SharkFest ‘16

Troubleshooting with Layer 2 Control Protocols

June 15, 2016

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Agenda

- Background
- Gotchas and Challenges with Layer 2 Control Protocols (L2CP)
- Layer 2
  - LACP
  - UDLD
  - Configuration Test Protocol (loopback)
  - Ethernet Flow-Control
- Between the lines
- Wrap-up

Background

About me

- From Germany (sorry the accent)
- More than 10 year Dual-CCIE (R/S, Security)
- Sniffer Certified Master
- Wireshark Certified Network Analyst
- VMware Certified Professional
- IPv6 Forum Certified Engineer (Gold)
- More than 18 years in the networking area

My first data network analyzer

- Wandel & Goltermann DA-30C – still working ☺

Gotchas & Challenges with L2CP

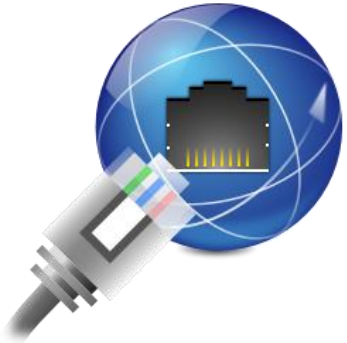
Capture Files:
https://app.box.com/v/sharkfest2016-layer2

Interference

- Physical Layer (1)
- Data Link Layer (2)
- Network Layer (3)
- Transport Layer (4)

BTW - what is a Link with Ethernet?

- Speed
- Duplex
- MTU
- Auto-Negotiation
- Flow-Control
- MDI/MDI-X
- Remote-Fault / Local-Fault / FEFI
- Carrier-Delay
- Debounce Timer
- EEE



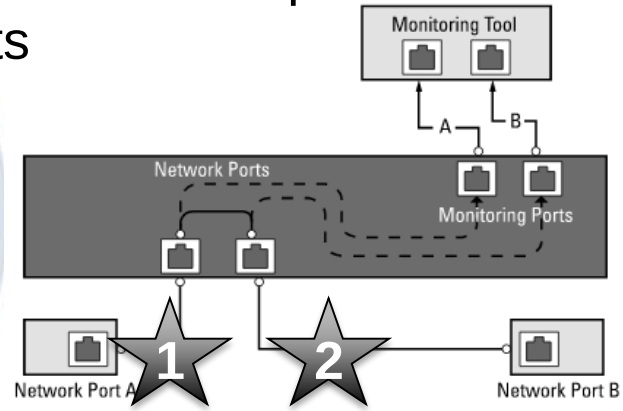
Challenge 1 - Different kind of links

- Copper
  - 10/100/1000/10000 traffic
- Fiber
  - 10BASE-FL
  - 100BASE-FX
  - 1000-BASE-X
  - 10G/40G/100G
  - …

Challenge 1.1 - Copper links

- Copper – 10/100/1000/10000 traffic
- Taps – Gotchas
  - The Tap negotiates separately with each side of the full-duplex link
  - One Link before – with Tap two Links segments
- SPAN – Gotchas

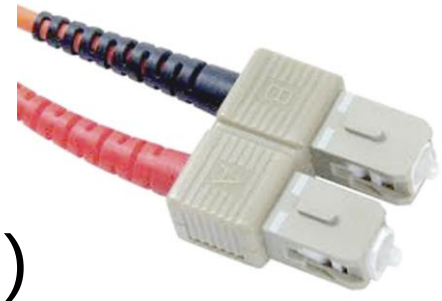
```
SW_2520(eth-25)# monitor
25: Cannot monitor a dynamic LACP trunk.
SW_2520(eth-25)#
```

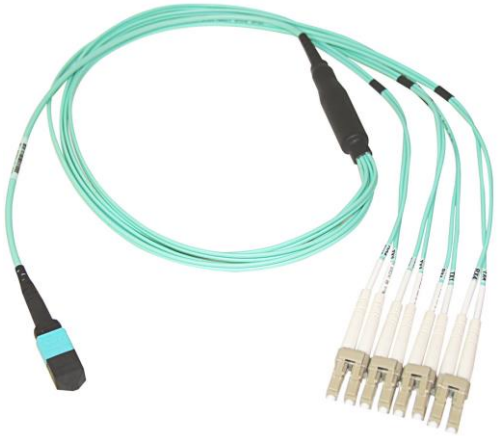


- Link Loss Carry Forward or Link Failure Propagation
- PoE (e.g for 802.11ac Wave 1 and Wave2 APs)

Challenge 1.2 - Fiber Links

- Duplex/Simplex
- Single strand BiDi
- Power Level / Split Ratio
- Multi-Wavelength Tap (CWDM/DWDM)
- Taps – the best for single data stream
  - Passive Optical Fiber TAPs
- QSFP+
  - BiDi Transceiver
- CFP, CFP2, CFP4, CXP
- SPAN – Gotchas



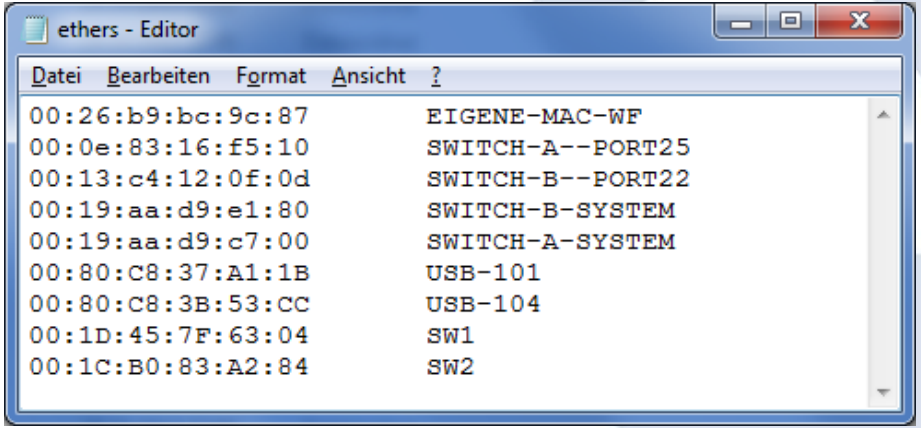


Challenge 1.3 – DAC & AOC

- Direct-Attach Cable
  - also known as a twinax cable
- Active Optical Cable (AOC)

Challenge 2 – Display Environment

- Know your MAC-Addresses and write it down
- Use aliases and well-known names

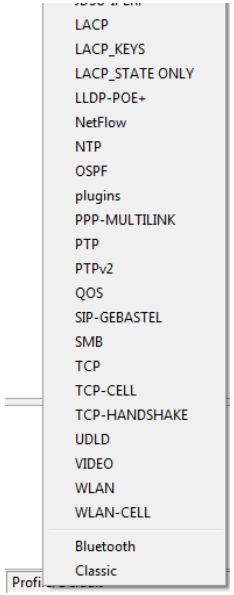


ethers - Editor

Datei Bearbeiten Format Ansicht ?

```
00:26:b9:bc:9c:87        EIGENE-MAC-WF
00:0e:83:16:f5:10        SWITCH-A--PORT25
00:13:c4:12:0f:0d        SWITCH-B--PORT22
00:19:aa:d9:e1:80        SWITCH-B-SYSTEM
00:19:aa:d9:c7:00        SWITCH-A-SYSTEM
00:80:C8:37:A1:1B        USB-101
00:80:C8:3B:53:CC        USB-104
00:1D:45:7F:63:04        SW1
00:1C:B0:83:A2:84        SW2
```

- Use Profiles



Challenge 3 – General

- Location
  - Local versus different Data centers
  - LAN versus WAN / MAN
  - Layer 2 VPNs
  - Virtualization
- Time stamping / correlation
- Cluster Systems
  - Multi-Chassis
  - Fabrics

Time for Questions

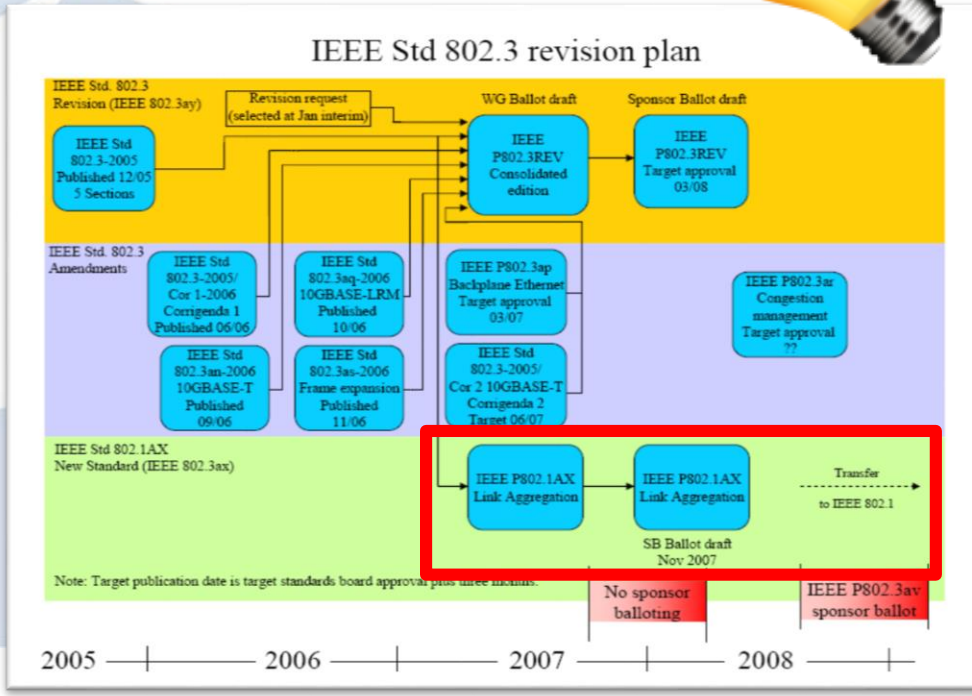
Link Aggregation Control Protocol (LACP)

Link Aggregation Control Protocol (LACP)

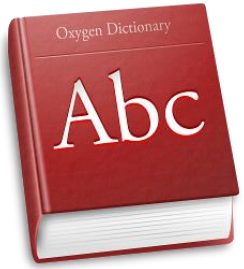
- What is LACP?
  - A Layer 2 protocol to logically bundle multiple physical ethernet links into one
- Why LACP?
  - for increasing bandwidth and build-in redundancy
- Who need it?
  - Everyone from the networking field
- Benefits?
  - Failover, load-sharing, acting as one
- Requirements
  - “… all interfaces in the channel group must be the same type and speed”

LACP Standards

- IEEE Std 802.3, 2000 Edition - Clause 43
  - 802.3ad
- IEEE Std 802.1AX™-2008
  - 802.1AX not 802.3ax
- IEEE Std 802.1AX™-2014
  - Revision of IEEE Std 802.1AX-2008



Terms



- Link Aggregation
- Link Aggregation Group (LAG)
- Link Aggregation Control Protocol (LACP)
- Link Aggregation interface
- Member interface (member link)
- Active, inactive and standby interfaces
- Aggregator port
- Actor / Partner
- Active / Passive
- Upper / Lower threshold for the number of active interfaces

LACP Requirements

- "… all interfaces in the channel group must be the same type and speed"
- "… as either Layer 2 or Layer 3 interfaces"
- the interfaces that participate in a Port-Channel can include both the copper and fiber-optic ports
- interface attributes

- Really – nothing forgotten ?
  - Please remember the Slide "what is a Link with Ethernet"

LACP Notes

- Link Aggregation Control and Marker Protocols are encoded with Ethertype
  - 0x8809
  - Destination Multicast MAC Address: 01-80-C2-00-00-02
- multiple physical links to provide a single logical link between exactly two entities
- in LACP there is no explicit confirmation from a neighbor that he had received LACPDU
- LACP selects a port for each frame

LACP Load-Balancing

- IPv4 packets
- IPv6 packets
- MPLS packets
- Layer 2 Frames except IPv4, IPv6 and MPLS packets
  - TRILL packets
  - FCoE packets

→ The Load-Balancing code is platform dependent and most use a hashing algorithm by the LAG

→ LACP isn't "additive", it's a LB mechanism!

