

# Channel (Wavelength) Control Protocol

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# Channel Control Principles

- ❑ For backward compatibility, ONUs may need to operate with some of the channels turned off
  - 2<sup>nd</sup> gen ONU can operate as the 1<sup>st</sup> gen ONU
  - 3<sup>rd</sup> gen ONU can operate as either 1<sup>st</sup> gen or 2<sup>nd</sup> gen ONU
  
- ❑ Individual channels also may be turned off
  - To save power
  - To perform diagnostic/maintenance (i.e., rogue ONU detection)
  - For optical protection
  - Other reasons
  
- ❑ Turning channels on/off means turning OLT/ONU receivers and transmitters on and off
  
- ❑ **Key Goal:** allow channels to be turned on/off without incurring any packet loss.

# Key Features of 100G-EPON Architecture

No dependencies between the numbers of upstream and downstream channels enabled in each ONU



- Channels can be enabled and disabled independently based on traffic load or specific diagnostic/maintenance needs
- EPON's DS/US bandwidth asymmetry can be changed dynamically

No fixed pairing between downstream and upstream channels



- A GATE arriving on any downstream channel may carry grants for any upstream channels.

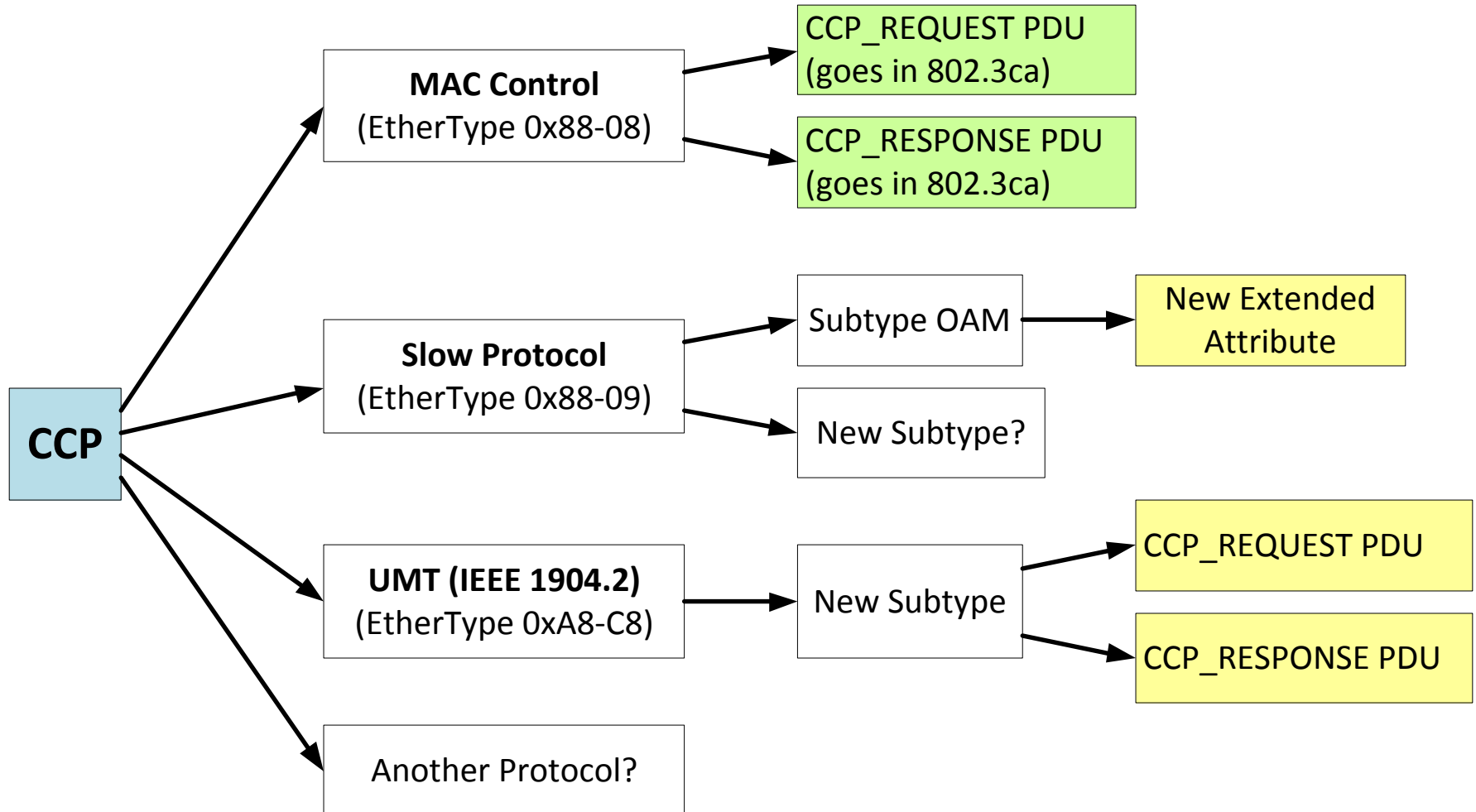
No fixed mapping of LLIDs to channels



- Any LLID provisioned at a given ONU may be served by any of the channels enabled in that ONU

# Channel Control Protocol (CCP)

- ❑ CCP needs just two messages: Request and Response
- ❑ What protocol type should we use?



# Request Message

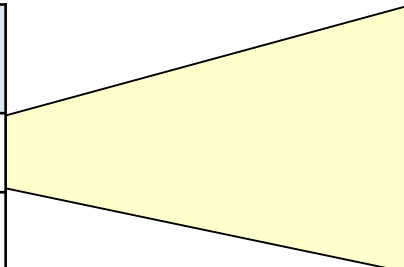
- Without any parameters – Query ONU for states of all channels (i.e., GetRequest)
- With a parameter **ChannelAction[8]** – enable/disable channels as requested (i.e., SetRequest)

