

Grant/Request Method for Ethernet PON

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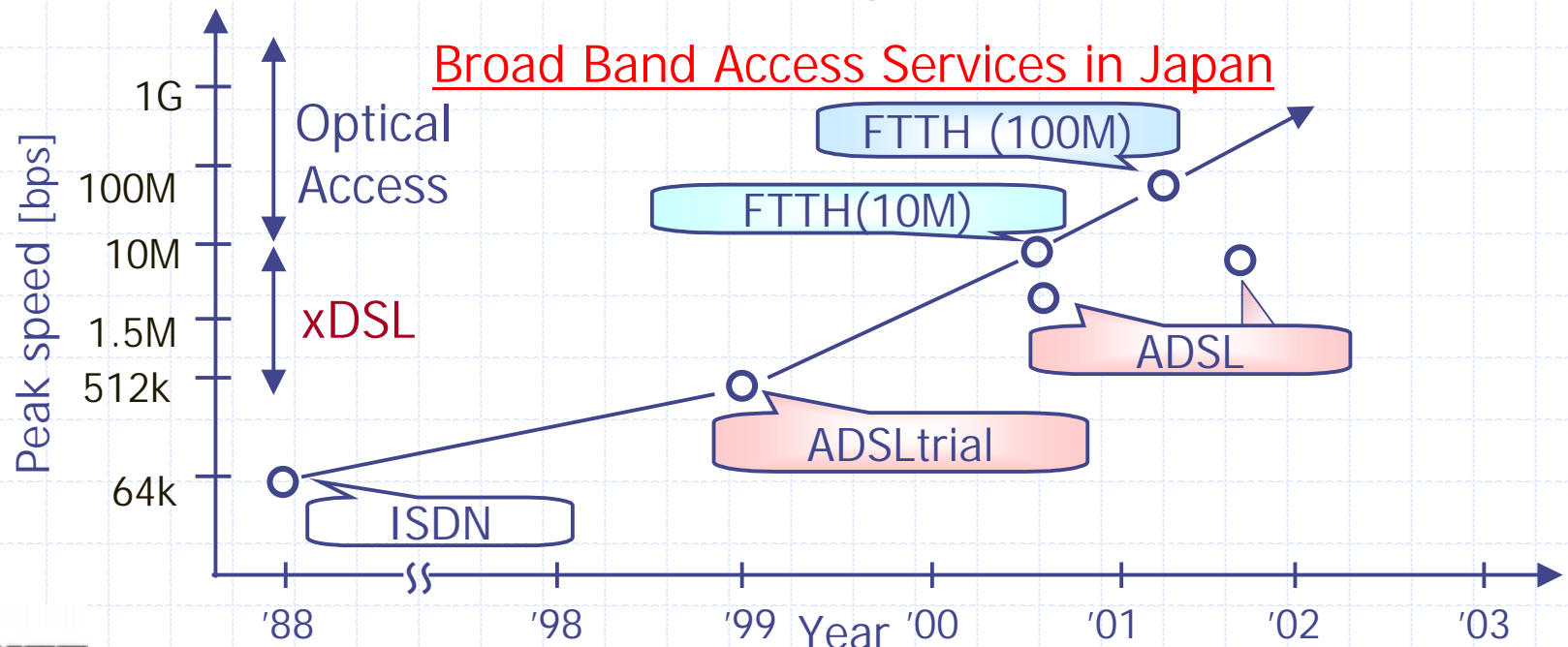
NTT Access Network Service Systems Laboratories

Outline

1. Necessity of Grant/Request
2. Grant/Request Requirements
3. Grant/Request Proposal
4. Grant/Request Algorithm: Example
5. Conclusions

Necessity of Grant/Request Method

- ◆ Broad band access services using dynamic bandwidth sharing with low tariff available in Japan.
- ◆ Dynamic bandwidth sharing function for PON system is now being studied in ITU-T (Rec. G.983.series) and FSAN.
- ◆ Peak speeds of services increasing, and Gbit class service with dynamic bandwidth sharing function will be required.
- ◆ Grant/Request method is needed for high performance.



