

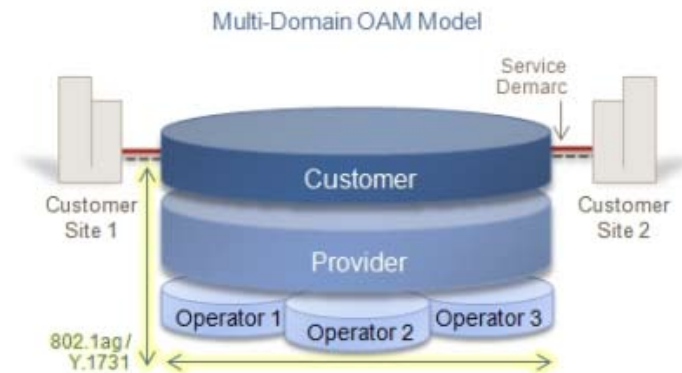
Ethernet Service OAM

Standards and Functionality

As Ethernet continues to replace legacy TDM services in QoS sensitive, high-capacity applications such as business services and WiMAX/LTE 4G wireless backhaul, ensuring service quality meets customer expectations requires a well managed, operationally efficient network. Ethernet connectivity and service layer Operations, Administration and Maintenance (OAM) standards are designed to simplify the management of Carrier Ethernet services with end-to-end service visibility, fault isolation, reporting and continuous performance monitoring. As specified in the IEEE 802.1ag and Y.1731 standards, these capabilities enable providers to manage Ethernet services regardless of the network path, topology, operators or network layer that carries the traffic between service endpoints.

Connectivity Fault Management (CFM)

Connectivity Fault Management (CFM), defined in both 802.1ag and Y.1731, divides the provider's end-to-end network into three distinct levels or maintenance domains: customer, provider, and operator (e.g. a partner carrier's network).



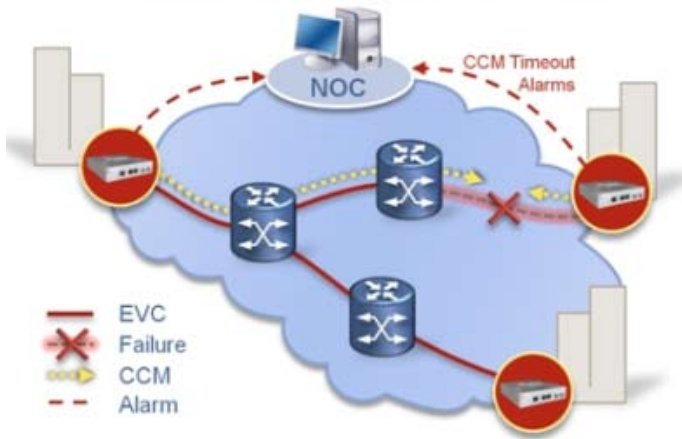
CFM respects this hierarchy by ensuring that faults identified in a lower layer (e.g. operator's network) are alarmed only to the next higher level (e.g. the service provider) so that appropriate action such as traffic rerouting can be performed, while the details of the problem (fault isolation) remain at the layer where the incident occurred. This ensures that the fault is regulated within the appropriate domain (by the operator or provider), while preventing a mass broadcast of alarms throughout all layers of the network.

The key features of Ethernet OAM CFM are Fault Detection, Verification, Isolation and Notification:

Fault Detection

Service faults (interruption) are detected by Continuity Check Messages (CCM) sent periodically from the service source to destination(s) at regular intervals. If service endpoints do not receive the expected CCMs within a specified timeout period, affected endpoints will indicate their loss of continuity with an alarm.

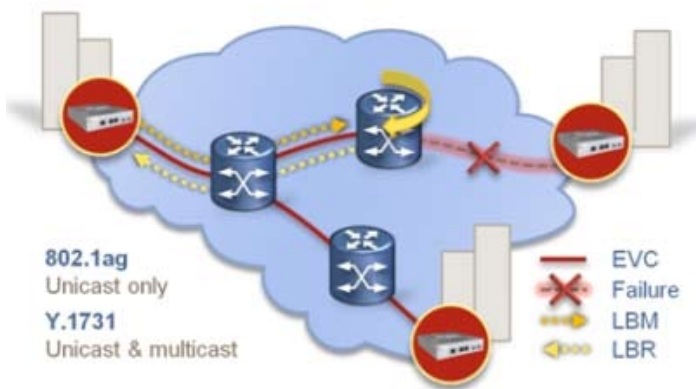
Fault Detection using Continuity Check Messages



Fault Verification

Equivalent to the IP “Ping” command, service faults can be verified using a Loopback Messages (LBM) and their replies (LBR). A series of LBMs can be sent to identify the location of the fault by querying maintenance endpoints (MEPs) and intermediate points (MIPs) along the service path.