ChannelAction Array

Array Index	Channel
0	DS0
1	US0
2	DS1
3	US1
4	DS2
5	US2
6	DS3
7	US3

ChannelAction Field

Bits	Description
0-7	Channel Action 0x00 – <b>No Action</b> 0x01 – <b>Disable Channel</b> 0x02 – <b>Enable Channel</b> 0x03-0xFF – values reserved



# Response Message

- Response Message carries an array of 8 **ChannelInfo** fields, each representing one channel.

## ChannelInfo Array

Array Index	Channel
0	DS0
1	US0
2	DS1
3	US1
4	DS2
5	US2
6	DS3
7	US3

## ChannelInfo Field

Bits	Description
0-3	Channel Status 0x0 – <b>Channel Absent</b> 0x1 – <b>Enabled</b> 0x2 – <b>Remotely disabled</b> (i.e., disabled by the NMS) 0x3 – <b>Locally disabled</b> (i.e., disabled by ONU if PMD failure is imminent) 0x4 – <b>Channel Failure</b> (i.e., PMD has failed) 0x5-0xF – values reserved
4-7	Action Result Code 0x0 – <b>No Action Requested</b> 0x1 – <b>Action Succeeded</b> 0x2 – <b>Action Failed</b> 0x3 – <b>No Change Required</b> (i.e, the channel is already in the requested state) 0x4 – <b>Invalid Command</b> (i.e., an attempt to turn on a non-existent channel) 0x5-0xF – values reserved

# Example Query Response

## □ Response to a Query of a 100G/50G ONU

Array Index	Channel	Channel Info Value	Description
0	DS0	0x01	Channel enabled; No action requested
1	US0	0x01	Channel enabled; No action requested
2	DS1	0x01	Channel enabled; No action requested
3	US1	0x04	Channel failure; No action requested
4	DS2	0x01	Channel enabled; No action requested
5	US2	0x00	Channel absent; No action requested
6	DS3	0x02	Channel disabled remotely; No action requested
7	US3	0x00	Channel absent; No action requested

# Example Request and Response

- Request to and Response from a 100G/50G ONU.

