ONU Auto Discovery

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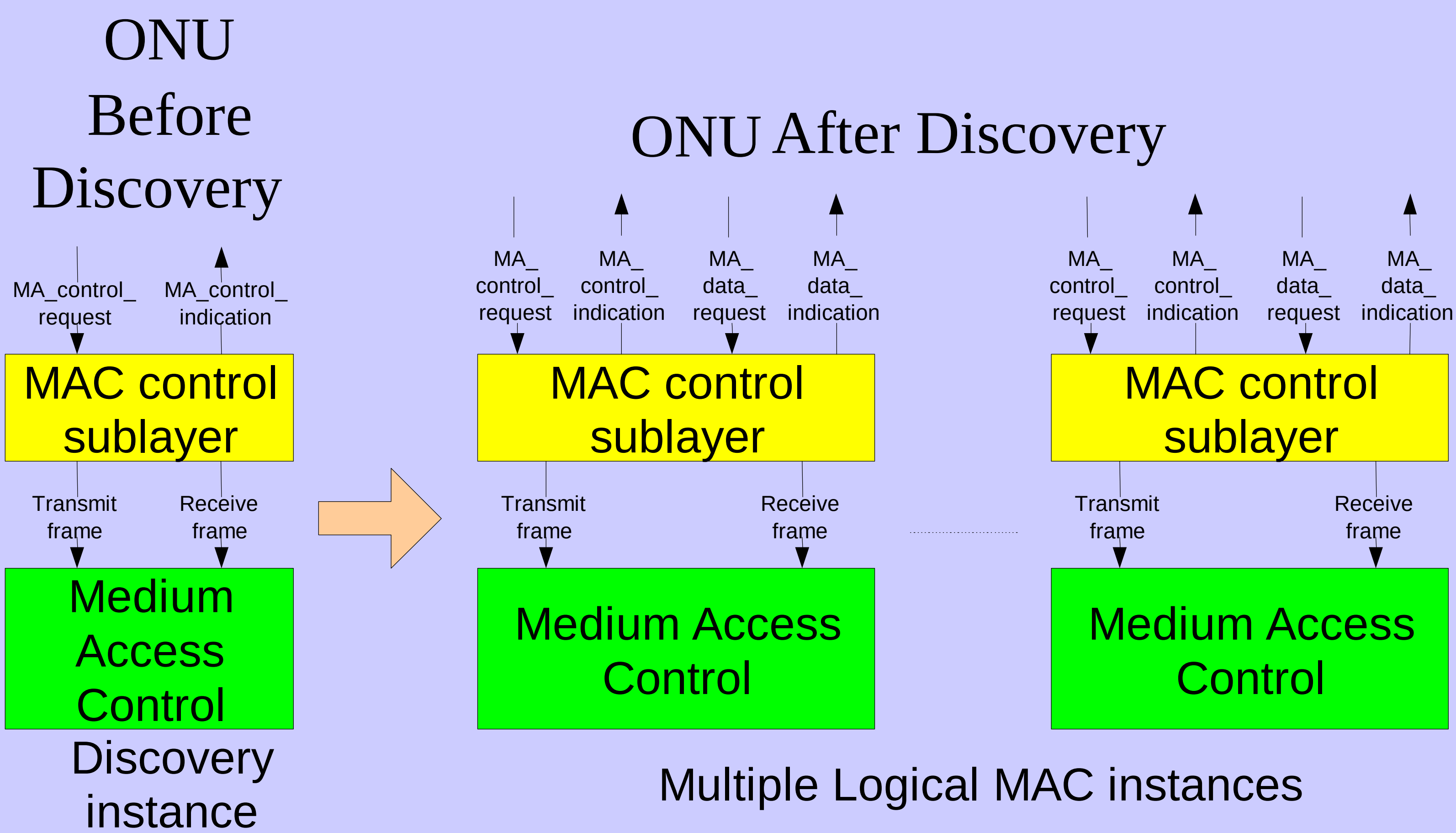
Summary and Status

