



The **Broadband** Company

Access Control in Ethernet PON

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July 9, 2001

PON: Nature of the Beast



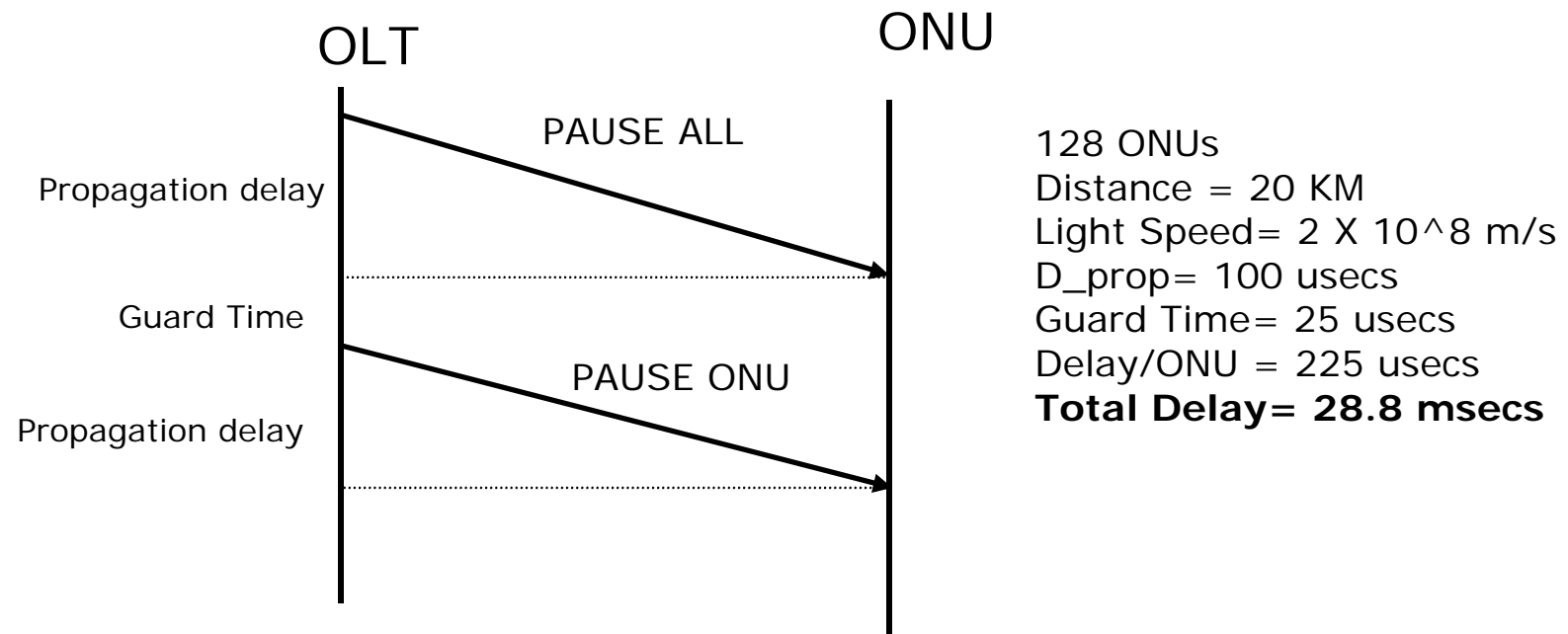
- **PON Features:** 1 Gbps, Shared US, Broadcast DS, 10 Km, >16 ONUs, Ethernet Framing and Control Proposed.
 - Master-Slave architecture
 - Shared US at 1 Gbps requires more control/ no contention
 - Economics of PON become more attractive with higher ONUs/PON. (e.g. 128 ONUs)
- **Traffic Mix with different QoS requirements**
 - Jitter Sensitive Voice
 - Delay/loss Sensitive Data
 - Best effort data

Master/Slave + More Users Sharing BW + QoS Services => Need MAC Capabilities beyond P-P Ethernet or CSMA/CD

Limitations of TDM/PAUSE Control



- Use of the PAUSE MAC Control Frame to periodically turn off all ONUs except one results in inordinate delay.

