Ethernet in the First Mile Operations, Administration and Maintenance (OAM) – A Tutorial

Overview

Ethernet is well on its way to becoming a preferred broadband access technology between carrier and customer networks. It will save carriers a fortune in capital expenditures and help them deliver many times the times the bandwidth that they can today. But as its usage continues to grow in public networks, Ethernet must, as a Layer 2 protocol, be able to report network behavior at Layer 2. Predecessor carrier technologies such as SONET and ATM have long had this ability; since these protocols are still used heavily in the carrier environment, the Operations, Administration and Maintenance (OAM) designed for Ethernet must be aware of them and able to coexist with their management solutions.

OAM refers to the tools and utilities to install, monitor and troubleshoot a network, helping carriers run their networks more efficiently. Without management features to monitor and troubleshoot the network, the only alternative is an expensive, time consuming truck roll, sending technicians into the field to diagnose and resolve problems on location

Ethernet Issues in Enterprise versus Carrier Environments

In the enterprise, Ethernet links and networks have been managed via Simple Network Management Protocol (SNMP). Although SNMP provides a very flexible management solution, it is not always efficient and is sometimes inadequate to the task. First, using SNMP assumes that the underlying network is operational because SNMP relies on IP connectivity; however, you need management functionality even more when the underlying network is non-operational. Second, SNMP assumes every device is IP accessible. This requires provisioning IP on every device and instituting an IP overlay network even if the ultimate end-user service is an Ethernet service. This is impractical in a carrier environment.

For these reasons, carriers look for management capabilities at every layer of the network. The Ethernet layer has not traditionally offered inherent management capabilities, so the 802.3ah OAM capabilities are a first step at providing them. Note that these capabilities are not intended to replace SNMP as a management utilities, but are there to enhance it.

802.3ah OAM is applicable to all of the emerging EFM technologies:

- Ethernet in the First Mile over Copper (EFMC)
- Ethernet in the First Mile over Fiber (EFMF)
- Ethernet in the First Mile using Passive Optical Networks (EPON)

Network operators have the freedom to choose and mix the three EFM topologies (copper, fiber, or passive optical networking) based on their business models, network architectures, and subscriber needs. They can build or upgrade their access networks with multiple EFM topologies and manage them with a common set of tools and OAM procedures.

Additionally, EFM OAM is backwards compatible with any existing full-duplex Ethernet technology, and can be implemented on non-EFM Ethernet links. This compatibility was facilitated by the decision to use standard Ethernet frames as the transport mechanism for management information.

Main Features of OAM for EFM

Although EFM OAM is compatible with any Ethernet technology and can be used on even small campus networks, it is geared towards reducing expenditures for first mile operators. The main functions provided are:

- Link performance monitoring
- Fault detection and fault signaling
- Loopback testing

As Figure 1 shows, OAM is an optional layer implemented in the data link layer between the MAC and LLC sub-layers.

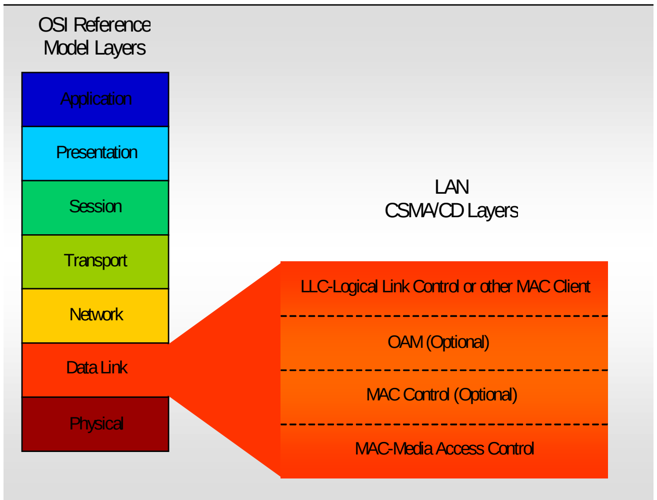

Figure 1: OSI Layers, including OAM support in Layer 2

Since the OAM portion of 802.3ah is optional, implementers can use proprietary or existing management solutions if they choose. If they do implement OAM, they can do so in either hardware (for performance) or software (for flexibility). Also, OAM can be deployed for part of a system and does not need to be implemented system-wide. OAM can be implemented on any full duplex point to point (P2P) link or emulated P2P link. Finally, OAM can be used simultaneously with 802.3x MAC flow control PAUSE function, although when doing so PAUSE inhibits all traffic, including OAM Protocol Data Units (OAMPDUs).

There is one caveat with the OAM support on gigabit links: the unidirectional fault signaling support in OAM is mutually exclusive with the auto negotiation capabilities of Gigabit Ethernet (802.3z); thus, 802.3z auto negotiation must be disabled for fault signaling to be sent over unidirectional links

Note: Although the following functions are often associated with carrier management, they are not implemented in 802.3ah:

- Station management
- Protection switching
- Provisioning and bandwidth allocation
- Speed/duplex negotiation
- End to end OAM communication

These functions are either outside the scope of 802.3 or were not deemed suitable for Ethernet OAM.

The OAM Protocol

The operation of OAM on an Ethernet interface does not adversely affect data traffic as OAM is a *slow protocol* with very limited bandwidth potential, and it is not required for normal link operation. This slow protocol can be implemented in hardware or software, ensuring media independence. By utilizing the slow protocol MAC address, OAM frames are intercepted by the MAC sublayer and cannot propagate across multiple hops in an Ethernet network. This implementation assures that OAMPDUs only affect the operation of the OAM protocol itself and not user data traffic.

The facets of the OAM protocol discussed in this section are:

– *Discovery:* how OAM enabled devices discover each other and notify one another of their capabilitites
– *Link monitoring:* attributes and status information for Ethernet links
– *Remote fault detection:* how downed or compromised links are detected and handled
– *Remote loopback:* the testing of segments and links by sending test frames through them
– *MIB variable retrieval:* getting information from a management information base
– *Organization specific enhancements:* the provision for vendor specific enhancements to the protocol

This functionality is largely enabled through a variety of specialized OAMPDUs, which are discussed in the next section.