Load-Balancing - Values in the frame/packet header

- Source MAC address
- Destination MAC address
- Source IP address
- Destination IP address
- Source port
- Destination port
- IPv6 Flow label
- MPLS label(s)

LACP – Marker Protocol

- Marker Generator
- Marker Responder
- Wireshark can dissect it
- The 802.3ad standard also provides two methods to ensure that packets are not disordered when moving conversations. They are time-outs and the Marker Generator
- Never captured by me – and I capture very often

LACP – Marker Protocol

- IEEE Standard versus Dissection

```
⊞ Frame 192: 124 bytes on wire (992 bits), 124 bytes captured (992 bits)
⊞ Ethernet II, Src: CiscoInc_7f:63:02 (00:1d:45:7f:63:02), Dst: Slow-Protocols (01:80:c2:00:0
⊟ Slow Protocols
    Slow Protocols subtype: Marker Protocol (0x02)
⊟ Marker Protocol
    Version Number: 0x01
    TLV Type: Marker Response Information (0x02)
    TLV Length: 0x14
    Requester Port: 32768
    Requester System: CiscoInc_7f:63:00 (00:1d:45:7f:63:00)
    Requester Transaction ID: 98304
    TLV Type: Unknown (0x3c)
    TLV Length: 0x00
    Requester Port: 0
    Requester System: MS-NLB-PhysServer-20_80:00:00:1c (02:14:80:00:00:1c)
    Requester Transaction ID: 2961416832
    TLV Type: Unknown (0x80)
    TLV Length: 0x00
    Requester Port:
    Requester Syste
    Requester Trans
```

Adjusted by Packet Editor - no real frame

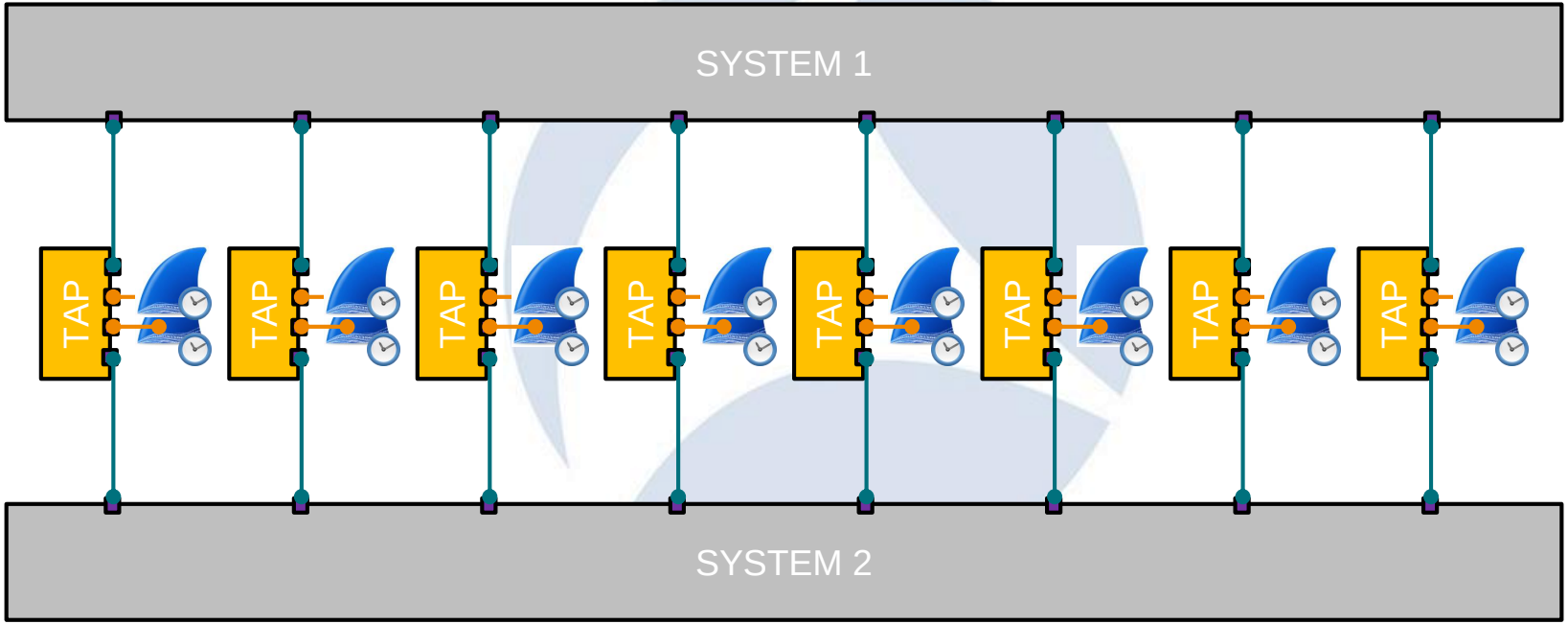
IEEE Std 802.1AX-2014
IEEE STANDARD FOR LOCAL AND METROPOLITAN AREA NETWORKS—LINK AGGREGATION

Marker PDU	Octets	Marker Response PDU
Subtype = Marker	1	Subtype = Marker
Version Number	1	Version Number
TLV_type = Marker Information	1	TLV_type = Marker Response Information
Marker_Information_Length= 16	1	Marker_Response_Information_Length = 16
Requester_Port	2	Requester_Port
Requester_System	6	Requester_System
Requester_Transaction_ID	4	Requester_Transaction_ID
Pad = 0	2	Pad = 0
TLV_type = Terminator	1	TLV_type = Terminator
Terminator_Length = 0	1	Terminator_Length = 0
Reserved	90	Reserved
FCS	4	FCS

Figure 6-27—Marker PDU and Marker Response PDU structure

Capturing LACP

Keep all your capture points in time sync



Capturing LACP - Reality

- Lab Environment
- The Hardware Ethernet Analyzers provides different methods to capture packets inline and full-duplex.
- Copper or Fiber – up to Gigabit
- Wireshark used for further analysis

LACP - Flow Graph

Wireshark · Flow · 8809-only

ZyxelCom_6c:c3:86 | HewlettP_b3:71:9f | HewlettP_b3:71:9e | ZyxelCom_6c:c3:89 | HewlettP_b3:71:9a | HewlettP_b3:71:9b | ZyxelCom_6c:c3:8b | HewlettP_b3:71:9
Slow-Protocols | ZyxelCom_6c:c3:85 | ZyxelCom_6c:c3:87 | ZyxelCom_6c:c3:8a | HewlettP_b3:71:9c | ZyxelCom_6c:c3:88 | ZyxelCom_6c:c3:8c

59.997898887	Link Aggregation Control ProtocolVersio...	
59.998833364	Link Aggregation C...	
60.046915769	Link Aggregation Control ProtocolVersion 1. Actor Port = 3 Partner Port = 4	
60.049111581	Link Aggregation Control ProtocolVersion 1. Actor Port = 5 Partner Port = 6	
60.050237982	Link Aggregation Control ProtocolVersion 1. Actor Port = 6 Partner Port = 5	
60.497776217	Link Aggregation Control ProtocolVersion 1. Actor Port = 6 Partner Port = 5	
60.997986272	Link Aggregation Control ProtocolVersion 1. Actor Port = 4 Partner Port = 3	
60.998352520	Link Aggregation C...	
60.998541092	Link Aggregation Control ProtocolVersion 1. Actor Port = 2 ...	
60.999209054	Link Aggregation Control ProtocolVersion 1. Actor Port = 5 Partner Port = 6	
89.997128673	Link Aggregation Control ProtocolVersio...	
89.998159531	Link Aggregation C...	
90.046299765	Link Aggregation Control ProtocolVersion 1. Actor Port = 3 Partner Port = 4	
90.047972605	Link Aggregation Control ProtocolVersion 1. Actor Port = 4 Partner Port = 3	
90.048528262	Link Aggregation Control ProtocolVersion 1. Actor Port = 5 Partner Port = 6	
90.049746854	Link Aggregation Control ProtocolVersion 1. Actor Port = 6 Partner Port = 5	
90.051370246	Link Aggregation C...	
90.052519276	Link Ag...	
90.499488444	Link Aggregation Control ProtocolVersion 1. Actor Port = 6 ...	
90.501033893		
90.999678384	Link Aggregation Control ProtocolVersion 1. Actor Port = 4 Partner Port = 3	
91.000007756	Link Aggregation C...	
91.000117547	Link Aggregation Control ProtocolVersion 1. Actor Port = 2 ...	
91.000265890	Link Aggregation Control ProtocolVersion 1. Actor Port = 3 Partner Port = 4	
91.000998386	Link Aggregation Control ProtocolVersion 1. Actor Port = 5 Partner Port = 6	
91.002500254	Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 8	
119.996708783	Link Aggregation Control ProtocolVersio...	
119.997582917	Link Aggregation C...	

after reload one component

LACP – Capture and Display Filter

Capture filter for selected interfaces: ether proto 0x8809

Compiled Filter Output

LAN-Verbindung

```
(000) ldh      [12]
(001) jeq      #0x8809        jt 2        jf 3
(002) ret      #262144
(003) ret      #0
```

slow

No.	Time	DELTA	SRC-MAC
3	12.538944000	0.000000000	00:16:35:b3:71:9f
4	12.581696000	0.042752000	b0:b2:dc:6c:c3:86
6	134.384160000	121.802464000	b0:b2:dc:6c:c3:86

```
▷ Frame 3: 124 bytes on wire (992 bits), 124 bytes cap
▷ Ethernet II, Src: HewlettP_b3:71:9f (00:16:35:b3:71:
◢ Slow Protocols
    Slow Protocols subtype: LACP (0x01)
◢ Link Aggregation Control Protocol
```

lacp

No.	Time	DELTA	SRC-MAC
3	12.538944000	0.000000000	00:16:35:b3:71:9f
4	12.581696000	0.042752000	b0:b2:dc:6c:c3:86
6	134.384160000	121.802464000	b0:b2:dc:6c:c3:86

```
▷ Frame 3: 124 bytes on wire (992 bits), 124 bytes cap
▷ Ethernet II, Src: HewlettP_b3:71:9f (00:16:35:b3:71:
◢ Slow Protocols
    Slow Protocols subtype: LACP (0x01)
◢ Link Aggregation Control Protocol
```

eth.src[0:3] == b0:b2:dc

Packets: 36 · Displayed: 20 (55.6%) · Load time: 0:0.2

LACP in Wireshark 2.0

https://www.wireshark.org/docs/dfref/s/slow.html

Wireshark · Display Filter Re...

WIRESHARK

News Get Acquainted ▾

		integer, 1 byte	1.12.9
slow.esmc.version.compliance	Expert Info	Label	1.12.0 to 1.12.9
slow.lacp.actorInfo	Actor Information	Unsigned integer, 1 byte	1.0.0 to 1.12.9

https://www.wireshark.org/docs/dfref/l/lacp.html

Wireshark · Display Filter Re...

