Introduction to PoE and the IEEE802.3af and 802.3at Standards

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Morty Eisen
Marcum Technology
meisen@marcumtechnology.com
Tel: 631-414-4856
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This Talk is about Power Over Ethernet not About Edgar Allen Poe

The Raven

Once upon a midnight dreary,
while I pondered, weak and weary,
Over many a quaint and curious volume of forgotten lore,
While I nodded, nearly napping, suddenly there came a tapping,
As of some one gently rapping, tapping at my chamber door.
"Tis some visitor," I muttered, "tapping at my chamber door -
Only this, and nothing more."

Edgar Allan Poe
Introduction to Power over Ethernet (PoE)

- Power over Ethernet or PoE technology describes a system to safely transfer electrical power, along with data, to remote devices over standard data cables in an Ethernet network (Cat3/Cat5/Cat5e/Cat6).
- The original IEEE 802.3af-2003 standard version of PoE supplies up to 15.4 W of DC power (minimum 44 VDC and 350 mA) to each device. Only 12.95 W is assured to be available at the powered device (PD) as some power is dissipated in the cable.
- No affect on network performance of 10/100/1000 Mbps links to the PD.
Introduction to Power over Ethernet (Cont.)

- Power is remotely supplied from a central location (e.g. wiring closet) for distances under 100 meters without the Ethernet devices having to be individually powered by an AC outlet.
- PDs include IP Phones, Wireless LAN Access Points, IP Security Cameras and various other network devices.
- IEEE 802.3af-2003 standard specifies Power over Ethernet (PoE) technology in two different methodologies:
  - Power-Supplying Equipment (PSE) may use either End-Span or Mid-Span
  - Powered devices (PD’s) accept power from either type of power source
- Over 70 million PoE PSE ports shipped in 2008

http://www.poweroverethernet.com/
PoE Key Benefits

• **Installation Cost Savings**
  – Eliminates the need for electrical outlet installation
  – Dramatically reduces cost of deployment – savings up to $1,000 per PD
  – No need for bulky AC power adaptors

• **Simplifies Installation**
  – Uses a single Cat5/5e/6 cable for both data and power

• **Centralized Power Backup**
  – Continuous operation during power interruptions

• **Centralized Power Management**
  – Devices can be remotely powered down during periods of low usage or for security purposes

• **SAFE Power**
  – Will not damage Non-PoE devices or legacy peripherals
PoE Switch = PSE End-Span

UPS – Battery Backup

IEEE 802.3af Compliant PoE Switch

PSE

PD’s

VoIP Phones
Network Cameras
Wireless LAN Access Points
Power Originating from an End-Span (Ethernet Switch)

**End-Span technology** - Power originates from a powered port on an Ethernet Switch and is super-imposed on data transmission wire pairs 1, 2, 3, and 6.

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Option A for Midspan: Power can be sourced from the PSE through the data lines via data transformer center taps.
Switch + PoE Injector = PSE Mid-Span

- UPS – Battery Backup
- Ethernet Switch
- PSE
- PD’s
- VoIP Phones
- Network Cameras
- Wireless LAN Access Points

Data In
Mid-Span
Data & Power Out
Power Originating from an External Mid-Span Device

**Mid-Span technology**-Power is added to the non-data wire pairs 4, 5, 7, and 8 from a patch-panel style hub.
Power over Ethernet PDs

Voice and Video IP Phones

WiFi Access Points  a/b/g/n

Network Security Cameras – Enclosures – Heaters – Pan and Tilt

Building / Access Control – Gas and Fire Alarms – Digital Signs

Digital and School Clocks – SIP IP Paging – Door locks - Gateways
Sample PD Circuit

LM5071 - Power Over Ethernet PD Controller with Auxiliary Power

Design PoE Power for IP Camera with LM5071 Supporting Aux Input

Support popular 12 Vdc or 24Vac Adapter to power IP Camera with LM5071 Aux input feature

