Troubleshooting EtherNet/IP Networks

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Technical Track

Introduction

Overview

- Mysterious counters
- Diagnostic tools
- Access mechanisms
- Ethernet counters
- Troubleshoot with counters
- Profile counter behavior
- Questions

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Mysterious Counters

Ethernet Statistics = Mystery

- Accessed
  - Via Ethernet Link Object (0xF6) or SNMP
- Few people understand them
  - Vague or terse definitions
- Fewer people know how to apply them
  - Relationships between counters
  - What a value does not mean
  - Rate VS value
- Misused or misinterpreted
  - Wrong conclusions derails troubleshooting
  - Wastes time chasing non-existent problems

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Diagnostic Tools

What tools are used instead?

- Ping (ICMP Echo)
  - Most often used tool
    - "Reach-ability"
    - Connection establishment ? Application : Network
  - Most often misused tool
    - No measure of congestion / delay
      - » Propagation delay inconsequential
      - » Processed at lower stack layer - Faulty comparison
    - No indication of disturbance / load related
  - Failed Ping
    - Numerous causes
    - Provides no useful information

Diagnostic Tools

What tools are used instead?

- Packet Capture
  - See “every” packet on the wire
    - Second most common diagnostic tool
    - Packet filtering, parsing, decomposition
    - Intricate detail
  - Complex – Micro view
    - Second most common misused diagnostic tool
    - Easy to get lost / mislead by detail
    - Only shows data for single link
    - Location of capture critical for good analysis
    - Use of hubs may disturb network of interest
    - Corrupted packets not visible

Diagnostic Tools

What tools are used instead?

- Web Pages
  - Often supported
    - Easy access
    - Usually has diagnostic page
      - » Often same data as Link Object (0xF6)
      - » De facto standard
  - Often different
    - No standard level of support
    - Vendor / device specific
  - This discussion – not assumed to exist
    - Concepts still relevant
    - General discussion favors general solutions

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Diagnostics Access

EtherNet/IP Access

- TCP/IP Ojbect (0xF5)
  - Mostly control parameters
  - IP params
  - Multicast params
  - ACD Status

- Ethernet Link Object (0xF6)
  - Useful Ethernet statistics
    - Interface Flags
    - Interface Counters
    - Media Counters

Diagnostics Access

SNMP Access

- Simple Network Management Protocol
  - MIB Browser – SNMP client software
  - MIB (Management Information Base) => Objects
  - OID (Object ID) ~= Object Address
- Supported by some industrial equipment
- Supported by most infrastructure
  - All “Managed” devices support SNMP
  - Diagnostics & configuration
- MIBs
  - MIB II
  - etherLikeMIB

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Ethernet Counters

EtherNet/IP Link Object (0xF6)

- Group 1 – Interface Flags
  - Link status – Up / Down
  - Duplex status – Operational value – HD / FD
  - Auto-negotiation status – Results of Auto-Neg

- Group 2 – Collision Centric Counters
  - Half-Duplex Only

Counter	
Deferred Transmissions	Carrier Sense detected line busy on TX event – defers TX
Single Collisions	Frame is successfully TX after 1 collision
Multiple Collisions	Frame is successfully TX after >1 collisions
Excessive Collisions	Frame **discarded** after >16 collisions
Late Collisions	Collision detected too late - **discarded**

Ethernet Counters

EtherNet/IP Link Object (0xF6)

- Group 3 – Other Important Counters

Counter	Definition
Alignment Errors	A count of frames received that do not end on a byte boundary and do not pass the FCS check.
FCS Errors	Frame Check Sequence – detects packet corruption.
In / Out Discards	Number of good packets discarded; input / output queue full.
In / Out Errors	Aggregation of a multiple specific errors.
In / Out Ucast Packets	Number of unicast packets rcvd/sent – including point-to-point & explicit messaging connections.
In / Out NUcast Packets	Number of non-unicast packets rcvd/sent including broadcast (ARP, DHCP, …) & multicast (class 0 & 1).
Carrier Sense Errors	Carrier signal not detected
SQE Test Error	For legacy equipment – not used today.
MAC Transmit / Receive Errors	Implementation specific “catch-all”

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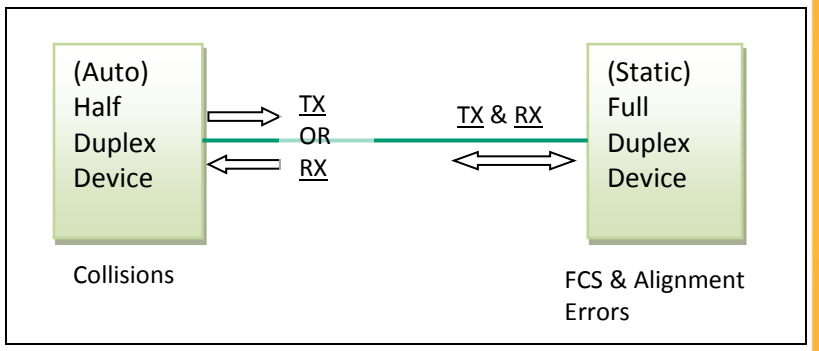
Duplex Mismatch