WIRESHARK

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Display Filter Reference: LACP

Protocol field name: lacp

Versions: 2.0.0 to 2.0.2

Back to Display Filter Reference

FIELD NAME	DESCRIPTION	TYPE	VERSIONS
lacp.actorInfo	Actor Information	Unsigned integer, 1 byte	2.0.0 to 2.0.2
lacp.actorInfoLen	Actor Information Length	Unsigned integer, 1 byte	2.0.0 to 2.0.2

LACP – in Detail

```
◢ Link Aggregation Control Protocol
    LACP Version Number: 0x01
    Actor Information: 0x01
    Actor Information Length: 0x14
    Actor System Priority: 32768
    Actor System: SWITCH-A-SYSTEM (00:19:aa:d9:c7:00)
    Actor Key: 10
    Actor Port Priority: 32768
    Actor Port: 274
  ▷ Actor State: 0x7d, LACP Activity, Aggregation, Synchronization, Collecting, Distributing, Defaulted
    Reserved: 000000
    Partner Information: 0x02
    Partner Information Length: 0x14
    Partner System Priority: 0
    Partner System: 00:00:00_00:00:00 (00:00:00:00:00:00)
    Partner Key: 0
    Partner Port Priority: 0
    Partner Port: 0
  ▷ Partner State: 0x00
    Reserved: 000000
    Collector Information: 0x03
    Collector Information Length: 0x10
    Collector Max Delay: 32768
    Reserved: 000000000000000000000000
    Terminator Information: 0x00
    Terminator Length: 0x00
    Reserved: 000000000000000000000000000000000000000000000000...
```

ACTOR

PARTNER

COLLECTOR

TERMINATOR

LACP – Flags (Actor)

```
◢ Actor State: 0x3d, LACP Activity, Aggregation, Synchronization, Collecting, Distributing
    .... ...1 = LACP Activity: Yes
    .... ..0. = LACP Timeout: No
    .... .1.. = Aggregation: Yes
    .... 1... = Synchronization: Yes
    ...1 .... = Collecting: Yes
    ..1. .... = Distributing: Yes
    .0.. .... = Defaulted: No
    0... .... = Expired: No
```

Activity control value for this link. Active = 1, Passive = 0 (lacp.actorState.activity), 1 Byte

Timeout control value for this link. Short Timeout = 1, Long Timeout = 0 (lacp.actorState.timeout), 1 Byte

Aggregatable = 1, Individual = 0 (lacp.actorState.aggregation), 1 Byte

In Sync = 1, Out of Sync = 0 (lacp.actorState.synchronization), 1 Byte

Collection of incoming frames is: Enabled = 1, Disabled = 0 (lacp.partnerState.collecting), 1 Byte

Distribution of outgoing frames is: Enabled = 1, Disabled = 0 (lacp.partnerState.distributing), 1 Byte

1 = Actor Rx machine is using DEFAULT Partner info, 0 = using info in Rx'd LACPDU (lacp.partnerState.defaulted), 1 Byte

1 = Actor Rx machine is EXPIRED, 0 = is NOT EXPIRED (lacp.partnerState.expired), 1 Byte

LACP – Lua script for the flags

- Lua dissectors are a great way to enhance Wireshark

No.	Time	Source	Destination	Protocol	Length	LACP Flags
7	19.000995712	HewlettP_b3:71:9b	Slow-Protocols	LACP	128	**DCSG*A,**DCSG*A
8	121.845225892	ZyxelCom_6c:c3:86	Slow-Protocols	LACP	128	EF***G*A,*FDC**S*
9	121.848485247	HewlettP_b3:71:9f	Slow-Protocols	LACP	128	**DCSG*A,*F***G*A
10	122.037726486	ZyxelCom_6c:c3:87	Slow-Protocols	LACP	128	EF***G*A,*FDC**S*
11	122.060262887	HewlettP_b3:71:9c	Slow-Protocols	LACP	128	**DCSG*A,*F***G*A
12	122.198438937	ZyxelCom_6c:c3:89	Slow-Protocols	LACP	128	EF***G*A,*FDC**S*
13	122.221484901	HewlettP_b3:71:9a	Slow-Protocols	LACP	128	**DCSG*A,*F***G*A

```
> Frame 7: 128 bytes on wire (1024 bits), 128 bytes captured (1024 bits)
> Ethernet II, Src: HewlettP_b3:71:9b (00:16:35:b3:71:9b), Dst: Slow-Protocols (01:80:c2:00:00:02)
> Slow Protocols
> Link Aggregation Control Protocol
v LACP Actor Flags
    LACP Flags: **DCSG*A
v LACP Partner Flags
    LACP Flags: **DCSG*A
```

See Lua Script "TCP Flags for Wireshark" by Didier Stevens - modified for LACP

LACP – System-ID

```
◢ Link Aggregation Control Protocol
    LACP Version Number: 0x01
    Actor Information: 0x01
    Actor Information Length: 0x14
    Actor System Priority: 32768
    Actor System: SWITCH-A-SYSTEM (00:19:aa:d9:c7:00)
    Actor Key: 10
    Actor Port Priority: 32768
    Actor Port: 274
  ▷ Actor State: 0x7d, LACP Activity, Aggregation, Synchronization, Collecting, Distributing, Defaulted
    Reserved: 000000
```

System-ID

System-ID = **System Priority** plus **System MAC** address

- The endpoint with the lower **System-ID** makes the decision about which ports are actively participating in the port-channel at any given time.
- **The lower the value** becomes the **Actor** and determines the links between the LACP partner switches that are in active and standby states for each LACP port channel.
- When the **System Priority** is same, the device with lower **System MAC** will have higher system-priority.

LACP – Actor Key

```
◢ Link Aggregation Control Protocol
    LACP Version Number: 0x01
    Actor Information: 0x01
    Actor Information Length: 0x14
    Actor System Priority: 32768
    Actor System: SWITCH-A-SYSTEM (00:19:aa:d9:c7:00)
    Actor Key: 10
    Actor Port Priority: 32768
    Actor Port: 274
  ▷ Actor State: 0x7d, LACP Activity, Aggregation, Synchronization, Collecting, Distributing, Defaulted
    Reserved: 000000
```

KEY

Actor Key

- Value assigned to aggregator ports and physical ports that are candidates for joining a LAG.
- Only ports with matching keys are allowed to aggregate.

LACP – Port-ID

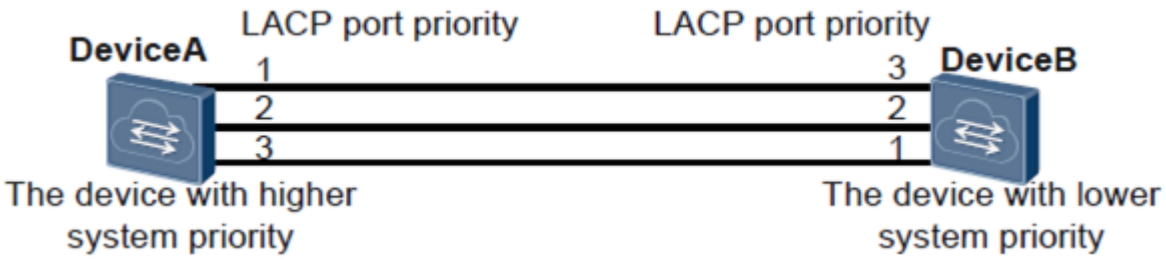
```
◢ Link Aggregation Control Protocol
    LACP Version Number: 0x01
    Actor Information: 0x01
    Actor Information Length: 0x14
    Actor System Priority: 32768
    Actor System: SWITCH-A-SYSTEM (00:19:aa:d9:c7:00)
    Actor Key: 10
    Actor Port Priority: 32768
    Actor Port: 274
  ▷ Actor State: 0x7d, LACP Activity, Aggregation, Synchronization, Collecting, Distributing, Defaulted
    Reserved: 000000
```

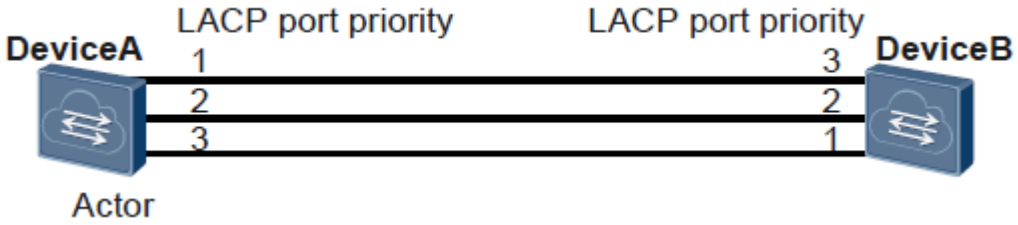
Port-ID

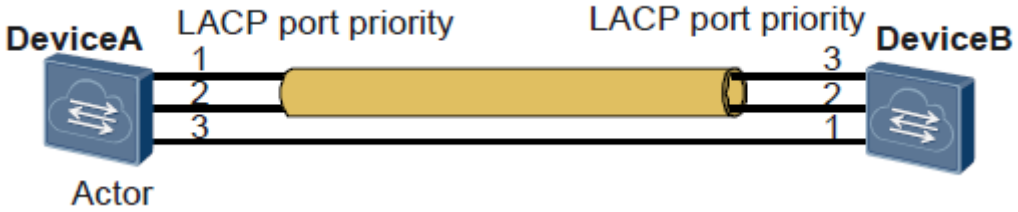
Port-ID = **Port Priority** plus **Port Number**

- The lower the range of the **Port-ID**, the more likely that the interface will be used for LACP transmission
- **Port Priority** decides which ports should be put in **standby mode** when there is a limitation that prevents all compatible ports from aggregating and which ports should be put into **active mode**.

LACP – Actor Election







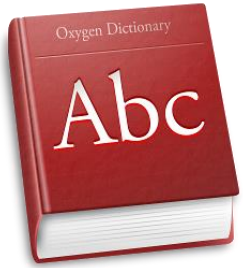
Decision Maker → Which ports are part of the aggregation

LACP interaction with LLDP

```
▲ Link Layer Discovery Protocol
  ▷ Chassis Subtype = MAC address, Id: 00:1e:58:b4:0f:c3
  ▷ Port Subtype = Locally assigned, Id: 1/1
  ▷ Time To Live = 120 sec
  ▷ Port Description = RMON Port  1 on Unit 1
  ▷ System Name =
  ▷ System Description = Gigabit Ethernet Switch
  ▷ Capabilities
  ▷ IEEE 802.3 - MAC/PHY Configuration/Status
  ▲ IEEE 802.3 - Link Aggregation
      1111 111. .... .... = TLV Type: Organization Specific (127)
      .... ...0 0000 1001 = TLV Length: 9
      Organization Unique Code: IEEE 802.3 (0x00120f)
      IEEE 802.3 Subtype: Link Aggregation (0x03)
    ▲ Aggregation Status: 0x01
        .... ...1 = Aggregation Capability: Yes
        .... ..0. = Aggregation Status: Disabled
      Aggregated Port Id: 0
  ▷ IEEE 802.3 - Maximum Frame Size
  ▷ End of LLDPDU
```

```
▲ IEEE 802.3 - Link Aggregation
    1111 111. .... .... = TLV Type: Organization Specific (127)
    .... ...0 0000 1001 = TLV Length: 9
    Organization Unique Code: IEEE 802.3 (0x00120f)
    IEEE 802.3 Subtype: Link Aggregation (0x03)
  ▲ Aggregation Status: 0x03
      .... ...1 = Aggregation Capability: Yes
      .... ..1. = Aggregation Status: Enabled
    Aggregated Port Id: 6
```

MC-LAG with LACP



- MC-LAG - LAG terminate on separate chassis
- MC-LAG is not covered under IEEE standard
- Multi-homing for redundancy
- Active-active to utilize all links which otherwise may get blocked by Spanning-Tree
- no modification of LAG partner
- Temporary loops or duplicates not acceptable
- Split brain handling
- One the way for multi-vendor implementation

MC-LAG – different vendors – different names

- Cisco:
  - StackWise
  - Virtual Switching System (VSS)
  - Virtual Port Channel (vPC)
- Juniper
  - Virtual Chassis (VC)
- HP
  - Intelligent Resilient Framework (IRF)
- Extreme Networks
  - Inter-Switch-Connection
- Force10
  - Virtual Link Trunking
- Avaya (Nortel)
  - Split multi-link trunking
- Cumulus Networking
  - Multi-Chassis Link Aggregation
- Arista Networks
  - MLAG
- … and many others