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Grant/Request Requirements

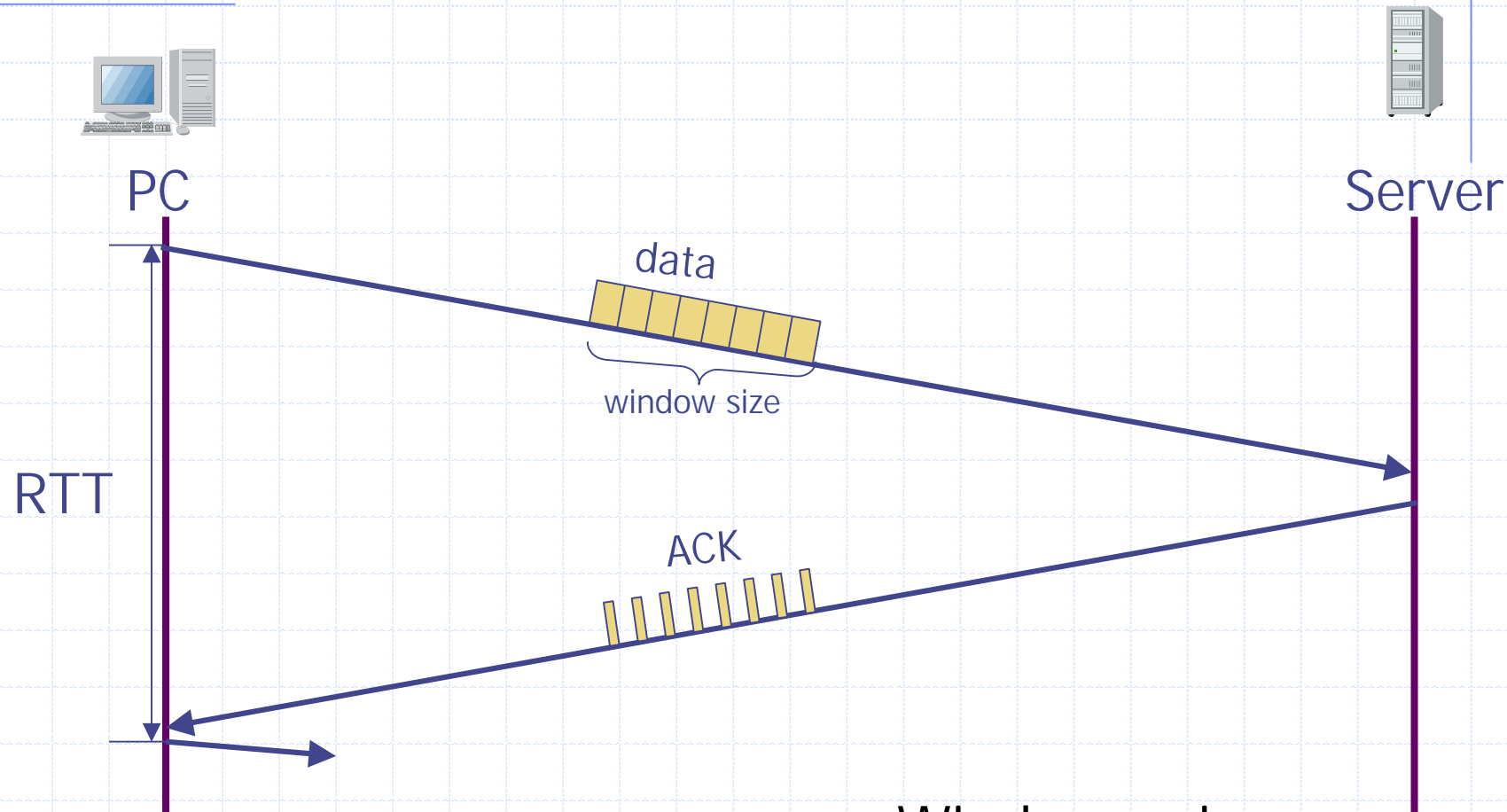
◆ Flexibility

- Single ONU supports multiple users and multiple services.
 - Grant should be given to each user and service flexibly.

◆ High performance

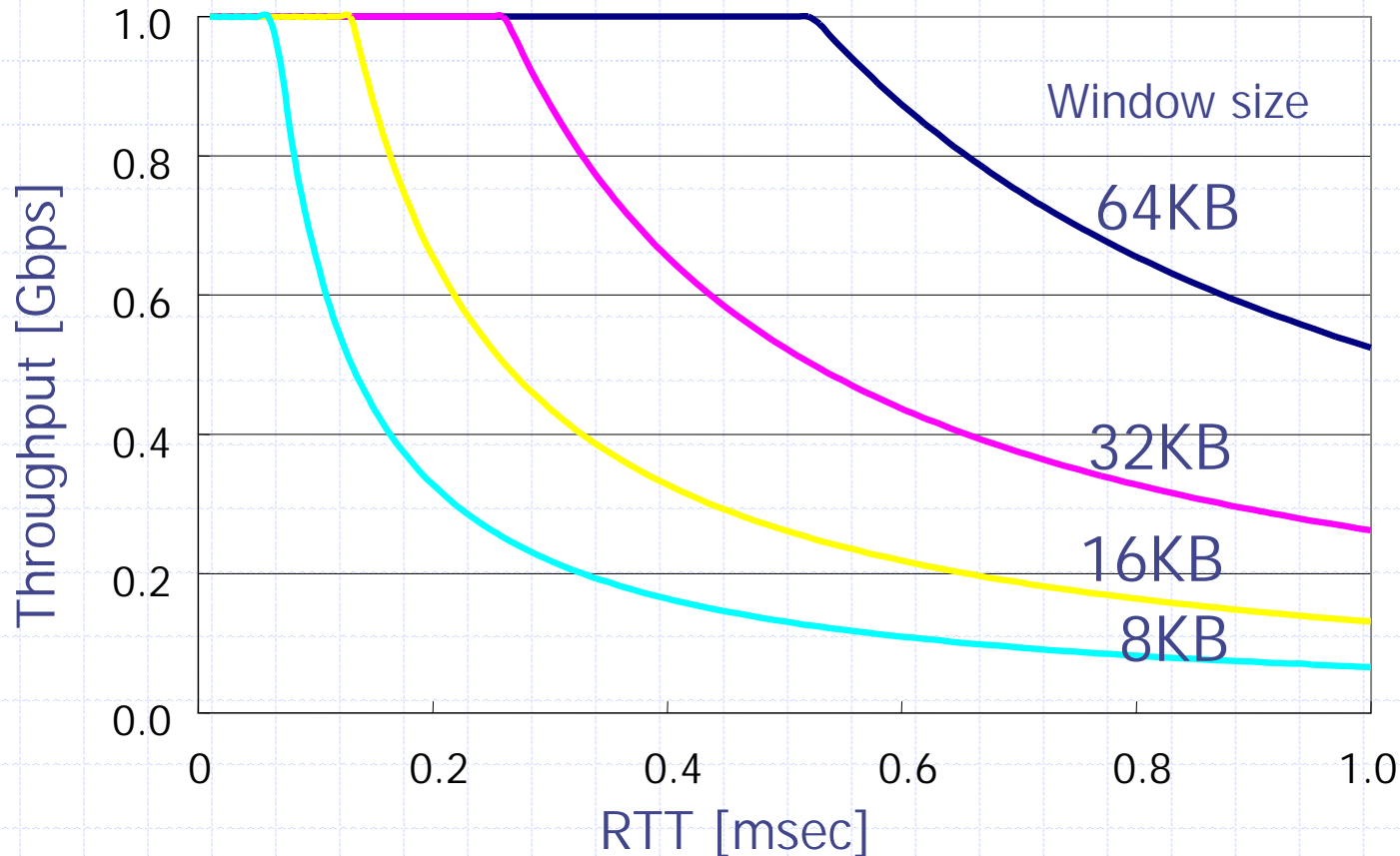
- Some applications require low delay and low delay variation.
- Low delay yields high TCP throughput.
- High bandwidth efficiency is required.

