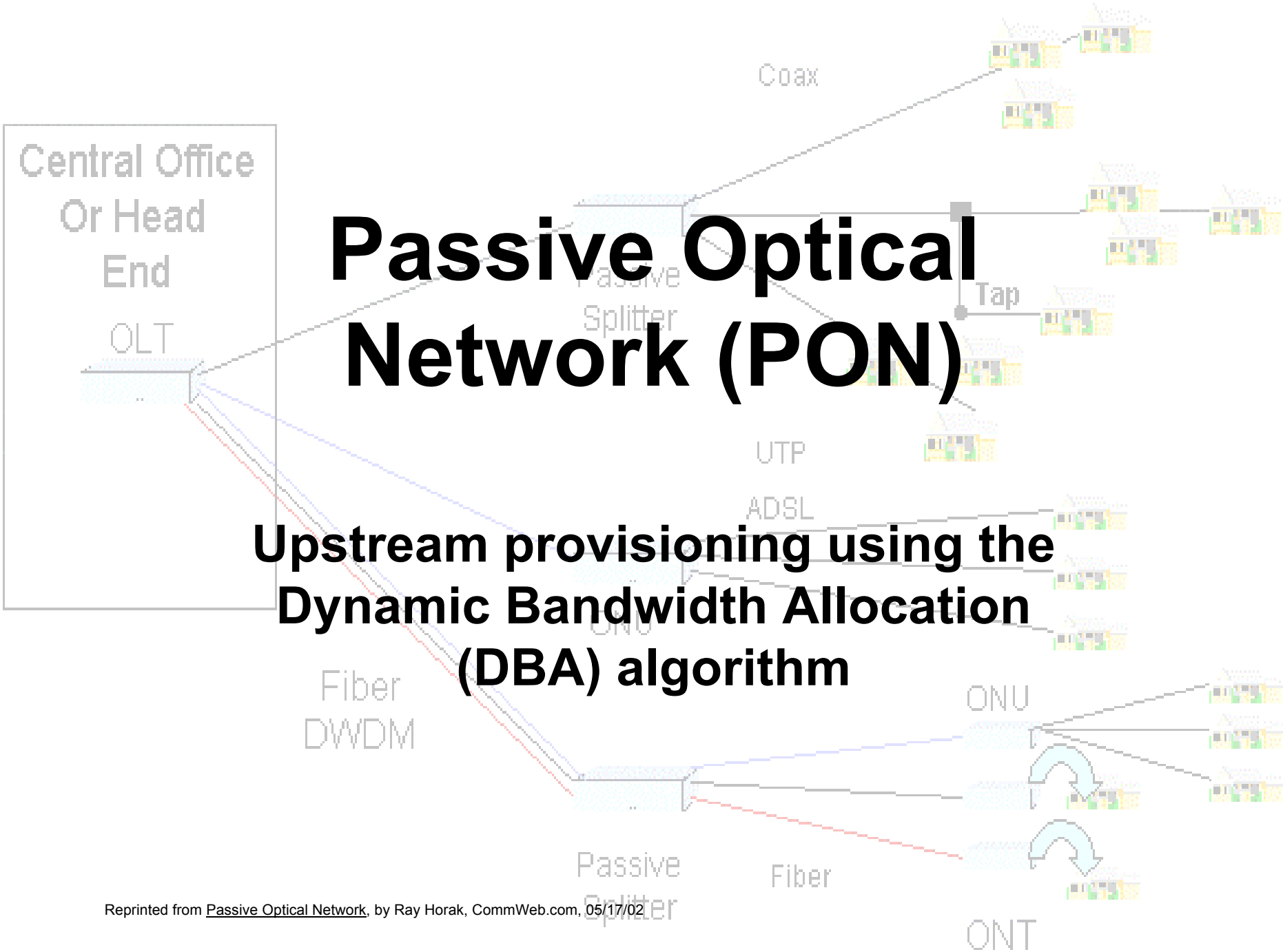


Passive Optical Network (PON)