## Initial Channel State

Array Index	Ch
0	DS0
1	US0
2	DS1
3	US1
4	DS2
5	US2
6	DS3
7	US3

ChInfo Value	Description
0x01	Channel enabled
0x01	Channel enabled
0x01	Channel enabled
0x04	Channel failure
0x01	Channel enabled
0x00	Channel absent
0x02	Channel disabled remotely
0x00	Channel absent

## Request Message

ChAction Value	Description
0x01	Enable channel
0x01	Enable channel
0x00	No action
0x02	Disable channel
0x02	Disable channel
0x01	Enable channel
0x02	Disable channel
0x02	Disable channel

## Response Message

ChInfo Value	Description
0x31	Channel enabled; No change required
0x31	Channel enabled; No change required
0x01	Channel enabled; No action requested
0x24	Channel failure; Action failed
0x12	Channel disabled remotely; Action succeeded
0x40	Channel absent; Invalid command
0x32	Channel disabled remotely; No change required
0x40	Channel absent; Invalid command



# Channel State Transition Matrix

- Shows channel state change for any initial state and any received command

## Received Command [CCP\_REQUEST(...)]

		Received Command [CCP_REQUEST(...)]		
		0x00 No action	0x01 Disable channel	0x02 Enable channel
Initial Channel State	0x0 Channel absent	0x00 Channel absent; No action requested.	0x40 Channel absent; Invalid command.	0x40 Channel absent; Invalid command.
	0x1 Channel enabled	0x01 Channel enabled; No action requested.	0x12 Channel disabled remotely; Action succeeded.	0x31 Channel enabled; No change required.
	0x2 Remotely disabled	0x02 Channel disabled remotely; No action requested.	0x32 Channel disabled remotely; No change required.	0x11 Channel enabled; Action succeeded.
	0x3 Locally disabled	0x03 Channel disabled locally; No action requested.	0x12 Channel disabled remotely; Action succeeded.	0x11 Channel enabled; Action succeeded.
	0x4 Channel Failure	0x04 Channel failure; No action requested.	0x24 Channel failure; Action failed.	0x24 Channel failure; Action failed.

# Enabling DS Channel -- OLT operation

## To enable a downstream channel $C$ :

- 1) If the OLT's channel  $C$  transmitter is off, turn it on.
- 2) Send ***CCP\_REQUEST(C, enable)*** to each ONU that shall use the downstream channel  $C$  (unicast or multicast on a channel other than  $C$ ).
- 3) After the OLT receives a ***CCP\_RESPONSE(C, success)*** from a given ONU, it may start transmitting data frames, MPCPDUs, OAMPDUs, and CCPDUs to this ONU on channel  $C$ .
  - Enabling a channel enables it for all LLIDs registered in the given ONU.
- 4) If the OLT does not receive the ***CCP\_RESPONSE(C, success)*** CCPDU from an ONU within a ***CcpTimeout*** interval, resend the ***CCP\_REQUEST(...)*** to this ONU at most ***CcpMaxRetry*** times.
  - ***CcpTimeout*** and ***CcpMaxRetry*** values are TBD
  - Failure handling: Issue NMS Alarm, deregister ONU?

# Enabling DS Channel -- ONU operation

- When ONU receives **CCP\_REQUEST (C, enable)**, it does the following:
  - 1) Turns on the receiver for downstream channel **C**.
  - 2) Transmits **CCP\_RESPONSE (C, succes )** CCPDU to the OLT using any of the enabled upstream channels (depending on PLID grant).

# Disabling DS Channel -- OLT operation

## To disable a downstream channel $C$ :

- 1) Stop transmitting data frames, MPCPDUs, OAMPDUs, and CCPDUs to all or some ONUs on channel  $C$ .
    - An envelope in progress can be terminated by transmitting another envelope header with envelope length = 0.
  - 2) Send ***CCP\_REQUEST(C, disable)*** to each ONU that shall stop using the downstream channel  $C$  (unicast/multicast on any channel including channel  $C$ ).
  - 3) If the OLT does not receive the ***CCP\_RESPONSE(C, success)*** CCPDU from an ONU within a ***CcpTimeout*** interval, resend the ***CCP\_REQUEST(...)*** to this ONU at most ***CcpMaxRetry*** times.
    - ***CcpTimeout*** and ***CcpMaxRetry*** values are TBD
    - Failure handling: Issue NMS Alarm, deregister ONU?
- ❑ Optional: Turn off the transmitter for channel  $C$ .