MC-LAG with LACP

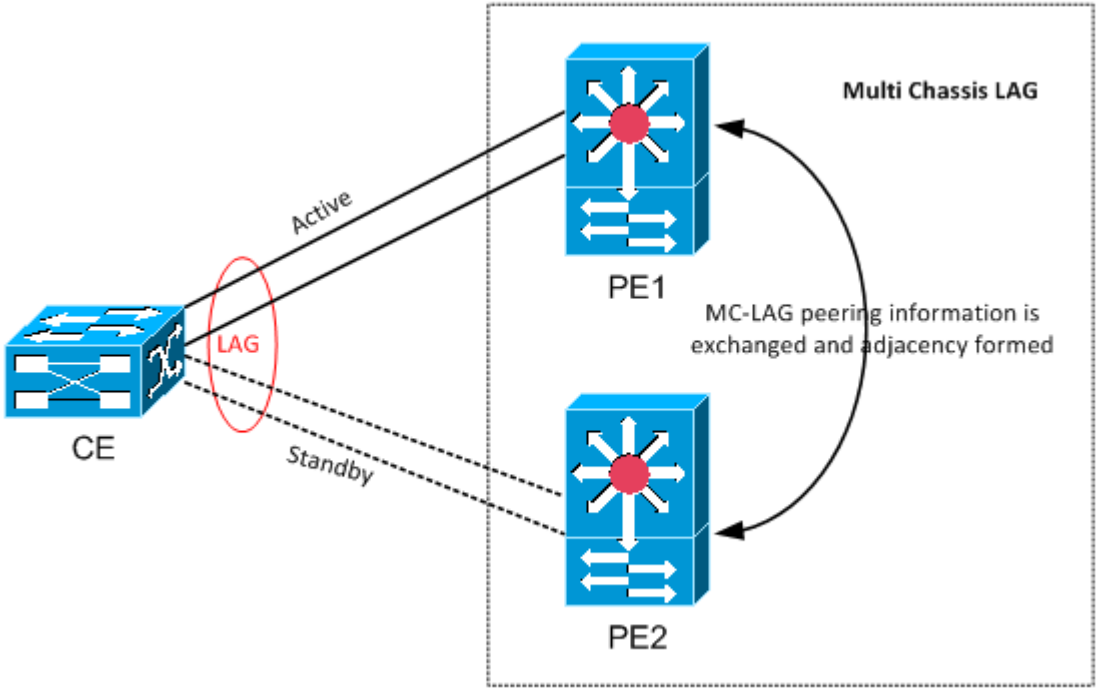
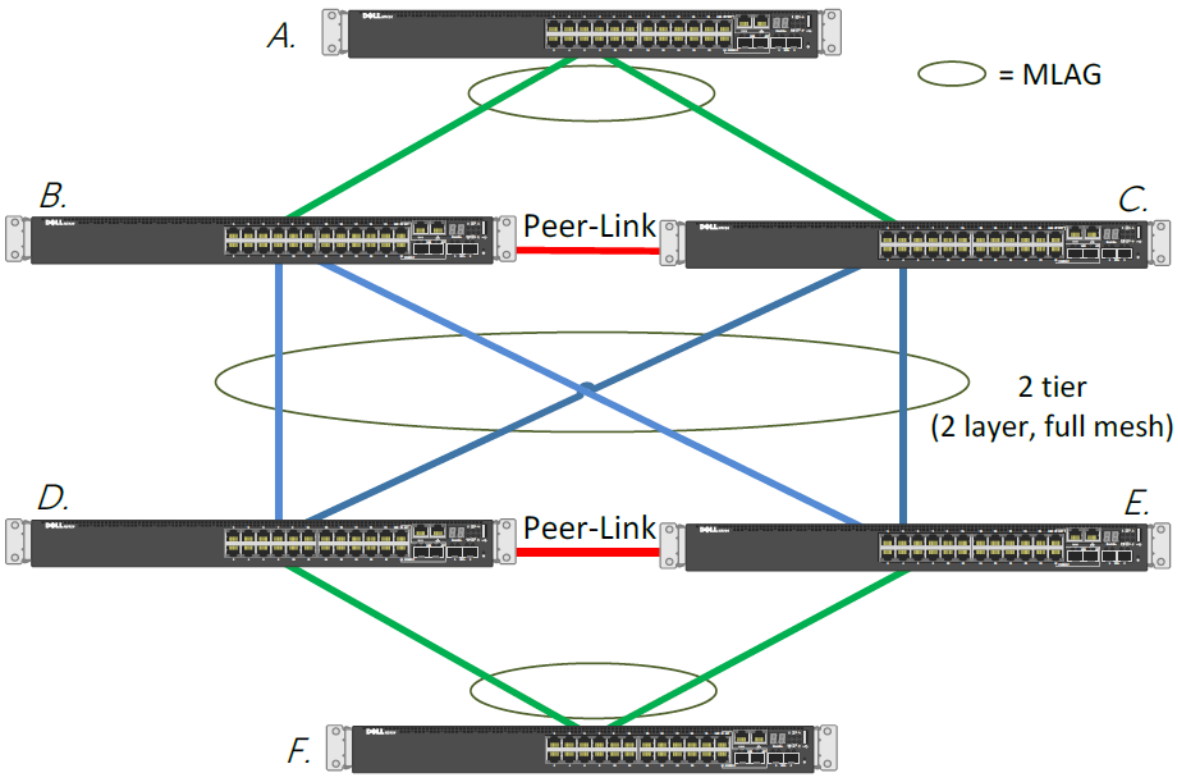
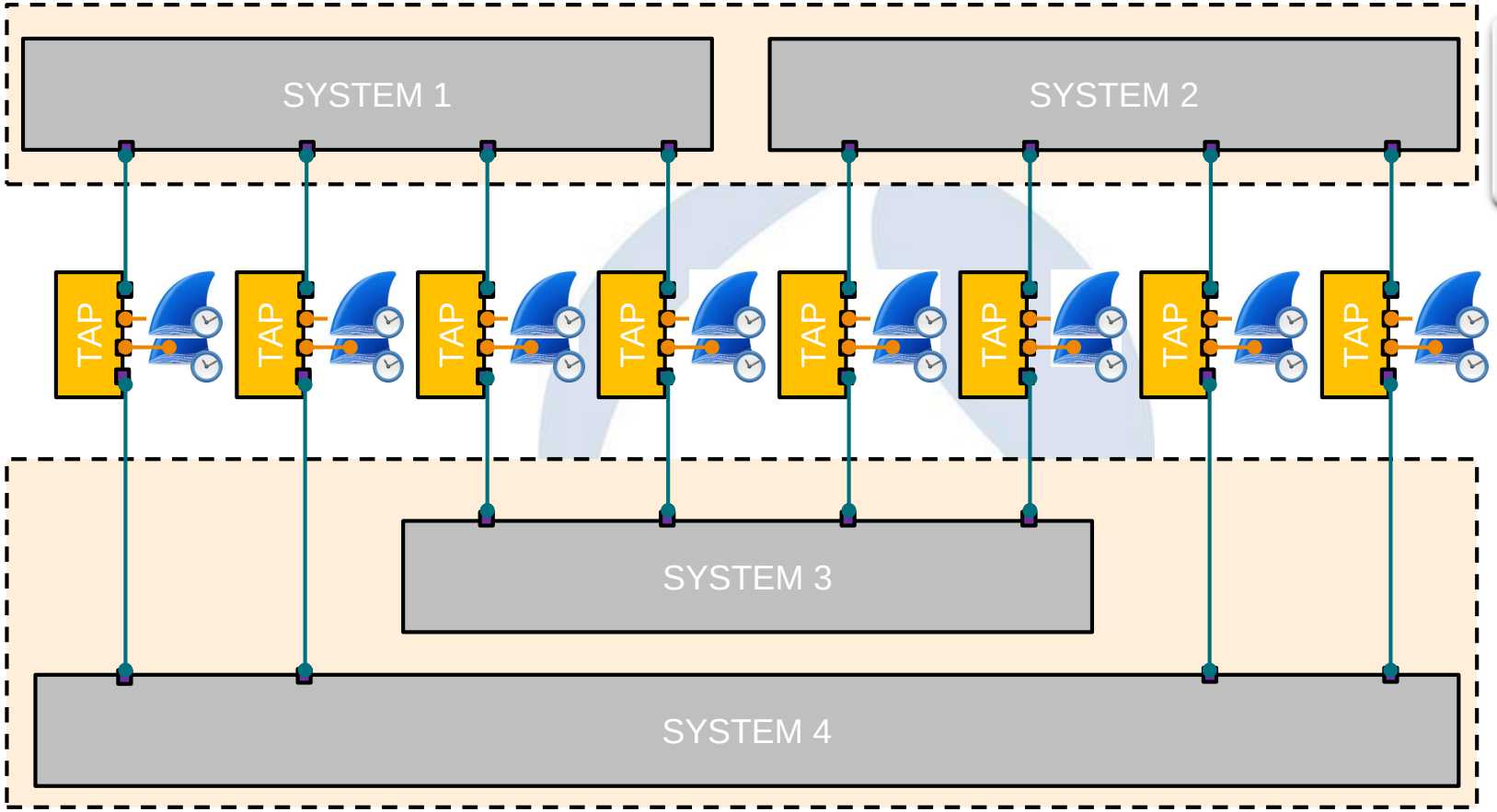


Figure 1. A basic MC-LAG Example

MLAG with LACP

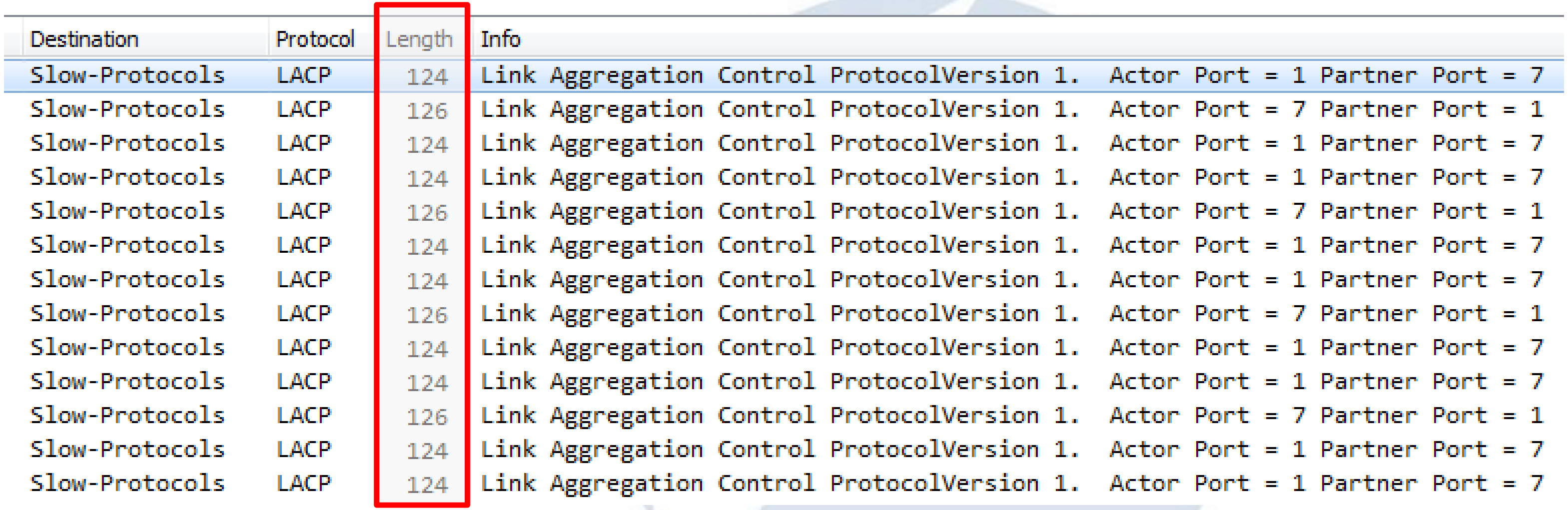


LACP in Fabric/Cluster/vPC/Switch Stacking



LACP Challenges from the field

Frame Size different



Destination	Protocol	Length	Info
Slow-Protocols	LACP	124	Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
Slow-Protocols	LACP	126	Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
Slow-Protocols	LACP	124	Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
Slow-Protocols	LACP	124	Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
Slow-Protocols	LACP	126	Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
Slow-Protocols	LACP	124	Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
Slow-Protocols	LACP	124	Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
Slow-Protocols	LACP	126	Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
Slow-Protocols	LACP	124	Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
Slow-Protocols	LACP	124	Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
Slow-Protocols	LACP	126	Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
Slow-Protocols	LACP	124	Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
Slow-Protocols	LACP	124	Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7