- **This Presentation is a "Freshened" version from the last EFM meeting (Gaglianello_1_0302.pdf)**
- **Additions are in RED.**
  - Terminology has been updated to align with recent presentations.
  - Contention Graph has been replaced with correct one.
- **Major pending issues that still need resolving are:**
  - Number of Logical MAC's per ONU
  - Discovery Contention Resolution Scheme
  - Dynamic Registration of Logical MAC's
  - Format of PON-Tags ==> LLID
  - Should LMAC traffic Be Coalesced into single Gate period

Discovery Process Conceptual View



Problem Description

- **Harmonizing a new ONU into a PON**
  - Knowing it's there
  - Knowing who it is
  - Negotiating System parameters such as:
    - Determining RTT
    - Laser turn-on/off times
    - Number of Logical MAC's per ONU
      - Can OLT limit LMAC's to one or some small number?
  - Assigning PON Tags (LLID's) for LMACs
    - (If more than one allowed)
  - Assigning/receiving Group-id's for ONU's

Discovery and Logical MACs

- **ONU's can have multiple logical instances, called Logical MACs (as shown in conceptual diagram).**
  - The use of these multiple instances is possibly out of scope?
- **Various Logical MAC Types (P2PE, SE, SCB) are being defined**
  - P2PE and / or SE MACs are required for 802.1d compliance
  - SCB is Native mode of EPON
- **During Discovery, At Least One LMAC is registered**
  - Multiple LMACs can be assigned during registration
  - Support for dynamic registration of Logical MACs after discovery is under consideration.
  - A minimum BW must be allocated for each LMAC
    - This BW is necessary for Gate/Report traffic

ONU Behavior During Discovery

- **At Power-up / Reset, an ONU enters Discovery State:**
  - Undiscovered ONU's Await Reception of "Discovery Gate" message from OLT
- **A discovery/default LLID (??) is used following ONU power-up/reset**
  - Single Copy Broadcast (SCB) can use the same default LLID value
- **Unregistered ONU responds only:**
  - If received message's LLID matches discovery/default LLID and the grant type is discovery

