HP Networking
LLDP & LLDP-MED Standards Leadership

Manfred Arndt

Distinguished Technologist - UC&C
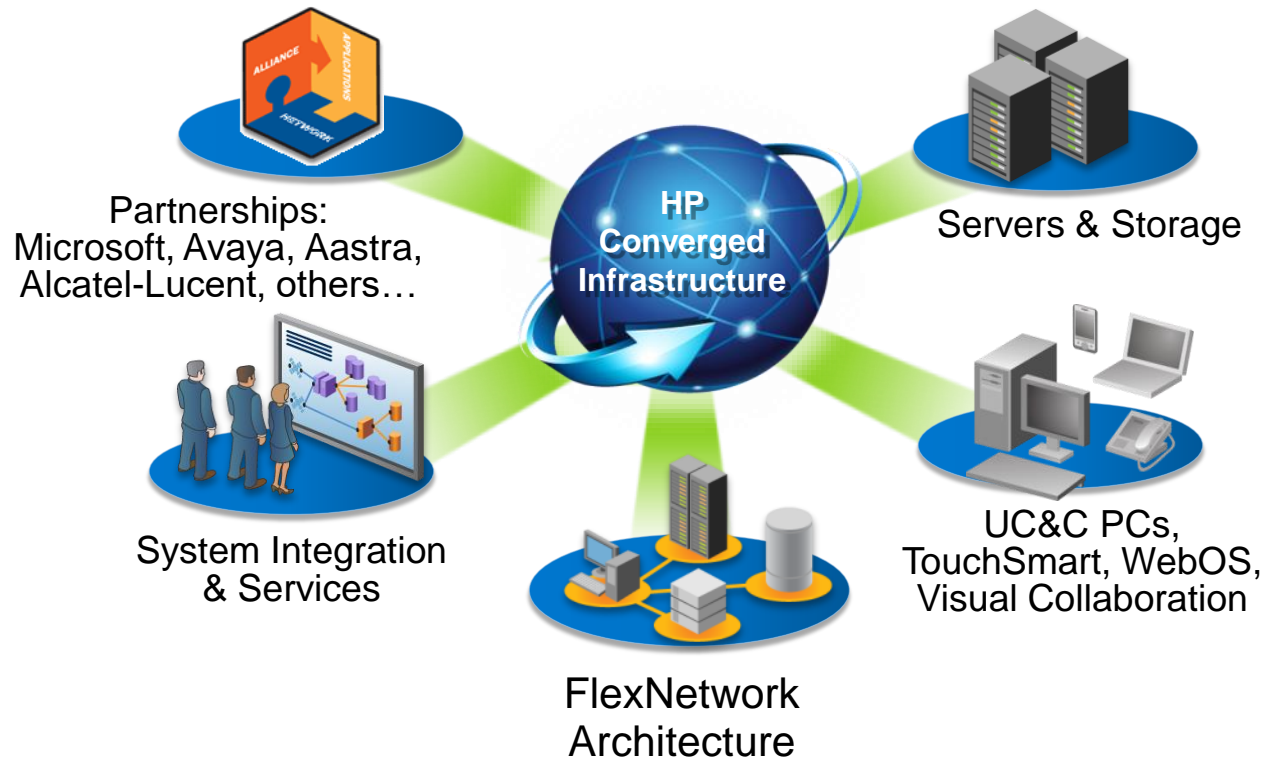
Advanced Technology Group, HP Networking

May 12, 2011

UC&C Solutions of the Future

Will be built on a converged infrastructure

Partnerships:
Microsoft, Avaya, Aastra,
Alcatel-Lucent, others…

System Integration
& Services

HP
Converged
Infrastructure

FlexNetwork
Architecture

Servers & Storage

UC&C PCs,
TouchSmart, WebOS,
Visual Collaboration

A comprehensive solution only from HP

Voice and Video Collaboration
Requires more intelligence at the user edge

RADIUS

VLAN, QoS

?
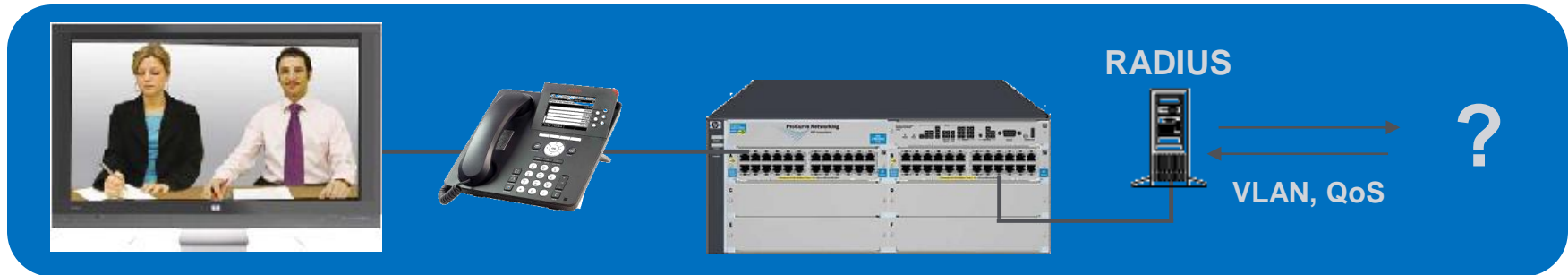
Single connection for PC and phone creates new challenges

1. How to authenticate multiple devices on the same port ?

2. How to manage policy provisioning ?

3. How to proactively monitor a multi-vendor and multi-service network ?

4. How to manage power of endpoint devices ?

Unified Communications requires more intelligence and control at the edge where users and IP phones connect

LLDP History...

- Strong industry need identified for link layer discovery

- ***Numerous proprietary discovery protocols exist today, notably Cisco Discovery Protocol (CDP). None of these interoperate!***

A first start at IETF ...