Timer different – not short or long

203.881216000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
204.881248000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
205.534944000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
205.881216000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
206.881248000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
207.534976000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
207.881248000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
208.881280000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
209.534944000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
209.881280000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
210.881312000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
211.534944000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
211.881312000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
212.881312000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
213.534944000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
213.881312000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
214.881344000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
215.534944000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
215.881344000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
216.881376000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
217.534944000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
217.881376000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
218.881376000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7
219.534944000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 7 Partner Port = 1
219.881376000	Link Aggregation Co	LACP: Link Aggregation Control ProtocolVersion 1. Actor Port = 1 Partner Port = 7

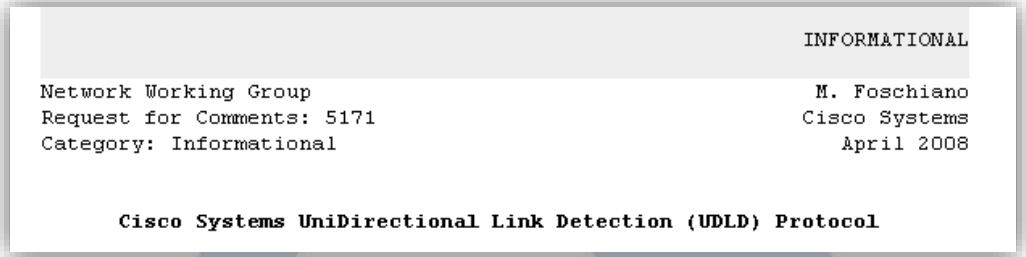
Every two seconds from the link partner

Time for Questions

Unidirectional Link Detection (UDLD)

UDLD Basics

- Cisco UDLD feature is documented in RFC 5171



INFORMATIONAL

Network Working Group
Request for Comments: 5171
Category: Informational

M. Foschiano
Cisco Systems
April 2008

Cisco Systems UniDirectional Link Detection (UDLD) Protocol

- Different names and implementations
  - Device Link Detection Protocol (DLDP)
  - D-Link Unidirectional Link Detection (DULD)
- Three Paket Formats
  - Probe
  - Echo
  - Flush

UDLD Basics

- Many vendors have their own proprietary solution
  - LACP protocol in a single member LAG
  - Own Ethertype
- Layer 1 "fault" indication is the "loss of light“
- Why it is needed – we use Auto-Negotiation with Remote-Fault?
  - Different wavelengths of optical signaling (10/100/1000)
  - EoSDH
- Used for miswiring detection

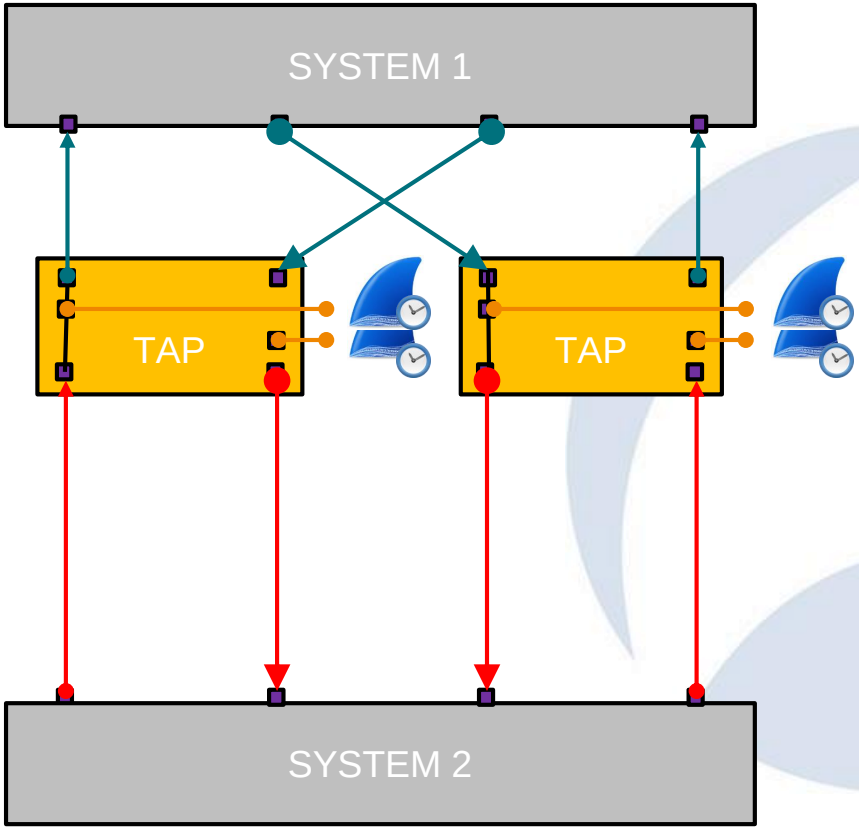
Cisco UDLD Notes

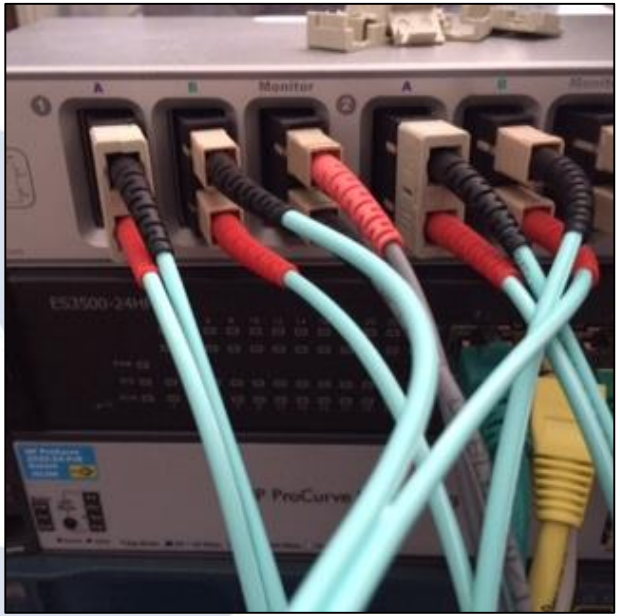
- Cisco UDLD are encoded with LLC, standard Subnetwork Access Protocol (SNAP) format and Protocol ID 0x111
- Destination Multicast MAC Address: 01:00:0C:CC:CC:CC
- Fast Hello enhancement available

UDLD Modes

- Aggressive Mode:
  - UDLD will declare link as unidirectional and will disable interface, if no reply has been received for subsequent 8 PDU message transmitted at an interval of 1 sec.
- Normal Mode:
  - Link will be disabled immediately if PDU reply has not been received within predefine timeout interval.

UDLD Capture





UDLD in Wireshark – Custom Columns

02_ana-1-faser-tausch-dann-err-disable-udld-only.pcapng

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

Title: Data | Type: Custom | Field Name: udld.data | Occurrence: 1

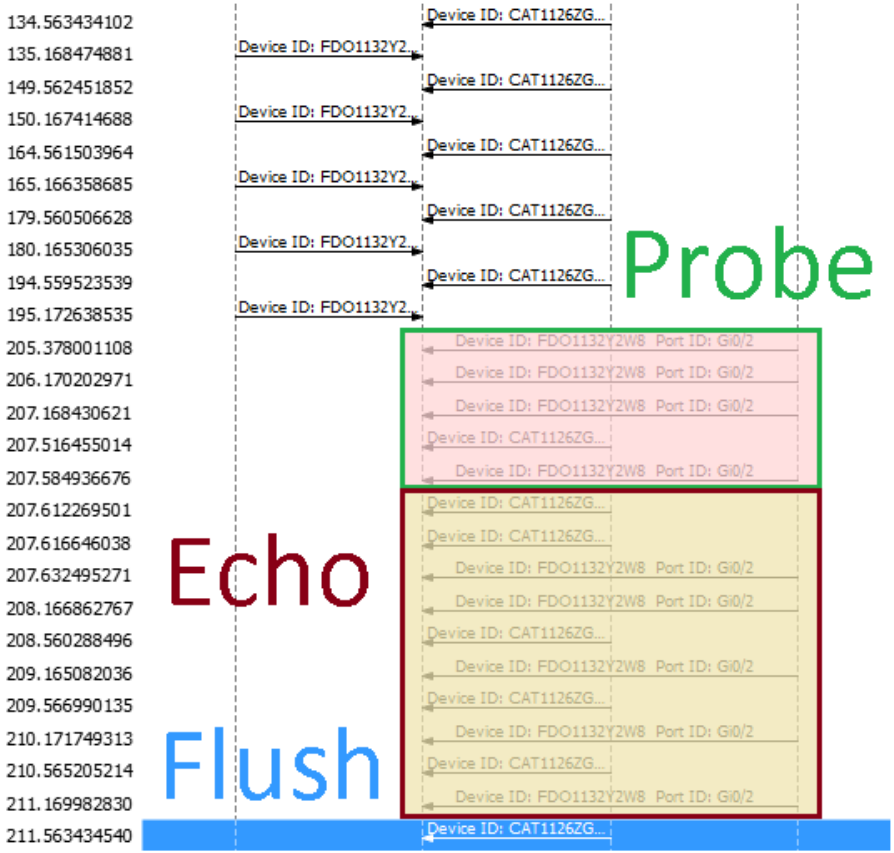
No.	Time	Delta	Source	Destination	Protocol	Length	Opcode	Recommended timeout	ReSynch	Sent through Interface	Data	Info
1	0.000000	0.000000	CiscoInc_7f:63:01	CDP/VTP/DTP/PAgP/UDLD	UDLD	109	Probe	0x00	0x00	Gi0/1	05	Device
2	14.393075	14.393075	CiscoInc_83:a2:81	CDP/VTP/DTP/PAgP/UDLD	UDLD	138	Probe	0x00	0x00	Gi0/1	05	Device
3	14.998707	0.605632	CiscoInc_7f:63:01	CDP/VTP/DTP/PAgP/UDLD	UDLD	109	Probe	0x00	0x00	Gi0/1	05	Device