TCP Throughput Relevant to RTT



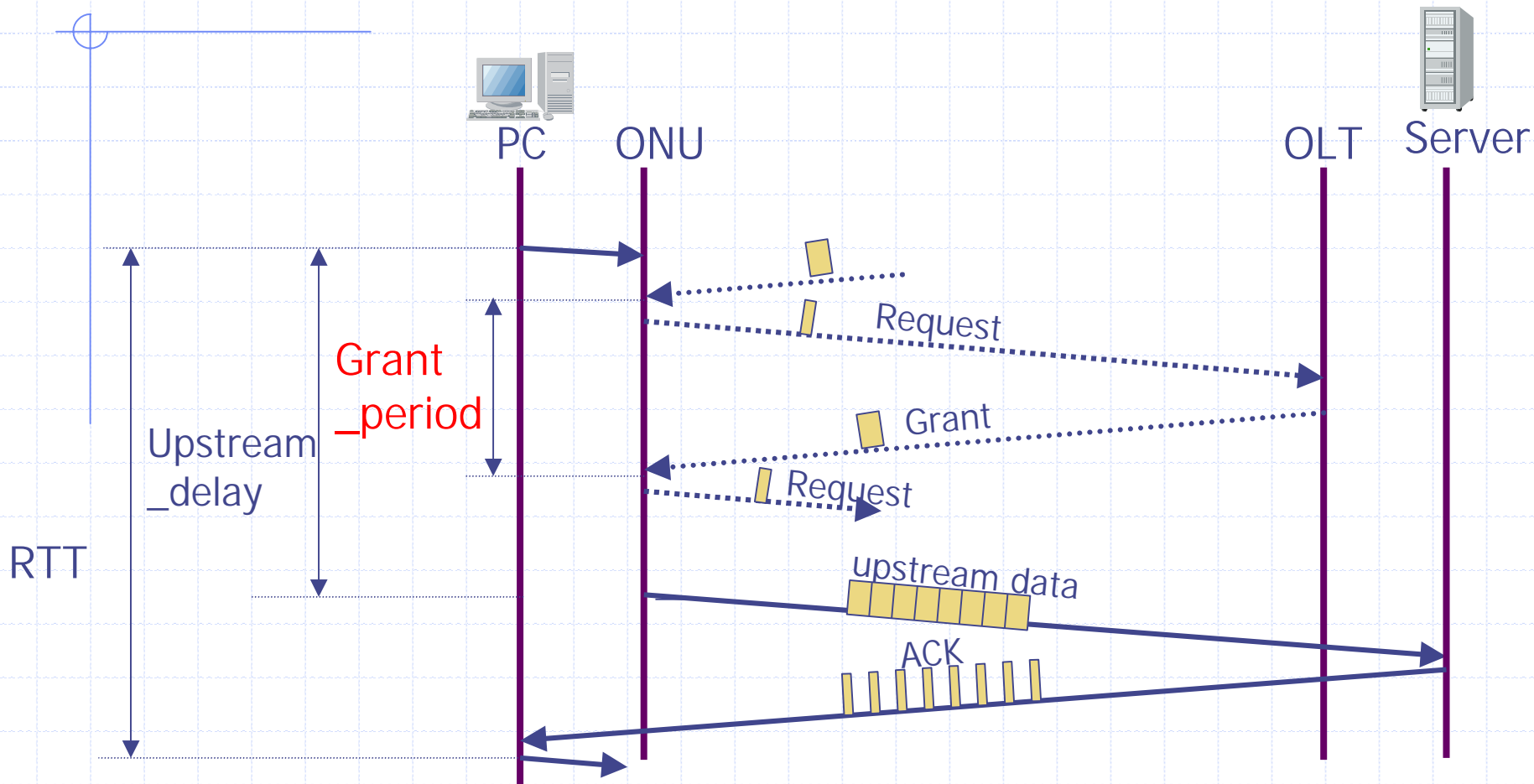
$$\text{Maximum TCP _ throughput} = \frac{\text{Window _ size}}{\text{RTT}}$$

TCP Throughput Relevant to RTT



RTT must be low to achieve high TCP throughput.

Need to shorten Grant Period



Shorten Grant period to shorten RTT.

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Grant/Request Proposal

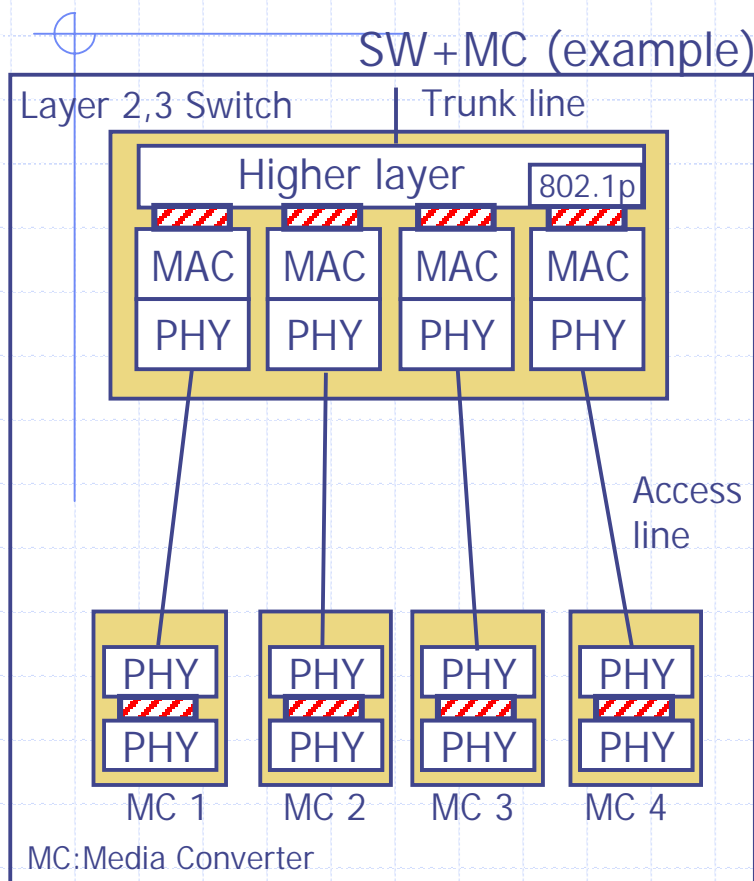
1. "Logical port" to be flexible network

- Upstream BW is allocated to each "logical port". OLT gives Grant to each logical port.
- Logical port is independent of ONU physical port.
- Authentication and service selection done for each logical port in higher layer protocol (ex. 802.1x).

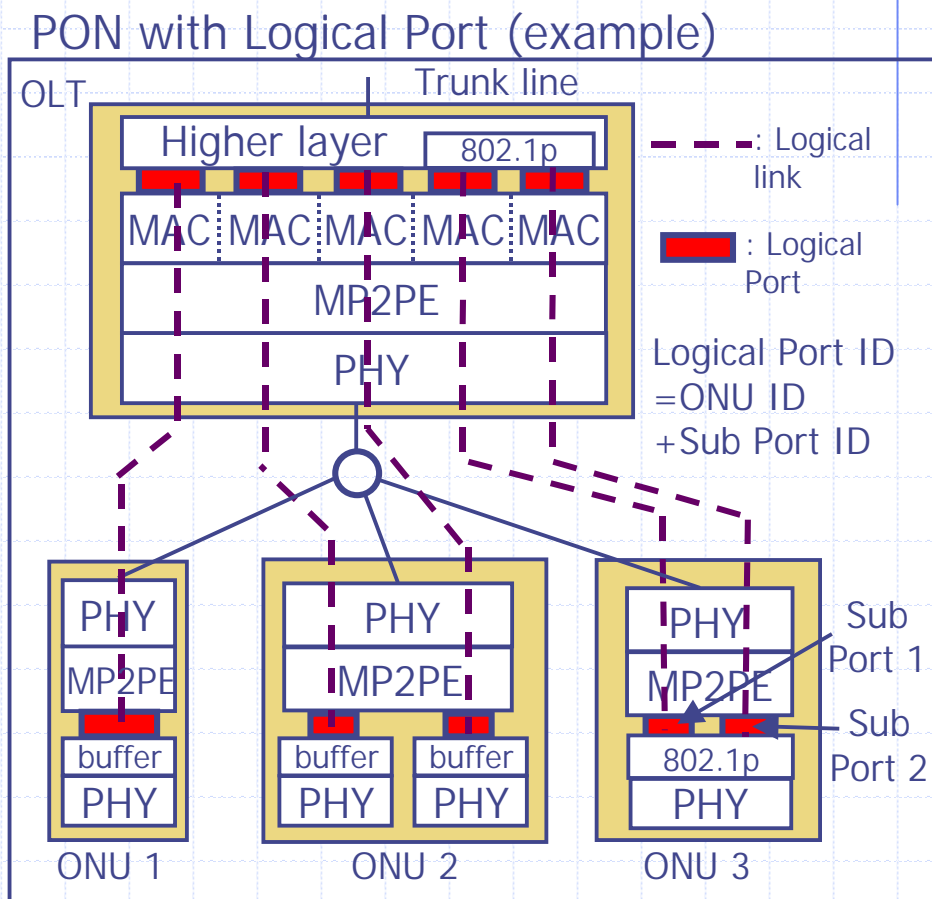
2. "Multiple Request Types" to shorten grant period efficiently

- ONU sends multiple buffering status information of logical port within a single Request.