- An IETF Working Group (PTOPOMIB) addressed this problem beginning in 1996, focusing on common framework/model for describing physical topology
- Completed an Informational MIB (RFC 2922, Physical Topology MIB, published Sept 2000), but didn't progress the discovery protocol

Enter IEEE …

- IEEE effort was first proposed to 802.1 in January 2002 to pick-up where the IETF effort left off, driven largely by Paul Congdon (HP Networking)
- IEEE 802.1AB-2005 "Link Layer Discovery Protocol" (LLDP) is complete!

HP Networking is first in the industry to support LLDP!
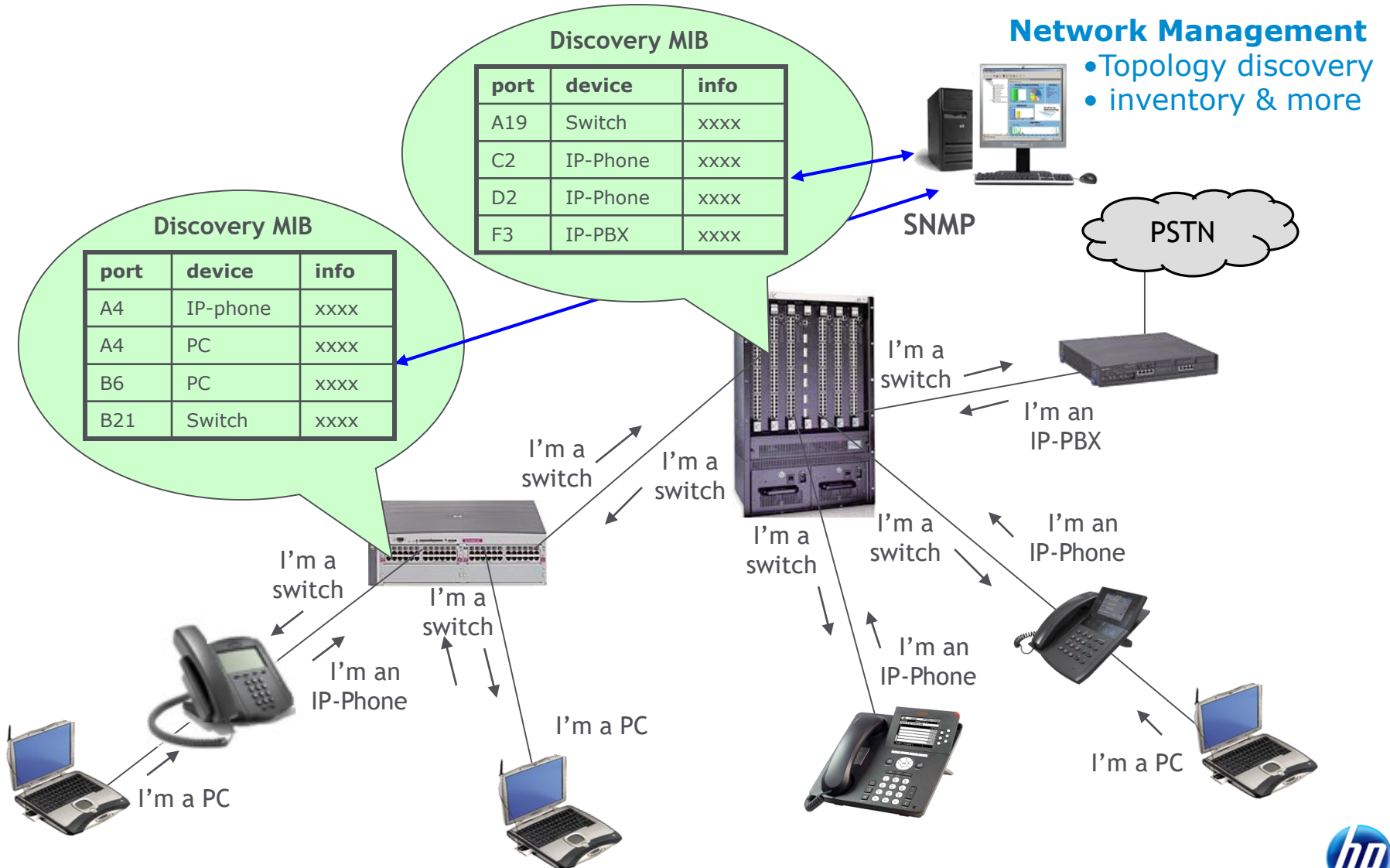
What is IEEE 802.1AB-2005?

Link Layer Discovery Protocol (LLDP)

- A vendor neutral layer 2 protocol, that is open and extendable standard
- Simple one-way neighbor discovery protocol with periodic transmissions
- LLDP frames are not forwarded, but constrained to a single link
- LLDP frames contain formatted **TLVs (type, length, value)**
  - Globally unique system and port identification
  - Time-to-Live information for ageing purposes
  - Optional system capabilities (e.g. router, IP phone, wireless AP)
  - Optional system name and description
  - Optional management address (both IPv4 and IPv6)
  - Organizational extensions
- Receiver stores information in an SNMP MIB
- Receiver ages MIB to **insure only valid** network data is available
- Management applications can harness the power via SNMP

