EFM P2MP Tutorial

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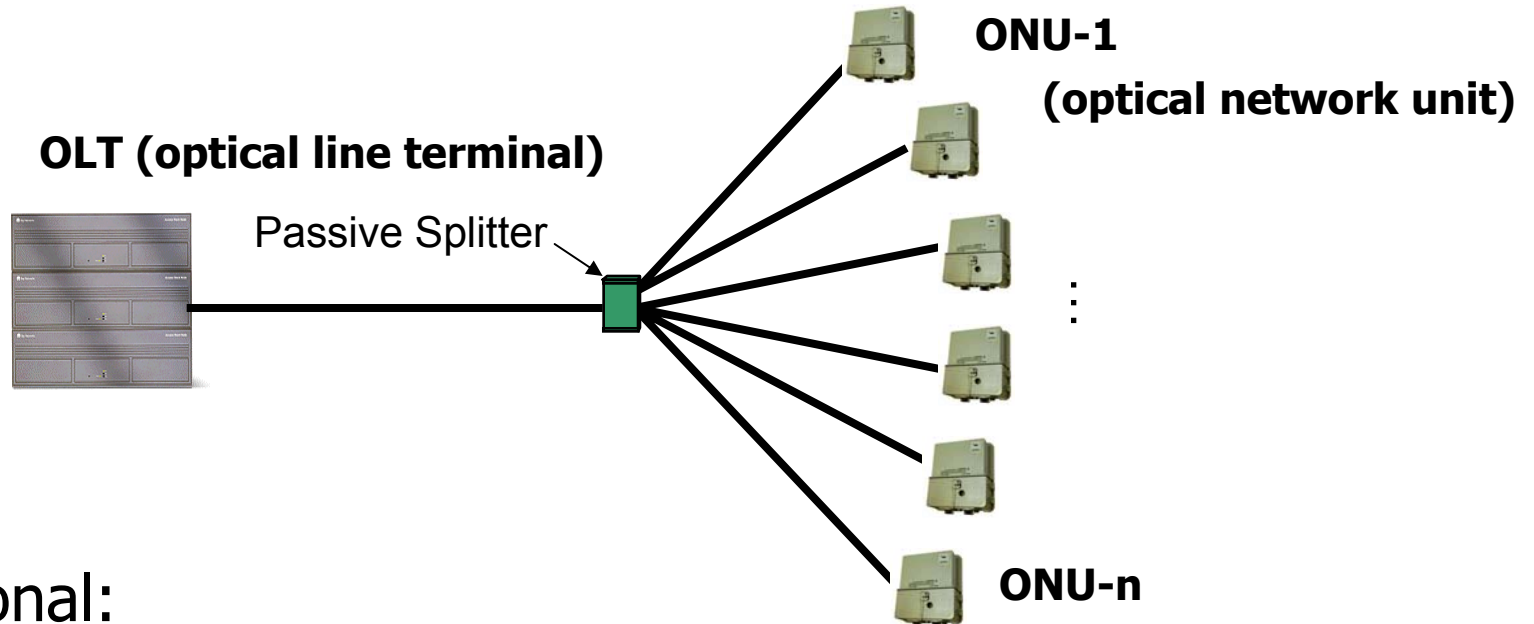
Agenda

- Shared fiber

- P2MP Layer model

- Link emulation

- Gating process

- Discovery process

- Timestamp model

- MPCP protocol elements

- Security threats

Sharing Fiber

OLT (optical line terminal)

Passive Splitter

ONU-1

**(optical network unit)**

:

ONU-n

- Rational:
  - Sharing fiber reduces deployment cost (material & labor)
  - Sharing equipment reduces operational and capital expenditure
  - Passive outside plant reduces operational and capital expenditure