Discovery

Discovery, the first phase of 802.3ah OAM protocol, identifies the devices in the network along with their OAM capabilities. Discovery relies on the Information OAMPDUs (discussed below). During discovery, the following information is advertised in TLVs within periodic Information OAMPDUs:

– *OAM configuration (capabilities):* Advertises the capabilities of the local OAM entity. With this information, a peer can determine what functions are supported and accessible, such as loopback capability.

- *OAM mode*: This is conveyed to the remote OAM entity. The mode can be either *active* or *passive*, and can also be used to determine device functionality
- *OAMPDU configuration:* This includes maximum OAMPDU size to receipt and delivery. This information along with the rate limiting of ten frames/sec can be used to limit the bandwidth allocated to OAM traffic.
- *Platform identity:* The platform identity is a combination of an Organization Unique Identifier (OUI) and 32-bits of vendor specific information. OUI allocation is controlled by the IEEE and OUIs are typically the first three bytes of a MAC address.

Discovery includes an optional phase where the local station can accept or reject the configuration of the peer OAM entity. For example, a node may require that its partner support loopback capability to be accepted into the management network. These policy decisions and not specified in the standard.

Timers

The protocol is driven by two timers, one which controls how frequently OAMPDUs must be sent, and one which controls how frequently OAMPDUs must be received to maintain the adjacency between devices.

OAMPDUs must be sent at least once per second. When there is no other OAMPDU to be sent within a one second window, an Information OAMPDU must be sent. Similarly, OAMPDUs must be received at least once every 5 seconds . When the timer expires, the local OAM entity assumes that the remote OAM entity is non-operational and resets its state machine.

Flags

Included in every OAMPDU is a flags field, which includes, among other information, the status of the discovery process. There status could be one of three possible values:

- *Discovering:* A discovery is in progress.
- *Stable:* This means that the discovery has completed. Once knowing this, the remote OAM entity can start sending any type of OAMPDU.
- *Unsatisfied:* When there are mismatches in OAM configuration that prevents OAM from finishing discovery, then the discovery process is unsatisfied and cannot continue.

Process Overview

The discovery process allows a local Data Terminating Entity (DTE) to detect OAM on a remote DTE. Once OAM support is detected, both ends of the link exchange state and configuration information (such as mode, PDU size, loopback support, etc.). If both DTEs are satisfied with the settings, OAM is enabled on the link. However, the loss of a link or a failure to receive OAMPDUs for five seconds may cause the discovery process to restart.

DTEs may either be in active or passive mode. Active mode DTEs instigate OAM communications and can issue queries and commands to a remote device. Passive mode DTEs generally wait for the peer device to instigate OAM communications and respond to, but do not instigate, commands and queries. Rules for what DTEs in active or passive mode can do are discussed in the following sections.

Rules for Active

A DTE in **Active** mode:

- Initiates the OAM Discovery process
- Sends Information PDUs
- May send Event Notification PDUs
- May send Variable Request/Response PDUs
- May send Loopback Control PDUs

Exceptions to this are:

- Does not respond to Variable Request PDUs from DTEs in Passive mode
- Does not react to Loopback Control PDUs from DTEs in Passive mode
- They can identify the platforms
- You can make policy decisions on whether to allow peering (for instance, this might determine whether you would support loopback)

Rules for Passive

A DTE in **Passive** mode:

- Waits for the remote device to initiate the Discovery process
- Sends Information PDUs
- May send Event Notification PDUs
- May respond to Variable Request PDUs
- May react to received Loopback Control PDUs
- Is not permitted to send Variable Request or Loopback Control OAMPDUs

Link Monitoring

Link monitoring tools are for detecting and indicating link faults under a variety of circumstances. Link monitoring uses the Event Notification OAMPDU, and sends events to the remote OAM entity when there are problems detected on the link. The error events defined in the standard are:

- Errored Symbol Period (errored symbols per second): the number of symbol errors that occurred during a specified period exceeded a threshold. These are coding symbol errors (for example, a violation of 4B/5B coding).
- Errored Frame (errored frames per second): the number of frame errors detected during a specified period exceeded a threshold.
- Errored Frame Period (errored frames per N frames): the number of frame errors within the last N frames has exceeded a threshold.
- Errored Frame Seconds Summary (errored secs per M seconds): the number of errored seconds (one second intervals with at least one frame error) within the last M seconds has exceeded a threshold.

Since 802.3ah OAM does not provide a guaranteed delivery of any OAMPDU, the Event Notification OAMPDU (discussed in the OAMPDU section below) can be sent multiple times to reduce the probability of a lost notification. A sequence number is used to recognize duplicate events.

Remote Failure Indication

Faults in Ethernet are difficult to detect, especially when caused by slowly deteriorating quality rather than completely disconnected links. A flag in the OAMPDU allows an OAM entity to convey failure conditions to its peer. The failure conditions are as follows:

- Link Fault: Loss of signal is detected by the receiver; this is sent once per second in the Information OAMPDU
- Dying Gasp: Unrecoverable condition (e.g., a power failure) has occurred; these may be sent immediately and continuously
- Critical Event: Unspecified critical event has occurred; these may also be sent immediately and continuously

Conditions for dying gasp and critical event are left to implementers. The unrecoverable condition for dying gasp could be interpreted as any condition that causes the equipment to restart. The link fault applies only when the physical sub-layer is capable of independent transmit and receive. When a link is not receiving a signal from its peer at the physical layer (for example, if the peer's laser was malfunctioning), the local entity can set this flag to let the peer know that its transmit path is inoperable.

The above conditions are severe, thus when they are set in the flag, the OAMPDU is not subject to normal rate limiting policy.

Remote Loopback

An OAM entity can put its remote entity into loopback mode using a loopback control OAMPDU. This helps you ensure the quality of links during installation or when troubleshooting. In loopback mode, every frame received is transmitted back on that same port except for OAMPDUs and pause frames. The periodic exchange of OAMPDUs must continue during loopback state to maintain the OAM session.

The loopback command is acknowledged by responding with an Information OAMPDU with the loopback state indicated in the state field. This allows you, for instance, to estimate if a network segment can satisfy an SLA. You can test delay, jitter and throughput (implementations for these tests will be vendor specific).