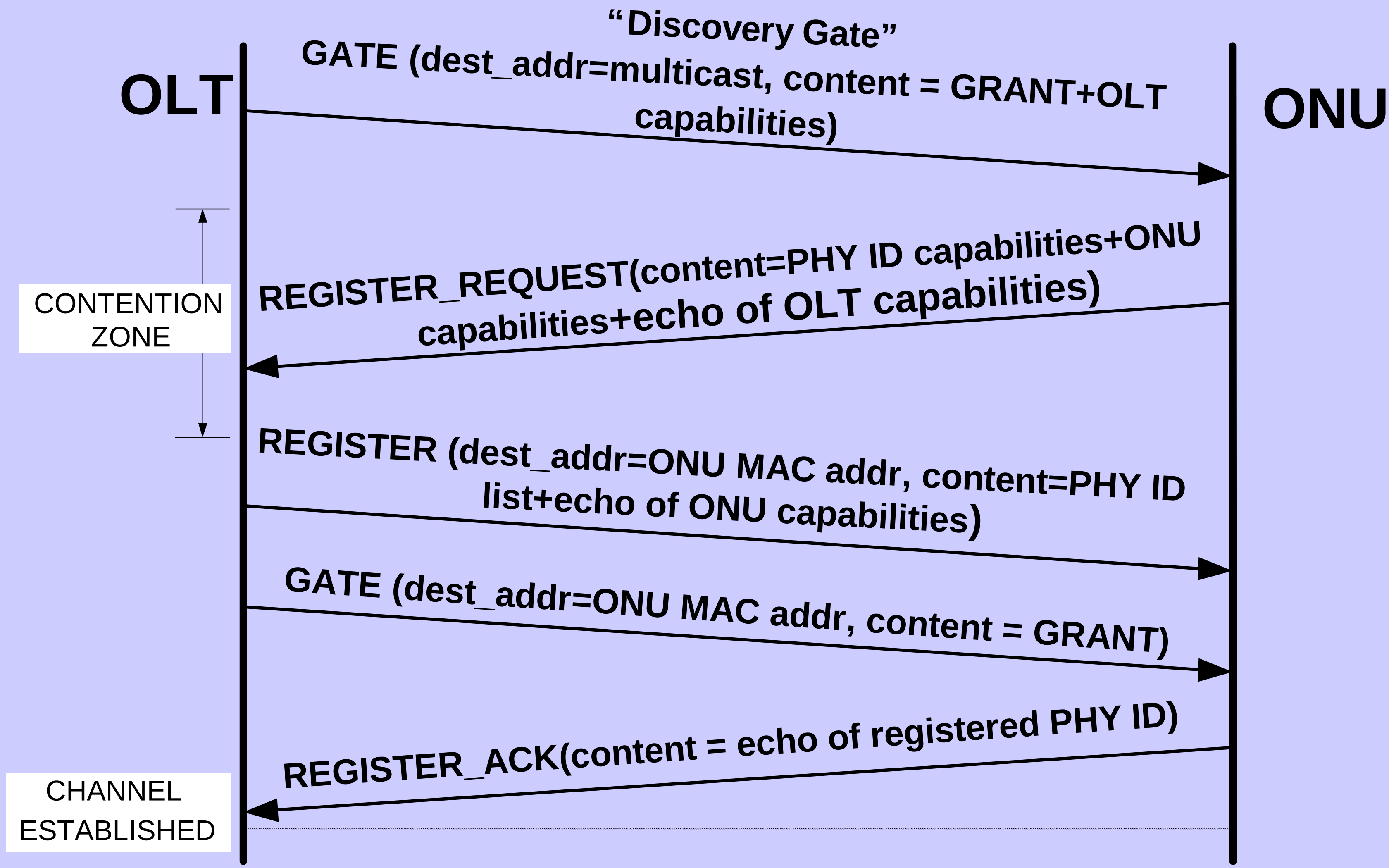
OLT Behavior During Discovery

- **OLT Must Periodically Reserve Time Periods for Discovery**
  - This Discovery Window must be large enough to handle maximum reach of 20 Km (200 usecs RTD)
    - The Frequency of discovery windows can be chosen for desired overhead
- **Since Undiscovered ONU Addresses are Unknown**
  - “Discovery Gates” are broadcast to all ONU’s
  - A globally assigned, link constrained, multicast MAC address should be defined (Request one from 802.xx)
- **It is also possible to send “Discovery Gates” using unicast MAC addresses if MAC addresses are known, perhaps through a Provisioning interface**

Discovery Protocol

- **Four MAC control messages implement the protocol**
  - **"Discovery GATE": Creates transmission opportunity for undiscovered devices**
  - **Register_Request: ONU response to "Discovery Gate"**
  - **Register: OLT response to Register_Request**
  - **Register_Ack: ONU response to Register**
- **ONU's can wake-up Simultaneously**
  - **Protocol must deal with contention in Register_Requests**
- **Multiple ONU's can potentially be registered within single Discovery time period**