Vout => DC12V, DC24V, AC12V, AC24V
Vout => DC12V 300mA, 5V 1.2A

Fully Compliant 802.3af Power Interface Port

http://www.national.com/analog/power/hv/poe
Splitters for PoE

Active PoE Splitters allow PoE power on non-PoE devices

Typical Splitters Feature
• Safe Power with IEEE detection
• IEEE connect and disconnection
• 10/100/1000
PoE Splitters Application Example
IEEE802.3af Distance Limitations

Standard Ethernet distance rules apply

**PoE Switch**

- 50 ft
- 75 ft
- 100 ft
- 300 ft

**1 Port PoE (Repeater)**

- Allows up to an additional 330 ft

**Maximum distance from the switch**

- 100 meters or 333 feet
- Even if you are using a mid-span
PoE Market Size

Projected 25+% growth rates for PDs and PSEs

Number of PoE Ports

Source: Def'Oro 2007 Forecast Report and IDC's 2007 Forecast for Network Cameras
Market and Competitive Analysis

- **Ethernet Switch Ports:** This report estimates that global shipments of PoE-enabled ports in enterprise switches are expected to reach over 132 million ports in 2012. By 2012, PoE ports will represent one quarter of all enterprise Ethernet ports.
- **Mid-Spans:** Mid-Span shipments will be healthy over the next several years as people who have not yet deployed PoE or PoE-Plus switches will still want to take advantage of PoE benefits without having to purchase new switch gear.
- **PDs:** In 2007, shipments of PoE-enabled business IP phones exceeded 10 million units. VDC expects shipments of enterprise wireless LAN access points to grow to 11.2 million units in 2012.
- **PoE Controllers:** There are only two vendors who have any significant market share of PSE controllers, Linear Technology and Microsemi. The PD controller market is a bit more fragmented, with several companies having significant market share in 2007.
Partial PoE Vendor List

- 3COM CORPORATION
- AKROS SILICON, INC
- ARUBA NETWORKS, INC
- AVAYA
- AXIS COMMUNICATIONS
- BROADCOM CORPORATION
- CISCO SYSTEMS, INC
- DVTEL, INC
- ENTERAYS NETWORKS, INC
- HEWLETT-PACKARD COMPANY
- HID GLOBAL
- LINEAR TECHNOLOGY CORPORATION
- MICROSEMI, INC (PowerDsine)
- MITEL NETWORKS
- MOTOROLA, INC
- NATIONAL SEMICONDUCTOR CORPORATION
- PANDUIT CORPORATION
- PHIHONG
- POLYCOM, INC
- SIFOS TECHNOLOGIES
- SILICON LABORATORIES, INC
- SILVER TELECOM
- TEXAS INSTRUMENTS,

Special thanks to slides and material from Microsemi, Phihong, Sifos, Cisco and National Semiconductor.

Microsemi, Phihong, Motorola (Symbol), & others have PoE engineers in Long Island
PoE Original Standard (802.3af-2003)

- IEEE802.3af (15.4W/port)
  - Approved in 2003 for PDs up to 12.95W (350mA) at 48V DC
  - PoE requires handshake before applying power
  - Power Sourcing Equipment (PSE) transmits power over 2 pairs (4 of 8 wires) on Cat5/5e/6 cable
  - Connect/disconnect protocol for applying/disconnecting power
    - Detect device that needs power
    - Determines power needed
    - When to turn on power
    - Detect device disconnect (AC and DC disconnect)
    - When to remove power
  - Physical layer mechanism for PSE’s to characterize power demands of individual PD’s and thus manage power delivered per port.

PoE Operation Modes with Respect to Input Voltage
802.3af Power Classification

In the start-up process when a PoE connection is made, the PD can advertise its power class which is an indication of how much power is required.