MIB Variable Retrieval

A MIB (Management Information Base) is a database of manageable variables; OAM provides a read-only access remote MIB variables limited to a specific MIB branch and leaf. The request-response nature of variable retrieval can also be used to implement measurement functions for estimating the link capability to support an SLA (similar to IP ping for measuring delay, jitter and throughput). This assumes that the time accessing the variable is negligible compared to propagation and queuing delay of the request and response.

Note: Only the retrieval of MIB variables is supported in 802.3ah OAM; you cannot set MIB variables.

Organization Specific Extensions

Organization extensions are available through organization specific OAMPDUs and organization specific TLVs within the standard OAMPDUs. These extensions carry an Organization Unique Identifier (OUI) in the frame to indicate the designator of the extension.

Vendors can use these extensions to implement extra events, to include additional information during discovery, or even to add a completely proprietary OAM protocol.

OAM Protocol Data Units

As stated above, the architecture of the OAM protocol is based on OAM protocol data units (OAMPDU), which are exchanged between two Ethernet ports. OAMPDUs are normal Ethernet frames that use a specific multicast destination address and EtherType.

Characteristics of OAMPDUs, and the OAMPDUs themselves, are discussed in the following sections.

OAMPDU Characteristics

This section discusses the unidirectional nature of OAMPDUs, as well as the size/rates of OAMPDUs and the Flags fields.

Unidirectional Nature

Ethernet has historically had the behavior that when one direction of communication fails on a link, the other direction of the link is taken down. This was done to eliminate the possibility of one-way transmissions, so that higher layer protocols don't have to deal with that error scenario.

With EFM OAM, however, certain physical layers can support a limited unidirectional capability. Legacy links indeed become inoperable when one direction fails, but newer links (such as 100BASE-X PCS, 1000BASE-X PCS, and 10GbE RS) can still send OAMPDUs unidirectionally to transmit fault information.

On technologies that support the feature, OAMPDUs can be transmitted across unidirectional links to indicate fault information. To the higher layers, the link is still failed in both directions, but to the OAM layer, some communication capabilities exist. The distinction between a unidirectional link and a "normal" link is shown in Figure 2.

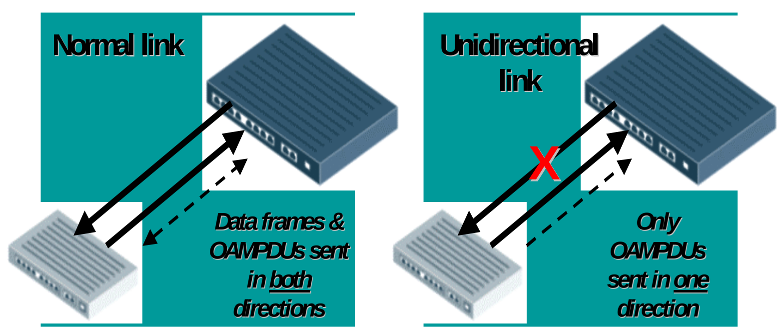

Figure 2: OAMPDUs Transmitted over Unidirectional Link

As Figure 3 shows, OAMPDUs only traverse a single link; they are not forwarded by bridges. Communication beyond a single link is left to higher layers.

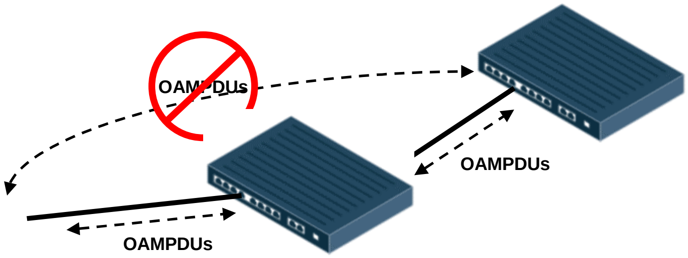

Figure 3: OAMPDUs are Single-Link Only

Size/Rate

OAMPDUs are standard length Ethernet frames; they must be untagged and within the normal frame length boundaries of 64 to 1518 bytes in length; the format is shown in Figure 4. The maximum PDU size is determined during the discovery process.

Octets	
6	01-80-c2-00-00-02 [*Slow Protocol*]
6	MAC Source Address
2	Type=88-09 [*Slow Protocols*]
1	Subtype = 0x03 [*OAM*]
2	Flags field
1	Code
42-1496	Data/Pad field
4	Frame Check Sequence
64-1518	

Figure 4: Format of OAMPDU

In Figure 5, you see the different OAMPDUs detailed, according to the contents of the code and data/pad fields.

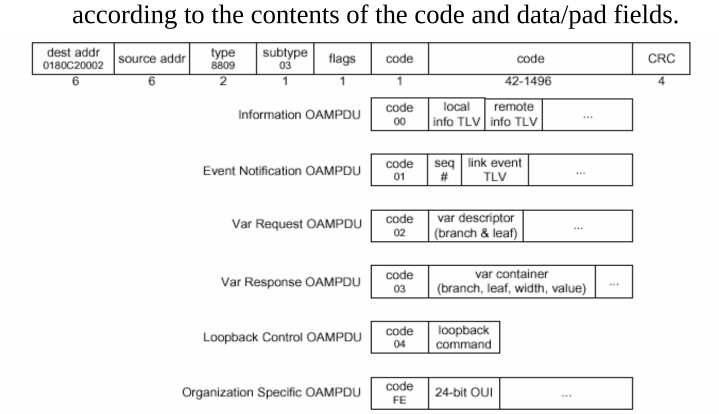

Figure 5: Codes and Data/Pad Contents for the Various OAMPDUs

There is a maximum transmission rate of ten OAMPDUs per second (This is the maximum rate as defined in Annex 43B as modified by 802.3ah) In order to increase the likelihood (in high BER conditions) that OAMPDUs will be received by a remote device, some OAMPDUs may be sent multiple times

Flags

A two byte flags field contains the discovery status of local and remote OAM entities, as well as fault indications. Figure 6illustrates the possible contents of the Flags field.