Discovery Sequence Summary



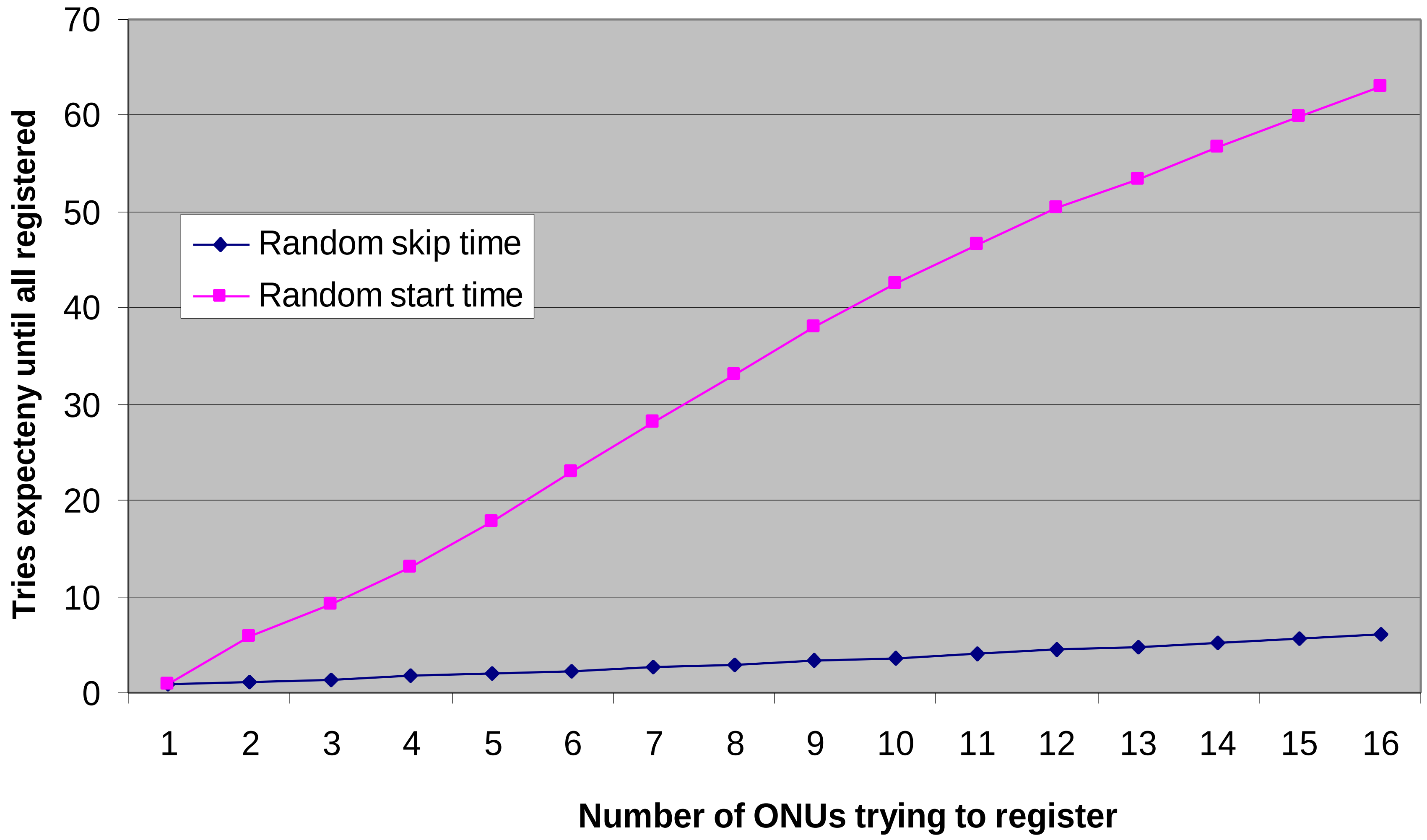
Sequence – Failure Modes

- **OLT assumes an ONU is unregistered if:**
  - REGISTER_ACK message is not received at the first grant opportunity
  - ONU responds to “Discovery GATE” messages
- **ONU assumes it is unregistered if:**
  - After sending a REGISTER_REQUEST message, it receives a “Discovery GATE” before receiving a REGISTER message
  - After sending a REGISTER_ACK message, it receives a “Discovery GATE” before receiving a “Normal GATE” message

Resolving Discovery Contention

- **Some sort of randomization must be applied to ONU Register messages to minimize collisions**
- **Two options are being investigated:**
  - ONU skips (ignores) random number of discovery windows if previous ONU response wasn't acknowledged
    - Graph represents exponentially growing backoff scenario
  - ONU responds to every discovery opportunity using a random delay within the discovery window
    - Graph represents the scenario in which the window size allows up to 8 ONUs to be registered within a single discovery window
    - Discovery window size is fixed for entire graph