<table>
<thead>
<tr>
<th>Class</th>
<th>Min. PSE Power</th>
<th>Max. PD Power</th>
<th>Sample PD’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4 Watts</td>
<td>3.84 Watts</td>
<td>IP Phones</td>
</tr>
<tr>
<td>2</td>
<td>7 Watts</td>
<td>6.49 Watts</td>
<td>IP Camera</td>
</tr>
<tr>
<td>3, 4, or 0</td>
<td>15.4 Watts</td>
<td>12.95 Watts</td>
<td>Wireless AP</td>
</tr>
</tbody>
</table>

“Power cannot be forced down the cable” - a common misconception -

The PD presents a load to the cable and draws as much as it needs. Most PoE powered devices will draw a fixed level of power.
IEEE802.3at Project Milestones

- Nov-2004: Study Group Created
- Jul-2005: IEEE802.3 recommended creation of Task Force
- Sep-2005: IEEE802.3at Power over Ethernet Enhancements Task Force Created
- Jan-2009: New Orleans, LA (interim) – last meeting
  - All comments on draft 3.3 addressed, draft 4.0 created, sponsor ballot
- Mar-2009: Vancouver, BC (plenary)
- Sep 11 2009: Ratification
IEEE802.3at Objectives

- At least 24W power supplied to the PD
  - As much as economically feasible
- Backwards compatible with IEEE802.3af-2003
  - Type 2 PD’s that cannot operate with less than 12.95W must give indication to user when connected to Type 1 PSE
  - Type 2 PD’s that can operate with less than 12.95W must be able to be powered by a Type 1 PSE
- PD MIB to be created
- Support for Gigabit Midspan

Type 1: “low power”
Type 2: “high power”
Devices Evolve and Require More Power

• Access Points migration to 802.11n
  – Cisco AP-1200 with g radio : 802.3af (6.5W)
  – Cisco AP-1200 with a+g radios : 802.3af (11.6W)
  – Cisco AP 1250 for 802.11n : ~ (20+W)

• Migration to Advanced Network Cameras
  – Sony SNC-Z20N Zoom Camera : 802.3af (<12.95W)
  – Sony SNC-RZ30N Pan/Tilt/Zoom : (21.6W)
  – Sony SNC-RZ30N Pan/Tilt/Zoom/Heated Enclosure : (50W)

• IP Phones evolving into Video Phones
  – Wooksung Video Phone : 18.4W
  – Packet8 Video Phone : 25W
  – Leadtek IP Broadband Video Phone : 25W
  – WorldGare Video Phone : 36W
IEEE 802.3af Enhancements

The 802.3at specification expands upon 802.3af in several key areas:

http://www.ieee802.org/3/at/

- Enable higher power PD’s such as wireless access points, panning security cameras, video phones, and audio appliances requiring continuous power to 25.5 watts up to 100M from the PSE.
- High Power PSE’s must furnish at least 30.0 Watts at the PSE port.
- Provide full backward compatibility and interoperability to existing 802.3af compliant PSE’s and PD’s.
- Enable Mid-Span PSE’s to support 1000BaseT connections.
- Restrict cost increases for PSE ports and PD equipment in areas such as PSE controller devices and PoE capable magnetics such that PoE+ (high power) could become ubiquitous.
- Improve potential power management granularity and power budgeting capability over time.
- Resolve well known issues of specification clarity inherent in the 802.3af specification.
IEEE802.3at Specifications

- **Cabling**: CAT5E required
- **Voltage**: PSE voltage from 44V to 57V (50V for Type-2 PSEs)
- **Current level**: 600mA assuming cable temperature is 50°C or lower
- **Polarity**: End-Spans can use MDI or MDI-X (Positive or Negative Polarity)
- **Pulse transformer inductance**:
  - End-Span PSE (Switch) & PDs: 120µH (allows usage of IEEE802.3af magnetics)
  - Mid-Span: 350µH, Midspan Alternative-A 10/100 installations require regulation
- **Power Feeding**: 2-pairs and 4-pairs possible
  - Focus on 2-pairs Medium Power: PSE 30W output, **PD 25.5W** input
  - 4-pairs High Power should be based on 2x2-pairs: PSE 60W output, **PD 51W** input
IEEE802.3at Specifications (cont.)