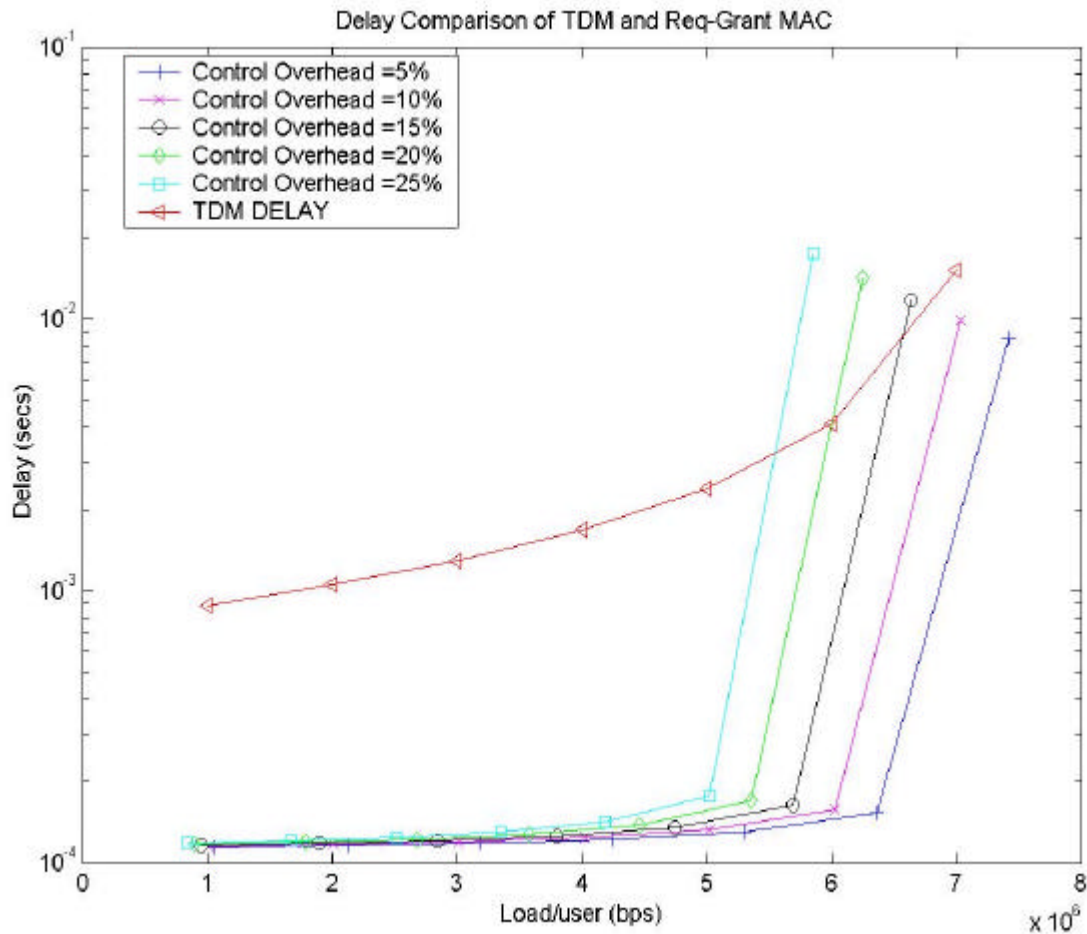


Limitations of TDM/PAUSE Control



- Large Latency (> 28 msec) between BW grants to any ONU, irrespective of size of grant.
- Uniform and fixed length transmission opportunities cause significant wastage of bandwidth due to:
 - Idle times of ONUs
 - No statistical Mux. gains obtained from burst by burst grant allocation.
- No differentiation among services based on QoS.
- BW wastage and additional latency resulting from guard bands to compensate for unknown ONU-OLT distance and timing offsets.
 - Gets worse with increasing distance from splitter.

TDMA vs Request-Grant



Link Speed= 1 GBps
of ONUs = 128
Propagation delay= 100 usecs
Load= 1-7 MBps/ONU

E-PON MAC Proposal



- To support services with QoS guarantees in a BW efficient manner, the MAC must provide:
 - **Initial Registration Opportunity**: Allow ONUs to come online, communicate address, distance and power and device capabilities
 - **Periodic Ranging**: Periodic messaging between OLT-ONU to correct timing and, if necessary, power offsets.
 - **BW Requests**: Upstream ONU request to change BW grants based on traffic load at ONU
 - **BW Grants**: Downstream message from OLT allocating transmission times to ONUs. OLT also decides if transmission opportunity is for data or control.