Supported by every major networking vendor: *HP, Avaya, Cisco, Alcatel, Brocade, Juniper, Extreme…and many more*
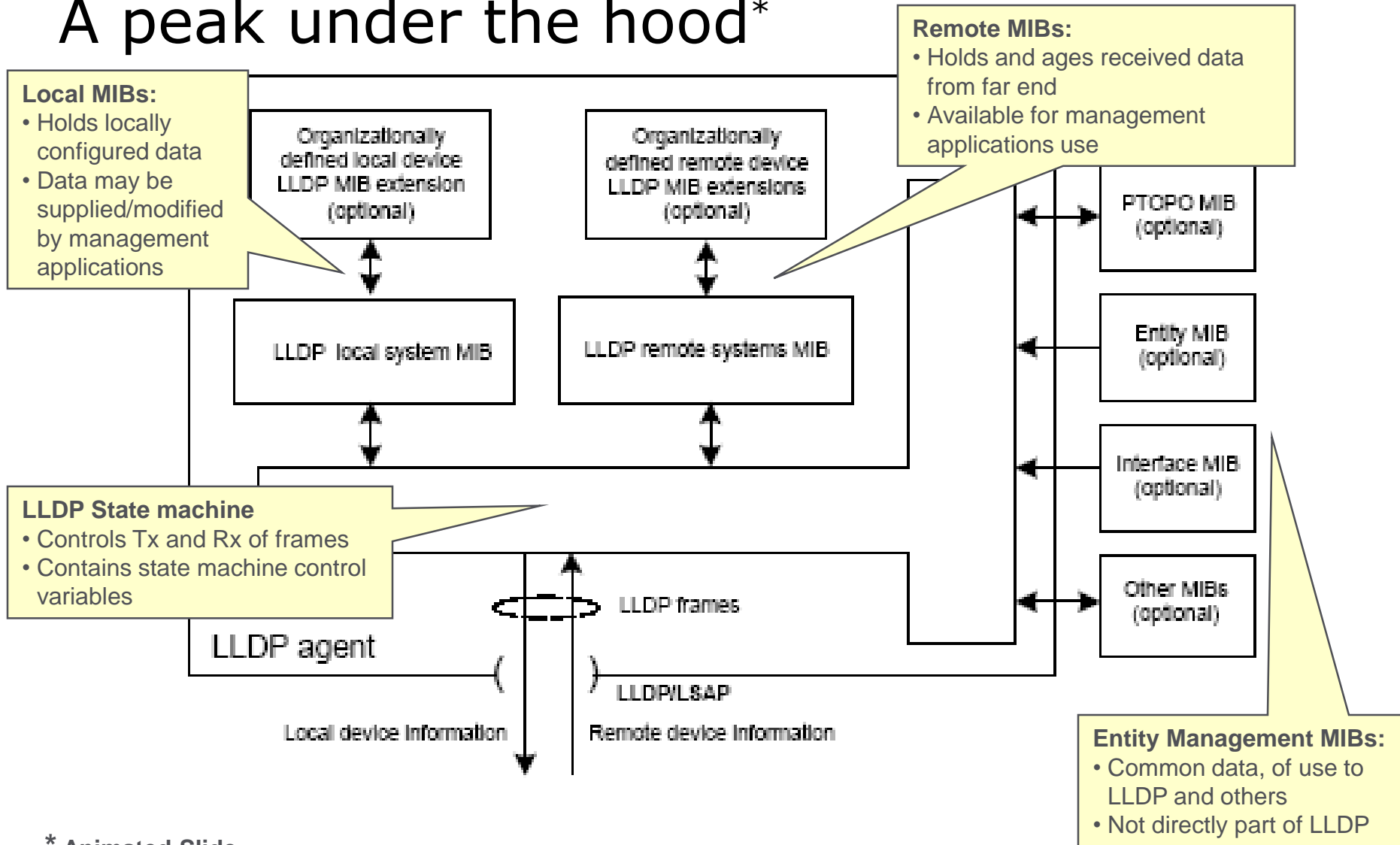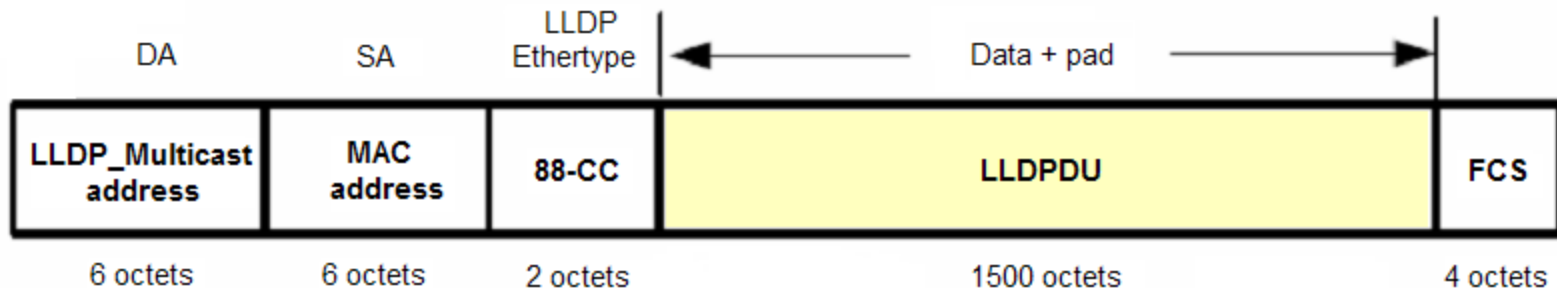
How Does LLDP Work?
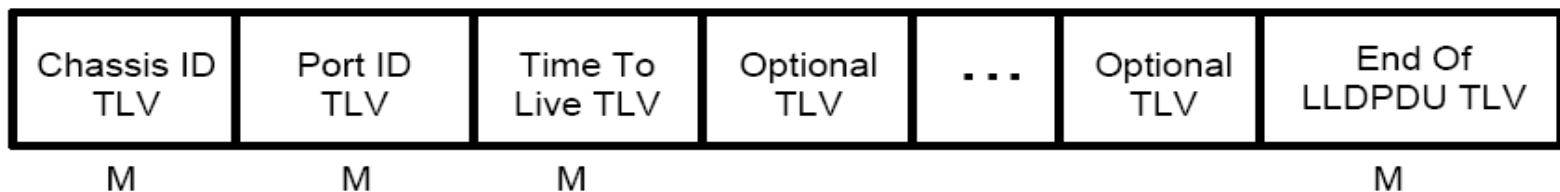
LLDP Entities & Agents
A peak under the hood*