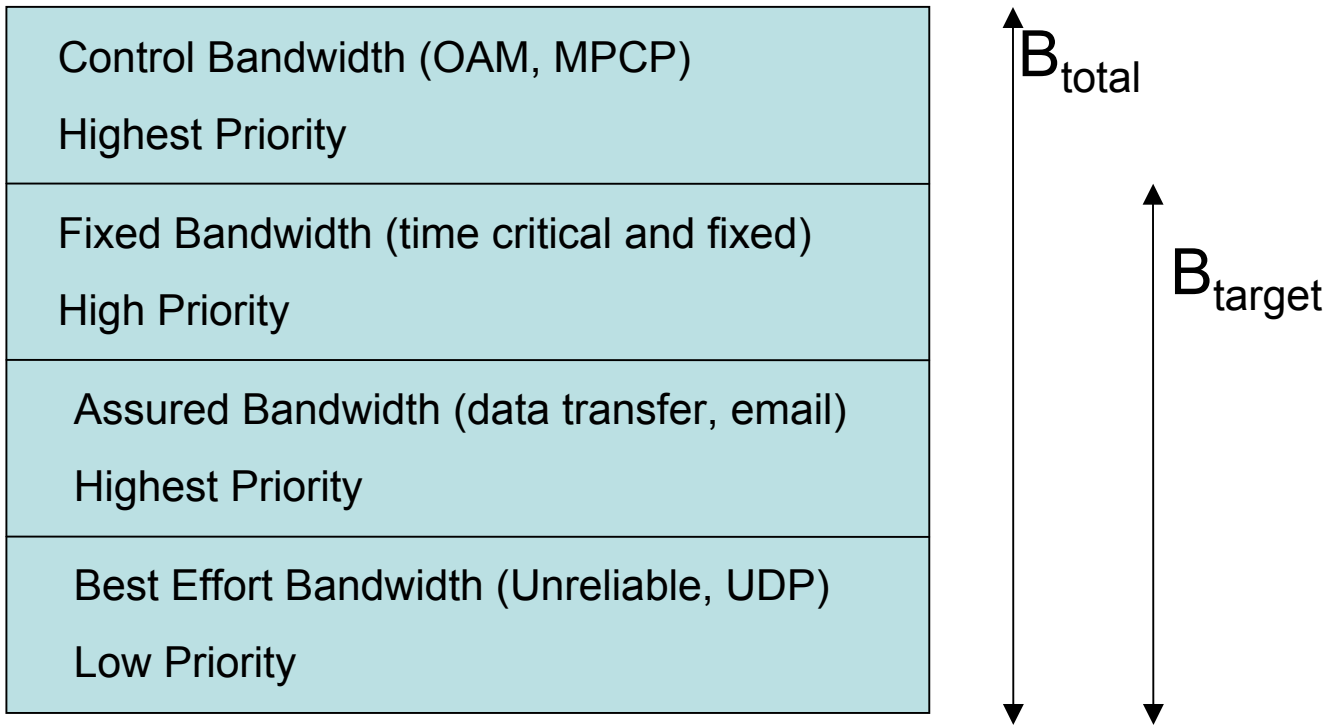
Upstream provisioning using the Dynamic Bandwidth Allocation (DBA) algorithm

Reprinted from Passive Optical Network, by Ray Horak, CommWeb.com, 05/17/02

In this student lecture we will cover:

- PON and need for upstream bandwidth allocation
- DBA algorithm for US bandwidth allocation
- MPCP to implement DBA control

DBA Model



PONs are a point to multi-point architecture

- DS traffic originates from single point (OLT)
- US traffic originates from multi-point (ONU)
- Finite downstream and upstream bandwidth
- Originally static multiplexing controlled US
- DBA algorithm double the traffic efficiency