Proposal 1 : Logical Port



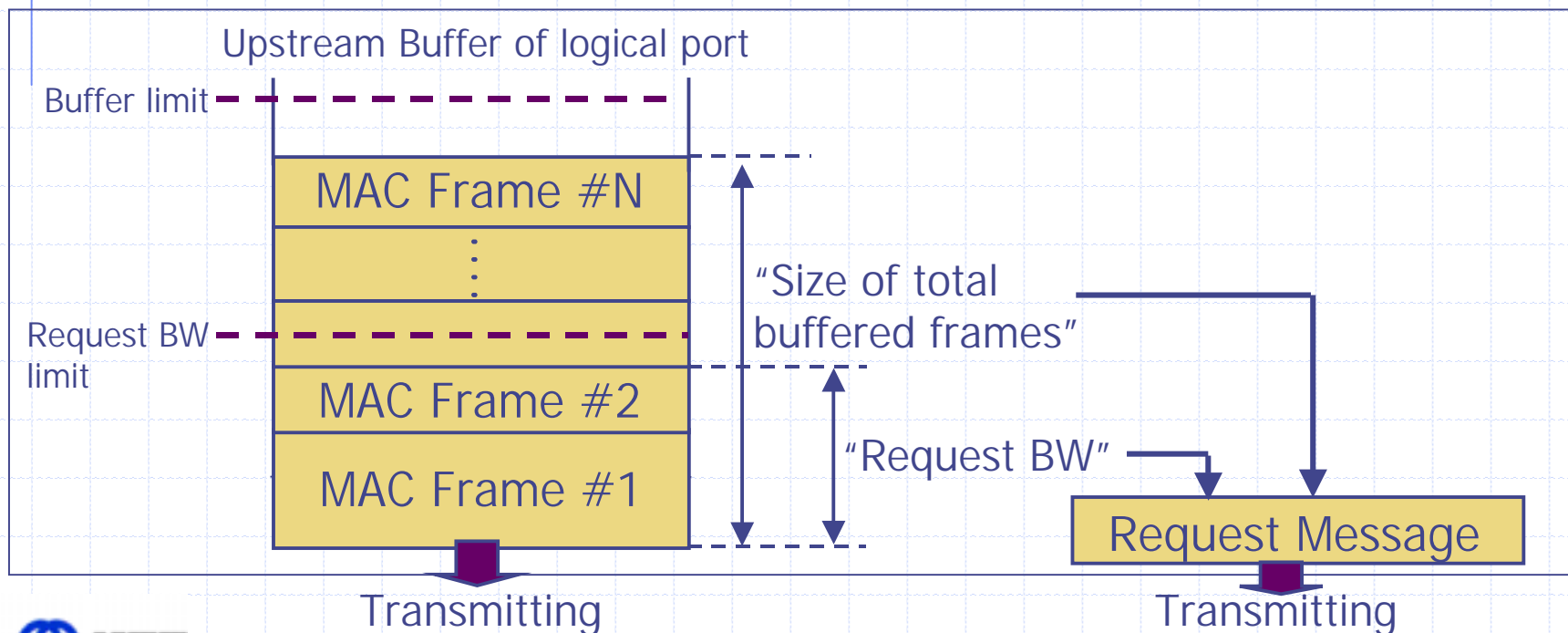
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- MP2PE (Multiple P2P Emulation) function transmits data with logical port ID.
- An ONU has single or multiple logical ports (sub ports).
- Various types of ONU can be realized.

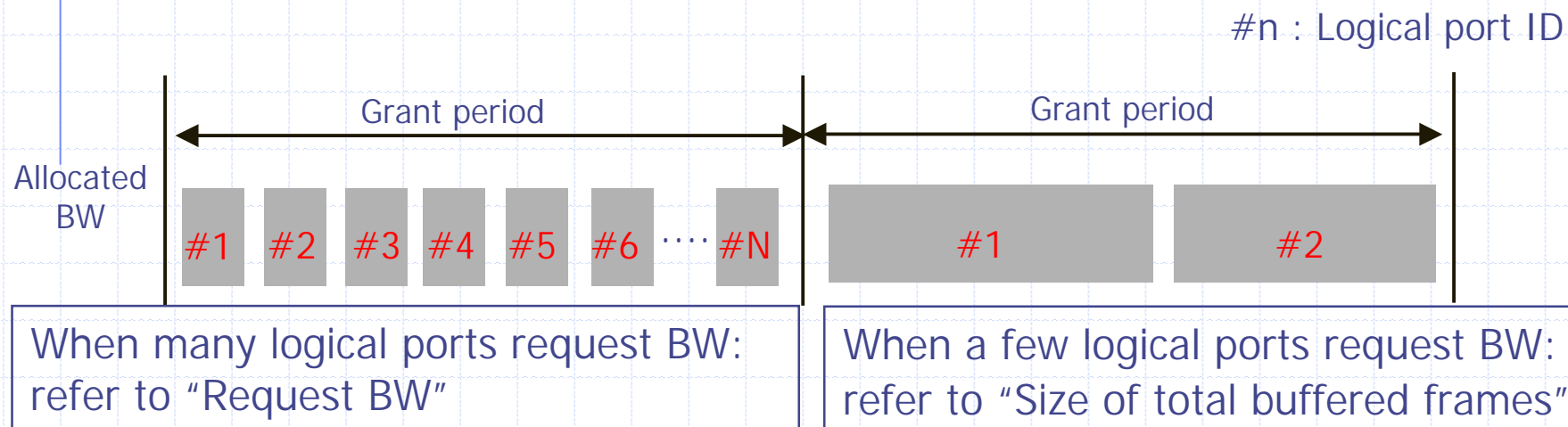
Proposal 2 : Multiple Request Types

- ◆ Request message holds multiple information on buffering status.
 - Buffered size under limitation. (Request Type = "Request BW")
 - Total buffered size. (Request Type="Size of total buffered frames")
 - Other buffering status information. (option)



BW allocation example

- ◆ According to upstream traffic, BW allocation function chooses reference Request Type.



Grant period can be shortened with high efficiency in both cases.