Local MIBs:
- Holds locally configured data
- Data may be supplied/modified by management applications

Remote MIBs:
- Holds and ages received data from far end
- Available for management applications use

LLDP State machine
- Controls Tx and Rx of frames
- Contains state machine control variables

Entity Management MIBs:
- Common data, of use to LLDP and others
- Not directly part of LLDP

Organizationally defined local device LLDP MIB extension (optional)

Organizationally defined remote device LLDP MIB extensions (optional)

PTOPO MIB (optional)

Entity MIB (optional)

LLDP local system MIB

LLDP remote systems MIB

Interface MIB (optional)

Other MIBs (optional)

LLDP frames

LLDP agent

LLDP/LSAP

Local device Information

Remote device Information

* Animated Slide

7

LLDP Frame Format

IEEE 802.3 LLDP frame format

DA	SA	LLDP Ethertype	Data + pad			FCS
LLDP_Multicast address	**MAC address**	**88-CC**		**LLDPDU**		**FCS**
6 octets	6 octets	2 octets		1500 octets		4 octets

LLDP Multicast = 01-80-C2-00-00-0E (same as STP except for last octet)

LLDPDU format

Chassis ID TLV	Port ID TLV	Time To Live TLV	Optional TLV	. . .	Optional TLV	End Of LLDPDU TLV
M	M	M				M

M - mandatory TLV - required for all LLDPDUs

TLVs (type, length, value) contain useful attributes

LLDP Benefits

Network Management
- Simplify and enhance the ability of network management tools in multi-vendor environments
- Enables discovery of accurate physical network topologies
  - What devices are neighbors and through what ports they connect
  - Even with multiple VLANs where all subnets may not be known
- Ensure proper aging so only valid network device data is presented

Network Inventory Data
- Most implementations are expected to support optional system name, system description, system capabilities and management address
- System description can contain the device's full name, version of hardware type and operating system
- Can provide device capability such as switches, routers and WLAN access points

Network troubleshooting
- Accurate topologies simplifies troubleshooting of enterprise networks
- Discover devices with misconfigured or unreachable IP addresses
- Detect speed and duplex mismatch (IEEE 802.3 extension)

TLV Extensibility
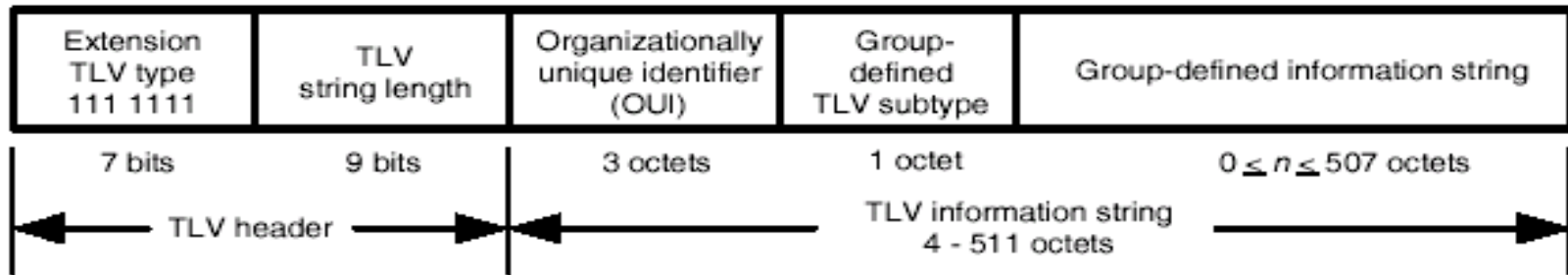
Easy to define organizational TLVs extensions

Extension TLV type 111 1111	TLV string length	Organizationally unique identifier (OUI)	Group-defined TLV subtype	Group-defined information string
7 bits	9 bits	3 octets	1 octet	$0 \leq n \leq 507$ octets
← TLV header →		→ TLV information string 4 - 511 octets →		

Figure 9-12—Basic format for organizationally-defined extension TLVs

There are currently four organizational extensions:
1. IEEE 802.1
   – Port VLAN, Port & Protocol VLANs, VLAN Name, Protocol Entity
2. IEEE 802.3
   – MAC/PHY configuration, Power, Link Aggregation, Maximum Frame Size
3. TIA TR-41.4 - LLDP-MED, ANSI/TIA-1057 (*covered next*)
4. PROFIBUS International (PNO) Extension for PROFINET discovery

IP Telephony Needs

Over and above basic data, VoIP has well defined needs:

- Plug-and-play provisioning
- Simplified management and accurate network topology
- Precise device move tracking for Emergency Call Service
- Rapid identification and troubleshooting of call quality issues
- VoIP specific inventory management
- Vendor-independence, allowing different IP telephony systems to interoperate on one network

Need an open standard discovery protocol!

Shared connections for PC and IP Phone

How to auto-configure the voice VLAN and QoS for IP phones?