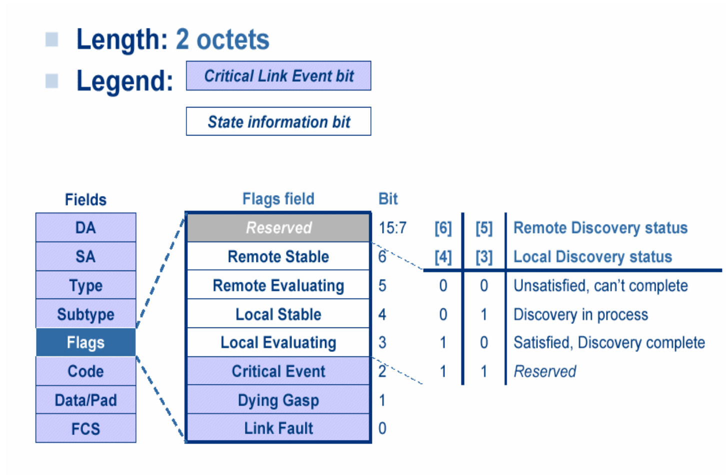

Figure 6: Flags Field

As discussed above, the Flags field indicates critical fault events, which may include link fault, dying gasp, or critical event.

Overview of OAMPDU Types

There are six types of OAMPDU (see the following table): information, event notification, variable request, variable response, loopback control and organization specific.

OAMPDU Type	Code	Length	Usage
Information	0x00	Varies	Discovery
Event Notification	0x01	Varies	Link monitoring and any other events
Variable Request	0x02	Varies	Get MIB variable(s)
Variable Response	0x03	Varies	Return MIB variable(s)
Loopback Control	0x04	64 octets	Control remote loopback state
Reserved	0x05 to 0xFD		
Organization Specific	0xFE	Varies	Miscellaneous use
Reserved	0xFF		

Most of the OAMPDU types also define a set of standard type-length-value (TLV) encoding of attributes within the type.

Note: Unknown/unsupported OAMPDUs are sent to the OAM client. This is different from typical Ethernet (802.3*x*) behavior, which filtered unsupported opcodes.

More detail on these OAMPDUs is provided in the following sections.

Information OAMPDU

Information OAMPDUs are used for discovery; they are variable-length OAMPDUs and use the code 0x00.

The different TLVs for Information PDUs are local information, remote information, and organization specific. Figure 7 illustrates these TLVs.

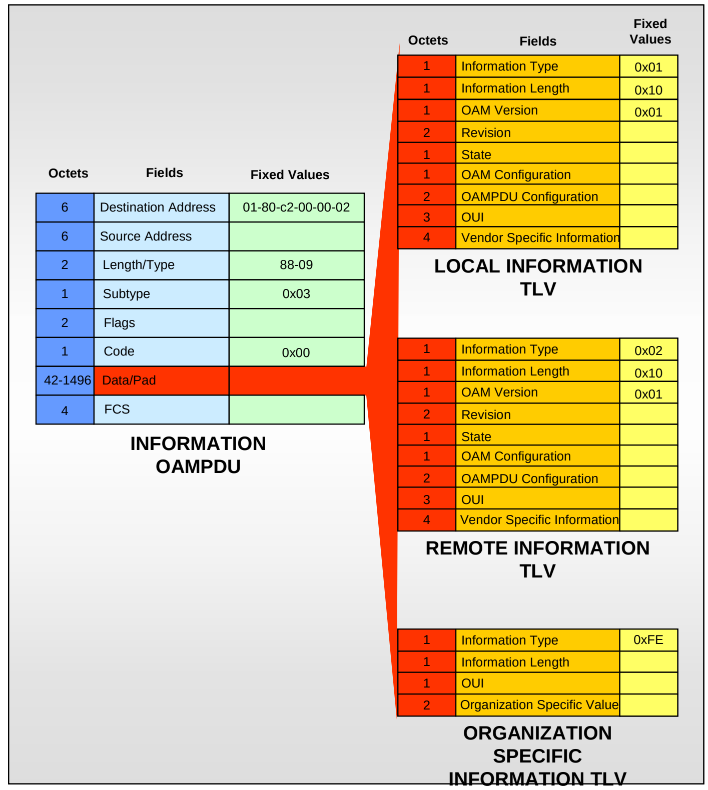

Figure 7: Information PDU

Local and remote information is used in the discovery process. The Organization Specific Information TLV is used for vendor extensions. It is encoded here because the source MAC address is not a simple indication of organization identification as many organizations have multiple OUIs assigned. The 32-bit vendor specific information is not defined and is used to encode the model or version of the platform. The platform identity field is intended to allow simple identification of the hardware device.

The following table summarizes the TLVs in the Information OAMPDU.

Information Type	Information TLV Name
0x00	End of TLV Marker
0x01	Local Information
0x02	Remote Information
0x03 – 0xFD	Reserved
0xFE	Organization Specific Information
0xFF	Reserved

A more detailed breakdown of the Informational OAMPDU for Local/Remote Information follows

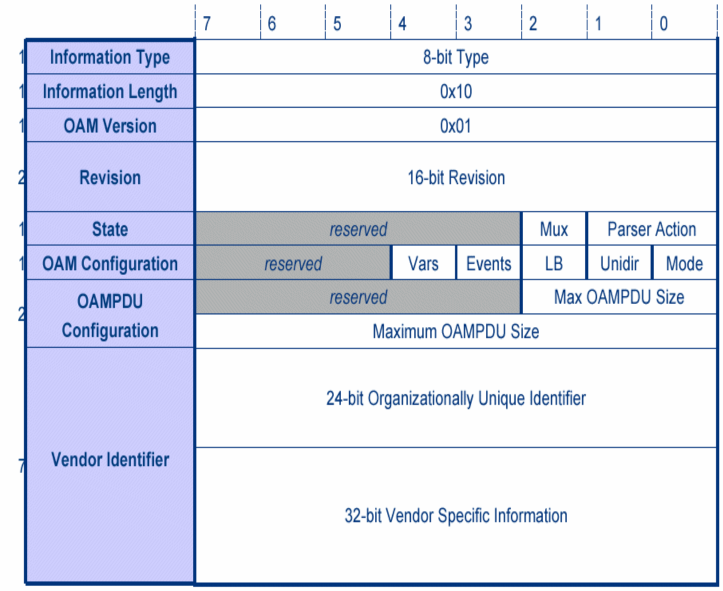

Figure 8: Local/Remote Information in the Information OAMPDU

Event Notification OAMPDU

The data field in the Event Notification OAMPDU contains one or more link event TLVs. This variable-length PDU is used for link monitoring.