Parameters of Grant/Request message

◆ Both message types

- ONU ID field: ~8bits
 - ◆ To specify ONU (ONU MAC address is too long).
 - ◆ Number of ONU is 16~128.
- Sub Port ID field
 - ◆ To specify ONU logical port.

◆ Grant message

- Granted BW field: 20bits
 - ◆ Need to assign BW in a few hundreds Koctets by the octet.

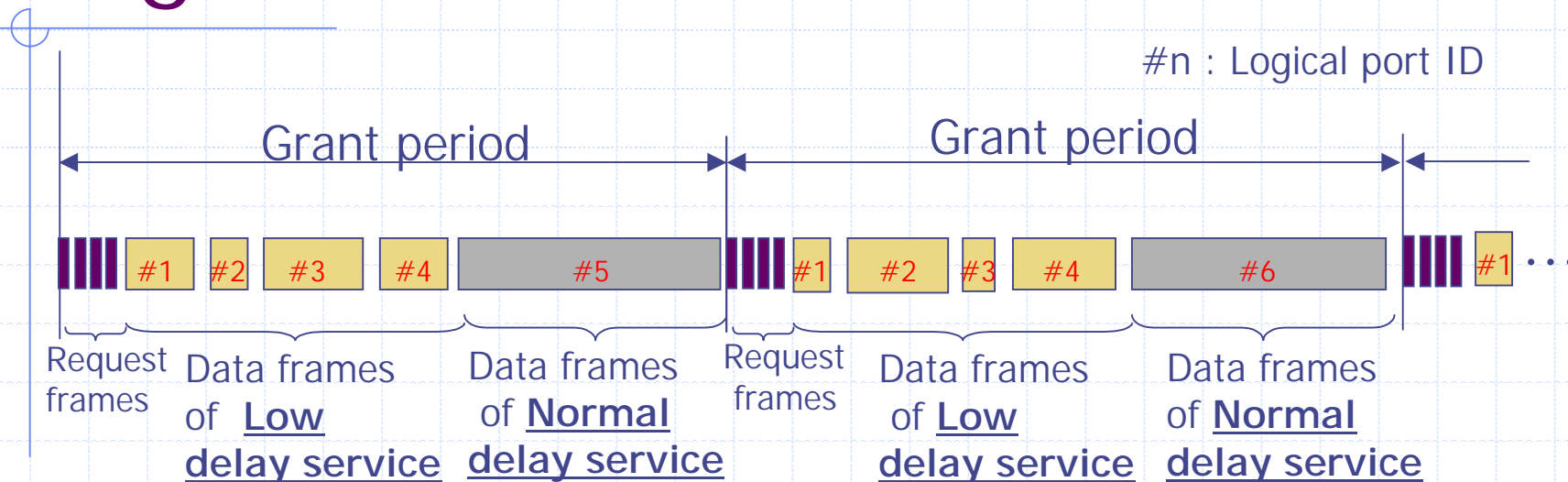
◆ Request message

- Request Type field
 - ◆ ID of multiple request type.
- Request information field
 - ◆ Buffering information of each request type.

Outline

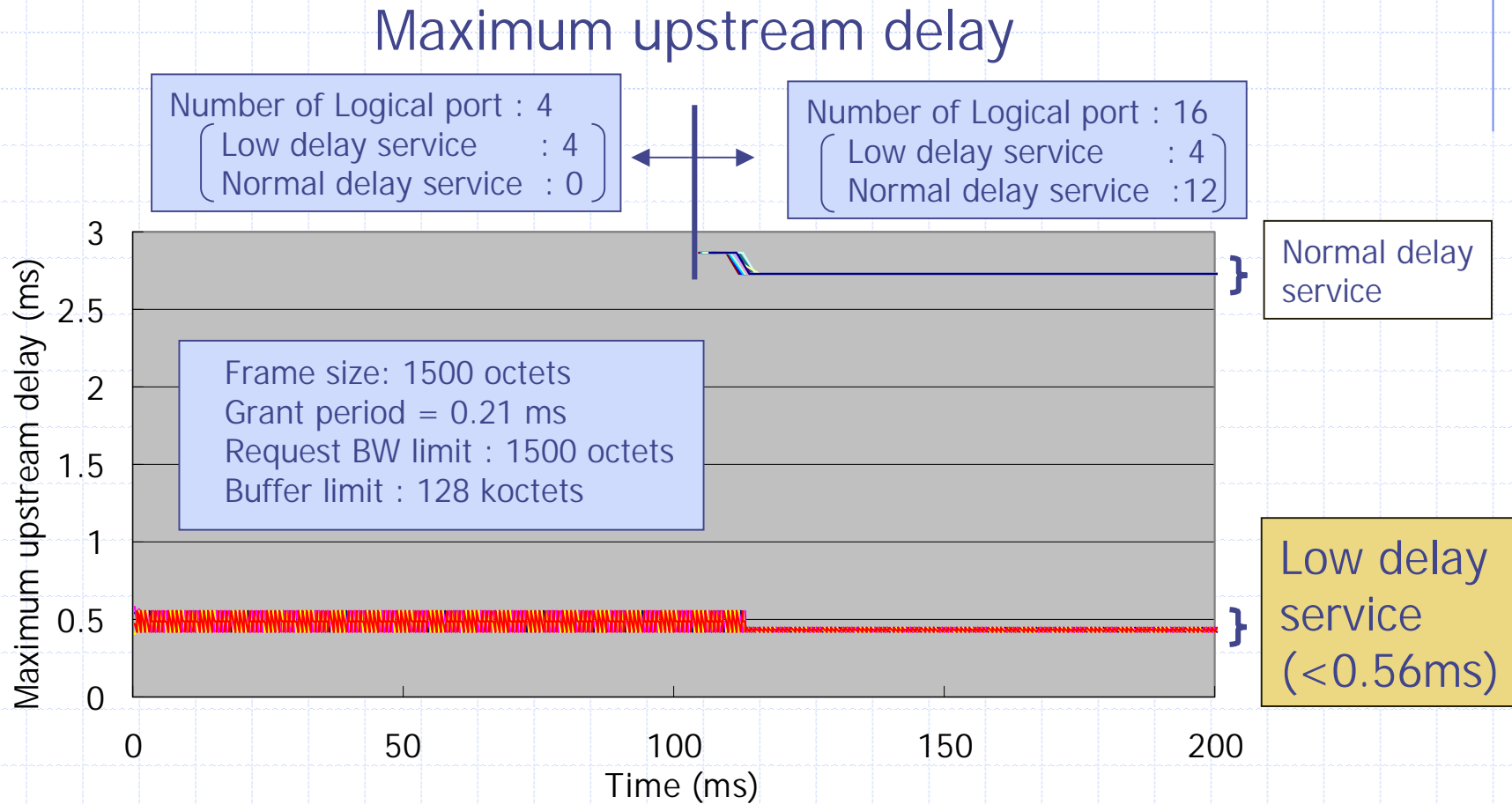
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Features of Grant/Request Algorithm



- ◆ “Logical port ID” is utilized to differentiate services (Low delay service / Normal delay service).
 - Low delay service precedes Normal delay service in a Grant period.
 - Low delay service has shorter Grant period than Normal delay service.
- ◆ “Multiple Request Types” utilized to shorten Grant period.
 - For Low delay service, data frames of Request BW are definitely allocated within one Grant period .