Fault Verification Using Loopback Messages (“Ping”)



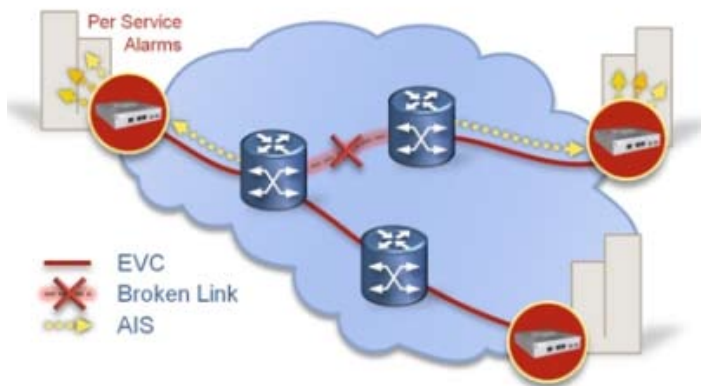
Fault Isolation

The location of a fault can be quickly determined by a Linktrace Message (LTM), analogous to the IP trace route function. When a LTM is sent to a service endpoint (MEP), all intermediate nodes (MIPs) respond with an LTR along path traveled by the LTM. The returned LTRs (and those not returned) uniquely identify the segment or node where the fault originates. Under normal operating conditions, Linktrace is also used by network elements to determine the path a service takes through the network – this route awareness is stored in a local database to expedite fault isolation, and for link protection purposes.

Fault Notification

Y.1731 also supports fault notification through Ethernet Alarm Indication Signals (AIS) based on the standard originally defined in the ATM protocol. AIS messages are broadcast by nodes on either side of a fault towards the service endpoints, which then replicates the alarm for all services affected. To ensure that a failure state is maintained, AIS messages are sent periodically until the service is restored. 802.3ah does not support AIS as these messages may cause issues in networks using (R)STP for link fault protection.

Fault Notification, Alarm Signal Messages (Y.1731 only)



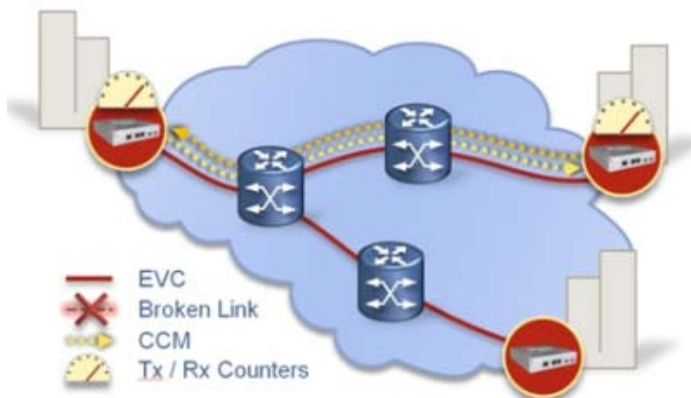
Performance Monitoring (PM)

In addition to CFM, Y.1731 also supports a number of performance monitoring (PM) functions to measure frame loss, delay and delay variation (jitter).

Frame Loss

CCM messages are used to determine bi-directional frame loss ratios for a service. Transmit / receive counters at the service endpoints measure the number of received vs. dropped packets.

Frame Loss Ratio Using CCM (dual-ended)

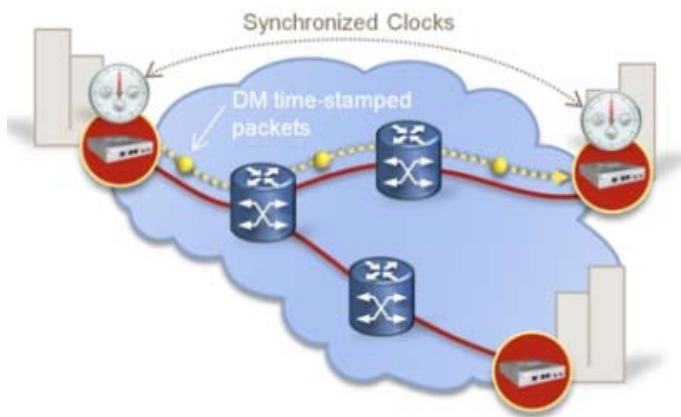


Frame Delay & Delay Variation

Y.1731 specifies techniques for both one-way and round-trip latency (frame delay) and jitter (delay variation). One-way delay and delay variation measurements require that the service endpoints have synchronized reference clocks, while round-trip delay measurements do not.