The OAM Link Event TLVs are summarized in the following table.

Event Type	Event TLV Name
0x00	End of TLV Marker
0x01	Errored Symbol Period Event
0x02	Errored Frame Event
0x03	Errored Frame Period Event
0x04	Errored Frame Seconds Summary Event
0x05 – 0xFD	Reserved
0xFE	Organization Specific Event TLV
0xFF	Reserved

These may be sent multiple times to increase the likelihood of reception (for example, in the case of high bit errors). These TLVs may include a time reference when generated.

On a field level, the Event Notification OAMPDUs are shown in Figure 9.

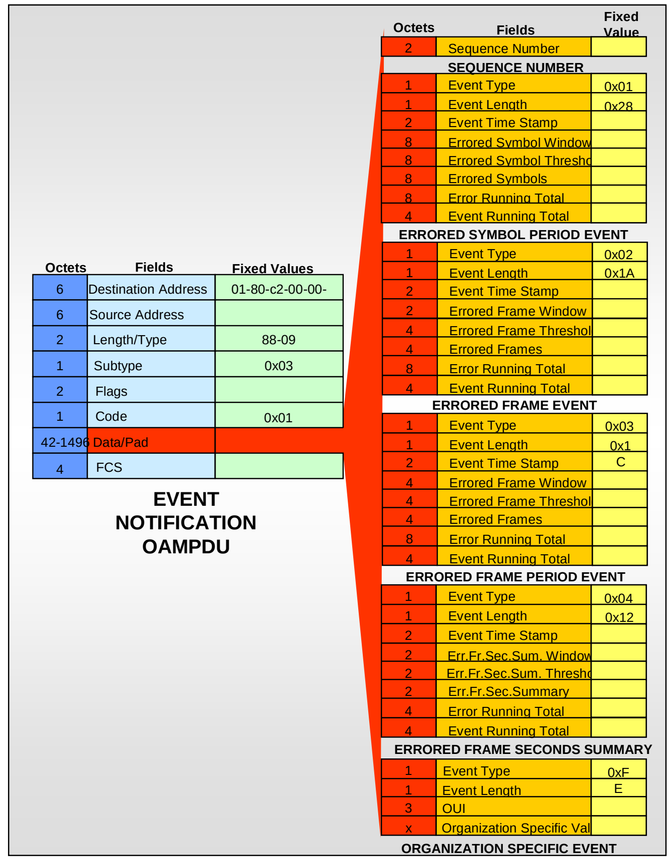

Figure 9: Event Notification OAMPDU

These are discussed in more detail in the following sections.

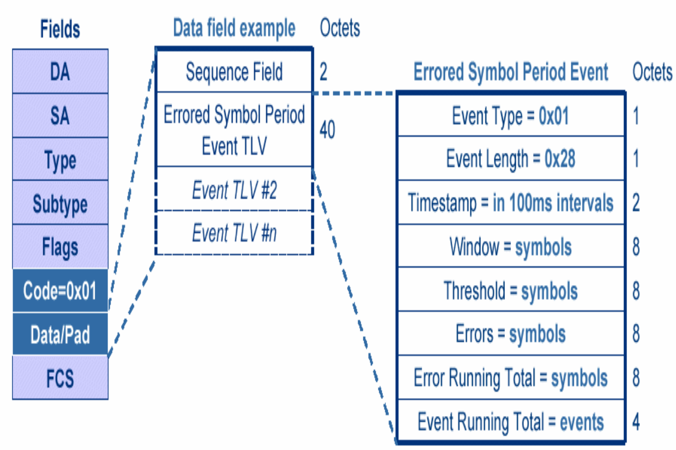

Figure 10: Errored Symbol Period Event TLV (Link Event Notification OAMPDU)

The errored symbol period event is a window, measured in number of symbols, where the number of errored symbols exceeded a threshold. As Figure 10 shows, this is a 40 octet TLV. The following table shows the potential values of these octets.

Fields	Width	Description
Timestamp	16 bits	Time reference, in 100 ms units, when generated
Window	64 bits	Lower bound: Symbols in one second Upper bound: Symbols in 60 seconds
Threshold	64 bits	Lower bound: 0 Upper bound: Unspecified
Errors	64 bits	Number of symbols errors in Window field
Total Errors	64 bits	Total number of symbol errors since reset
Total Errors	32 bits	Total number of events sent since reset

Errored Frame Event TLV

The Errored Frame Event TLV is a window, measured in 100 ms intervals, where the number of errored frames exceeds a threshold. This is a 26 octet TLV. Its fields are described in the following table.

Fields	Width	Description
Timestamp	16 bits	Time reference, in 100 ms units, when generated
Window	16 bits	Lower bound: 1 second Upper bound: 60 seconds
Threshold	32 bits	Lower bound: 0 Upper bound: Unspecified
Errors	32 bits	Number of frame errors in Window field
Total Errors	64 bits	Total number of frame errors since reset
Total Errors	32 bits	Total number of events sent since reset

Errored Frame Period Event TLV

The Errored Frame Period Event TLV is a window, measured in received frames, where the number of errored frames exceeded a threshold. This is a 28 octet TLV. Its fields are described in the following table.

Fields	Width	Description
Timestamp	16 bits	Time reference, in 100 ms units, when generated
Window	32 bits	Lower bound: number of 64 byte frames in one second Upper bound: number of 64 byte frames in 60 seconds
Threshold	32 bits	Lower bound: 0 Upper bound: Unspecified
Errors	32 bits	Number of frame errors in Window field
Total Errors	64 bits	Total number of frame errors since reset
Total Errors	32 bits	Total number of events sent since reset

Errored Frame Seconds Summary TLV

The errored frame seconds summary is a window, in 100ms intervals, where the number of errored frames exceeded a threshold. This is a 22 octet TLV. Its fields are described in the following table.

