Connectivity Fault Management
Layer-2 Performance Monitoring and Troubleshooting

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Overview

- Context, Concept and Goals
- Standardisation
- Protocol
- Use Cases, CFM deployments
- First Test results, CFM output examples
- Todos
Connectivity Fault Management
Context and Goals

- Ethernet services in multiple operator/administrative domain environments introduce complexity to operators task: Effective isolation of link faults or performance degradation on L2 End-to-End services spanning multiple administrative domains.

- CFM has been standardised in IEEE 802.1ag, key points:
  - Measurement point instances run directly in L2 devices
  - Maintenance Domain Levels, -> Interdomain usability
  - Continuous and on demand measurements
  - Signalling of failure states between devices
  - Configurable consequent actions can trigger immediate end-to-end service recovery

- Additionally support is provided by ITU-T Y.1731:
  - Frame loss and delay measurements,
  - Ethernet Alarm signalling: RDI and AIS
An Example Deployment Scenario

MD: Maintenance Domain
MA: Maintenance Association

 MEP : Maintenance End Point
(further distinguished: UP-MEP, DOWN-MEP)

MIP : Maintenance Intermediate Point

MEP,MIP behaviour: MEPS generate CFM Message, MEPS and MIPs process CFM Message
• CFM Message with MD-Level > MIP/MIP Level : transparently pass
• CFM Message with MD-Level < MEP/MIP Level : discard
• CFM Message with MD-Level = MIP/MIP Level processes CFM Message (respond, transport or accepts)
Ethernet frame with an ethertype of 0x8902

CFM Frame format

<table>
<thead>
<tr>
<th>MD Level 3 bits</th>
<th>CFM Version 5 bits</th>
<th>CFM OpCode 8 Bits</th>
<th>CFM PDUs variable</th>
</tr>
</thead>
</table>

CFM PDUs

Figure 3. A CFM message frame format

5 PDU Types are defined by OpCode Values.

- Continuity Check Message (CCM)
- Loopback Message (LBM):
  - Loopback Reply Message (LBR)
- Linktrace Message (LTM)
- Linktrace Reply Message (LTR)
Continuity Check Protocol

- Used for Fault Detection, Notification, and Recovery
- Per-Maintenance Association *multicast* "heart-beat" messages are transmitted at a configurable periodic interval by MEPs (3.3ms, 10ms, 100ms, 1s, 10s, 1min, 10min) - Uni-directional (no response required)
- Carries status of port on which MEP is configured
- Catalogued by MIPs at the same MD-Level, terminated by remote MEPs in the same MA
Loopback Protocol
- Used for Fault Verification - **Ethernet Ping**
- Can be used for on-demand frame loss and rtt measurements
- MEP can transmit a unicast Loopback Message (LBM) to a MEP or MIP in the same MA
- MEP can also transmit a *multicast* LBM (defined by ITU-T Y.1731), where only MEPS in the same MA respond
- Receiving MP responds by transforming the LBM into a unicast Loopback Reply (LBR) sent back to the originating MEP

Linktrace Protocol
- Used for Path Discovery and Fault Isolation - **Ethernet Traceroute**
- MEP can transmit a multicast message (LTM) in order to discover the MPs and path to a MIP or MEP in the same MA
- Each MIP along the path and the terminating MP return a unicast LTR to originating MEP
Use case: Customer backbone access access through leased ethernet service

Problems

- Failure on Ethernet Leased Line Service is not always signalled to NRENS L2 device. Failure isolation on two domains not always effective.
- Performance degradation on customer IP access link cannot effectively isolated to one of the domains.
Use case: Customer backbone access through leased ethernet service (with CFM)

- Deployment of CFM
  - Link interrupts on Ethernet Leasd Line can be detected and signalled into NRENs L2 Switch on ms time range. Consequent actions can be triggered (Link down)
  - Performance degradation can be detected directly on Ethernet Leased line service, frame OWD and frame loss ratio at 0.3%.
  - Fault on Customer IP access link can be isolated rapidly to a Ethernet domain.
Use case example: Interdomain L2 Ethernet service between NRENs