MAC Control Frames



- Additional MAC Control Frames will need to be defined to implement the additional functions.
 - Initial Registration Frame
 - Ranging Request Frame
 - Ranging Response Frame
 - BW Request Frame
 - BW Grant Frame

MAC Control Frames



- The frames can conform to the standard Ethernet MAC Control Frame Format, except the BW Grant Frame will need to be > 64 bytes.
 - 6 octets of Source and 6 octets Destination address.
 - Type field of 2 octets to indicate MAC Control Frame.
 - 2 Octets to specify MAC Control OPCODE: Define 5 new OpCodes for the 5 frames.
 - OpCode Specific Data: For all control frames except BW Grant, payload < 44 bytes. BW Grants require > 44 bytes for reduced latency and improved utilization.

Initial Registration



- Two step process:
 - OLT provides each ONU with a dedicated US transmission opportunity to transmit a Initial Registration MAC Control Frame. Highly efficient during initialization and outage.
 - Once a large number of ONUs are registered, OLT provides periodically a transmission opportunity for Initial Reg. Control frames.
 - Multicast addressing: Allow any ONU to use Tx. Opportunity
 - ALOHA random access: Stabilization techniques include binary exponential back-off as in 802.3 CSMA/CD.
 - Good Throughput as few ONUs in contention mode

Periodic Ranging



- OLT transmits a periodic Ranging Request MAC Control Frame on DS to each specific ONU's address.
- OLT provides ONU with a dedicated US transmission opportunity (in a BW Grant Frame) to send a Ranging Response MAC control frame.
- Ranging Response frame contains power and timing offset information specific to the ONU.