# Disabling DS Channel -- ONU operation

- When ONU receives **CCP\_REQUEST (C, disable)**, it does the following:
  - 1) Turns off the receiver for downstream channel **C**.
  - 2) Places **CCP\_RESPONSE(C, success)** CCPDU into the upstream PLID queue

# Enabling US Channel -- OLT operation

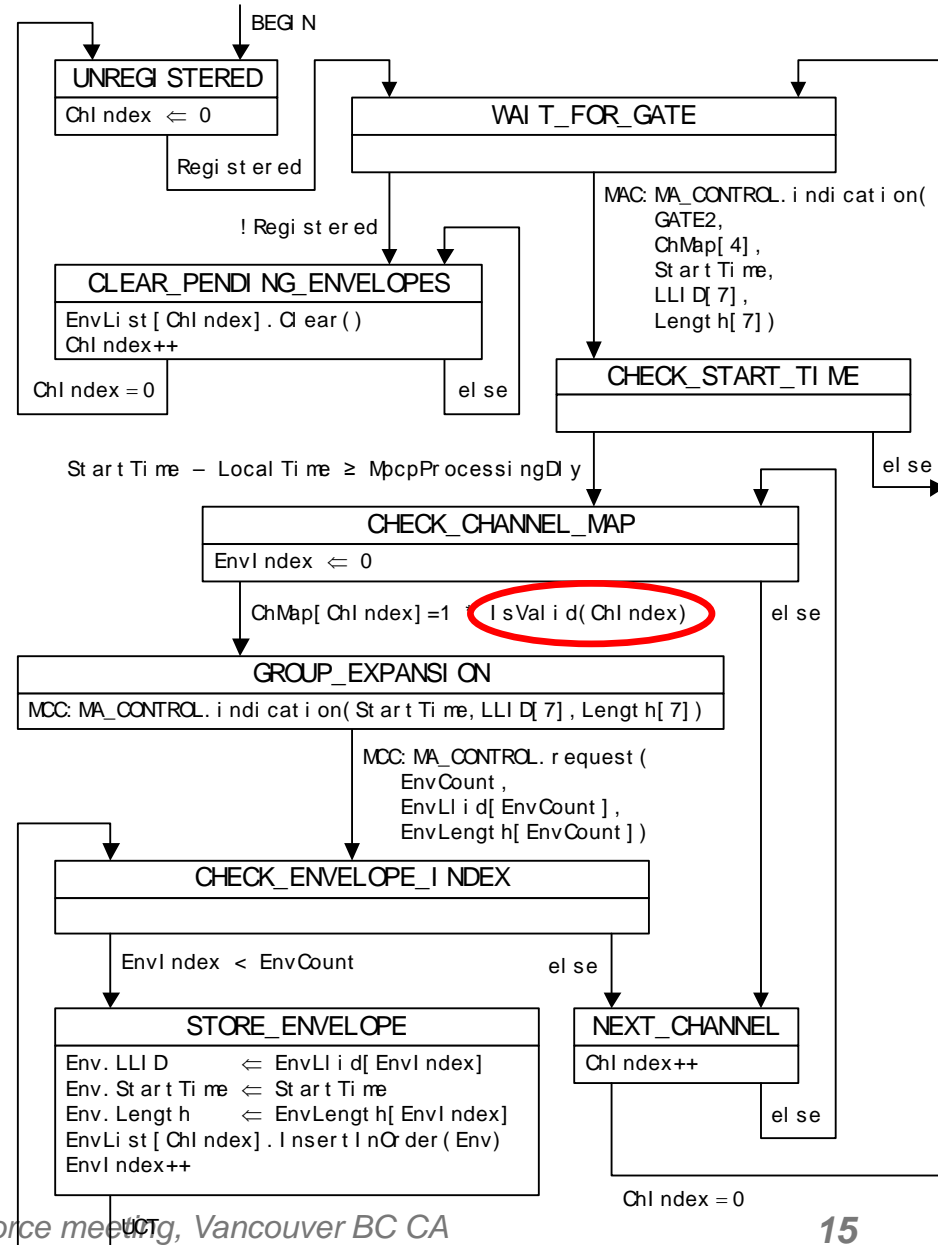
## To enable an upstream channel $C$ :