- **Power Detection & Removal Essentially Unchanged**
  - 25K signature resistance will not be changed

- **Classification**
  - Classic Method enhancement: 2-Event Classification (two pulse) that is transparent to 802.3af but allows Type-2 PD presents Class 4 to request maximum power.
  - Type-2 PSE may use either single-event or 2-event classification
  - PD must support Layer 1 and Layer 2 classification
  - PSE must support either Layer 1 or Layer 2 classification
  - Layer 2 Classification Method: Using a data link layer protocol such as Link Layer Discovery Protocol (LLDP).

- **1000Base-T Mid-Span in scope of IEEE802.3at**
  - Any Mid-Span power interface can be Type A (4,5,7,8) or Type B (1,2,3,6)
## 802.3at Power Classification

<table>
<thead>
<tr>
<th>Category</th>
<th>PSE Power</th>
<th>PD Power</th>
<th>L1 Classification</th>
<th>L2 Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type-1</td>
<td>15.4 Watts</td>
<td>.44 - 13 Watts</td>
<td>PSE: Optional</td>
<td>PSE: Optional</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PD: Required</td>
<td>PD: Optional</td>
</tr>
<tr>
<td>Type-2</td>
<td>30.0 Watts</td>
<td>13 - 25.5 Watts</td>
<td>PSE: Required</td>
<td>PSE: Optional</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PD: Required</td>
<td>PD: Required</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PSE Type</th>
<th>Classification</th>
<th>Guaranteed Power at PSE Output</th>
<th>Minimum Power at PSE Output</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type-1</td>
<td>Class 0</td>
<td>15.4</td>
<td>~ 0.5</td>
<td>Watts</td>
</tr>
<tr>
<td></td>
<td>Class 1</td>
<td>4.0</td>
<td>~ 0.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Class 2</td>
<td>7.0</td>
<td>~ 4.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Class 3</td>
<td>15.4</td>
<td>~ 7.0</td>
<td></td>
</tr>
<tr>
<td>Type-2</td>
<td>Class 4</td>
<td>30.0</td>
<td>~ 15.4</td>
<td></td>
</tr>
</tbody>
</table>
## All Possible PSE/PD Combinations

<table>
<thead>
<tr>
<th>PSE TYPE</th>
<th>PD TYPE</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type 1(.af)</td>
<td>Type 1(.af)</td>
<td>Existing 802.3af system, class 0, 1, 2, or 3.</td>
</tr>
<tr>
<td>Type 1(.af)</td>
<td>Type 2(.at)</td>
<td>Type 1(.af) PSE sees class 4 and powers per 802.3af specification, i.e. 15.4W. Type 2(.at) PD can only assume Type 1 PSE and must operate with 15.4W and alert user not enough power.</td>
</tr>
<tr>
<td>Type 2(.at) L1</td>
<td>Type 1(.af)</td>
<td>Type 2(.at) PSE sees class 0, 1, 2, 3 and powers per 802.3af specification.</td>
</tr>
<tr>
<td>Type 2(.at) L1</td>
<td>Type 2(.at)</td>
<td>Type 2(.at) PSE sees class 4 and powers with maximum allowable 802.3at power level. Type 2(.at) PD sees two class pings and knows Type 2 PSE connected. Power information is known before PD is powered.</td>
</tr>
<tr>
<td>Type 2(.at) L2</td>
<td>Type 1(.af)</td>
<td>Type 2(.at) PSE sees class 0, 1, 2, 3 and powers per 802.3af specification. Layer 2 communication fails to establish. Power level is maintained at .af levels. PD sees .af behavior and operates under .af specs.</td>
</tr>
<tr>
<td>Type 2(.at) L2</td>
<td>Type 2(.at)</td>
<td>Type 2(.at) PSE sees class 4 and powers with 15.4W. Layer 2 communication is established and mutual identification is established. High power operation begins.</td>
</tr>
</tbody>
</table>


Clay Stanford Linear Technology
802.3at Use of LLDP

• 802.3at has moved in the direction of supporting both layer 1 PD classification as well as layer 2 PD classification that will offer both very high power management granularity and will enable dynamic negotiation of power levels between PSE and PD.