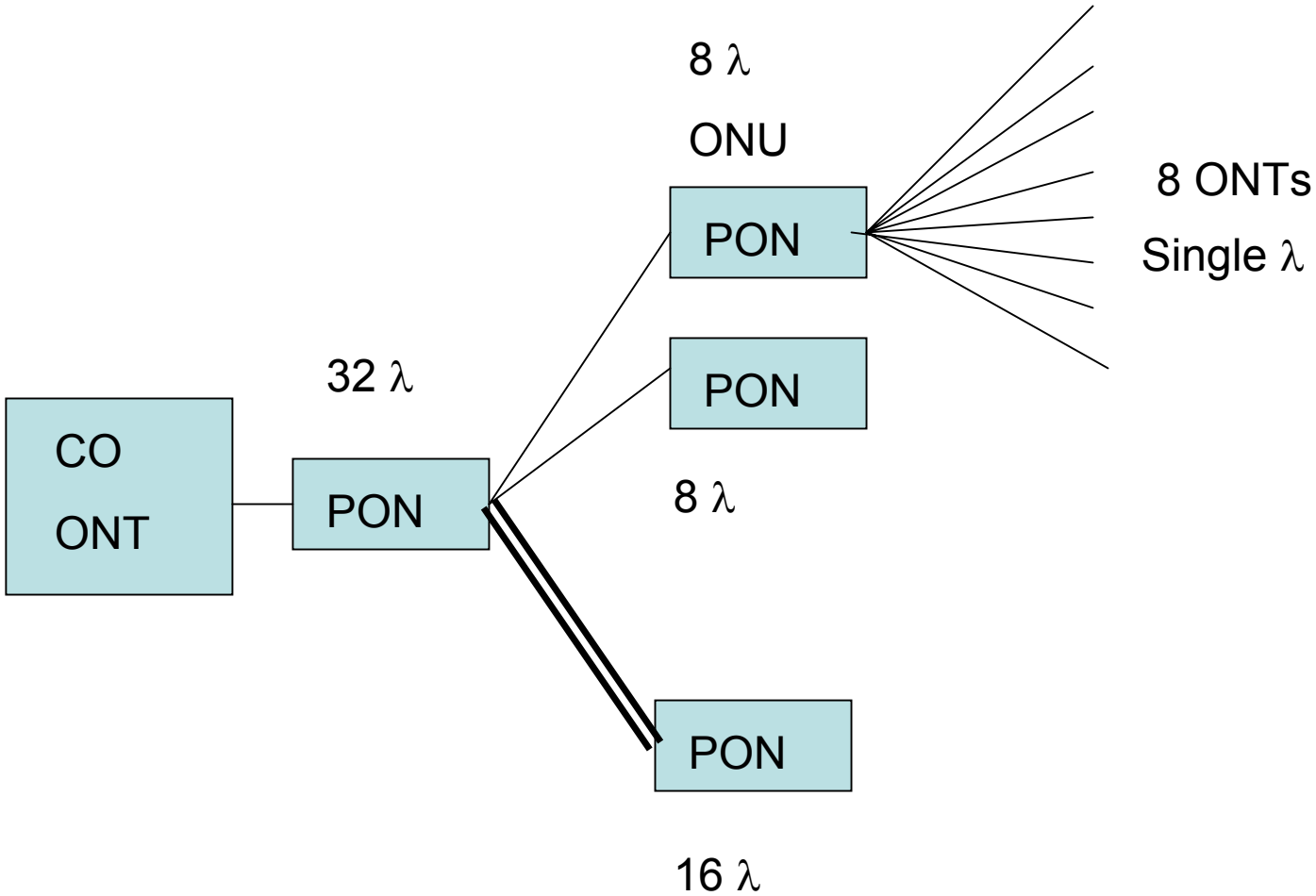
PON Components:
Optical Line Terminals (OLT), Optical Network Units (ONUs), passive splitters, and Optical Network Terminals (ONTs).

Time Division Multiplexed (TDM):
PONs use optical **power** splitters.

Wave Division Multiplexed (WDM):
PONs use optical **wavelength** splitters.

PONs uses small (about the size of a pack of chewing gum), relatively inexpensive optical splitters, placed near the ONT.

PON is usually refers to TDM technology, where BPON designates WDM technology.


8 λ
ONU
8 ONTs
Single λ
PON
PON
32 λ
CO
ONT
PON
8 λ
PON
16 λ

Current TDM APON implementations generally are asymmetric, running at speeds of 622 Mbps downstream and 155 Mbps upstream.

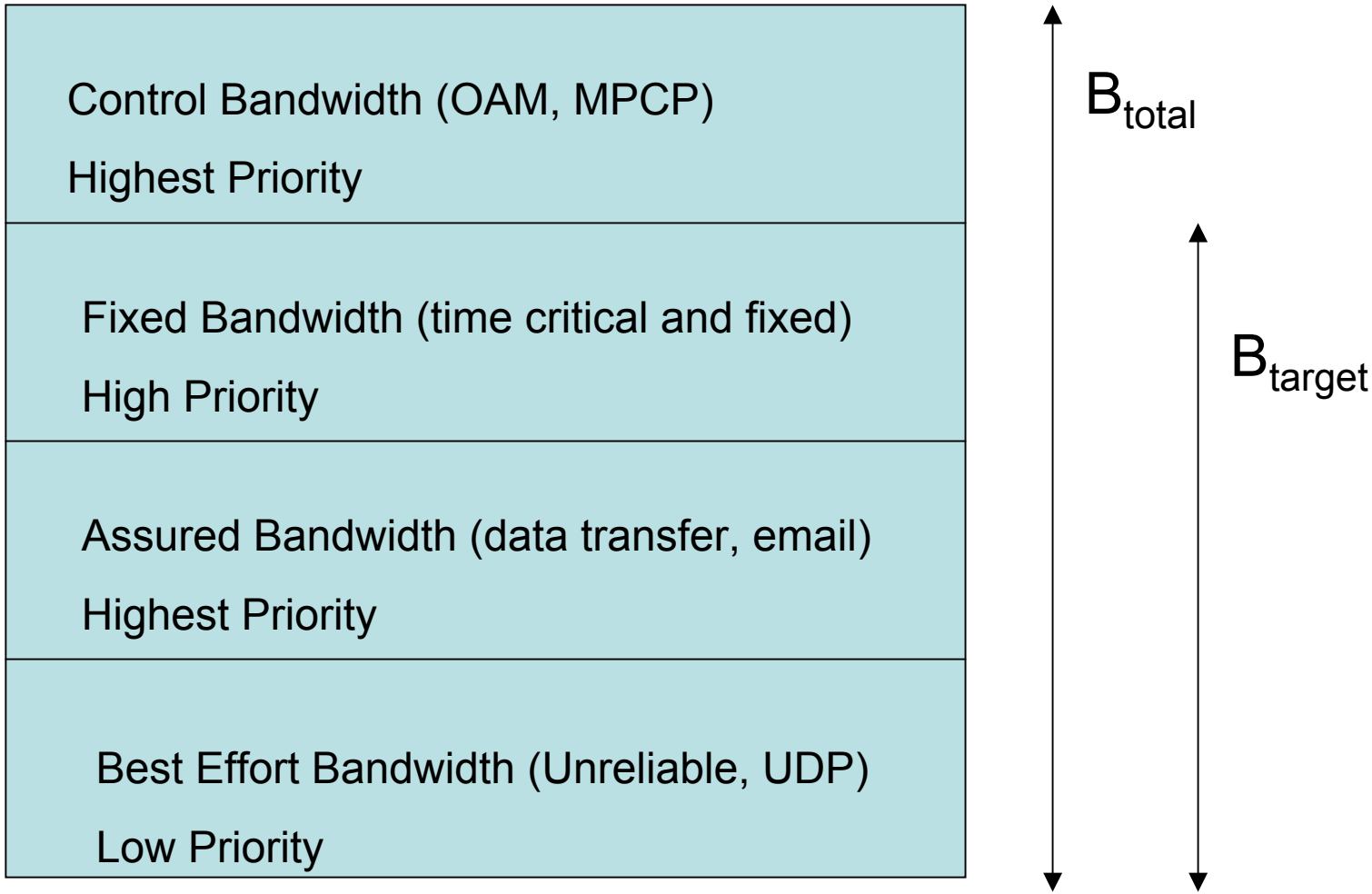
The upstream becomes a “bottle neck”.