- 1) If the OLT's channel  $C$  receiver is off, turn it on
- 2) Send ***CCP\_REQUEST(C, enable)*** to each ONU that shall use the upstream channel  $C$  (use unicast or multicast PLID).
- 3) After receiving the ***CCP\_RESPONSE(C, success)*** message, from an ONU, OLT may start granting this ONU on channel  $C$ .
- 4) If the OLT does not receive the ***CCP\_RESPONSE(C, success)*** from some of the ONUs within a ***CcpTimeout*** interval, resend the ***CCP\_REQUEST(C, enable)*** to the these ONU(s) at most ***CcpMaxRetry*** times.

# Enabling US Channel -- ONU operation

When ONU receives **CCP\_REQUEST(C, enable)**, it does the following:

- 1) Enables the transmitter for upstream channel **C**.
- 2) Starts accepting GATEs for channel **C** (i.e., function **IsValid(C)** in GATE Reception SD starts returning true).
- 3) Places **CCP\_RESPONSE(C, success)** CCPDU into the upstream PLID queue.



# Disabling US Channel -- OLT operation

## To disable an upstream channel C:

- 1) Send **CCP\_REQUEST(C, *disable*)** to each ONU that shall stop using the upstream channel C (use unicast or multicast PLID).
- 2) If the OLT does not receive the **CCP\_RESPONSE(...)** message from any ONUs within a **CcpTimeout** interval, resend the **CCP\_REQUEST(C, *disable*)** to the these ONU(s) at most **CcpMaxRetry** times
  - **CcpTimeout** and **CcpMaxRetry** values are TBD
  - Failure handling: Issue NMS Alarm, deregister ONU?
- 3) Optional: Turn off the receiver for channel C.



# Disabling US Channel -- ONU operation

- When ONU receives **CCP\_REQUEST** (**C**, **disable**), it does the following:
  - 1) Purges all pending envelope grants for channel **C** (i.e., calls **EnvList[C].Clear()**, see GATE Reception SD)
  - 2) If there is an active envelope being transmitted on channel **C**, ONU can take one of two actions:
    - a. Complete the transmission of the entire active envelope.
    - b. Terminate the envelope immediately after the transmission of the current frame has completed. The envelope is terminated by inserting another envelope header with length = 0.
  - 3) After completing the transmission of the active envelope (if any) on channel **C**, the ONU turns off the transmitter for this channel.
  - 4) ONU places **CCP\_RESPONSE**(**C**, **success**) CCPDU into the upstream PLID queue

# Small(ish) things to decide

- ❑ Timeout interval (***CcpTimeout***)
  - The same as the normal MPCP timeout – 1 sec?
- ❑ Number of retransmissions (***CcpMaxRetry***)
  - 3 as in SW download?
- ❑ Fool-proof operation
  - ONUs do not turn off the last receiver (and the last transmitter?) even if instructed by the OLT by mistake.
- ❑ ONU boot options
  - **Option 1:**
    - On power-up, only lane 0 is enabled (upstream and downstream);
    - Wait for explicit ***CCP\_REQUEST(... enable)*** messages for other lanes.
  - **Option 2:**
    - On power-up, all supported upstream and downstream lanes are enabled;
    - ONU may send/receive on all supported lanes (2 lanes @ 50G, 4 lanes @ 100G)
  - **Option 3:**
    - Extend **REGISTER\_REQ** MPCPDU to show ONU's supported lanes (capabilities)
    - Extend **REGISTER** MPCPDU to tell ONU which US and DS lanes shall be activated

# Thank You