Sharing the Upstream

- Upstream collisions avoided through coordination using MPCP (Multi-Point Control Protocol)
- Transmission by one ONU at a time
- Control message allows ONU to transmit
- Scheduling algorithm (out of scope):
  - Transmission order
  - Length of every burst

| ONU 1 | ONU 2 | ONU 3 | ONU 1 | ONU 3 |

time
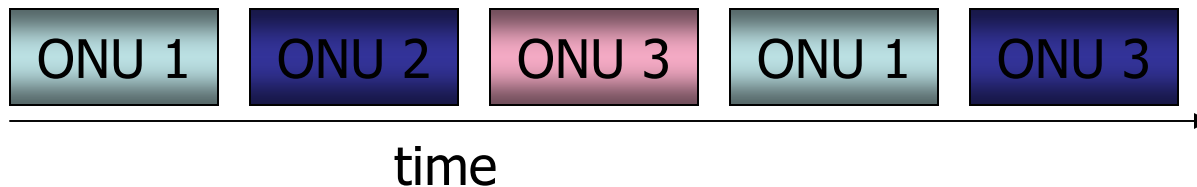
Sharing the Downstream
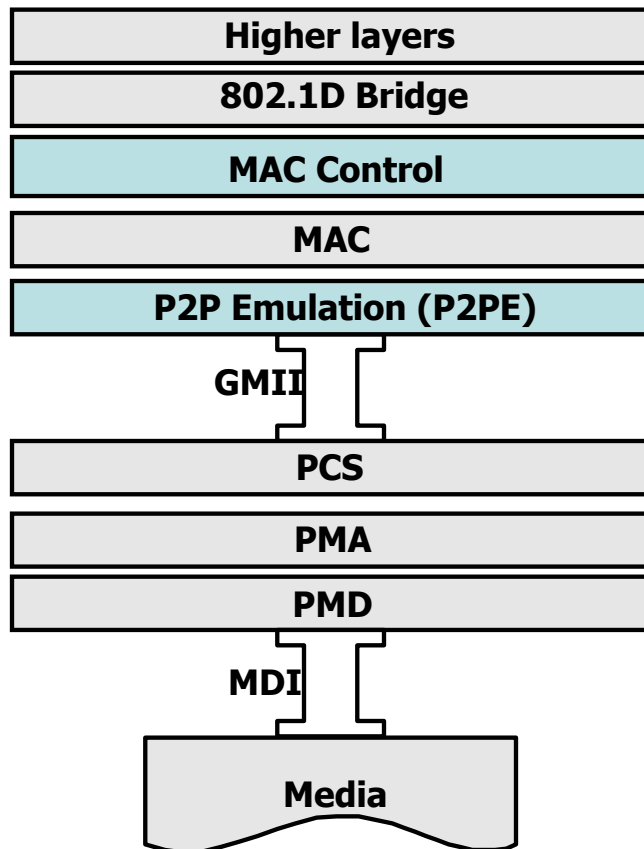
- Single transmitter, multiple recipients
- Broadcast of all traffic
- ONU filters traffic not intended for reception
- Aggregation of point-to-point tunnels and single-copy-broadcast channel

Eavesdropping Galore!

Layering Diagram

Below MAC
Switched Ethernet emulation

Higher layers
802.1D Bridge
MAC Control
MAC
P2P Emulation (P2PE)