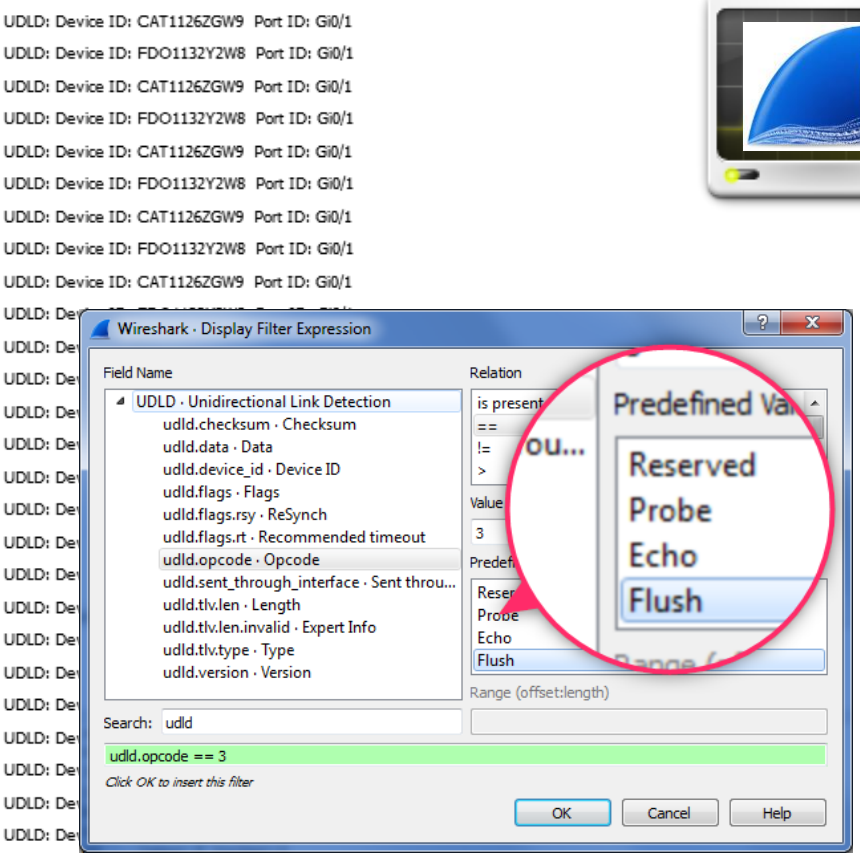
```
▷ Frame 1: 109 bytes on wire (872 bits), 109 bytes captured (872 bits) on interface 0
▷ IEEE 802.3 Ethernet
▷ Logical-Link Control
◢ Unidirectional Link Detection
    001. .... = Version: 1
    ...0 0001 = Opcode: Probe (1)
  ▷ Flags: 1
    Checksum: 0x3aca
  ▷ Device ID: FDO1132Y2W8
  ◢ Port ID: Gi0/1
      Type: Port ID (0x0002)
      Length: 9
      Sent through Interface: Gi0/1
  ◢ Type: Echo, length: 28
      Type: Echo (0x0003)
      Length: 28
      Data: 00000001000b434154313132365a47573900054769302f31
  ◢ Type: Message interval, length: 5
      Type: Message interval (0x0004)
      Length: 5
      Data: 0f
  ◢ Type: Timeout interval, length: 5
      Type: Timeout interval (0x0005)
      Length: 5
      Data: 05
  ◢ Type: Device name, length: 9
      Type: Device name (0x0006)
      Length: 9
      Data: 756e74656e
  ◢ Type: Sequence number, length: 8
      Type: Sequence number (0x0007)
      Length: 8
      Data: 00000007
```

Data (udld.data),

Field occurrence is very useful in such case. Every udld.data field as a custom column

UDLD in Wireshark – Flow Graph





UDLD Challenges from the field

UDLD non-Cisco

*udld-mrv-os904-port3-fiber-interface.enc [Wireshark 2.0.3 (v2.0.3-0-geed34f0 from master-2.0)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: Expression... Clear Apply Save | MP-MRU | KEIN-FRAGMENT | CONFREQ

No.	Time	DELTA	SRC-MAC	DST-MAC	Source	Destination	Protocol	Length	Info
1	0.000000000	0.000000000	3c:a7:2b:02:25:ce	01:00:0c:cc:cc:cc	MrvCommu_02:25:ce	CDP/VTP/DTP/PAgP/UDLD	LLC	96	U, func=UI; SNAP, OU
2	0.987850346	0.987850346	3c:a7:2b:02:25:ce	01:00:0c:cc:cc:cc	MrvCommu_02:25:ce	CDP/VTP/DTP/PAgP/UDLD	LLC	96	U, func=UI; SNAP, OU
3	1.978028084	0.990177738	3c:a7:2b:02:25:ce	01:00:0c:cc:cc:cc	MrvCommu_02:25:ce	CDP/VTP/DTP/PAgP/UDLD	LLC	96	U, func=UI; SNAP, OU
4	2.967884832	0.989856748	3c:a7:2b:02:25:ce	01:00:0c:cc:cc:cc	MrvCommu_02:25:ce	CDP/VTP/DTP/PAgP/UDLD	LLC	96	U, func=UI; SNAP, OU
5	3.957929313	0.990044481	3c:a7:2b:02:25:ce	01:00:0c:cc:cc:cc	MrvCommu_02:25:ce	CDP/VTP/DTP/PAgP/UDLD	LLC	96	U, func=UI; SNAP, OU
6	4.947967089	0.990037776	3c:a7:2b:02:25:ce	01:00:0c:cc:cc:cc	MrvCommu_02:25:ce	CDP/VTP/DTP/PAgP/UDLD	LLC	96	U, func=UI; SNAP, OU
7	5.938009056	0.990041967	3c:a7:2b:02:25:ce	01:00:0c:cc:cc:cc	MrvCommu_02:25:ce	CDP/VTP/DTP/PAgP/UDLD	LLC	96	U, func=UI; SNAP, OU

```
⊞ Frame 4: 96 bytes on wire (768 bits), 96 bytes captured (768 bits)
⊞ IEEE 802.3 Ethernet
⊟ Logical-Link Control
  ⊞ DSAP: SNAP (0xaa)
  ⊞ SSAP: SNAP (0xaa)
  ⊞ Control field: U, func=UI (0x03)
    Organization Code: Encapsulated Ethernet (0x000000)
    Type: Unknown (0x0111)
⊟ Data (70 bytes)
    Data: 220307640001000f3131343831303033383000000020006 33...
    [Length: 70]
```

There is a workaround ☺
Use Wireshark Legacy with Packet Edit

UDLD non-Cisco

Frame 4: 96 bytes on wire (768 bits), 96 bytes captured (768 bits)
IEEE 802.3 Ethernet
Logical-Link Co
DSAP: SNAP (0
SSAP: SNAP (0
Control field
Organization
Type: Unknown
Data (70 bytes)
Data: 2203076
[Length: 70]

Expand Subtrees
Collapse Subtrees
Expand All
Collapse All
Apply as Column
Apply as Filter
Prepare a Filter
Colorize with Filter
Follow TCP Stream
Follow UDP Stream
Follow SSL Stream
Copy
Export Selected Packet Bytes
Edit Packet
Wiki Protocol Page
Filter Field Reference
Protocol Help
Protocol Preferences
Decode As...
Disable Protocol...
Resolve Name
Go to Corresponding Packet
Show Packet Reference in New Window

Wireshark Legacy only

Enable Packet Editor (Experimental): ☐

4 2.967884832 MrvCommu_02:25:ce CDP/VTP/DTP/PAgP/UDLD LLC 96 U, fun

Frame 4: 96 bytes on wire (768 bits), 96 bytes captured (768 bits)
IEEE 802.3 Ethernet
Logical-Link Control
DSAP: SNAP (0xaa)
SSAP: SNAP (0xaa)
Control field: U, func=UI (0x03)
Organization Code: Encapsulated Ethernet (0x000000)
Type: Unknown (0x0111)
Data (70 bytes)
Data: 22030764000100 0f313134383130303338300000002000633...
[Length: 70]

Editing finfo: ....
<not added by proto_tree_add_item()>
Organization Code: Cisco (0x00000c)
Hex edit
0000 00 00 0c

```
0010  03 00 00 00 01 11 22 03  07 64 00 01 00 0f 31 31   ......". .d....11
0020  34 38 31 30 30 33 38 30  00 00 02 00 06 33 00 00   48100380 .....3..
0030  03 00 08 00 00 00 00 00  04 00 05 07 00 05 00 05   ........ ........
0040  07 00 06 00 13 4f 70 74  69 53 77 69 74 63 68 20   .....Opt iSwitch
0050  39 30 34 00 00 07 00 08  00 00 00 04 4d e1 cc 9c   904..... ....M...
```

UDLD non-Cisco

```
4 2.967884832   MrvCommu_02:25:ce CDP/VTP/DTP/PAgP/UDLD LLC 96   U, func=UI; SNAP, OUI 0x000000 (En...

Frame 4: 96 bytes on wire (768 bits), 96 bytes captured (768 bits)
IEEE 802.3 Ethernet
  Destination: CDP/VTP/DTP/PAgP/UDLD (01:00:0c:cc:cc:cc)
  Source: MrvCommu_02:25:ce (3c:a7:2b:02:25:ce)
  Length: 78
  Trailer: 4de1cc9c
Logical-Link Control
  DSAP: SNAP (0xaa)
  SSAP: SNAP (0xaa)
  Control field: U, func=UI (0x03)
  Organization Code: Cisco (0x00000c)
  PID: UDLD (0x0111)
Unidirectional Link Detection
  001. .... = Version: 1
  ...0 0010 = Opcode: Echo (2)
  Flags: 3
  Checksum: 0x0764
  Device ID: 1148100380
    Type: Device ID (0x0001)
    Length: 15
    Device ID: 1148100380
  Port ID: 3\000
    Type: Port ID (0x0002)
    Length: 6
    Sent through Interface: 3
  Type: Echo, length: 8
    Type: Echo (0x0003)
    Length: 8
    Data: 00000000
  Type: Message interval, length: 5
    Type: Message interval (0x0004)
    Length: 5
    Data: 07
  Type: Timeout interval, length: 5
    Type: Timeout interval (0x0005)
    Length: 5
    Data: 07
  Type: Device name, length: 19
    Type: Device name (0x0006)
    Length: 19
    Data: 4f70746953776974636820393034 00
  Type: Sequence number, length: 8
    Type: Sequence number (0x0007)
    Length: 8
    Data: 00000004

0000  01 00 0c cc cc cc 3c a7  2b 02 25 ce 00 4e aa aa   ......<. +.%..N..
0010  03 00 00 0c 01 11 22 03  07 64 00 01 00 0f 31 31   ......". .d....11
0020  34 38 31 30 30 33 38 30  00 00 02 00 06 33 00 00   48100380 .....3..
0030  03 00 08 00 00 00 00 00  04 00 05 07 00 05 00 05   ........ ........
0040  07 00 06 00 13 4f 70 74  69 53 77 69 74 63 68 20   .....Opt iSwitch
0050  39 30 34 00 00 07 00 08  00 00 00 04 4d e1 cc 9c   904..... ....M...
```

Works for this vendor
Maybe a bug – will discuss that with the wireshark developers ☺ afterwards

Time for Questions

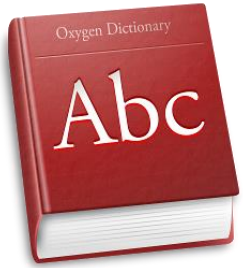
Configuration Test Protocol (loopback)

Loop Detection Protocol

- Loop detection protocol
  - Pro Port
  - Pro VLAN (Trunk)
- Ethertype 0x9000
- Different Destination MAC Adresses
  - CF-00-00-00-00-00
  - 01-0F-E2-00-00-07
  - 00-00-F4-27-71-01
  - 01-A0-C5-AA-AA-AB
  - …

Loop Detection Protocols

- CTP from the archive



ETHERNET SPECIFICATION: Configuration Testing Protocol

8. ETHERNET CONFIGURATION TESTING PROTOCOL

The *Ethernet Configuration Testing Protocol* provides a minimum testing capability of communication between stations on an Ethernet. It is the only Client Layer protocol specified in this document and has the only assigned Ethernet type field value in this document. All Ethernet stations must support the configuration testing functions.