Fields	Width	Description
Timestamp	16 bits	Time reference, in 100 ms units, when generated
Window	16 bits	Lower bound: 10 seconds Upper bound: 900 seconds
Threshold	16 bits	Lower bound: 0 Upper bound: Unspecified
Errors	16 bits	Number of frame errors in Window field
Total Errors	64 bits	Total number of errors caused since reset
Total Events	32 bits	Total number of events sent since reset

Organization Specific Event TLV

Organizations may define events that are of variable length and are distinguished by the OUI. This is a variable length TLV; its fields are described in the following table.

Fields	Width	Description
OUI	24 bits	Organizationally Unique Identifier
Varies	Varies	Varies

MIB Variable Request/Response OAMPDU

The MIB variables accessible through OAM must be in the Ethernet (csmacdmgt) branch of the MIB tree. This branch is illustrated in the Figure 11. Note that the MIB referenced here is the IEEE 802.3 CMIP MIB defined in Clause 30 of the IEEE 802.3 specification. This MIB does not necessarily exactly reflect the SNMP MIB.

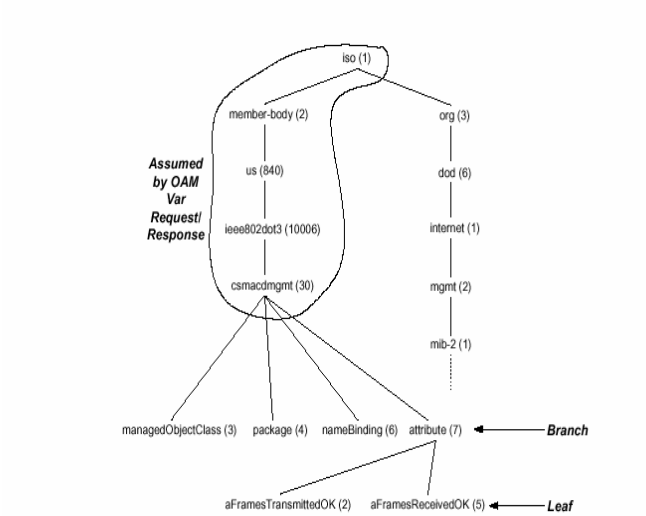

Figure 11: MIB Hierarchy

The OAMPDU for MIB variable request/response is shown in Figure 12.

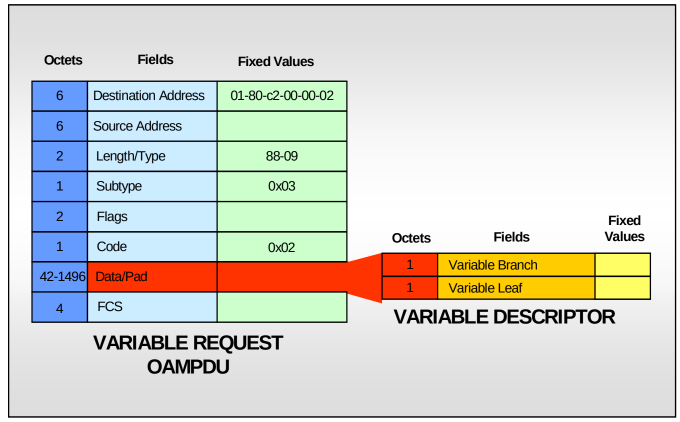

Figure 12: Variable Request OAMPDU

More detail on the data fields for this OAMPDU is shown in Figure 13.

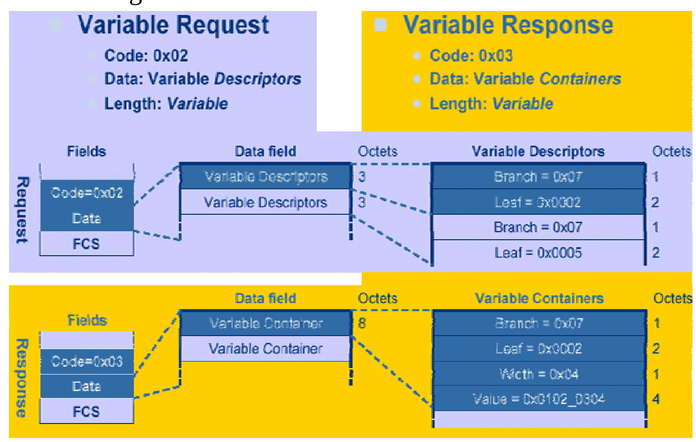

Figure 13: Data Fields for MIB Variable Request/Response OAMPDUs

The process of variable retrieval involves transferring Ethernet counters and statistics via Variable Containers/Descriptors. The variables are referenced using Annex 30A CMIP registration arcs.

Examples of OAM variable information retrieval are shown in the following table.

	CMIP Registration Arcs	
Variable	**Branch**	**Leaf**
aFramesTransmittedOK	0x07	0x02
aFrameCheckSequenceErrors	0x07	0x06
aOctetsReceivedOK	0x07	0x0E

Loopback Control OAMPDU

The Loopback Control OAMPDU provides the loopback command. It is illustrated in Figure 14

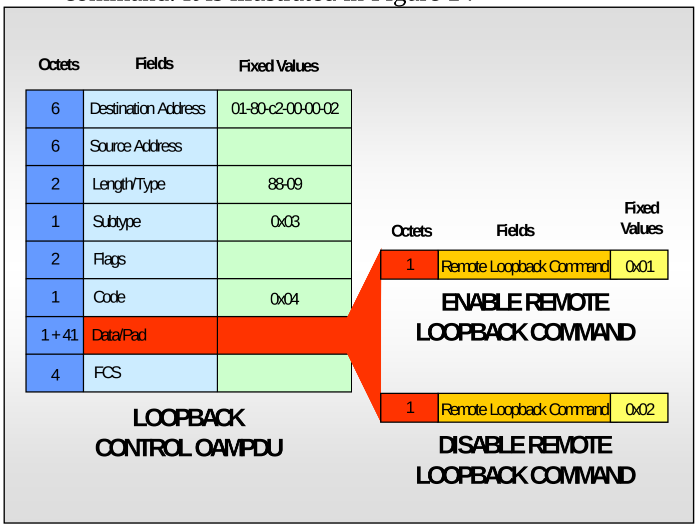

Figure 14: Loopback Control OAMPDU

The Loopback Command OAMPDU is 64 octets. You can enable or disable a loopback using this OAMPDU.