GMII

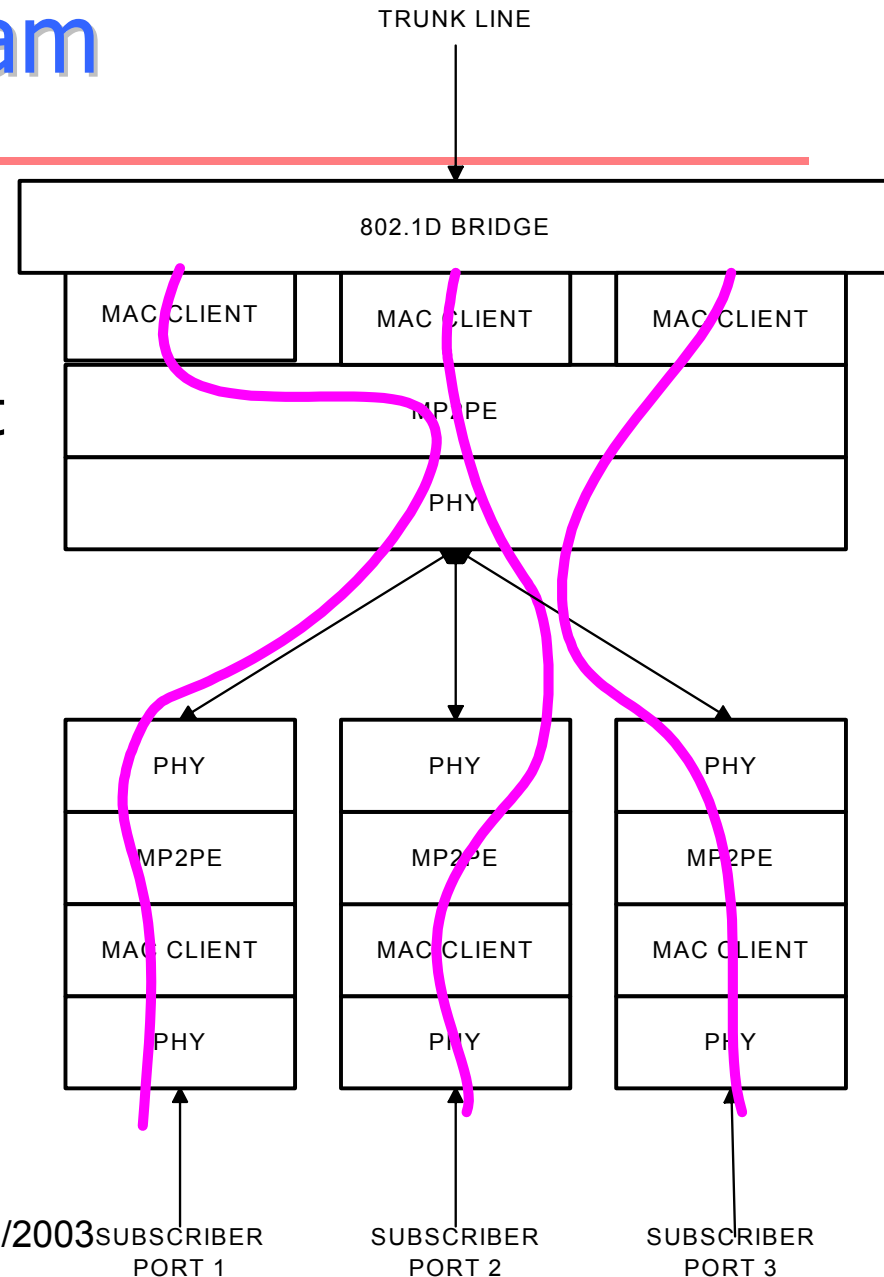| PCS |
|---|
| PMA |
| PMD |

MDI

Media

- Emulation layer creates private path to each ONU
- MAC Control is used for MPCP
  – Same as PAUSE

Network Layer Diagram

- Emulated point-to-point link created per ONU

- Bridge sees single MAC Client for every link pair

- Private paths mean no networking problems exist

Networking Isolation
Not Privacy

TRUNK LINE

| 802.1D BRIDGE |
| MAC CLIENT | MAC CLIENT | MAC CLIENT |
| MP2PE |
| PHY |

PHY	PHY	PHY
MP2PE	MP2PE	MP2PE
MAC CLIENT	MAC CLIENT	MAC CLIENT
PHY	PHY	PHY

SUBSCRIBER PORT 1

SUBSCRIBER PORT 2

SUBSCRIBER PORT 3

Link Emulation

7 OCTETS	PREAMBLE	
1 OCTET	SFD	
6 OCTETS	DESTINATION ADDRESS	
6 OCTETS	SOURCE ADDRESS	
2 OCTETS	LENGTH/TYPE	
46-1500 OCTETS	MAC CLIENT DATA	
	PAD	
4 OCTETS	FRAME CHECK SEQUENCE	
	EXTENSION	