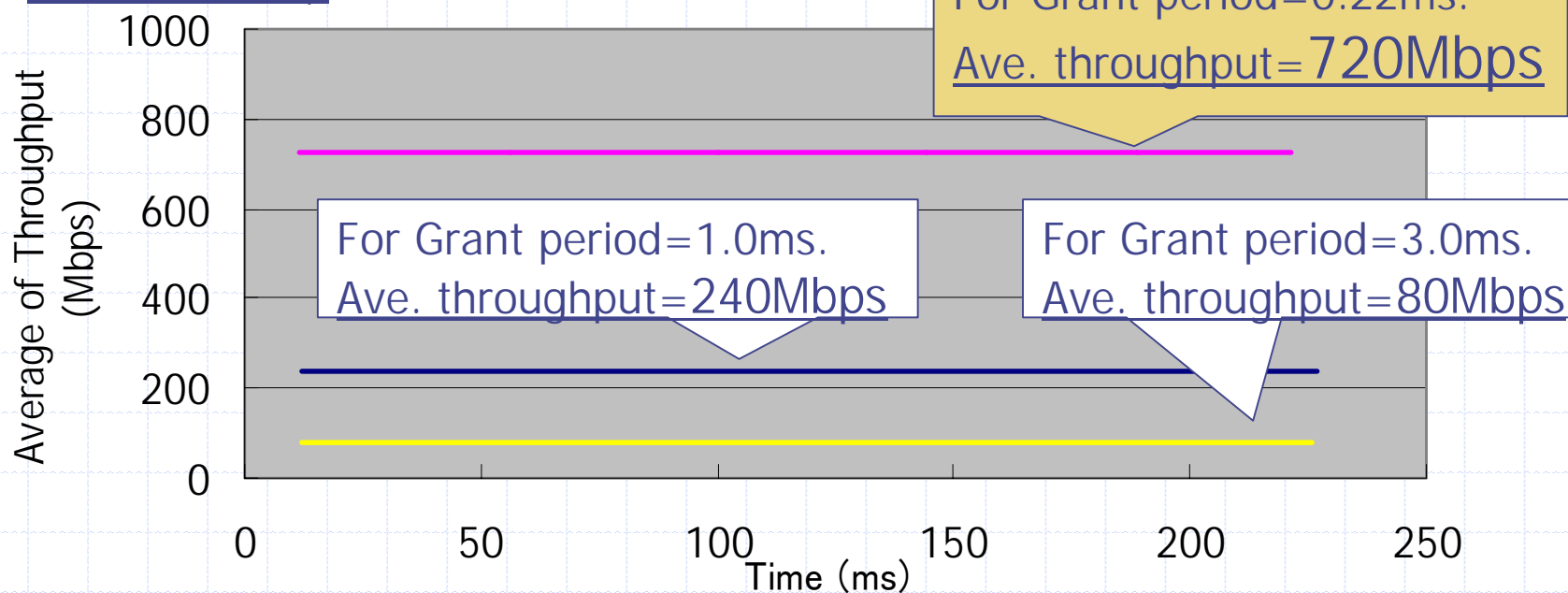
Simulation Result (1)



Upstream delay in Low delay service is kept low.

Simulation Result (2)

Average TCP throughput with TCP flow control (window size=60KB)



Number of Logical ports: 1
Low delay service : 1
Normal delay service : 0

MAC Frame size: 1500octets
Propagation delay=0.1ms
(distance between OLT and ONU=20km)

Request BW limit : 1500 octets
Buffer limit : 128 koctets

High TCP throughput is achieved by keeping grant period short.

Conclusions

- ◆ Grant/Request method is necessary for high system performance.
- ◆ Flexible Grant/Request method proposed.
 - By “logical port”, Grant can be given flexibly to each user and each service in one ONU; it enables flexible operation.
 - “Multiple Request Types” shorten Grant period and make TCP throughput high.
- ◆ An example of Grant/Request Algorithm and simulation results were shown.

Appendix

Details of possible solution are described in this Appendix.

Further discussion is needed.