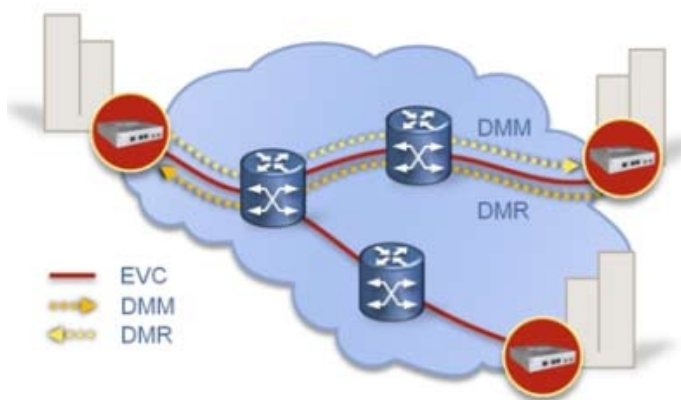
One way delay is measured by sending a time stamped Delay Measurement (DM) test packet through the network to the far end node (MEP), that compares the original timestamp to its current reference clock to calculate latency. Delay variation is the difference in the delay of two subsequently received DM packets.

Frame Delay / Jitter Measurements, 1-Way



Round-trip delay is measured by sending a Delay Measurement Message (DMM) frame, whose time stamp is returned to the originating node in a Delay Measurement Reply (DMR) frame.

Frame Delay / Jitter Measurements, Round Trip



Throughput Measurement

The Y.1731 standard does not specify a method to conduct in-service or intrusive throughput measurement, a key specification in Service Level Agreements (SLAs) outlining committed, excess and burst profiles for a service. JDSU has leveraged the flexibility in the Y.1731 standards and adapted the LBM/LBR message format to allow transparent CIR and EIR throughput measurement without affecting customer traffic. This allows throughput to be verified during peak usage conditions - accurately reflecting service performance under real-world conditions, unlike intrusive tests performed during early-hour maintenance windows.

OAM Standards Summary

The following table summarizes how the 802.1ag and Y.1731 standards address key aspects of Connectivity Fault Management (CFM) and Performance Monitoring (PM). Complementing these connectivity and service layer OAM standards are the 802.3ah Ethernet in the first mile specification, now ratified as 802.3-2005, and a framework in development at the Metro Ethernet Forum (MEF) focused on customer-level OAM that integrates with existing standards.

OAM Function	802.1ag	Y.1731	Method	
CFM	Fault Detection	✓	✓	CCM
	Fault Verification / Loopback	✓	✓	LBM / LBR ("Ping")
	Fault Isolation	✓	✓	LTM / LTR
	Discovery	✓	✓	LTM / LTR & Multicast LBM*
	Fault Notification		✓	AIS / RDI
PM	Frame Loss		✓	CCM, LTM / LTR
	Frame Delay		✓	DM (1 way), DMM / DMR
	Delay Variation		✓	DM (1 way), DMM / DMR

*Y.1731 only

Product Highlight: EtherNID & MetroNID Demarcation Units

JDSU's EtherNID™ and MetroNID™ packet assurance demarcation units feature the full functionality of the latest 802.1ag, Y.1731 and 802.3ah OAM standards, and are capable of acting as maintenance endpoints (MEPs) or intermediate points (MIPs) in any topology, including multi-vendor, multi-carrier and multi-technology networks. This capability allows service providers to establish and benefit from Ethernet OAM visibility without the need to upgrade access platforms or expensive edge routers to those supporting the latest OAM standards.

EtherNID and MetroNID units are strategically located at the service demarcation (end) points, ensuring complete end-to-end OAM visibility even over leased access links and wholesale networks. In addition to OAM-based CFM and PM functions, providers can leverage the rich service creation and assurance functionality offered by the ESAP™ Ethernet Service Assurance Platform, including the industry's only real-time SLA-Meter, in-service throughput testing and a fully automated RFC-2544 test suite.

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