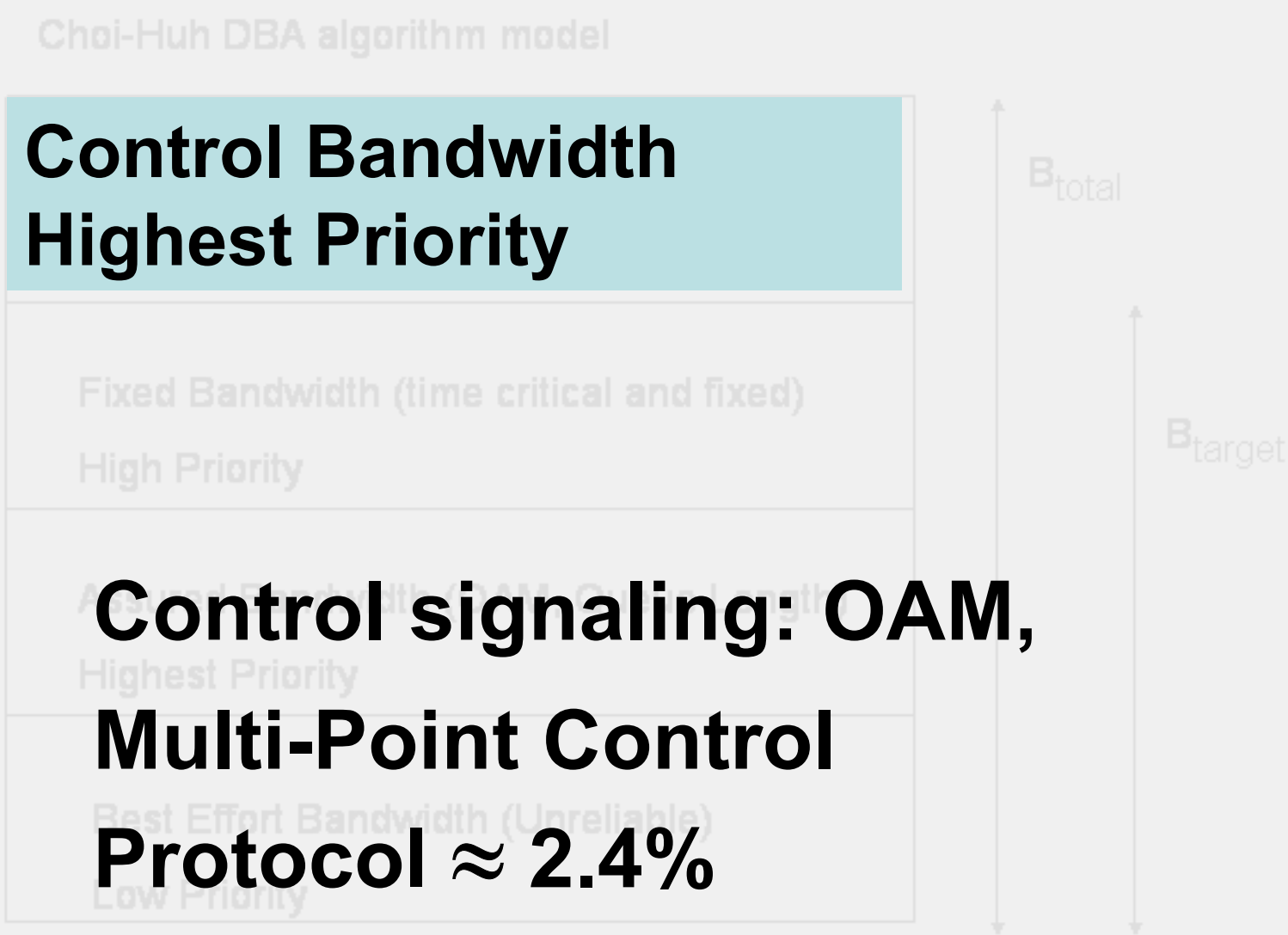
EPON is typically a symmetrical 1 Gbps

Issues in EPON systems using TDMA

- Allocation of one fixed timeslot for every ONU is inefficient
- Statistical multiplexing leads to variable polling cycle time
  - Jitter, Delay, and SLA
- Solution: Dynamic Bandwidth Allocation using multi-point control protocol