1. CDP
   – Proprietary protocol, with limited vendor support

2. 'Dual-stage' DHCP process with vendor specific options
   – Supported by majority of IP phone vendors (Note: not supported by Cisco)
     1. Phone boots on untagged data vlan and discover voice VLAN via DHCP options
     2. Phone reboots using voice VLAN ID and restarts DHCP process
   – *Dual stage DHCP is error prone, less reliable and vendor specific*

3. Manual configuration
   – Set the admin or voice VLAN ID using the IP phone keypad
   – Extremely tedious and rarely used

DHCP server

LAN

IP PBX

Untagged data VLAN

Tagged voice VLAN

IP phone

Untagged data VLAN

PC
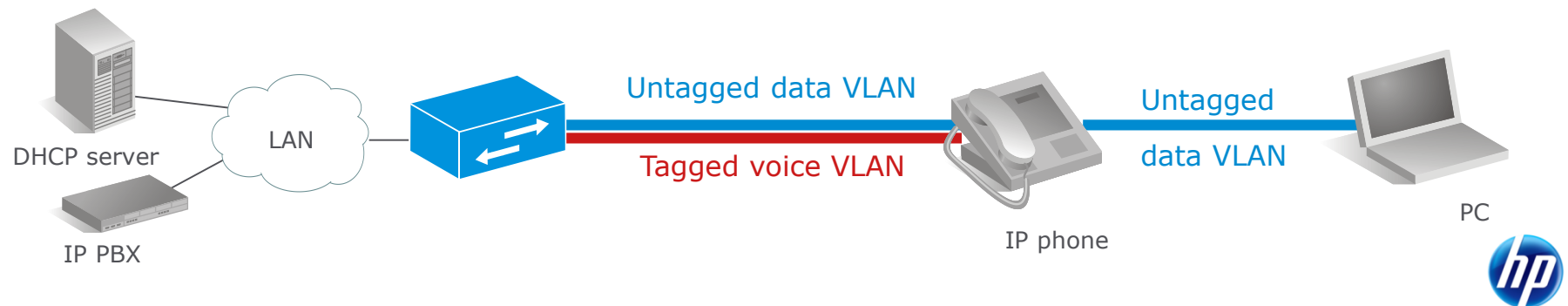
LLDP-MED History...

IEEE-802.1AB-2005 (Link Layer Discovery Protocol) is complete and seeing widespread adoption

LLDP provides the base capabilities, but is not sufficient for IP Telephony and Real-time Video

LLDP-MED (Media Endpoint Devices) initiative formed
- HP Networking approached Mitel and several others leading vendors to extend LLDP to address additional needs, early 2004
- TIA (*Telecommunications Industry Association)* was selected
  - Co-authored by HP Networking (Manfred Arndt), Mitel and Avaya
- Published as ANSI/TIA-1057 (April 2006)

HP Networking is first in the industry to support LLDP-MED!

What Does LLDP-MED Provide?

Interoperability
- Provide vendor-independent management capabilities, enabling different convergence endpoints to interoperate on one network

Automatic deployment of convergence network policies
- Voice or video VLAN
- Layer 2 and Layer 3 QoS policies

Location Services, including Emergency Call Service (ECS)
- Enablement of E-911, 999, 112 for IP telephony through physical location

Detailed Inventory Management Capabilities
- Location information and accurate topology is made available
- Switch acts as proxy to collect model, manufacturer, software, firmware and asset information – since few end-point devices support SNMP
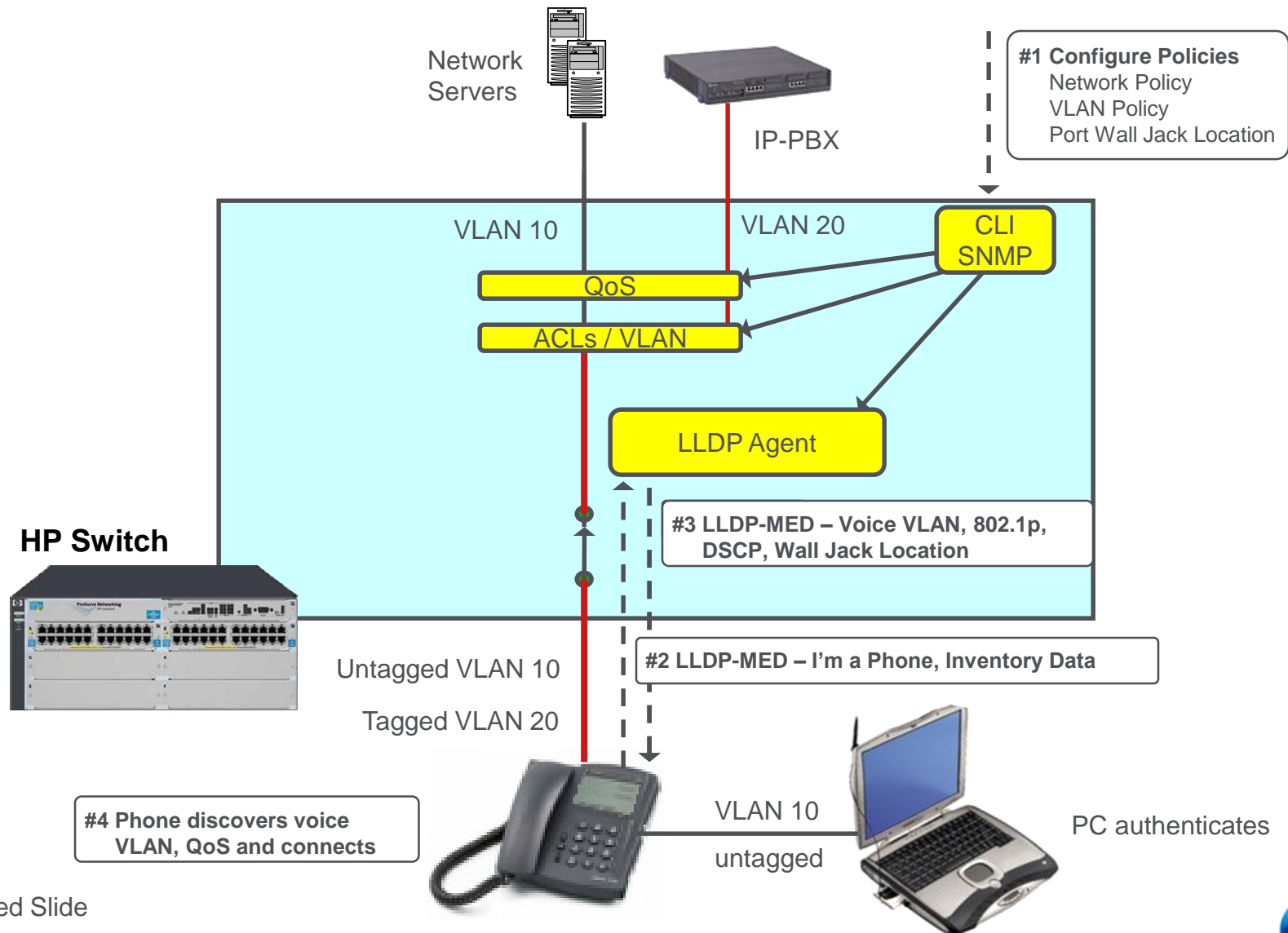
Advanced PoE
- Fine grain power management to support more phones per switch
- Backup power conservation to extend UPS battery life during disasters