8.1 Goals

For more information see
http://www.mit.edu/~jhawk/ctp.pdf

Loopback from the field

Loop Detection Protocols

```
▷ Frame 3: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface 0
◢ Ethernet II, Src: D-LinkCo_b4:0f:c3 (00:1e:58:b4:0f:c3), Dst: Ethernet-Configuration-Test-protocol-(Loopback) (cf:0
  ▷ Destination: Ethernet-Configuration-Test-protocol-(Loopback) (cf:00:00:00:00:00)
  ▷ Source: D-LinkCo_b4:0f:c3 (00:1e:58:b4:0f:c3)
    Type: Loopback (0x9000)
◢ Configuration Test Protocol (loopback)
    skipCount: 0
    Relevant function: Unknown (256)
    Function: Unknown (256)
◢ Data (42 bytes)
    Data: 00010000001e58b40fc30fc3000000000000000000000000..
    [Length: 42]

0000  cf 00 00 00 00 00 00 1e  58 b4 0f c3 90 00 00 00   ....
0010  00 01 00 01 00 00 00 1e  58 b4 0f c3 0f c3 00 00   ....
0020  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ....
0030  00 00 00 00 00 00 00 00  00 00 00 00               ....
```

```
◢ Packet comments
    [2016-03-26 - Werner Fischer]
  ▷
    "config loopdetect mode vlan-based"
▷ Frame 4: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on i
◢ Ethernet II, Src: D-LinkCo_b4:0f:c3 (00:1e:58:b4:0f:c3), Dst: Ethernet-
  ▷ Destination: Ethernet-Configuration-Test-protocol-(Loopback) (cf:00:
  ▷ Source: D-LinkCo_b4:0f:c3 (00:1e:58:b4:0f:c3)
    Type: Loopback (0x9000)
◢ Configuration Test Protocol (loopback)
    skipCount: 0
    Relevant function: Unknown (256)
    Function: Unknown (256)
◢ Data (42 bytes)
    Data: 00010001001e58b40fc30fc3000000000000000000000000...
    [Length: 42]

0000  cf 00 00 00 00 00 00 1e  58 b4 0f c3 90 00 00 00   ........ X......
0010  00 01 00 01 00 01 00 1e  58 b4 0f c3 0f c3 00 00   ........ X......
0020  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ........ ......
0030  00 00 00 00 00 00 00 00  00 00 00 00               ........ ....
```

Loop Detection Protocols

- Every vendor has it own solution
  - TLV coded

```
0000  01 a0 c5 aa aa ab fc f5  28 4d 6d 47 90 00 01 00   ........ (MmG....
0010  27 75 4b 01 06 fc f5 28  4d 6d 47 02 02 00 06 03   'uK....( MmG.....
0020  06 45 53 33 35 30 30 04  04 00 08 c1 40 05 06 45   .ES3500. ....@..E
0030  53 33 35 30 30 00 00 00  00 00 00 00 3e 43 dd 3c   S3500... ....>C.<
```

  - You should read the HEX-code – also in 2016

Loop Detection Protocols – Port Testing

- Every vendor has it own solution

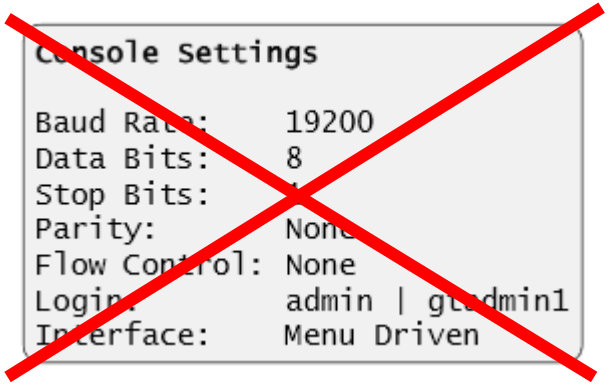
```
▷ Frame 1: 64 bytes on wire (512 bits), 64 bytes captured (512 bits)
▷ Ethernet II, Src: AlliedTe_00:00:00 (00:00:cd:00:00:00), Dst: AlliedTe_00:00:01 (00:00:cd:00:00:01)
◢ Configuration Test Protocol (loopback)
    skipCount: 0
    Relevant function: Unknown (3840)
    Function: Unknown (3840)
◢ Data (46 bytes)
    Data: 3c54657374696e6720706f7274303e00000000000000000000...
    [Length: 46]

0000  00 00 cd 00 00 01 00 00  cd 00 00 00 90 00 00 00   ........ ........
0010  00 0f 3c 54 65 73 74 69  6e 67 20 70 6f 72 74 30   ..<Testi ng port0
0020  3e 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   >....... ........
0030  00 00 00 00 00 00 00 00  00 00 00 00 82 61 e5 ca   ........ .....a..
```

Time for Questions

Ethernet Flow-Control

Ethernet Flow-Control

- Hard to catch
  - Depends on your capture equipment
- Ethertype 0x8808
- Different Modes
  - No PAUSE
  - Symmetric PAUSE
  - Asymmetric PAUSE
  - Symmetric PAUSE and Asymmetric PAUSE
- With Auto-Negotiation or without it



Ethernet Flow-Control Priority Resultion

IEEE
Std 802.3-2008

REVISION OF IEEE Std 802.3:

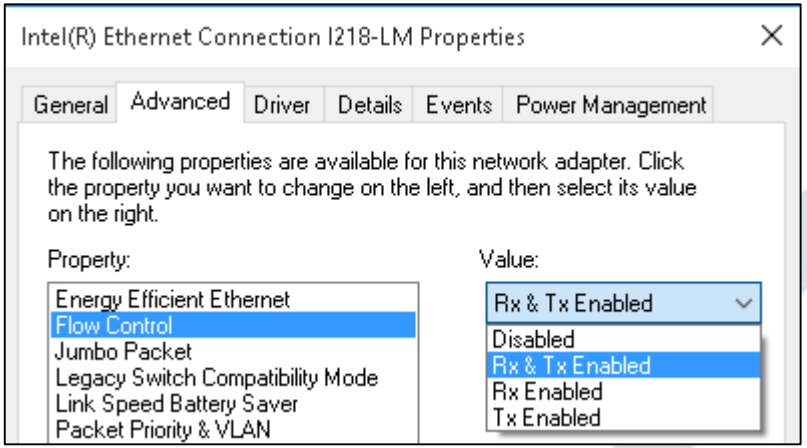
Table 37–4—Pause priority resolution

Local Device		Link Partner		Local Resolution	Link Partner Resolution
PAUSE	ASM_DIR	PAUSE	ASM_DIR		
0	0	—	—	Disable PAUSE Transmit and Receive	Disable PAUSE Transmit and Receive
0	1	0	—	Disable PAUSE Transmit and Receive	Disable PAUSE Transmit and Receive
0	1	1	0	Disable PAUSE Transmit and Receive	Disable PAUSE Transmit and Receive
0	1	1	1	Enable PAUSE transmit, Disable PAUSE receive	Enable PAUSE receive, Disable PAUSE transmit
1	0	0	—	Disable PAUSE Transmit and Receive	Disable PAUSE Transmit and Receive
1	0	1	—	Enable PAUSE Transmit and Receive	Enable PAUSE Transmit and Receive
1	1	0	0	Disable PAUSE Transmit and Receive	Disable PAUSE Transmit and Receive
1	1	0	1	Enable PAUSE receive, Disable PAUSE transmit	Enable PAUSE transmit, Disable PAUSE receive
1	1	1	—	Enable PAUSE Transmit and Receive	Enable PAUSE Transmit and Receive

Ethernet Flow-Control

- Depending on the bandwidth of the link, the PAUSE frames are sent at a specific interval of time.
- The PAUSE time is measured in units of PAUSE "quanta“ and is defined to be 512 bit times
  - Fast Ethernet 5.12µs, 0.512µs for Gigabit Ethernet, 0.0512µs for 10-Gigabit Ethernet, 0.0128µs for 40-Gigabit Ethernet and 0.00512µs for 100-Gigabit Ethernet (e.g. 512Bits/1.000.000.000Bit/sec for GE)
- 65535*512/1.000.000.000 = 0.03355392 seconds = 33.55ms.

Ethernet Flow-Control - Settings




```
Router#sh controller FastEthernet 0/0 | b PHY registers
 PHY registers:
  Register 0x00:   1000  782D  0040  61E4  01E1  C1E1  000D  2001
  Register 0x08:   0000  0000  0000  0000  0000  0000  0000  0000
  Register 0x10:   1000  0300  0000  0000  0200  007B  0300  0000
  Register 0x18:   003B  851F  9F00  008A  082B  0000  80A0
Bytes_recvd 2706029297 Bytes_sent 636605627 Frames_recvd 54499753 Frames_sent 7456645
total_bytes_RX 2706029297 Total_frames_RX 54499753 Bcast_frames_recvd 18797931
Mcast_frames_RX 21756491 CRC_err 0 Ovr_sized_frames 0
Fragments 0 Jabber 0 collision 0
Late_collision 0 64B frame 26323978; 65_127B_frames 17093799
128_255B_frames 14987201 256_511B_frames 2319326 512_1023B_frames 723842
1023_maxB_frames 508252 Rx_error 0 Dropped_frames 0
Mcast_frames_tx 1488314 Bcast_frames_tx 2839987 Sml_frame_recvd 0
```

```
# ethtool ens817
   Settings for ens817:
     Supported ports: [ FIBRE ]
     Supported link modes:   1000baseKX/Full
                             10000baseKX4/Full
                             10000baseKR/Full
                             40000baseCR4/Full
                             40000baseSR4/Full
     Supported pause frame use: Symmetric Receive-only
     Supports auto-negotiation: Yes
     Advertised link modes:  1000baseKX/Full
                             10000baseKX4/Full
                             10000baseKR/Full
                             40000baseCR4/Full
                             40000baseSR4/Full
     Advertised pause frame use: Symmetric
     Advertised auto-negotiation: Yes
     Link partner advertised link modes:  40000baseCR4/Full
     Link partner advertised pause frame use: No
     Link partner advertised auto-negotiation: Yes
     Speed: 40000Mb/s
     Duplex: Full
     Port: Direct Attach Copper
     PHYAD: 0
     Transceiver: internal
     Auto-negotiation: on
     Supports Wake-on: d
     Wake-on: d
     Current message level: 0x00000014 (20)
           link ifdown
     Link detected: yes
```

MAC PAUSE Frames

```
▷ Frame 453: 64 bytes on wire (512 bits), 64 bytes captured (512 bits)
◢ Ethernet II, Src: EIGENE-MAC-WF (00:26:b9:bc:9c:87), Dst: Spanning-tree-(for-bridges)_01 (01:80:c2:00:00:01)
  ▷ Destination: Spanning-tree-(for-bridges)_01 (01:80:c2:00:00:01)
  ▷ Source: EIGENE-MAC-WF (00:26:b9:bc:9c:87)
    Type: MAC Control (0x8808)
◢ MAC Control
    Opcode: Pause (0x0001)
    pause_time: 1664
```

macc

```
0000  01 80 c2 00 00 01 00 26  b9 bc 9c 87 88 08 00 01
0010  06 80 00 00 00 00 00 00  00 00 00 00 00 00 00 00
0020  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00
0030  00 00 00 00 00 00 00 00  00 00 00 00 ac c3 7a 28
```

```
▷ Frame 455: 64 bytes on wire (512 bits), 64 bytes captured (512 bits)
◢ Ethernet II, Src: EIGENE-MAC-WF (00:26:b9:bc:9c:87), Dst: Spanning-tree-(for-bridges)
  ▷ Destination: Spanning-tree-(for-bridges)_01 (01:80:c2:00:00:01)
  ▷ Source: EIGENE-MAC-WF (00:26:b9:bc:9c:87)
    Type: MAC Control (0x8808)
◢ MAC Control
    Opcode: Pause (0x0001)
    pause_time: 0
```

```
0000  01 80 c2 00 00 01 00 26  b9 bc 9c 87 88 08 00 01   .......& ........
0010  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ........ ........
0020  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00   ........ ........
0030  00 00 00 00 00 00 00 00  00 00 00 00 97 90 16 84   ........ ........
```