Choi-Huh DBA algorithm model





Control signaling: OAM, Multi-Point Control Protocol ≈ 2.4%

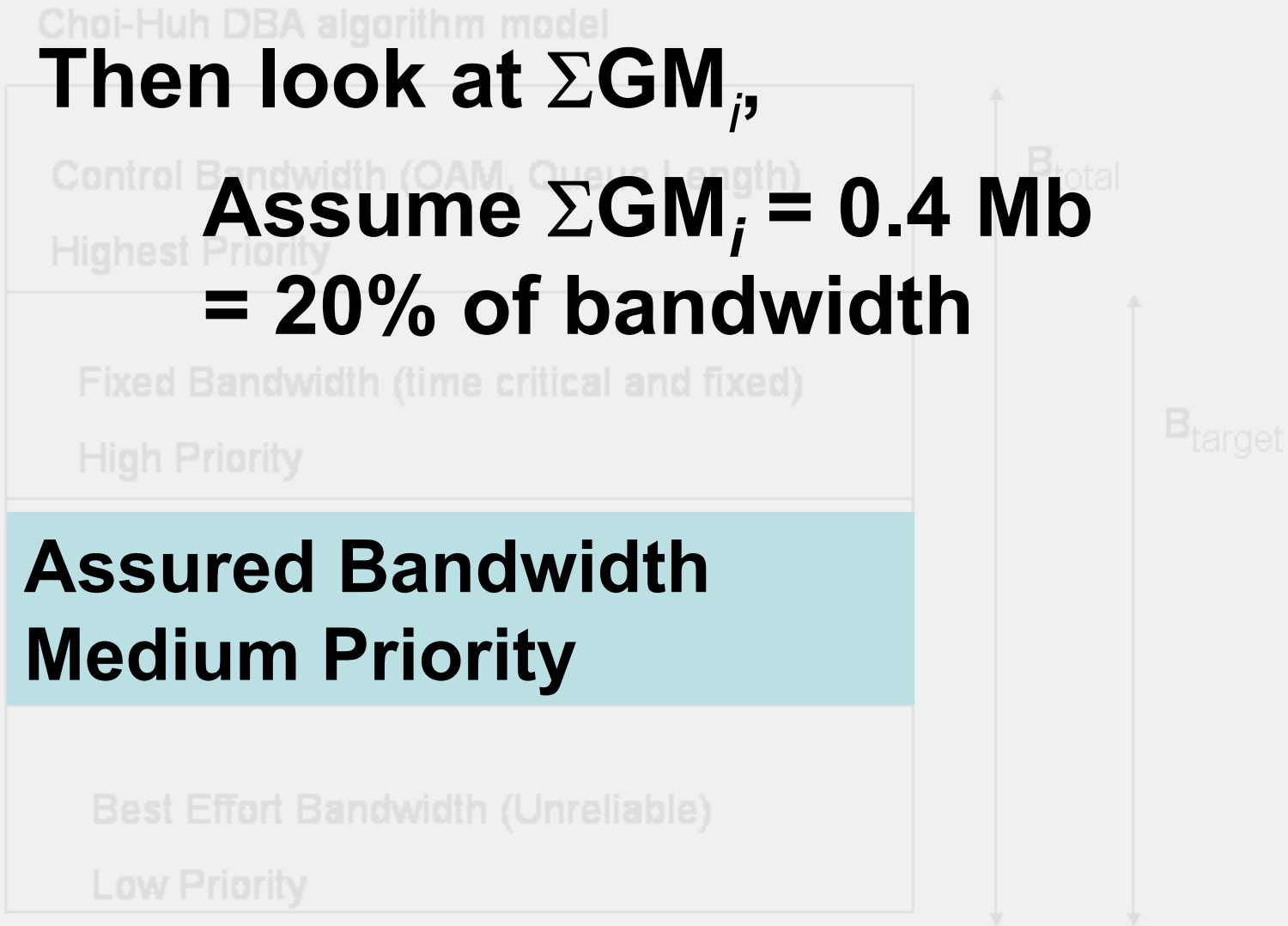
High Priority: $GH_i = BH_i$

Fixed Bandwidth
High Priority

First look at ΣGH_i,

ΣGH_i = 1.2 Mb

= 60% of bandwidth



Then look at ΣGM_i,

Assume ΣGM_i = 0.4 Mb
= 20% of bandwidth

Low Priority: $B_{best} = B_{target} - \Sigma (GH_i + GM_i)$

then $GL_i = (RL_i / \Sigma RL_i) * (B_{best})$

$GL_i = QL_i / T_{update}$

Best Effort Bandwidth
Low Priority

Control Bandwidth
High Priority: $GH_i = BH_i$ } Guaranteed

Med Priority: If $\Sigma RM_i \leq B_{target} - \Sigma GH_i$

then $GM_i = RM_i (QM_i / T_{update})$

else if $\Sigma RMi > B_{target} - \Sigma GHi$,

then $GMi = (RM_i / \Sigma RM_i) * (B_{target} - \Sigma GH_i)$