OAM Remote Loopback

In remote loopback, the local DTE sends a Loopback Control OAMPDU requesting the remote end to go into loopback mode until it is turned off. The local DTE sends arbitrary data frames, and the remote DTE returns them.

Note: When the BER is better than one error 10 ** -6 bits, there is a high probability that the frame error rate is equal to the bit error rate.

Remote loopback, which can be implemented in either hardware or software, is illustrated in Figure 15. Frames are discarded at the local side when received back.

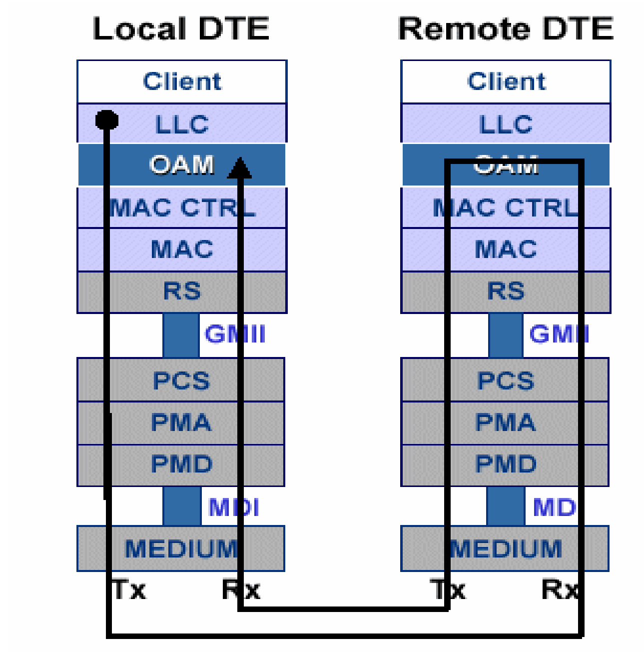

Figure 15: Remote Loopback

The OAM Sublayer

Loopback functionality is best understood in terms of the OAM sublayer. A block diagram of this sublayer is shown in Figure 16

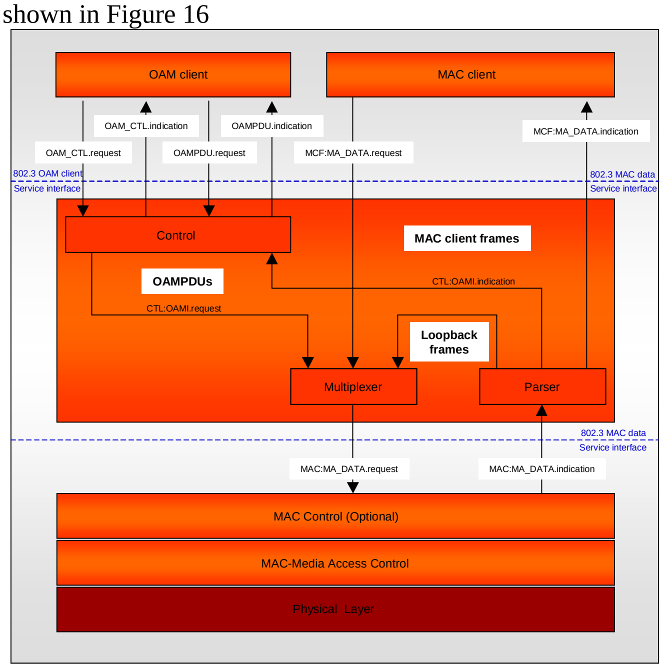

Figure 16: OAM Sublayer

The OAM sublayer consists of a MAC and OAM client, a control plane, a multiplexer, and a parser. These components are described in the following table.

Component	Function
MAC client	802.3 MAC data is sent to the multiplexer and received from the parser
OAM client	• Configures OAM sublayer through Control • Processes received OAMPDUs • Transmits PDUs
Control	Provides interface with OAM client entity
Parser	• Inspects received frames, sends OAMPDUs to Control (and then to OAM client) • Based on configuration, sends: o Non-OAMPDUs to upper layer, or o Non-OAMPDUs to multiplexer
Multiplexer	Multiplexes PDUs and non-PDUs

Starting and Exiting Remote Loopback

Figure 1 illustrates the OAM algorithm for starting a remote loopback. The local DTE stops sending data frames and sends a Loopback Control OAMPDU to the remote DTE, which configures the parser to “loopback” and sends an Information OAMPDU back to the local site. Then the local DTE starts sending loopback frames.

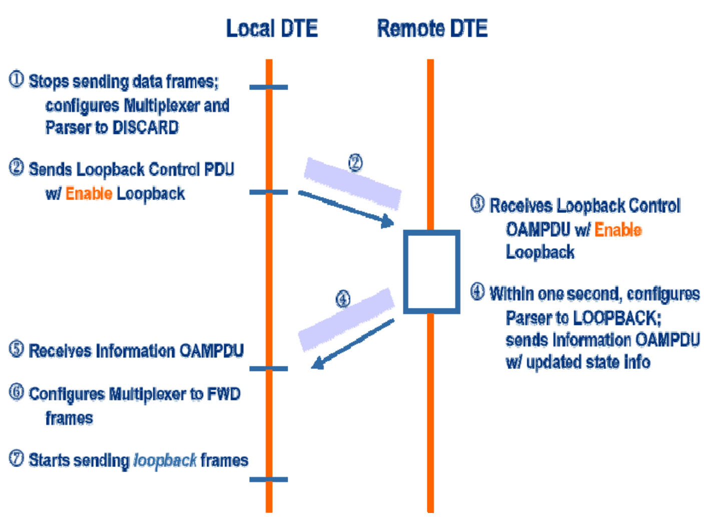

Figure 17: Starting Remote Loopback

The process of exiting remote loopback, illustrated in Figure 18, begins with the local DTE stopping the transmission of loopback frames.