SOP	3 OCTET
RESERVED	2 OCTETS
LOGICAL PHY ID	2 OCTETS
CRC	1 OCTET

- Tag prepended in preamble to identify Link
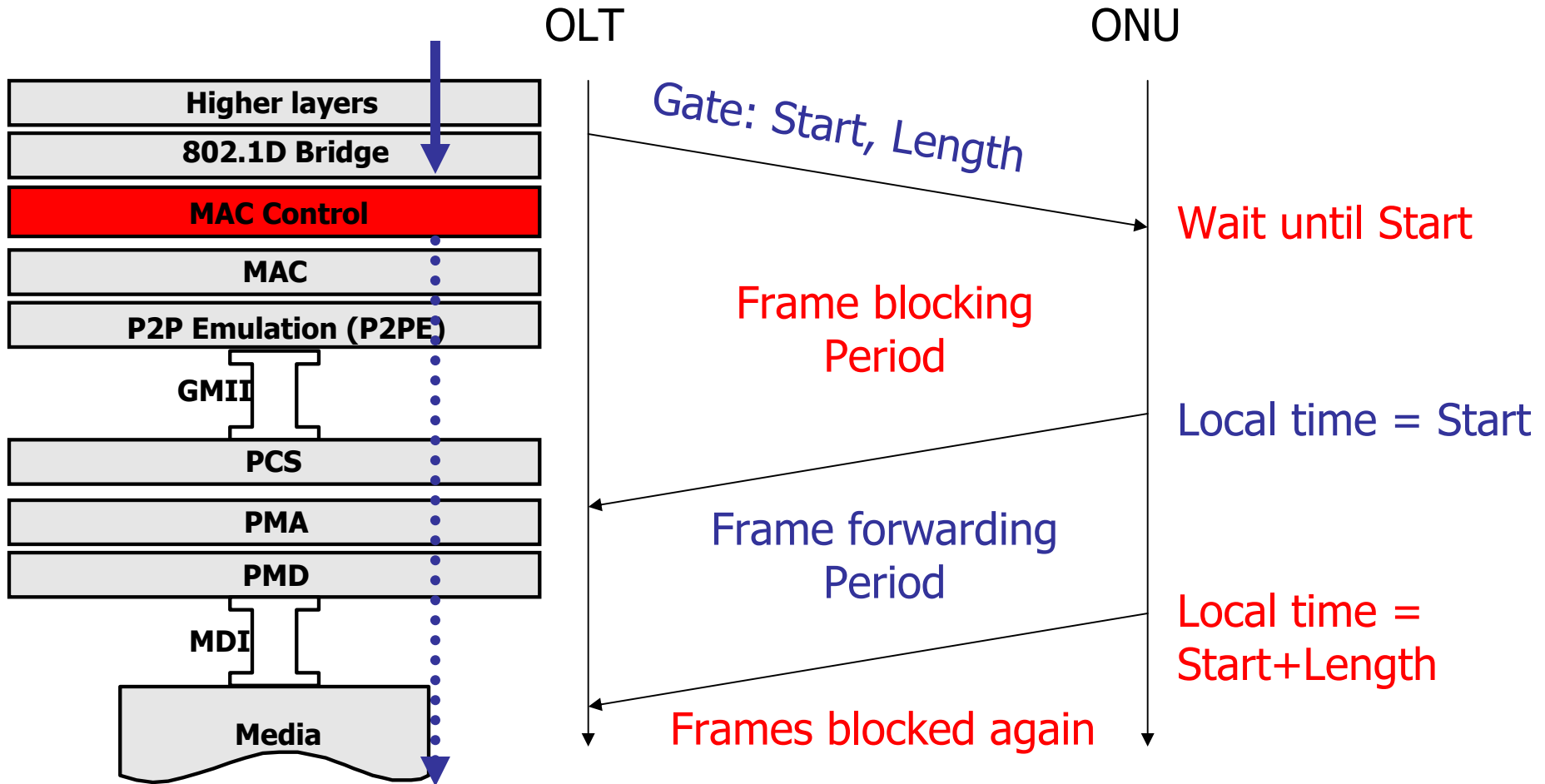- Stripped by receiver