Low Priority: $B_{best\ effort} = B_{target} - \Sigma (GH_i + GM_i)$

then $GL_i = (RL_i / \Sigma RL_i) * (B_{best\ effort})$

$GL_i = QL_i / T_{update}$

Multi-Point Control Protocol (MPCP)

Specifies point-to-multi-point communication between PON OLT and ONTs.

MPCP is a MAC layer protocol. Supported by bridging elements.

Functions:

- Provide ONT/ONU timing synchronization
- Implements Auto Discovery
- Bandwidth/Timeslot assignments to ONTs

Active message exchange:

OLT Gate: DS S/D, Time stamps, ONT discovery, continuous ranging, and dynamic time slot.
Grant Levels: High, Med, and Low

ONU Report: US Queue level, length, and amount

Auto-Discovery:

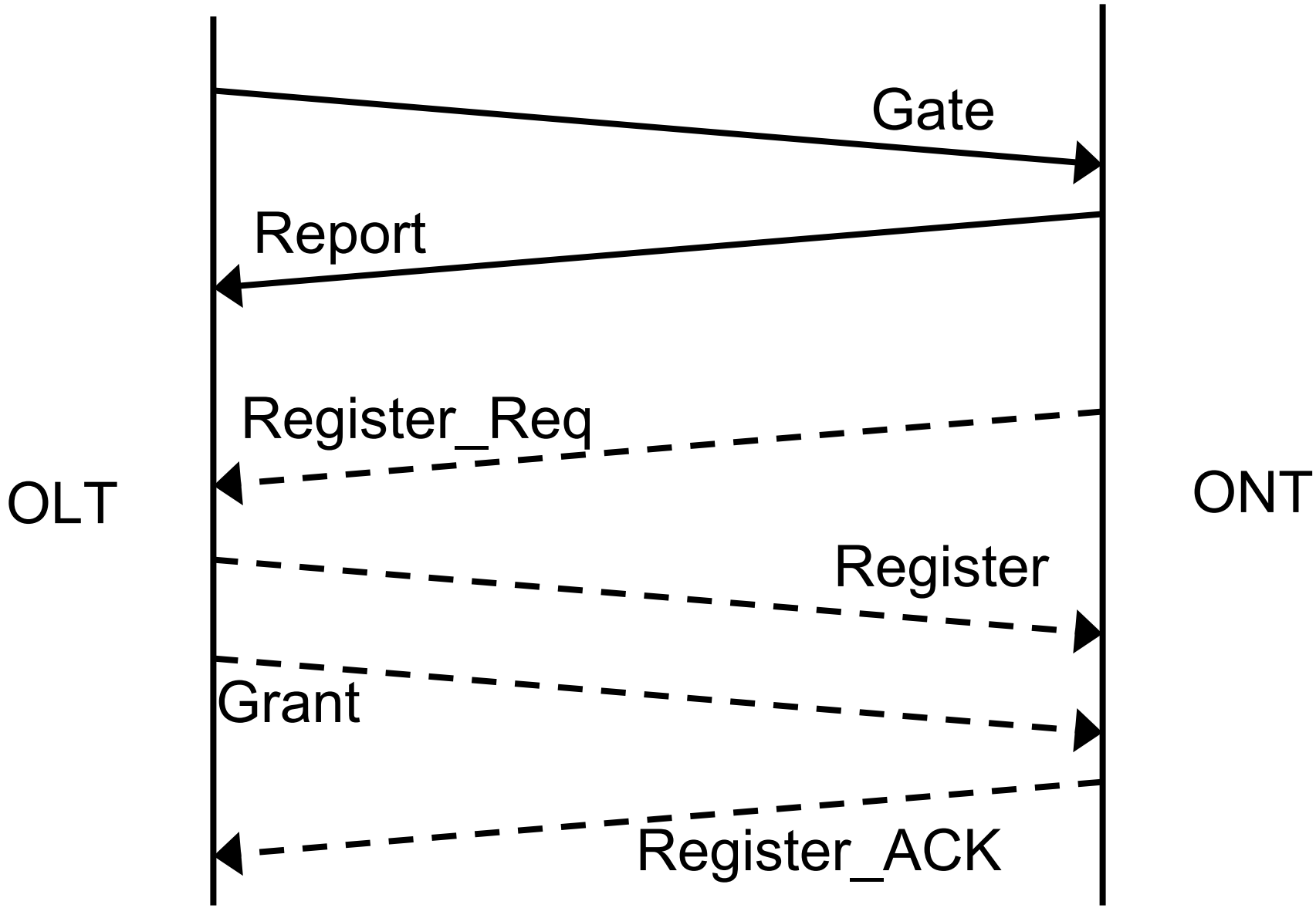
OLT Gate: Multi-cast, I am granting to ONU MAC address.

