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 Object (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/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

<table>
<thead>
<tr>
<th>Counter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deferred Transmissions</td>
<td>Carrier Sense detected line busy on TX event – defers TX</td>
</tr>
<tr>
<td>Single Collisions</td>
<td>Frame is successfully TX after 1 collision</td>
</tr>
<tr>
<td>Multiple Collisions</td>
<td>Frame is successfully TX after &gt;1 collisions</td>
</tr>
<tr>
<td>Excessive Collisions</td>
<td>Frame <strong>discarded</strong> after &gt;16 collisions</td>
</tr>
<tr>
<td>Late Collisions</td>
<td>Collision detected too late - <strong>discarded</strong></td>
</tr>
</tbody>
</table>
# Ethernet Counters

## EtherNet/IP Link Object (0xF6)

### Group 3 – Other Important Counters

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

#### 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

<table>
<thead>
<tr>
<th>Attribute ID</th>
<th>EtherNet/IP</th>
<th>SNMP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Interface Flags (Duplex configuration and operational status)</td>
<td>Dot3StatsDuplexStatus (1.3.6.1.2.1.10.7.2.1.19)</td>
</tr>
<tr>
<td>5</td>
<td>Alignment Errors</td>
<td>dot3StatsAlignmentErrors (1.3.6.1.2.1.10.7.2.1.2)</td>
</tr>
<tr>
<td></td>
<td>FCS Errors</td>
<td>dot3StatsFCSErrors (1.3.6.1.2.1.10.7.2.1.3)</td>
</tr>
<tr>
<td></td>
<td>Late Collisions</td>
<td>dot3StatsLateCollisions (1.3.6.1.2.1.10.7.2.1.8)</td>
</tr>
<tr>
<td></td>
<td>Excessive Collisions</td>
<td>dot3StatsExcessiveCollisions (1.3.6.1.2.1.10.7.2.1.9)</td>
</tr>
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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**

<table>
<thead>
<tr>
<th>Problem Type</th>
<th>Normal Collisions Rate</th>
<th>Error Collisions Rate</th>
<th>FCS / Alignment Errors Rate</th>
<th>Discards Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duplex Mismatch</td>
<td>0</td>
<td>0</td>
<td>High</td>
<td>Zero to few</td>
</tr>
<tr>
<td>AutoNeg (HD) End</td>
<td>High</td>
<td>Med</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>Overloaded Devices</td>
<td>Med to High</td>
<td>Med to High</td>
<td>Low</td>
<td>Rate &gt;&gt; 0 indicates potential problem</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise / Cable Fault</td>
<td>Med</td>
<td>Med</td>
<td>High</td>
<td>Zero to few</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cable too long</td>
<td>Med</td>
<td>High</td>
<td>High</td>
<td>Zero to few</td>
</tr>
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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)