Contention Resolution Comparison



Comparison of two schemes

- **Compare case where 8 ONU's are registering simultaneously**
  - For Random Discovery Gate Time Case:
    - It takes 3 discovery windows to register all 8 ONU's
      - For 0.1 sec discovery window rate ==> 0.3 seconds
      - For 1 sec discovery window rate ==> 3 seconds
  - For Random Discovery Gate Skip Case:
    - It takes 26 discovery windows to register all 8 ONU's
      - For 0.1 sec discovery window rate ==> 2.6 seconds
      - For 1 sec discovery window rate ==> 26 seconds

Protocol Implications on Link Efficiency

- **Link efficiency is impacted by:**
  - **Frequency of discovery windows**
    - Link efficiency goes down with more frequent discovery windows
      - Frequency also impacts length of time-out for error recovery
  - **Length of discovery windows**
    - Larger windows allow more ONUs to be registered per window
    - Link efficiency goes down with larger discovery windows
  - **Values for these parameters are left up to system implementers/designers**

Protocol Implications on Link Efficiency: An Example

- For Max Reach, 200 usecs RTD, window must be 200 usecs plus enough time for:
  - single register_request message (random “discovery gate” skip case)
  - several register_request messages (random start time case)
- For 64 byte messages: approximately 2 usecs link occupancy
  - 1 usec for message, 1 usec for (guard band + Laser turn-on/off).
- For
  - random “discovery gate” skip case: use 2 usecs
  - random start time case: use (16 * 2 usecs) = 32 usecs
- This totals:
  - For random “discovery gate” skip case: 202 usecs
  - For random start time case: 232 usecs

Example Continued

The Overhead for Discovery for various Window Rates:

Rate	Random “Discovery Gate” skip	Random start time
0.1 second:	0.202%	0.232%
1 second:	0.0202 %	0.0232 %
5 seconds:	0.00404%	0.00464%
10 seconds:	0.00202%	0.00232%

– For rates 1 second and above, these overheads appear negligible
– Both schemes overhead is dominated by RTD for Maximum reach

Logical MAC Implications on Link Efficiency

- **Link efficiency is impacted by Number of LMACs in a PON due to the need for Guard-Bands separating traffic from different ONUs / LMACs.**
  - **Assume:**
    - **1 msec "Gate-Report Cycles"**
    - **1 usec Guard-Band**
    - **64 ONU's**
    - **1, 8, or 16 LMACs per ONU.**
    - LMACs are treated as independent ONU's
- **Total time taken up by Guard-Bands is:**
    - 1000 * 1e-6 * 64 * 1 = 64 msecs ==> 6.4 % overhead
    - 1000 * 1e-6 * 64 * 8 = 512 msecs ==> 51.2 % overhead
    - 1000 * 1e-6 * 64 * 16 = 1024 msecs ==> 102.4 % overhead
- **Some form of coalescing LMAC traffic into single transmission Gate period should be explored.**

Unresolved Issues for ONU Auto Discovery

- Assignment of LLID's or use existing ONU MAC addresses
  - **Will not use the MAC address value in the LLID**
- Support for Dynamic registration of individual Logical MACs
- Alternative ways to Assign BW to Logical MACs
  - **Treat LMACs as complete independent ONU's which allows OLT to designate bandwidth**
  - **Let ONU request Total BW needed by all LMACs**
- Discovery Contention Resolution Scheme.
  - **We Still Need to choose one**
- Number of Logical MACs allowed of each type (P2PE, SCB, SE)
  - **Does one only need to worry about total LMACs per ONU, not types?**
- Static provisioning of MAC addresses versus Discovery protocol
  - **Static provisioning Is always an option but does not obviate the need for a Plug-and-Play discovery protocol definition.**
- Explore ways to Coalesce all LMAC traffic from a given ONU into single gate period to save guard-band overhead.