Cause

- 2 Devices
  - Dev1 => Static Duplex Config = FD
  - Dev2 => Auto-Negotiation
- Link Negotiation
  - Speed from link pulse
    - OK = 100 MB
  - Duplex
    - Dev1 – no negotiation – always FD
    - Dev2 – IEEE802.3 – MUST HD
- Infrastructure Devices
  - Default = Auto-Negotiation



Duplex Mismatch

Effect

- CSMA/CD Circuitry
  - Carrier Sense Multiple Access / Collision Detection
  - Used in HD – Not used in FD

- Collision Detection
  - Dev2 (Auto-HD)
    - Uses CSMA/CD - Detects collision
    - Re-TX after collision detection
  - Dev1 (FD)
    - No CSMA/CD – No collision detection
    - Never Re-TX after collision
    - Frame lost forever

Duplex Mismatch

Anatomy of a Collision

- Collision
  - HD end starts TX
  - Detects collision – increments counter
  - Stops TX & Sends Jam signal (101010101)
  - TXed frame = Few bytes good frame + Jam
  - Discards inbound frame from FD end – never Re-TX
- FCS / Alignment Errors
  - FD end detects FCS & Alignment Errors
  - Discards bad frame
- Duplex Mismatch Performance
  - Much worse than HD-HD Link

Duplex Mismatch

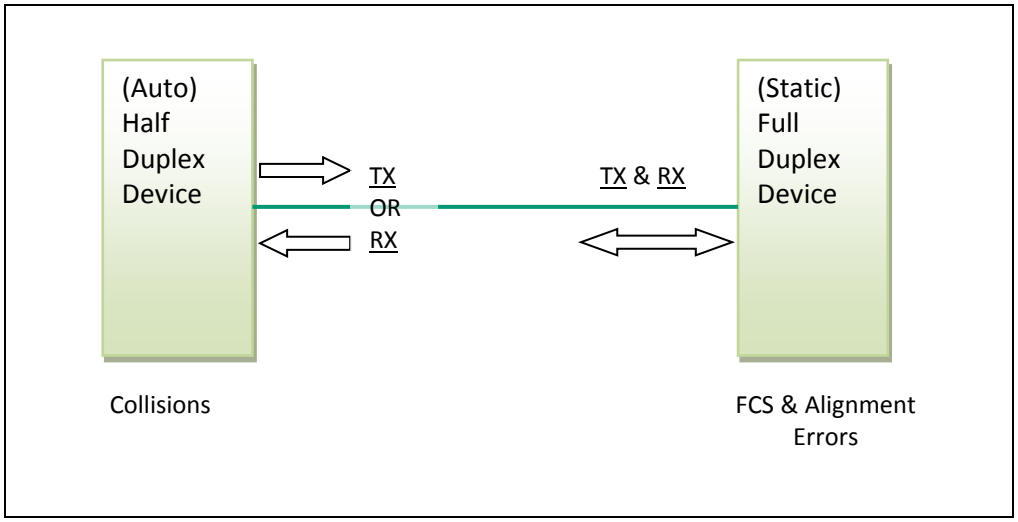
Detection

- Explicitly Check for Dup. Mismatch
  - Implies that I suspect the problem
  - Check device configs
  - Interface flags of 0xF6
- Use Link Object from end devices
  - Interface flags & counters
- Switch to Device Links
  - Few switches support EtherNet/IP
  - Switches support SNMP
    - Same counters available via SNMP
  - Duplex status illusive in SNMP

Duplex Mismatch

Take away

- Effects
  - Packet loss very high
  - Performance < half duplex link
  - Slow / Dropped Conections
- Half Duplex End
  - Many collisions
  - Maybe some FCS & Alignment Errors
  - Few Late & Excessive Collisions



- Full Duplex End
  - Zero collisions
  - Many FCS & Alignment Errors
  - Zero Late & Excessive collisions

Duplex Mismatch

EtherNet/IP VS. SNMP

EtherNet/IP		SNMP	
Ethernet Link Object (0xF6)		**RFC 3635 - etherLike MIB (1.3.6.1.2.1.10.7)**	**RFC 1213 – MIB II (1.3.6.1.2.1)**
Attribute ID:	**Name:**		
2	Interface Flags (Duplex configuration and operational status)	Dot3StatsDuplexStatus (1.3.6.1.2.1.10.7.2.1.19)	None
5	Alignment Errors	dot3StatsAlignmentErrors (1.3.6.1.2.1.10.7.2.1.2)	ifInErrors (1.3.6.1.2.1.2.2.1.14)
	FCS Errors	dot3StatsFCSErrors (1.3.6.1.2.1.10.7.2.1.3)	
	Late Collisions	dot3StatsLateCollisions (1.3.6.1.2.1.10.7.2.1.8)	ifOutErrors (1.3.6.1.2.1.2.2.1.20)
	Excessive Collisions	dot3StatsExcessiveCollisions (1.3.6.1.2.1.10.7.2.1.9)	