IP telephony network troubleshooting
- Detect speed and duplex mismatch*
- Detect improper static voice policy configurations

* Frequent cause of voice and video quality issues, but very hard to diagnose

How LLDP-MED auto-config works*

Network Servers

IP-PBX

#1 Configure Policies
Network Policy
VLAN Policy
Port Wall Jack Location

VLAN 10

VLAN 20

CLI
SNMP

QoS

ACLs / VLAN

LLDP Agent

HP Switch

#3 LLDP-MED – Voice VLAN, 802.1p, DSCP, Wall Jack Location

Untagged VLAN 10

#2 LLDP-MED – I'm a Phone, Inventory Data

Tagged VLAN 20

#4 Phone discovers voice VLAN, QoS and connects

VLAN 10

untagged

PC authenticates

* Animated Slide

Key Points

LLDP runs after 802.1X authentication

- Improved security, since unauthorized devices can not learn switch IP, or gain access to the voice network by spoofing discovery frames

802.1D compliant switches never forward LLDP frames

- Proprietary protocols leak across switches depending on implementation or if the protocol is disabled, resulting in less reliable physical topology

LLDP-MED provides "Fast Start" behavior

- Rapid startup and location discovery is an important aspect for IP Telephony
- At startup, endpoints will initially advertise at a faster rate for a limited time
- Network devices only transmit LLDP-MED TLVs after a MED Endpoint is detected, then also at a fast start rate for a limited time

Easy to use, with minimal configuration required

- Assign a "voice" VLAN to ports
- Assign the wall jack location to ports (for physical location, like E-911)

Managing Multi-vendor UC&C Deployments

HP collaborated with the majority of leading IP phone vendors

- To provide implementation guidance and interoperability testing of LLDP-MED and multi-user 802.1X authentication, to insure successful UC deployments

LLDP-MED is widely adopted by Enterprise IP Telephony vendors, including:

- Aastra
- Alcatel-Lucent
- Avaya / Nortel
- Cisco
- Microsoft Lync
- Mitel
- Polycom
- ShoreTel
- Siemens
- Snom

Cisco supports LLDP on the majority of their products
- Feature Navigator tool lists more than 2,300 results*

CDP is only required for legacy networks
Customers making new IT investment should use the LLDP standard, for flexibility and prevent costly vendor lock in

*http://tools.cisco.com/ITDIT/CFN/Dispatch?act=featSelect&task=init&featStartsWith=I

Additional Standards Based on LLDP

Easy to define new TLVs extensions

Many additional standards based on LLDP and growing…

1. IEEE 802.3at-2009 (PoE+)

   – PoE Plus for 30W with intelligent power management

2. IEEE 802.3az-2010 (EEE)

   – Energy Efficient Ethernet

3. Draft IEEE Data Center Bridging (DCBX)

4. Draft IEEE Edge Virtual Bridging (EVB)

5. Draft IEEE Audio Video Bridging (AVB)

6. LLDP is references in several draft IETF specifications for best practice in support of Emergency Calling (e.g. E-911)

IEEE 802.3at-2009 (PoE+)
PoE Plus for 30W with intelligent power management

PoE+ provides up to 30W at the PSE and 25.5W at the PD

HP helped drive LLDP as an efficient Layer-2 power management protocol for enhanced power allocation, to include the following:

- Fine-grain power negotiation (in 0.1W increments)
- Ongoing dynamic re-negotiation (e.g. need more power for video call)
- Power priority (e.g. must keep "red phone" alive)

Provides advanced capabilities with minimal complexity

Provides visibility into power consumption within the network

Practical for both cost-restrained and feature rich endpoints

Proliferation of PoE endpoints expected

- Video cameras, door locks, card access readers, clocks, etc.

HP Networking is first in the industry to support PoE Plus !

IEEE 802.3at-2009 (PoE+)
PoE Plus for 30W with intelligent power management

PoE+ uses LLDP for L2 power classification

- All PD (clients) ***must*** support both L1 and L2 classification
- PSE (switch) may use L2 and must support L1 classification
- Extends the 802.3af PoE TLV to request dynamic increase and decrease of maximum power

Note: will result in many new clients supporting LLDP

IEEE 802.3az-2010
Energy Efficient Ethernet

Standard Ethernet requires a lot of power to keep physical transmitter chips and maintain link, even when no traffic is present

EEE provides a method to facilitate rapid transition to and from lower power consumption in response to changes in network demand:

- Saves energy by rapidly cycling between Active and Low Power Idle

- Allows energy use to scale based on bandwidth utilization, while still providing method for devices to quickly respond to network activity