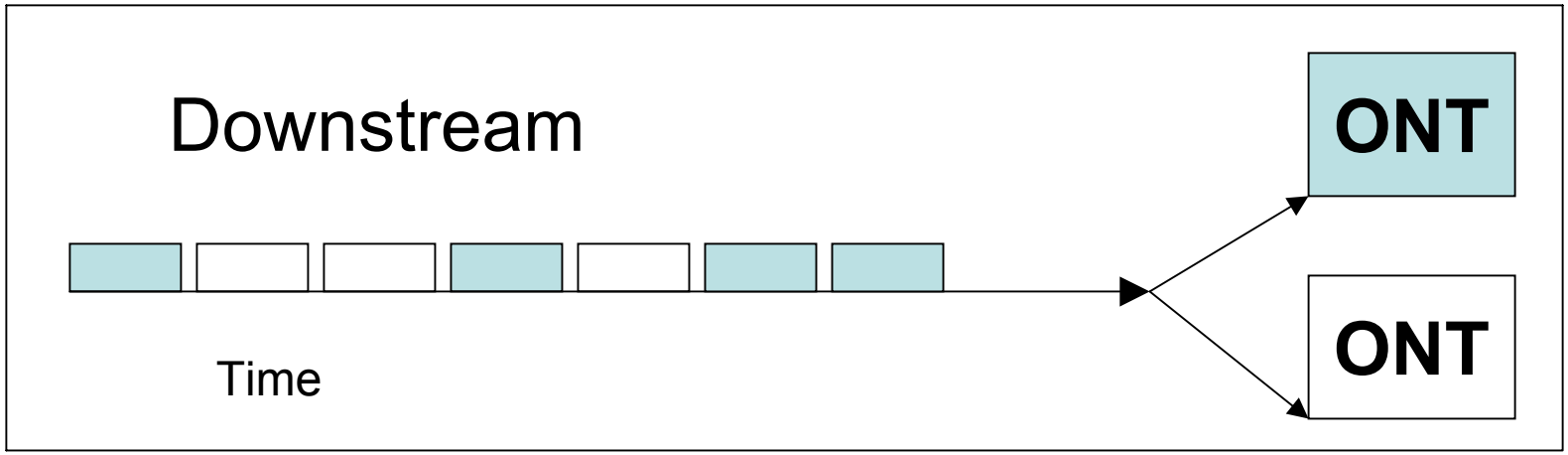
ONU Register_Request: I want time slots and here is who I am. Echo OLT.