P2MP Tutorial 3/10/2003

Tag Filtering Rules
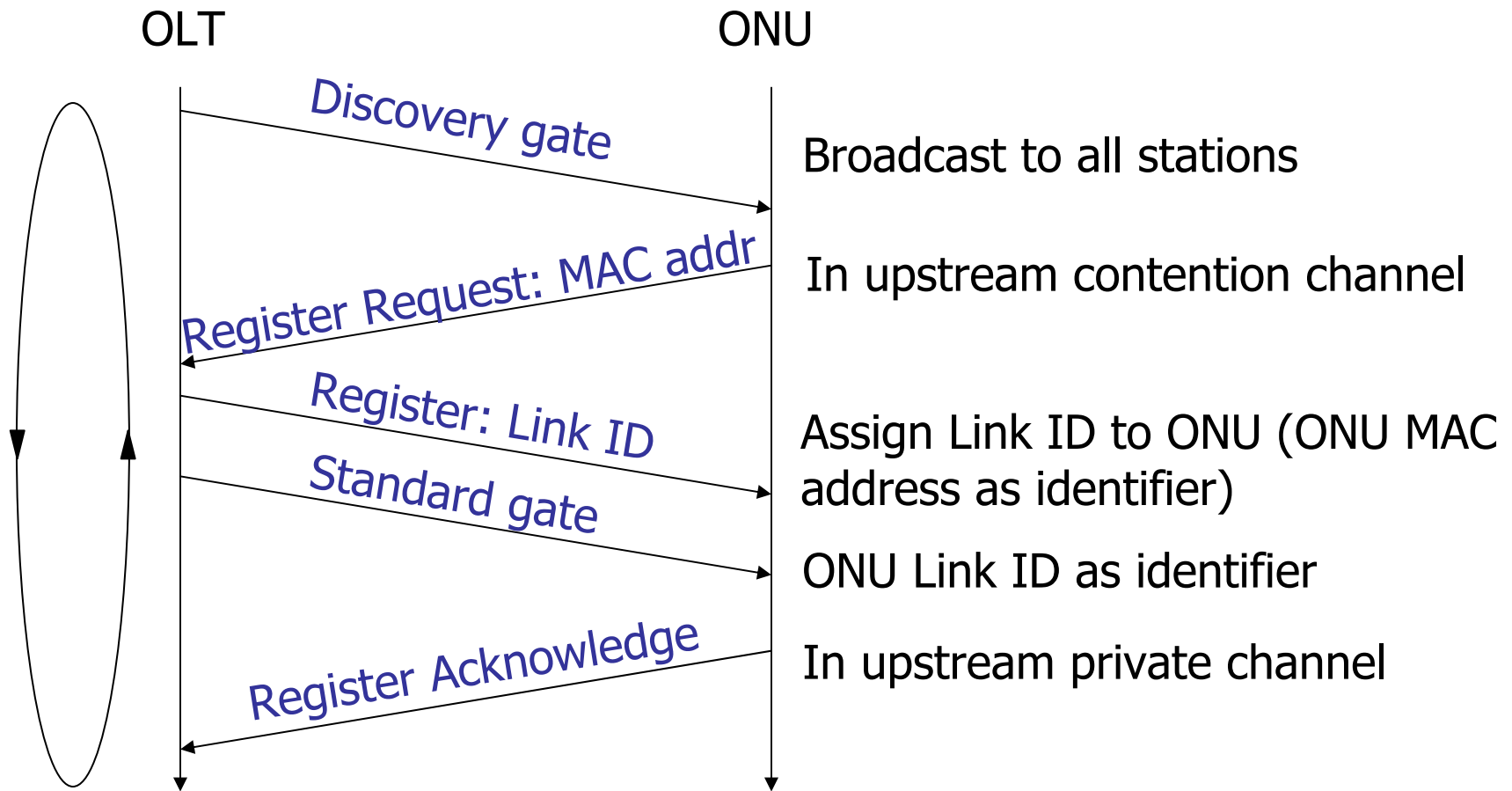
- Tag contains: LLID (logical link ID), broadcast mode bit
- Two simple rules for admission:
  - Broadcast: accept frame if LLID <> self
  - Not broadcast: accept frame if LLID = self
- All other cases frame discarded

Gating Process

OLT ONU

Higher layers

802.1D Bridge

MAC Control

MAC

P2P Emulation (P2PE)

GMII

PCS

PMA

PMD

MDI

Media

Gate: Start, Length

Wait until Start

Frame blocking Period

Local time = Start

Frame forwarding Period

Local time = Start+Length

Frames blocked again

Discovery Process

OLT   ONU

Discovery gate → Broadcast to all stations

Register Request: MAC addr ← In upstream contention channel

Register: Link ID → Assign Link ID to ONU (ONU MAC address as identifier)