- Provides method to communicate when to power down and resume operation of additional circuits for much greater system power savings
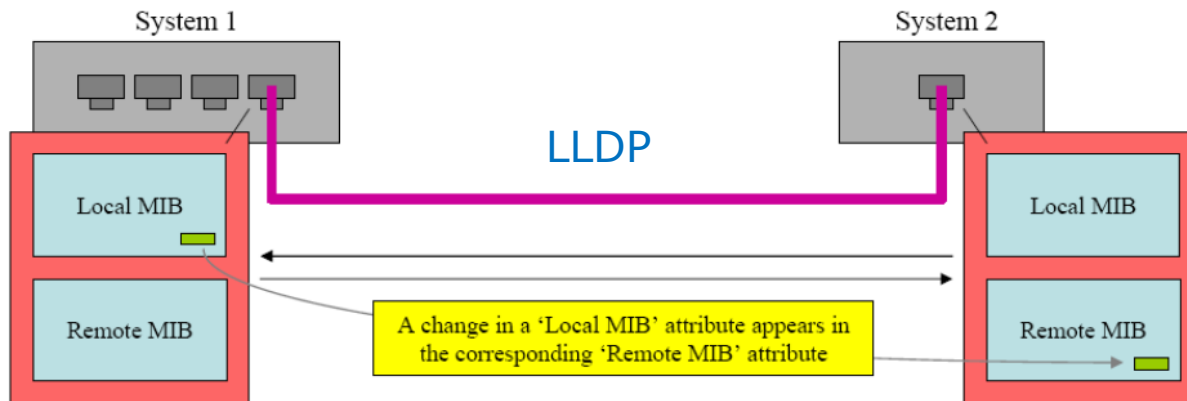 - E.g. CPU, memory, fans (but outside of scope of this standard)
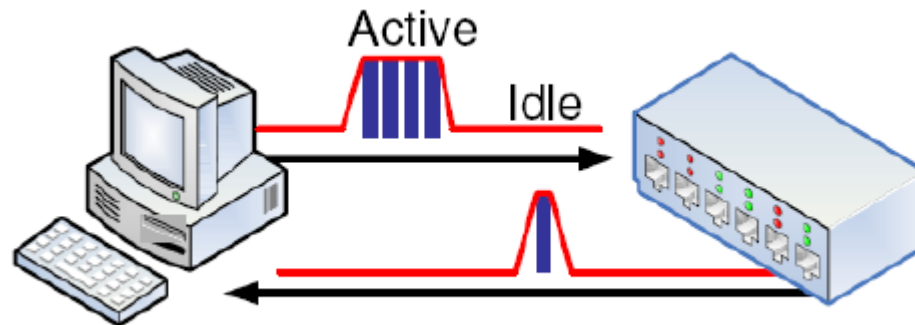
PHY wake time around 20 usec, system wake time will be longer

IEEE 802.3az-2010
Energy Efficient Ethernet

802.3az uses LLDP for control policy parameter discovery

- PHY recovery times will be different for different PHY types
- Allow choice between energy savings or performance

System 1 | System 2

LLDP

Local MIB | Local MIB
Remote MIB | Remote MIB

A change in a 'Local MIB' attribute appears in the corresponding 'Remote MIB' attribute

HP Networking is first in the industry to support EEE !

Emergency Call Services (ECS) Challenges

Legacy PBX

- E911 physical location is statically assigned to a phone number
- Moving phone required manual re-provisioning

IP Telephony Challenges

- Users can pick-up phones and simply move them (just like a PC), invalidating manually assigned locations
- Self reported location is notoriously inaccurate, especially for roaming or nomadic users

LLDP can play an important part in automatic physical location acquisition, but requires industry wide support

Automatic physical location for ECS

Requirements:
- Timely updates
- Plug-and-play with minimal network configuration required
- Interoperability and reliability, critical to Emergency Call Service
- Ability to validate client location is highly desirable

Edge switch

Call Control servers

Location Server

UC client
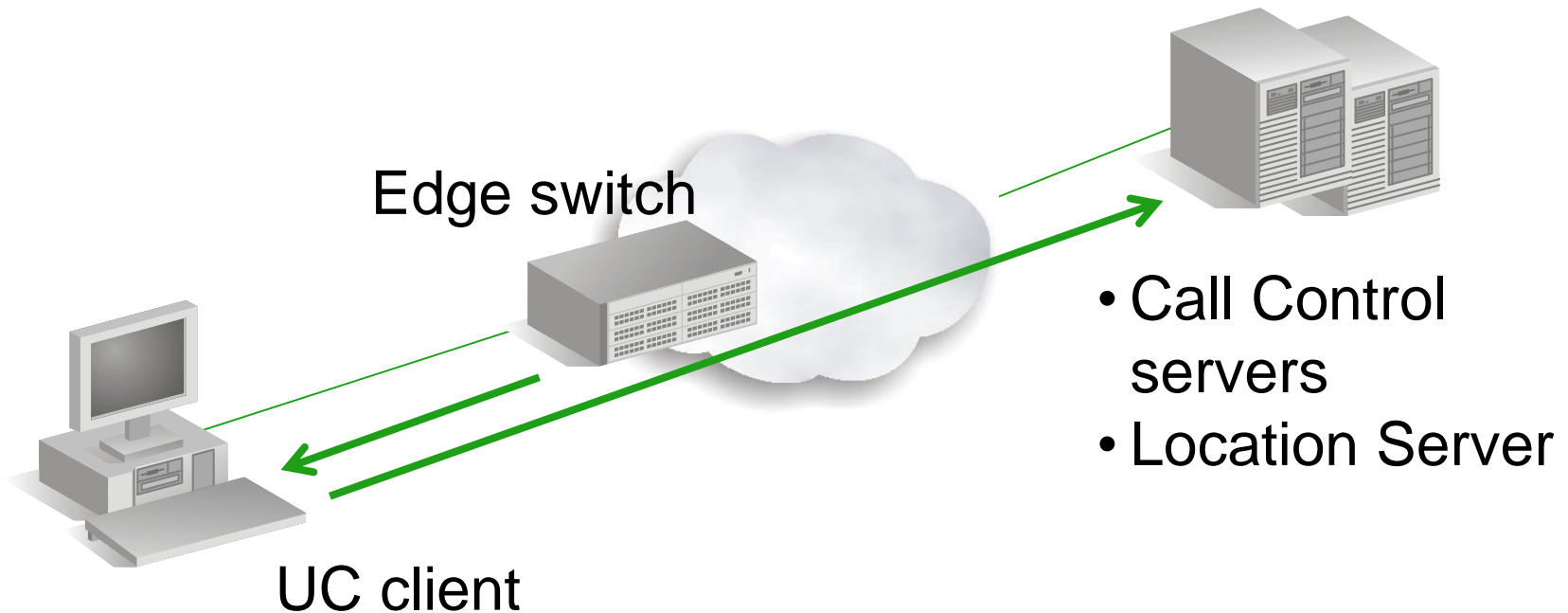
Emergency Call Service Standards referencing LLDP