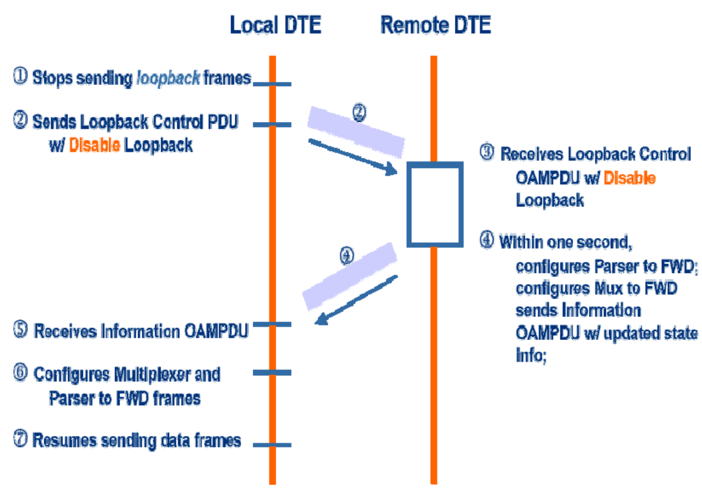

Figure 18: Exiting Remote Loopback

Organization Specific OAMPDU

There is an organization specific code that allows specific extensions. When this code (0xFE) is used, and organizationally unique identifier OUI is specified in the data field, and the contents of the rest of the data field is defined by the organization that owns the OUI.

Figure 19 illustrates this support.

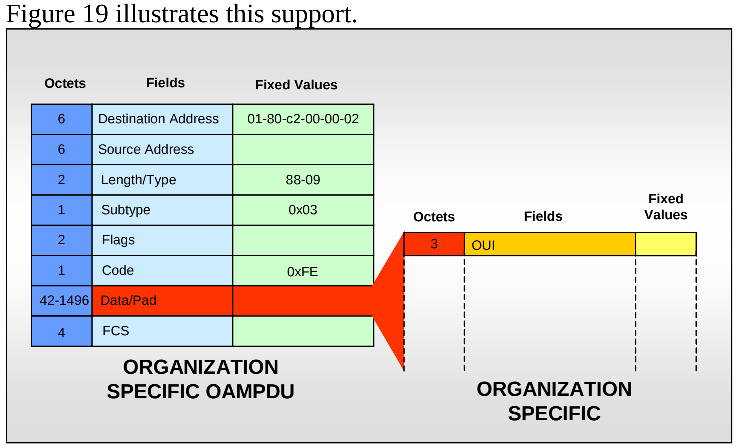

Figure 19: Organization-Specific OAMPDU

Conclusion

OAM is implemented as a sublayer at Layer 2. It supports the most critical management functionality needed in the first mile: fault detection and troubleshooting. The OAMPDUs report events, allow the retrieval of variables, and support loopbacks for troubleshooting.

Appendix

Terminology

Term	Definition
Access Node	The network side of the first mile where an operator's access equipment is located. Options exist to deploy the Access Node in a Central Office (Telephony Local Exchange) or remotely at the curbside or in a building.
CWDM	Coarse Wave Division Multiplexing
Ethernet	A packet-based protocol that is used universally in local area networks and strong candidate for cost efficient deployment in access and metropolitan networks.
EFMC	Ethernet in First Mile topology for voice-grade copper.
EFMF	Ethernet in First Mile using Point-to-Point Fiber topology
EFMP	Etehrnet in First Mile using Point-to-Multipoint topology, based on Passive Optical Networks (PONs).
EFMA	Ethernet in First Mile Alliance. An alliance of companies whose goal is to focus the necessary resources to make IEEE 802.3ah a successful industry standard. In 2004, the EFMA became part of the Metro Ethernet Forum
FTTB	Fiber to the building
FTTC	Fiber to the curb
FTTH	Fiber to the home
First Mile	Also called the last mile, the subscriber access network or the local loop, the first mile is the communications infrastructure of the business park or the neighborhood.
IEEE	Institute of Electrical and Electronics Engineers. A standards setting body responsible for many telecom and computing standards, including the Ethernet in the First Mile standard, IEEE 802.3ah.
MDU	Multi-dwelling unit, such as an apartment house or hotel.
MTU	Multi-tenant units, such as an apartment house or office building.
OAM	The specification for managing EFM.
Network operator	Also called service providers and local exchange carriers, they provide access network services to subscribers.
PON	Passive Optical Network. A single, shared optical fiber that has inexpensive optical splitters located near the subscribers.
PMD	Physical Media Dependent sub-layer
PHY	Physical Layer
PSTN	Public Switched Telephone Network.

References and Resources

Reference	Description
IEEE 802.3-2002	"CSMA/CD Access Method and Physical Layer Specifications", http://standards.ieee.org/reading/ieee/std/lanman/restricted/802.3-2002.pdf
IEEE 802.1Q	"Virtual Bridged Local Area Networks", http://standards.ieee.org/reading/ieee/std/lanman/802.1Q-1998.pdf
MEF 10	MEF Technical Specification "Ethernet Service Attributes, Phase 1", http://www.metroethernetforum.org/PDFs/Standards/MEF10.pdf
MEN Technical Overview	" Metro Ethernet Networks – A Technical Overview", http://www.metroethernetforum.org/PDFs/WhitePapers/metro-ethernet-networks.pdf

Disclaimer

This paper reflects ongoing work within the MEF captured in a series of technical specifications which are a work in progress. The official MEF specifications are available at www.metroethernetforum.com/techspec. These represent a 75% member majority consensus as voted by members of the MEF Technical Committee at the time of their adoption.

This paper will be updated as new work emerges from the MEF Technical Committee. Updates versions are available at http://www.metroethernetforum.org

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About the Metro Ethernet Forum

The Metro Ethernet Forum (MEF) is a non-profit organization dedicated to accelerating the adoption of optical Ethernet as the technology of choice in metro networks worldwide.

The Forum is comprised of leading service providers, major incumbent local exchange carriers, top network equipment vendors and other prominent networking companies that share an interest in metro Ethernet. As of December 2005, the MEF had over 70 members