• The Layer 2 scheme will use a link layer discovery protocol (LLDP) as currently defined in the new IEEE 802.3BC standard with additional protocol rules defined in IEEE 802.3at. LLDP is a link (point-to-point) MAC protocol historically used to allow switches and routers to automatically “discover” what is around them and to populate and maintain a MIB that can be used for viewing a network architecture.

• The 802.3at standard was contingent on the adoption of the new IEEE 802.3BC Standard which covers Ethernet Organizationally Specific Type, Length, Values (TLVs)
IEEE 802.3at Specification Latitude

- The 802.3at standard allows for the following PSE/PD Topologies
  - High Power, over 4-pairs (two 802.3at PDs per device)
  - Medium Power 802.3at, over 2-pairs
  - 802.3af complaint, over 2-pairs
- 2-pairs End-Span can support 4-pairs PD with Mid-Span
- Standard and Proprietary Detection Schemes
Sample 15.4W and 30W Mid-Span Products

- **POE125U-8C (15.4W/Port)**
  - 8 Port Legacy Power 15.4W
  - 19” Rack Mountable with Optional Brackets
  - All Ports = Full Power
  - Gigabit compliant
  - Native Cisco legacy support
  - SNMP (optional)

- **POE125U-4AT (30W/Port)**
  - 4 Port 802.3at PoE Plus Power
  - 19” Rack Mountable with Optional Brackets
  - All Ports = Full Power
  - Gigabit compliant

Sample 30W End-Span Cisco Products - Line Card

Upcoming PoEP Standard and Devices

New Standard—IEEE802.3at for 30W/Port

WS-4548-RJ45V+  WS-X4648-RJ45V+E

30W Capable TODAY!

Next Gen PoEP Devices Expected CY2009 Onwards

Sample 30W End-Span Cisco Products - Power Supplies

Catalyst 4500 PoE Power Supplies

<table>
<thead>
<tr>
<th>Input Circuits</th>
<th>Voltage</th>
<th>Circuit Power</th>
<th>PoE Power</th>
<th>Class 3 PD (Max)</th>
<th>30W PD (Max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>110V/220V</td>
<td>1000W</td>
<td>800W</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>Single</td>
<td>220V</td>
<td>1360W</td>
<td>1400W</td>
<td>84</td>
<td>43</td>
</tr>
<tr>
<td>Dual</td>
<td>110V/220V</td>
<td>1383W</td>
<td>3700W (220V)</td>
<td>223 (220V)</td>
<td>114</td>
</tr>
<tr>
<td>Dual</td>
<td>110V/220V</td>
<td>2200W</td>
<td>1850W (110V)</td>
<td>289 (220V)</td>
<td>148</td>
</tr>
</tbody>
</table>

Compatible with E-Series and Classic Chassis
All Catalyst 4500 Chassis support 1+1 Power Redundancy

Sample 30W End-Span Cisco - Products Features

Catalyst 4500 Linecards
Intelligent PoE Delivery and Control

- **PoE Monitoring** lets you display the true power consumption of inline powered devices attached to the switch, so you have an idea of your actual power consumption.

- **PoE Policing** protects a switch from faulty inline powered devices that may draw more current than they were designed for.

- **CDP and LLDP** used to negotiate power per port:
  - Allocation based on device needs
  - Maximize number of devices
  - Right-size the power supply

Available on Catalyst 4500 with IOS 12.2(50)SG

Sample 4 Wire 802.3at Mid-Span Product 60W

http://www.microsemi.com/PowerDsine/Products/Midspan/PD_9501G.asp
IEEE Interoperability Testing

- 802.3af and 802.3at PSEs and PDs should be tested and evaluated by vendors and third party labs.