Challenges

- Fast fault isolation if performance degradation on End-to-End link
- Fast signalling of segment interrupts to neighbour domains or user switch
Use case example: Interdomain L2 Ethernet service between NRENs (with CFM)
Result examples
typical CFM configuration

Switch r-test1
-----------------
ethernet cfm ieee
ethernet cfm global
ethernet cfm alarm notification all
ethernet cfm domain CFMD1 level 3
  service PORTMEP port
  continuity-check interval 3.3ms
  continuity-check loss-threshold 10
interface GigabitEthernet1/0/5
  ethernet cfm mep domain CFMD1 mpid 111 service PORTMEP

Switch r-test2
-----------------
ethernet cfm ieee
ethernet cfm global
ethernet cfm alarm notification all
ethernet cfm domain CFMD1 level 3
  service PORTMEP port
  continuity-check interval 3.3ms
  continuity-check loss-threshold 10
interface GigabitEthernet0/0/5
  ethernet cfm mep domain CFMD1 mpid 222 service PORTMEP

MD Name CFMD1, Level 3
MA Name: PORTMEP
MEP ID: 111
MEP ID: 222
### Result examples
typical CFM state output

![Diagram of L2 Sw. connected with lines to MD Name CFMD1, Level 3 and MA Name: PORTMEP]

#### Local MEPs:

<table>
<thead>
<tr>
<th>MPID</th>
<th>Domain Name</th>
<th>Lvl</th>
<th>MacAddress</th>
<th>Type</th>
<th>CC</th>
<th>Dir</th>
<th>Port</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>111</td>
<td>CFMD1</td>
<td>3</td>
<td>0081.c4c9.f705</td>
<td>Port</td>
<td>N</td>
<td>Yes</td>
<td>CFMD1</td>
<td>Down</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MEP ID: 111</th>
</tr>
</thead>
</table>

#### Remote MEPs:

<table>
<thead>
<tr>
<th>MPID</th>
<th>Domain Name</th>
<th>MacAddress</th>
<th>IfSt</th>
<th>PtSt</th>
</tr>
</thead>
<tbody>
<tr>
<td>222</td>
<td>CFMD1</td>
<td>00a2.ee16.fd45</td>
<td>Up</td>
<td>N/A</td>
</tr>
<tr>
<td>3</td>
<td>CFMD1</td>
<td>Gi1/0/5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>PORTMEP</td>
<td>Port none</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MPID: 111 Domain: CFMD1 MA: PORTMEP
Result examples (MAC ping, MAC traceroute)

r-test1#ping ethernet mpid 222 domain CFMD1 service PORTMEP
Type escape sequence to abort.
Sending 5 Ethernet CFM loopback messages to 00a2.ee16.fd45, timeout is 5 seconds:!!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms

r-test2#trace ethernet mpid 222 domain CFMD1 service PORTMEP
Type escape sequence to abort. TTL 64. Linktrace Timeout is 5 seconds
Tracing the route to 00a2.ee16.fd45 on Domain CFMD1, Level 3, service PORTMEP, port
Traceroute sent via Gi1/0/5

B = Intermediary Bridge
! = Target Destination
* = Per hop Timeout

<table>
<thead>
<tr>
<th>Hops</th>
<th>MAC</th>
<th>Ingress Forwarded</th>
<th>Ingress Egress</th>
<th>Ingr Action</th>
<th>Relay Action</th>
<th>Previous Hop</th>
</tr>
</thead>
<tbody>
<tr>
<td>! 1</td>
<td>00a2.ee16.fd45 Gi0/0/5</td>
<td>IngOk</td>
<td></td>
<td></td>
<td>RlyHit:MEP</td>
<td>0081.c4c9.f705</td>
</tr>
</tbody>
</table>
First results

- Modern access switches and routers do support a wide range of CFM features.
- Link states are signalled, consequent actions can be triggered
- Continuous measurements and on-demand measurements are working
- Alarms are working

Todos

- Check and test interfaces with Network Management Stations
  - SNMP MIBs
  - CLIs output
  - How to read measurement results from MEPs and MIPs into NMS
  - Check alarm features
  - How to start on demand measurements from NMS
- Think on multi-domain deployment scenarios, L2 problem isolation requires improvements
- CFM support on end systems: toolset on Linux and other OS