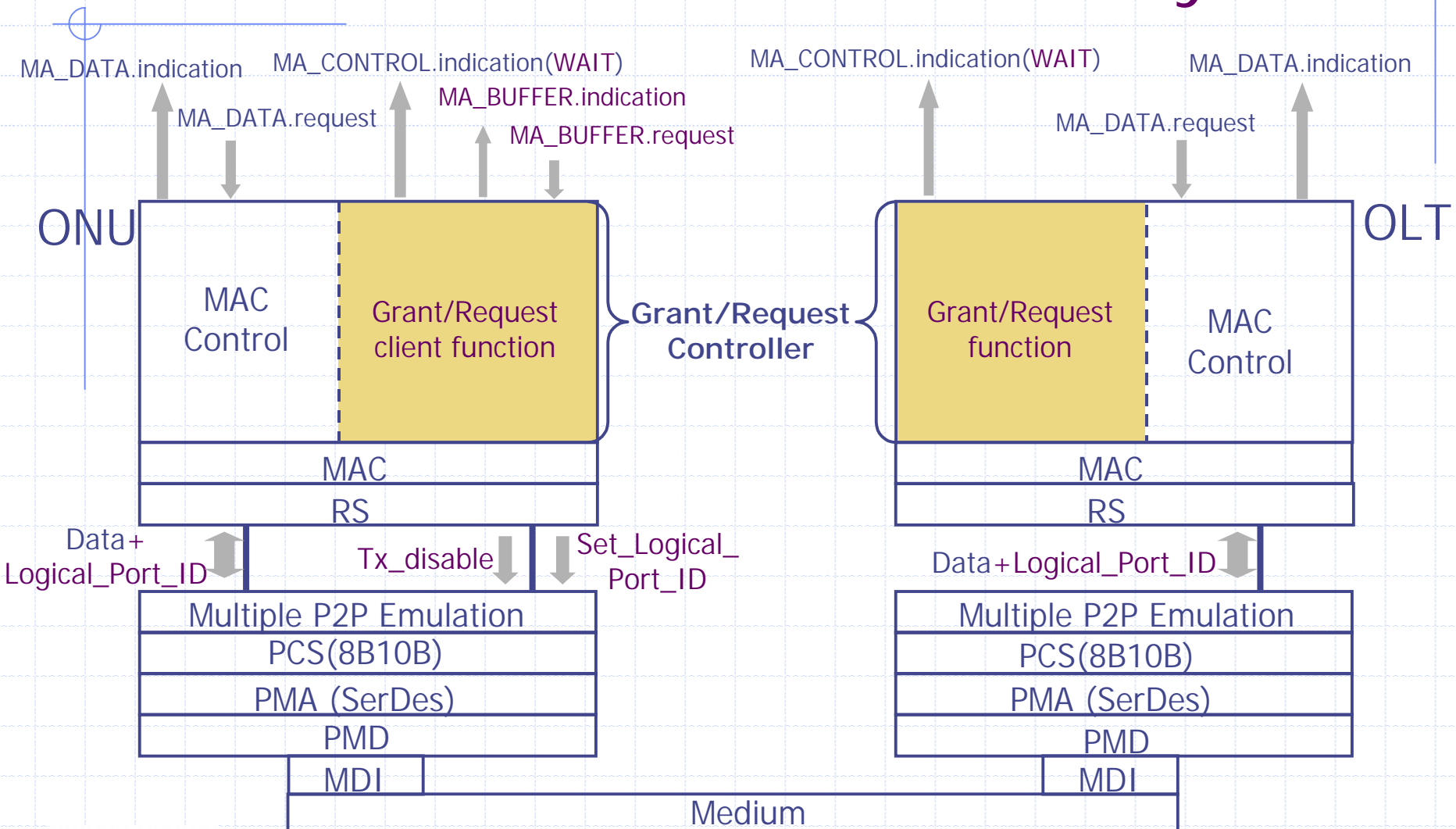
Grant/Request function in EPON

- ◆ “Where to put that Grant/Request message?” is equal to “Which layer has Grant/Request function?”
- ◆ 2 possible solutions:
 - 1. MAC Control Frame (Grant/Request in MAC Control sub layer)
 - ◆ With new Op-Code for Grant/Request.
 - ◆ The length limit of MAC control frame is expanded.
 - 2. IDLE replacement (Grant/Request in PHY layer)
 - ◆ 10b-coded Grant/Request message is replaced /I/.
 - ◆ Using /K/* for message delimiter.
- ◆ Need to discuss which layer has the function.
 - Layer structure and BW efficiency are different.

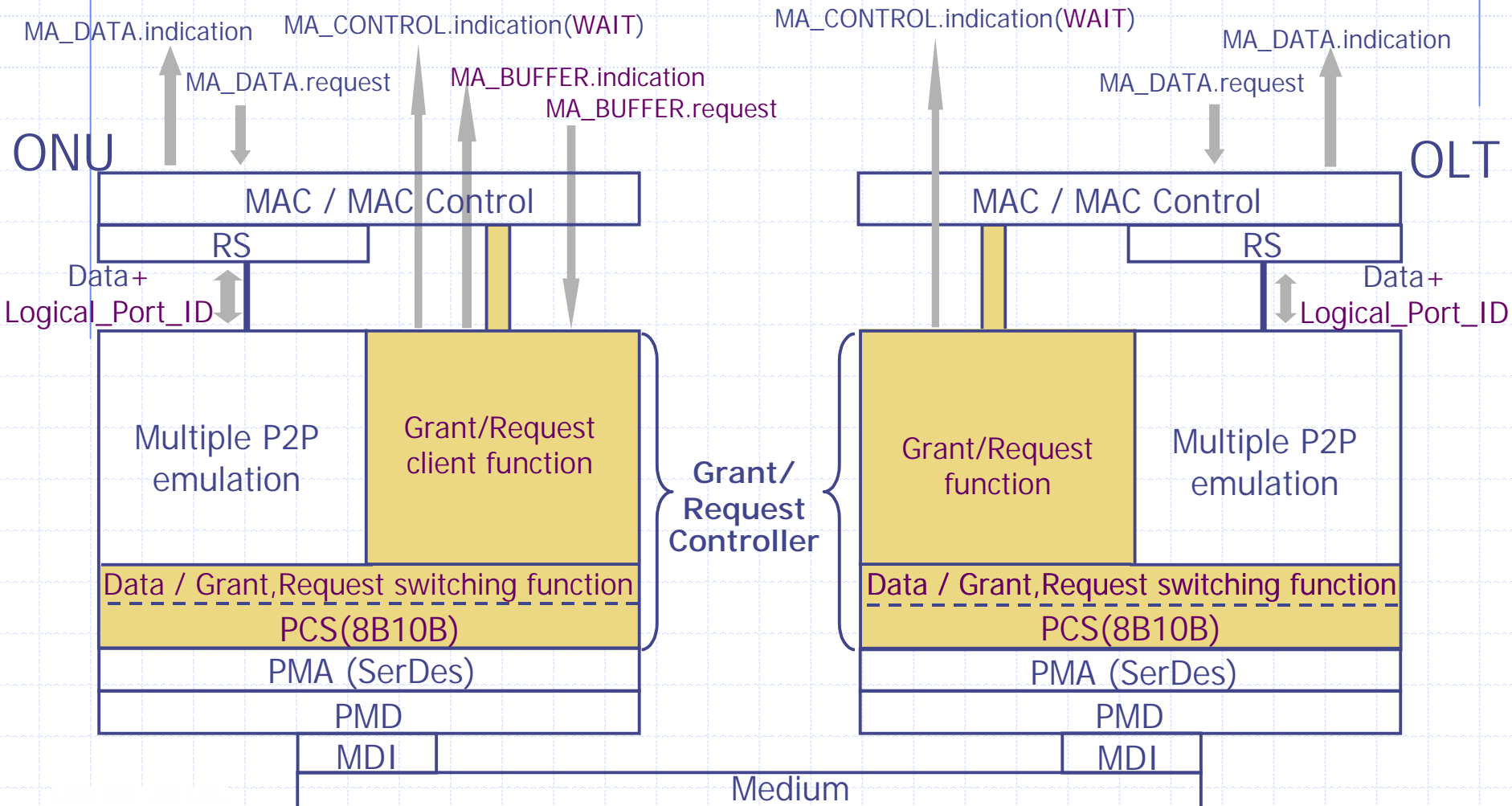
/I/:IDLE ordered_set /K/:special code-group

*:/K28.1/ is not used in GE, XGE and has comma for alignment instead of /K28.5/.

Possible Solution 1 : Grant/Request function in MAC control sublayer



Possible Solution 2 : Grant/Request function in PHY layer



Service message

(MAC client \leftrightarrow MAC Control Sublayer)

New parameter

- MA_DATA.request(destination_address, source_address, m_sdu, service_class, **logical_port_ID**)
 - Message to transmit data from MAC client.
- MA_DATA.indication(destination_address, source_address, m_sdu, reception_status, **logical_port_ID**)
 - Message to pass data to MAC client.

New command

- MA_CONTROL.indication(**wait_command**, **wait_status**, **logical_port_ID**)
 - To stop transmitting data if no grant (ONU) or transmitting grant (OLT) .

New primitive

- MA_BUFFER.indication** (get_buffer_status_command, buffer_type , logical_port_ID)
 - Message to get buffering status of logical_port_ID.
- MA_BUFFER.indication** (assign_buffer_status_command, granted_BW, logical_port_ID)
 - Message to assign granted BW for logical_port_ID.
- MA_BUFFER.request** (report_buffer_status_command, buffer_status, buffer_type , logical_port_ID)
 - Reporting buffering status of logical_port_ID.