- The University of New Hampshire Interoperability Lab (IOL) tests compliance to the standards and interoperability between devices and also verifies that all data remains uncorrupted.
  
  http://www.iol.unh.edu/services/testing/ethernet/tools/poe/

- Some PSE vendors perform free but limited PD compatibility testing
  - http://www.microsemi.com/PowerDsine/Products/SelectionGuide.asp

- Other vendors sell automated conformance testing solutions designed to assess PSE compliance to 802.3af and to the emerging 802.3at specification at a very detailed level.
  
  http://www.sifos.com/Products/PSEConformanceTestSuite/tabid/133/Default.aspx
PD Compliance Testing at UNH-IOL

• The Power over Ethernet consortium offers a PD compliance test suite based on the specifications defined in Clause 33 of the IEEE Std 802.3af™-2003. This test suite investigates the conformance of a Powered Devices.

• Several areas are covered including signature characteristics, pin-out, polarity insensitivity and classification.

• The testing is performed using methodologies developed by the UNH-IOL, using UNH-IOL developed hardware and software, thus providing unbiased, independent, third-party test results.

• The test suite for this service is available and may be viewed online.
Conclusions and Recommendations

The IEEE 802.3at is a gradual evolutionary improvement to the IEEE 802.3af standard.

In the near term, this market will continue it’s 20% annual growth and continue to focus on VOIP terminals, Wireless APs and IP Cameras.

The migration to the IEEE802.3at will be slow but steady as more vendors determine how to take advantage of 25 - 50 W of power delivered over Ethernet and design and test new PDs that can take advantage of the higher power.

A new PoE standard will be required and completed in the next 6-7 years.
## Power Requirements by Solution

<table>
<thead>
<tr>
<th>Power Range (W)</th>
<th>13 to 20 W</th>
<th>20 to 30 W</th>
<th>30 to 40 W</th>
<th>40 to 50 W</th>
<th>50 to 80 W</th>
<th>80W to 120W</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Components</strong></td>
<td>802.11n</td>
<td>RFID Readers</td>
<td>Access Controls</td>
<td>PTZ IP Cameras / With heaters</td>
<td>Laptops</td>
<td>PTZ IP Cameras / With heaters</td>
</tr>
<tr>
<td></td>
<td>Biometric Access Control</td>
<td>Video IP Phones</td>
<td>Video IP Phones</td>
<td>Thin Clients</td>
<td>Thin Clients</td>
<td>Desktops</td>
</tr>
<tr>
<td></td>
<td>Thin Clients</td>
<td>PTZ IP Cameras</td>
<td>PTZ IP Cameras</td>
<td>Point of Sales</td>
<td>Point of Sales</td>
<td>Laptops</td>
</tr>
<tr>
<td></td>
<td>Alarm Systems</td>
<td>Workgroup switches</td>
<td>Workgroup switches</td>
<td>Information Kiosks</td>
<td>Information Kiosks</td>
<td>High Power Wireless</td>
</tr>
<tr>
<td></td>
<td>Thin Clients</td>
<td>Point of Sales</td>
<td>Point of Sales</td>
<td>Thin Clients</td>
<td>Thin Clients</td>
<td>Thin Clients</td>
</tr>
<tr>
<td></td>
<td>Industrial Sensors</td>
<td>Information Kiosks</td>
<td>Information Kiosks</td>
<td>Information Kiosks</td>
<td>Information Kiosks</td>
<td>Information Kiosks</td>
</tr>
</tbody>
</table>
The Ultimate PoE Vision

PoE Powered Notebooks, Netbooks, Thin Clients and Kiosks
PoE at Every Conference Room, Hotel Room & Home
The PoE Challenge

Engineers created this Power over Ethernet Shaver!

What PoE Device can you Design?

Thank You