Standard gate → ONU Link ID as identifier

In upstream private channel

Register Acknowledge ←

Retry until successful

Timestamp Model

- All MPCPDUs (multi-point control protocol data unit) timestamped with local timer

- ONU constantly updates timer based on value received form OLT

- Difference of incoming timestamp to local time allow OLT to calculate for RTT (round trip time)

RTT Measurement Example

1. OLT sends GATE at absolute T1

2. ONU receives GATE at T2, and resets local clock to show T1

3. ONU sends REPORT at time T3, showing timestamp T4

4. OLT receives REPORT at absolute T5
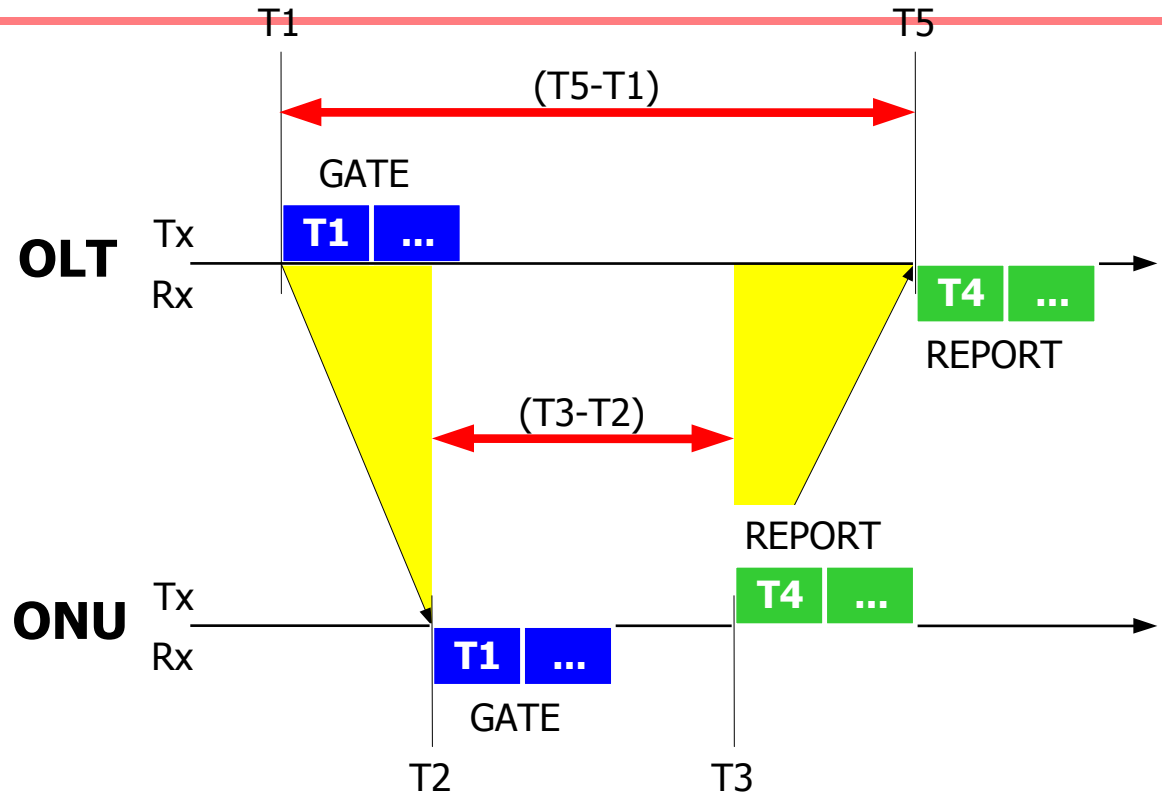
$$RTT = T2-T1+T5-T3 \quad AND \quad T3-T2 = T4-T1$$

$$\Rightarrow \quad RTT = T5-T4$$

MPCP Protocol Data Unit Structure

Destination Address	6
Source Address	6
Length/Type = 88-08	2
Opcode	2
Timestamp	4
Data/Reserved/Pad	40
FCS	4