BW Grant MAC Control Frame



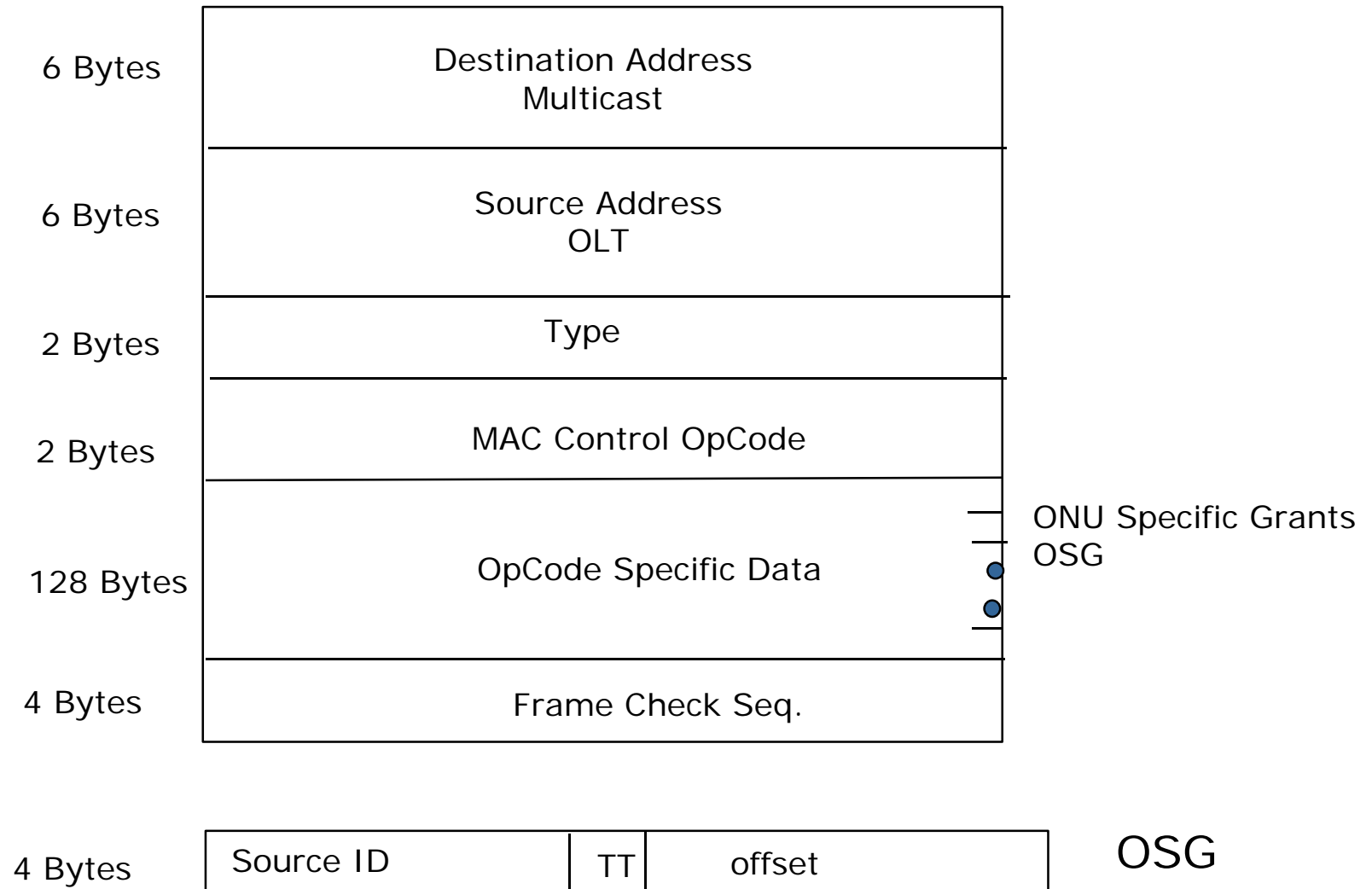
- **MAC level “timing” concept in request-grant process.**
- **BW Grant Frame control the US activity for a specified length of time.**
 - Which ONU transmits and for how long ?
 - What kind of packets transmitted by ONU ? E.g. Initial Reg., Ranging, Data etc.
- **Define the Traffic Type fields** : This field in the BW Grant message determines what packets the ONU can transmit during its assigned opportunity.
 - 00: Initial Registration Control Frame
 - 01: Data Request Control Frame
 - 10 :Ranging Control Frame
 - 11: Data

BW Grant MAC Control Frame



- **Define a mapping from the ONU specific MAC address to a 16 Bit Source ID. (5 suffices for 32 ONUs).**
- **Multicast destination Addressing in the BW Grant Frame**
- **In the opcode-specific data the fields consist of the following:**
 - 32 Bit Grant Start Time
 - 32 Bit Grant End Time
 - 32 Bits of data defining single grant to an ONU.
 - 16 Bits of Source ID
 - 2 Bits of Traffic Type
 - 14 bits of Time Offset: Time within the Grant Interval at which this particular grant is activated.
- **With a limit of 44 bytes on opcode specific data only 9 grants can be given /frame. With > 32 ONUs and different traffic types, highly desirable to extend data to at least 128 bytes**
 - Alternately, keep limits on MAC frames and send multiple BW Grant Frames.

BW Grant Control Frame



Advantages of BW Grants



- **The BW Grants cover variable lengths of time and contains grants to multiple ONUs in a single message.**
 - Reduced latency and protocol overhead Burst by burst bandwidth allocation resulting in Statistical Multiplexing = > lower delay and higher utilization.
 - Differentiation among different traffic types e.g. voice and best effort data.
 - Prioritization of services and ONUs
 - Transmission Opportunities for Initial registration and ranging in same message.
 - High degree of flexibility in BW management
- **The BW Grant Control Frame construction algorithms are vendor specific**
 - Interfaces to be developed between MAC and higher layers to enable MAC building BW Grants from OSGs

Summary



- The PAUSE frame based TDM access control has prohibitive delay penalty, lacks flexibility and is inefficient.
- Access Control in shared media PON requires initial registration, ranging and bandwidth request-grant mechanisms.
- New functions can be implemented by defining MAC Control Frames.
- Concept of MAC level timing and control of transmission opportunities through OLT defined BW Grant Frame affords great efficiency and flexibility.