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Electrical Noise

Causes

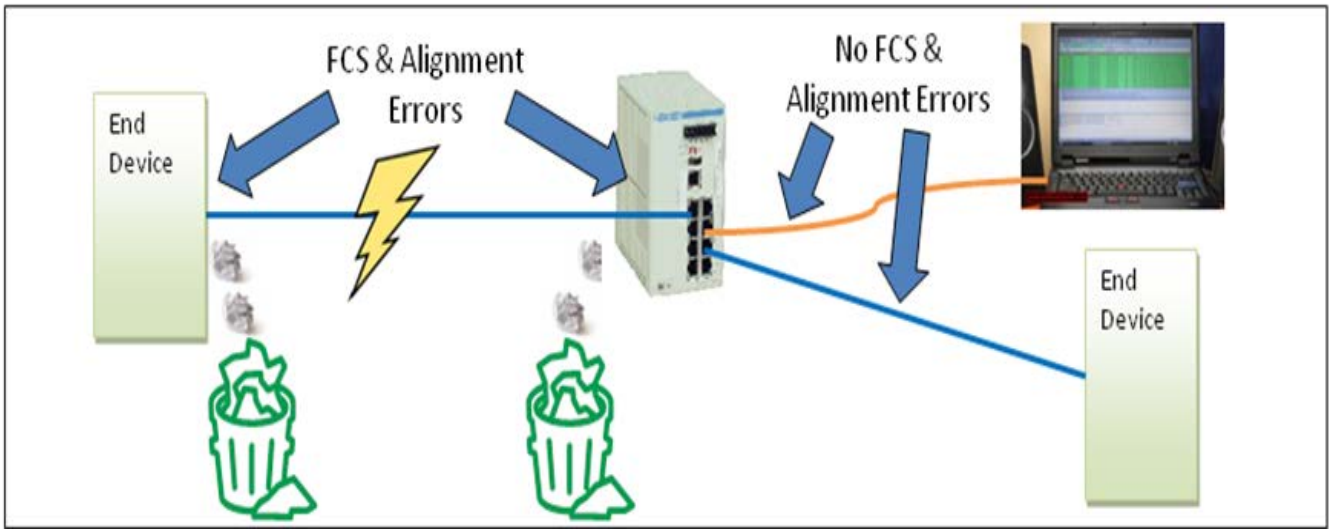
- Electrical Interference
  - Causes packet corruption
  - FCS / Alignment Errors

- Sources of Interference
  - Cabling
    - – Bends, crushed, corrosion
    - – Routing – motors, power feeds, fluorescent lights
    - – Shielding **&** grounding
    - – Connectors – to much untwist
    - – X-talk – TX & RX channels

Electrical Noise

Detection

- Ping
  - Stochastic – low probability ping gets clobbered
- Packet Capture
  - Corrupted frames discarded at receiving interface
  - Never shown in packet capture



Electrical Noise

Detection

- Full Duplex Link
  - FSC & Alignment Errors
  - Noise or Duplex Mismatch?
    - No collisions – both ends at FD
- Half Duplex Link
  - FCS & Alignment Errors
  - Both ends – few Single / Multi Collisions – expected
- FCS / Alignment on 1 end only – No Collisions
  - Suspect bad single pair
- Understand failure modes
  - Relative position of count values matters

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Profiling Types of Errors

Relative Counter Values

- Not absolute – General Guide

Problem Type		Normal Collisions Rate	Error Collisions Rate	FCS / Alignment Errors Rate	Discards Rate
Duplex Mismatch	Static Config (FD) End	0	0	High	Zero to few
	AutoNeg (HD) End	High	Med	Low	
Overloaded Devices	Half Duplex	Med to High	Med to High	Low	Rate >> 0 indicates potential problem
	Full Duplex	0	0		
Noise / Cable Fault	Half Duplex	Med	Med	High	Zero to few
	Full Duplex	0	0		
Cable too long	Half Duplex	Med	High	High	Zero to few
	Full Duplex	0	0	High	

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Overloaded Device

Cause

- Line rate > processing rate
  - “Bursty” traffic - overloads buffers
  - Maximum sustainable rate
    - Packet size
    - Type of packets
    - Unicast / multicast / broadcast
  - Multicast flooding
    - IGMP Snooping – pruning delay
    - Topology change

Overloaded Device

Effect & Detection

- Full Buffers
  - No room for new packets => dropped
  - Increments Discard counter
  - Sluggish, retries, connection timeouts
- In / Out Discards
  - Link Object – Interface Counters
  - SNMP – MIB II – interface table
    - ifInDiscards (ifTable.13)
    - ifOutDiscards (ifTable.19)
- High CPU utilization
  - Optional attribute – Connection Manager Object (0x06)