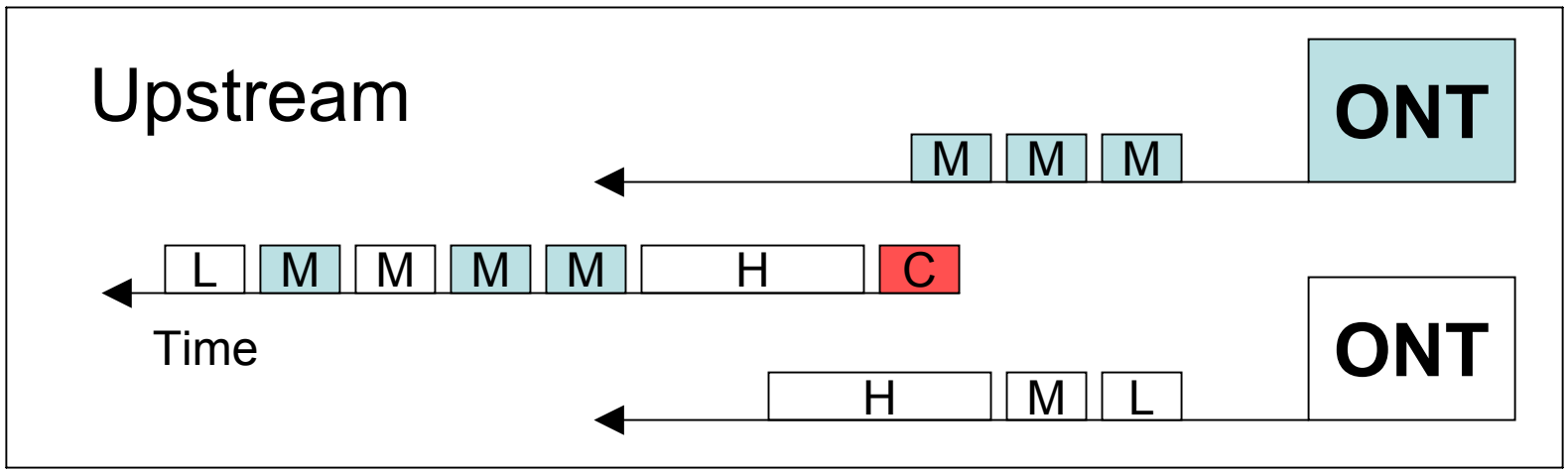
OLT Register: New ONU MAC address, Echo ONU

OLT Gate: New ONU MAC address, Grant

ONU Register_ACK: I got the message, Channel established


Gate
Report
Register_Req
OLT
ONT
Register
Grant
Register_ACK


Downstream
ONT
ONT
Time


Upstream
ONT
M
M
M
L
M
M
M
M
H
C
Time
ONT
H
M
L

Results of PONs using DBA with MCPL

- Implement QoS
  - Less delay for time critical applications
  - Less jitter
- One-tenth average transfer delay
- Double bandwidth utilization
- Added revenue due to “over subscription”

Conclusions

- Static Multiplexing is inefficient when many PON ONTs are not used
- DBA enables the QoS allocation to enable statistical multiplexing with jitter.
- DBA algorithm uses MPCP to query and grant transmission allocation to ONUs. MCPC is a standard MAC protocol.

Resources

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2. Gaglianello, Robert, “MPCP: Multi-Point Control Protocol for EPONs”, 802.3ah EPON Security Track meeting, September 2002, URL (http://www.ieee802.org/linksec/meetings/MeetingsMaterial/Sep02/Gaglianello_sec_1_0902.pdf.)
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4. Liu, Zheng-Yang, “Guaranteeing QoS in PON Designs”, CommsDesign.com, CMP Media LLC, October 3, 2002, URL (http://www.commsdesign.com/design_corner/OEG20021003S0012.)

5. Wang, W., Soto, W., Ly, A., Ivancovsky, D., Anderson, T., Rundquist, R., “DBA (Dynamic Bandwidth Allocation) Overview”, EFM Interim meeting, 10/10/2001, URL (http://grouper.ieee.org/groups/802/3/efm/public/sep01/wang_1_0901.pdf.)
6. Bemmel, Vincent, “MPCP and TDM Services”, IEEE 802.3ah EFM, St. Louis, MO, Mar. 12, 2002, URL (http://grouper.ieee.org/groups/802/3/efm/public/mar02/bemmel_1_0302.pdf.)
7. InStat MDR, “Installation Cost Key to Passive Optical Network Growth Opportunity”, Reed Elsevier, Inc., May 20, 2002, URL (http://www.instat.com/newmk.asp?ID=217.)
8. Horak, Ray, “Passive Optical Network (PON)”, CommWeb.com, CMP Media LLC, May 17, 2002, URL (www.commweb.com/techcenters/main/experts/3783/COM20020219S0005.)
9. Shumate, P. W., “Passive Optical Network (PON)”, IEEE LIOS, Piscataway, NJ, March 12,2003, URL (http://www.ileos.org/info/passive_optical_network.asp.)

Questions

1. What is the reason that the Dynamic Bandwidth Allocation algorithm being proposed for TDM PON upstream, instead of the TDM PON downstream?
2. How is QoS implemented in Dynamic Bandwidth Allocation algorithm?
3. How much bandwidth is available for “Best effort” for the following 32 ONT APON upstream (155 Mbps) application?

   Each report = 64 bytes every 2ms plus 1 us guard band per report,
   High Priority/report for all PONs = 120 kb,
   Med Priority/report for all PONs = 100 kb.