- Additional opcodes defined for MAC Control PDU

- EtherType 88-08

- Not forwarded across bridges

- Not tagged

- 64 bytes long

- All MPCPDUs contain timestamp

GATE MPCPDU

Field	Bytes
Destination Address	6
Source Address	6
Length/Type = 88-08	2
Opcode = 00-02	2
Timestamp	4
Number of grants/Flags	1
Grant #1 Start time	0/4
Grant #1 Length	0/2
Grant #2 Start time	0/4
Grant #2 Length	0/2
Grant #3 Start time	0/4
Grant #3 Length	0/2
Grant #4 Start time	0/4
Grant #4 Length	0/2
AGC Settling Time	0/2
CDR Lock Time	0/2
Pad/Reserved	11-3!
FCS	4

- Opcode 00-02
- Signals start of transmission to ONU:
  - Start time for transmission
  - Length of transmission

- Up-to 4 grants in single GATE
- Additional flags to signal grant behavior

REPORT MPCPDU

Field	Bytes
Destination Address	6
Source Address	6
Length/Type = 88-08	2
Opcode = 00-03	2
Timestamp	4
Number of queue sets	1
Report bitmap	1
Queue #0 Report	0/2
Queue #1 Report	0/2
Queue #2 Report	0/2
Queue #3 Report	0/2
Queue #4 Report	0/2
Queue #5 Report	0/2
Queue #6 Report	0/2
Queue #7 Report	0/2
Pad/Reserved	0-39
FCS	4

Repeated n times as indicated by *Number of queue sets*

- Opcode 00-03
- Signals queue status at ONU
- Feedback for effective bandwidth allocation

- Multiple report sets in message
  - Each set for up to 8 queues

REGISTER_REQ MPCPDU

Destination Address	6
Source Address	6
Length/Type = 88-08	2
Opcode = 00-04	2
Timestamp	4
Flags	1
Pending grants	1
Pad/Reserved	38
FCS	4

- Opcode 00-04
- Signals start of registration sequence

- Contention may occur during registration request

REGISTER MPCPDU

Destination Address	6
Source Address	6
Length/Type = 88-08	2
Opcode = 00-05	2
Timestamp	4
Assigned port	2
Flags	1
AGC Settling time	2
CDR Lock Time	2
Echoed pending grants	1
Pad/Reserved	32
FCS	4

- Opcode 00-05
- Signals acceptance of registration attempt
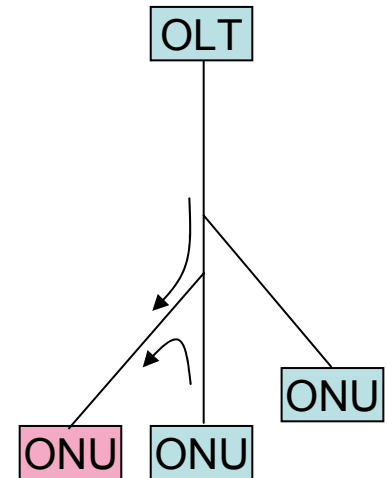
- Assigns private link

REGISTER_ACK MPCPDU

Field	Bytes
Destination Address	6
Source Address	6
Length/Type = 88-08	2
Opcode = 00-06	2
Timestamp	4
Flags	1
Echoed assigned port	2
Echoed AGC settling time	2
Echoed CDR lock time	2
Pad/Reserved	33
FCS	4

- Opcode 00-06
- Final handshake in registration sequence

Security Threats

- Downstream is broadcast and select. Eavesdropping all downstream traffic is easy.

- Upstream:
  - In most cases eavesdropping is not possible without physical intrusion because of the high directivity of optical splitters and low reflections. Eavesdropping the nearest neighbor might be possible in special cases by using advanced equipment.
  - MPCP gate messages reveal origin (LLID), approximate amount, and time profile of upstream traffic of other ONUs.

OLT

ONU

ONU ONU

Security Layering Options

Higher layers

Option 1 ....

OAM

MAC Control

Option 2 ....

MAC

Option 3 ....

P2P Emulation (P2PE)

GMII

PHY

PDU — Client only

PDU — Client + Control

| MAC HDR | PDU | FCS |

Option 4 – stream approach – not workable