100 Mbit/s,
1 Gbit/s,
10 Gbit/s,
40 Gbit/s
or 100 Gbit/s?

Flow-Control information with LLDP

```
> Frame 54: 304 bytes on wire (2432 bits), 304 bytes captured (2432 bits)
> Ethernet II, Src: Enterasy_03:10:61 (00:1f:45:03:10:61), Dst: LLDP_Multicast (01:80:c2:00:00:0e)
v Link Layer Discovery Protocol
  > Chassis Subtype = MAC address, Id: 00:1f:45:03:10:60
  > Port Subtype = Interface name, Id: ge.1.1
  > Time To Live = 120 sec
  > Port Description = Unit: 1 1000BASE-T RJ45 Gigabit Ethernet Frontpanel
  > System Name = C3-LABOR-DACHBODEN
  > System Description = Enterasys Networks, Inc. C3G124-24 06.61.08.0013
  > Capabilities
  > Management Address
  > IEEE 802.1 - Port VLAN ID
  > IEEE 802.1 - Protocol Identity
  > IEEE 802.1 - Protocol Identity
  > IEEE 802.3 - MAC/PHY Configuration/Status
  > IEEE 802.3 - Link Aggregation
  > IEEE 802.3 - Maximum Frame Size
  > End of LLDPDU
```

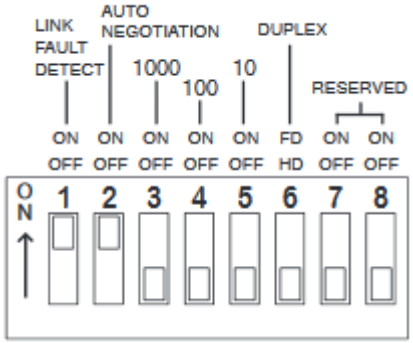
```
v IEEE 802.3 - MAC/PHY Configuration/Status
    1111 111. .... .... = TLV Type: Organization Specific (127)
    .... ...0 0000 1001 = TLV Length: 9
    Organization Unique Code: IEEE 802.3 (0x00120f)
    IEEE 802.3 Subtype: MAC/PHY Configuration/Status (0x01)
  v Auto-Negotiation Support/Status: 0x03
      .... ...1 = Auto-Negotiation: Supported
      .... ..1. = Auto-Negotiation: Enabled
  v PMD Auto-Negotiation Advertised Capability: 0x6c11
      .... .... .... ...1 = 1000BASE-T (full duplex mode): Capable
      .... .... .... ..0. = 1000BASE-T (half duplex mode): Not capable
      .... .... .... .0.. = 1000BASE-X (-LX, -SX, -CX full duplex mode): Not capable
      .... .... .... 0... = 1000BASE-X (-LX, -SX, -CX half duplex mode): Not capable
      .... .... ...1 .... = Asymmetric and Symmetric PAUSE (for full-duplex links): Capable
      .... .... ..0. .... = Symmetric PAUSE (for full-duplex links): Not capable
      .... .... .0.. .... = Asymmetric PAUSE (for full-duplex links): Not capable
      .... .... 0... .... = PAUSE (for full-duplex links): Not capable
      .... ...0 .... .... = 100BASE-T2 (full duplex mode): Not capable
      .... ..0. .... .... = 100BASE-T2 (half duplex mode): Not capable
      .... .1.. .... .... = 100BASE-TX (full duplex mode): Capable
      .... 1... .... .... = 100BASE-TX (half duplex mode): Capable
      ...0 .... .... .... = 100BASE-T4: Not capable
      ..1. .... .... .... = 10BASE-T (full duplex mode): Capable
      .1.. .... .... .... = 10BASE-T (half duplex mode): Capable
      0... .... .... .... = Other or unknown: Not capable
  > Same in inverse (wrong) bitorder
    Operational MAU Type: 1000BaseTFD - Four-pair Category 5 UTP, full duplex mode (0x001e)
> IEEE 802.3 - Link Aggregation
```

PFC – Priority Based Flow-Control

```
▷ Frame 1: 64 bytes on wire (512 bits), 64 bytes captured (512 bits)
◢ Ethernet II, Src: 0e:fc:00:d5:3d:00 (0e:fc:00:d5:3d:00), Dst: Spanning-tree-(for-bridges)_01 (01:80:c2:00:00:01)
  ▷ Destination: Spanning-tree-(for-bridges)_01 (01:80:c2:00:00:01)
  ▷ Source: 0e:fc:00:d5:3d:00 (0e:fc:00:d5:3d:00)
    Type: MAC Control (0x8808)
◢ MAC Control
    Opcode: Class Based Flow Control [CBFC] Pause (0x0101)
  ◢ CBFC Class Enable Vector: 0x0008, C3
      .... .... .... ...0 = C0: False
      .... .... .... ..0. = C1: False
      .... .... .... .0.. = C2: False
      .... .... .... 1... = C3: True
      .... .... ...0 .... = C4: False
      .... .... ..0. .... = C5: False
      .... .... .0.. .... = C6: False
      .... .... 0... .... = C7: False
  ◢ CBFC Class Pause Times
      C0: 0
      C1: 0
      C2: 0
      C3: 65535
      C4: 0
      C5: 0
      C6: 0
      C7: 0
```

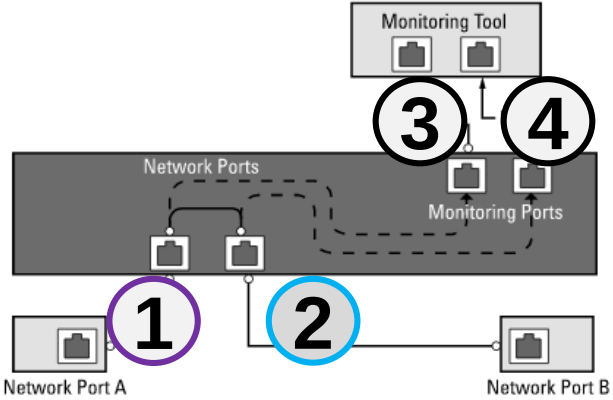
Flow-Control with Copper Taps

- Remember the Taps – Gotchas
  - two Links segments for the Network Ports
  - also two Links for the Monitoring Ports



Vendor A		
Line Type	RJ-45	RJ-45
Remote Duplex	Half or Full	Half or Full
Remote Pause	Rx Only	Rx Only
Remote Fault Code	None	None

Vendor B		
Line Type	RJ-45	RJ-45
Remote Duplex	Half or Full	Half or Full
Remote Pause	Tx and Rx	Tx and Rx
Remote Fault Code	None	None



Flow-Control Challenges from the field

Strange Flow-Control Implementation

AT900-FLOWCONTROLTEST.enc

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help

Apply a display filter ... <Ctrl-/>

No.	Time	DELTA	SRC-MAC	DST-MAC	Source	Destination	Protocol	Length	Info
1	0.000000000	0.000000000	01:80:c2:00:00:01	01:80:c2:00:00:01	Spanning-tree-(for-bridges)_01	Spanning-tree-(for-bridges)_01	MAC CTRL	64	Pause: pause_time: 65535 quanta
2	0.000862401	0.000862401	01:80:c2:00:00:01	01:80:c2:00:00:01	Spanning-tree-(for-bridges)_01	Spanning-tree-(for-bridges)_01	MAC CTRL	64	Pause: pause_time: 0 quanta
3	0.008910637	0.008048236	01:80:c2:00:00:01	01:80:c2:00:00:01	Spanning-tree-(for-bridges)_01	Spanning-tree-(for-bridges)_01	MAC CTRL	64	Pause: pause_time: 65535 quanta
4	0.009773037	0.000862400	01:80:c2:00:00:01	01:80:c2:00:00:01	Spanning-tree-(for-bridges)_01	Spanning-tree-(for-bridges)_01	MAC CTRL	64	Pause: pause_time: 0 quanta
5	0.017822111	0.008049074	01:80:c2:00:00:01	01:80:c2:00:00:01	Spanning-tree-(for-bridges)_01	Spanning-tree-(for-bridges)_01	MAC CTRL	64	Pause: pause_time: 65535 quanta
6	0.018683674	0.000861563	01:80:c2:00:00:01	01:80:c2:00:00:01	Spanning-tree-(for-bridges)_01	Spanning-tree-(for-bridges)_01	MAC CTRL	64	Pause: pause_time: 0 quanta
7	0.026732748	0.008049074	01:80:c2:00:00:01	01:80:c2:00:00:01	Spanning-tree-(for-bridges)_01	Spanning-tree-(for-bridges)_01	MAC CTRL	64	Pause: pause_time: 65535 quanta

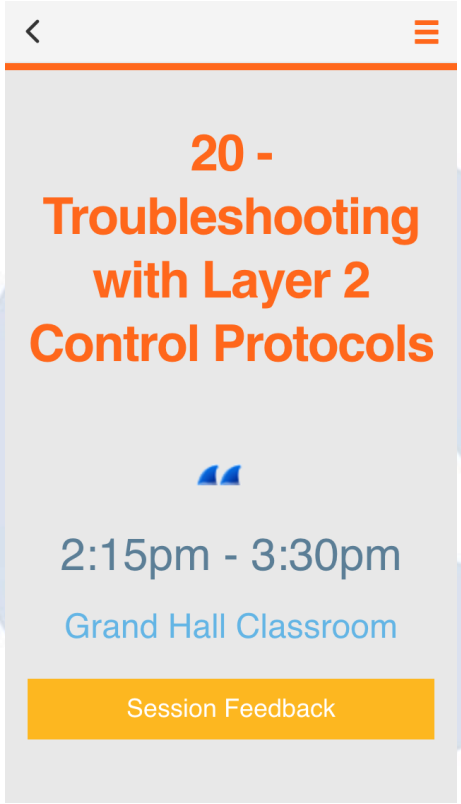
```
▷ Frame 1: 64 bytes on wire (512 bits), 64 bytes captured (512 bits)
◢ Ethernet II, Src: Spanning-tree-(for-bridges)_01 (01:80:c2:00:00:01), Dst: Spanning-tree-(for-bridges)_01 (01:80:c2:00:00:01)
  ▷ Destination: Spanning-tree-(for-bridges)_01 (01:80:c2:00:00:01)
  ◢ Source: Spanning-tree-(for-bridges)_01 (01:80:c2:00:00:01)
    ▷ [Expert Info (Warn/Protocol): Source MAC must not be a group address: IEEE 802.3-2002, Section 3.2.3(b)]
      Address: Spanning-tree-(for-bridges)_01 (01:80:c2:00:00:01)
      .... ..0. .... .... .... .... = LG bit: Globally unique address (factory default)
      .... ...1 .... .... .... .... = IG bit: Group address (multicast/broadcast)
  Type: MAC Control (0x8808)
◢ MAC Control
  Opcode: Pause (0x0001)
  pause_time: 65535
```

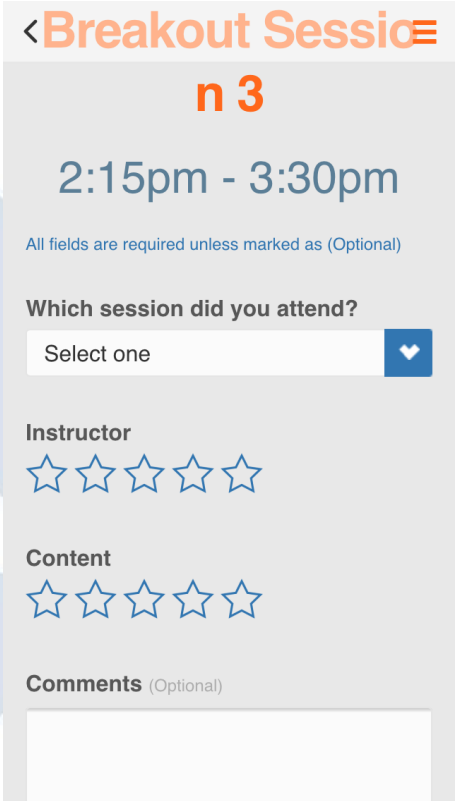
Time for Questions

Session Summary

- Wireshark's capabilities of dissection, filtering and others will help your analysis in a Layer 2 environment
- Pay attention to the capture points and any data that could be used as a "signature" to correlate traces with Layer 2 events
- Time sync of all capture points is a must
- Read standards from IETF / IEEE / MEF – reflex and ask yourself what's going on the wire here

Please provide Session Feedback





Thank You for attending the session and enjoy the rest of the conference / party ☺