Gothic: new definition

Grant message format

Possible Solution 1
MAC Control Frame

48	DA	Multicast
48	SA	OLT MAC address
16	Type	88-08
16	Op-Code	00-02
8	Message Length/Type	Length
24		Grant Offset
8		ONU ID
4		Sub Port ID
20		End Time
		⋮ Repeat if necessary
32	FCS	CRC

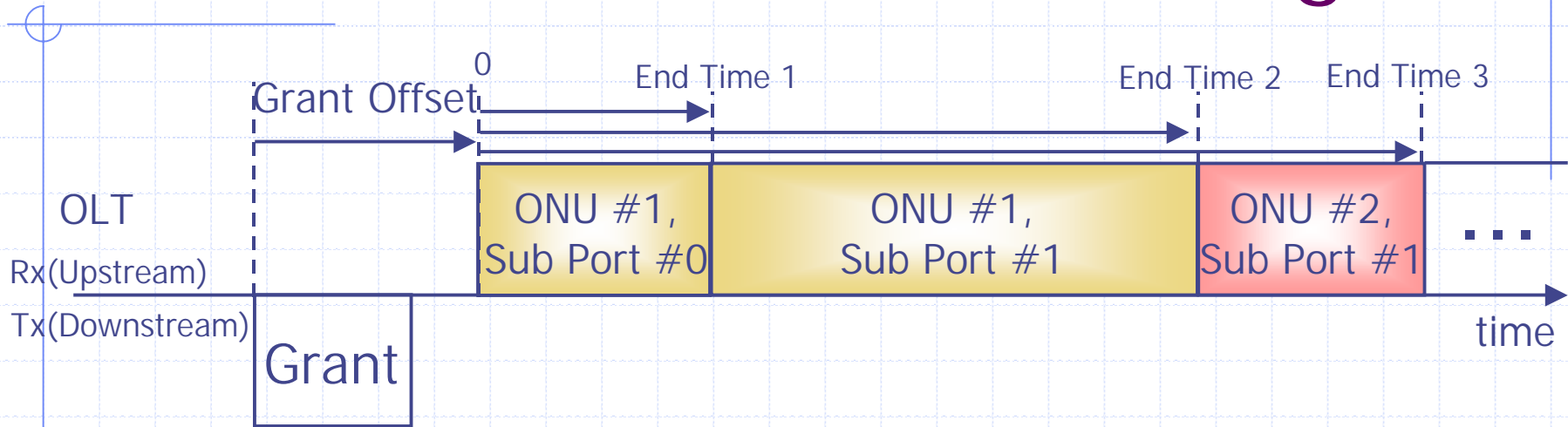
Possible Solution 2
PHY IDLE replacement

		/T/ /R/
8	Message Delimiter	/K28.1/
8	Message Length/Type	Type = Grant
24		Grant Offset
8		ONU ID
4		Sub Port ID
20		End Time
		⋮ Repeat if necessary
	MCS	CRC
		/I/ or /S/

MCS: Message Check Sequence

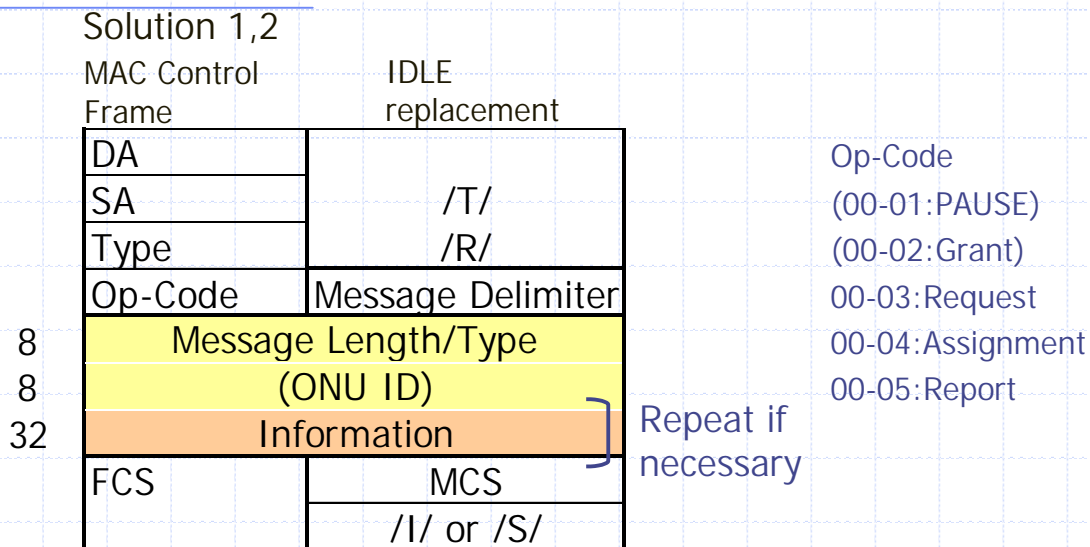
Sub Port ID	ONU can transmit
Control port { 0	Report message "ONU MAC address" (for Initial Registration)
1	Report message "Ranging Response" (for Ranging)
2	Other report message
3	Request message
4...15	Data of Sub port

Parameters of Grant message



- ◆ Each ONU knows own RTT (by Ranging) and adjusts transmission time.
- ◆ Differential “End Time” means Granted BW for specified Sub Port of an ONU.
 - ◆ i.e. ONU #1 can transmit data of Sub Port #1 from “End Time 1” to “End Time 2”.

Common (Request/Other) message format



- ◆ Other PON information messages are used for PON functions : Initial registration, Ranging.
 - Other PON information message:
 - ◆ Assignment message(OLT transmitting)
 - For assign ONU ID, assign ranging result.
 - ◆ Report message(ONU transmitting)
 - Response for ranging, report ONU MAC address.
 - (Refer Sub Port ID field of Grant message.)

Request message format (detail)

Possible Solution 1
MAC Control Frame

48	DA	OLT/Multicast
48	SA	ONU MAC address
16	Type	88-08
16	Op-Code	00-03
8	Message Length/Type	Length
8		(PAD)
4		Sub Port ID
4		Request Type
24		Request Information
		⋮ Repeat if necessary
32	FCS	CRC

Possible Solution 2
PHY IDLE replacement

		/T/ /R/
8	Message Delimiter	/K28.1/
8	Message Length/Type	Type = Request
8		ONU ID
4		Sub Port ID
4		Request Type
24		Request Information
		⋮ Repeat if necessary
	MCS	CRC
		/I/ or /S/

Sub Port ID	ONU Request
0...3	Reserved
4...15	Data BW for Sub Port

Request Type	Request Information
0	"Request BW" (under limitation)
1	"Size of total buffered frames"
2...15	Reserved