IETF Drafts

- *draft-ietf-ecrit-phonebcp* - Emergency Services Best Practices
- All telephone and mobile devices should support LLDP-MED location, DHCP snooping and HELD (at layer 7) must also be supported
- Network devices must support one of LLDP-MED, DHCP or L7
- HELD has limited value in Enterprises, since location is based only on IP address (more granular location required in some jurisdictions)
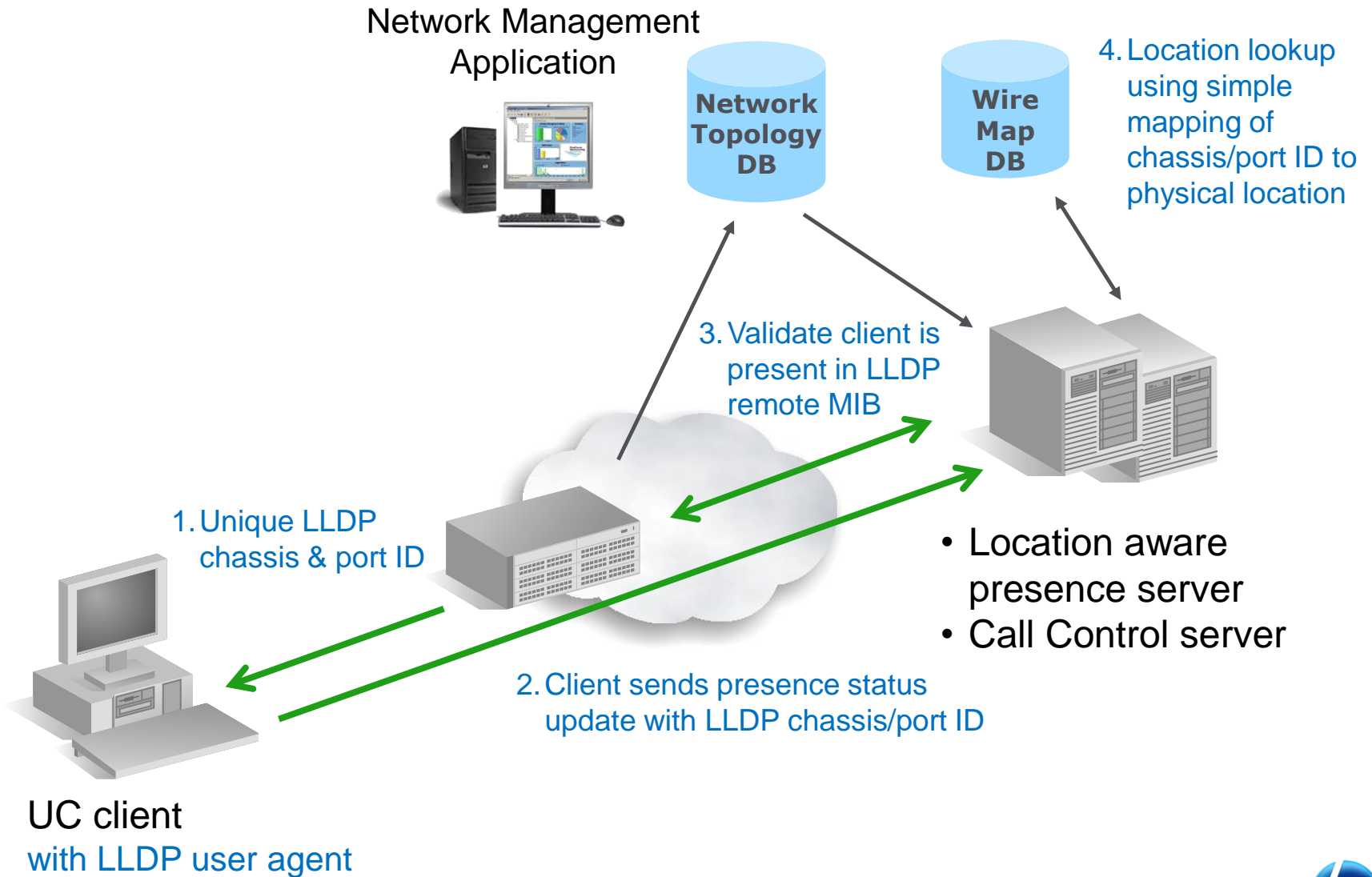
DSL Drafts

- "*Requirements for CPE in Support of Accessing Emergency Services*"
- Client devices should support LLDP-MED and the location TLV (in addition to DHCP and L7)
- LLDP-MED is first in the state machine if multiple services are running

This is encouraging and may help drive additional adoption of LLDP for location services, including possibly mass market devices

LLDP based Location Concepts

Network Management Application

Network Topology DB

Wire Map DB

4. Location lookup using simple mapping of chassis/port ID to physical location

3. Validate client is present in LLDP remote MIB

1. Unique LLDP chassis & port ID

- Location aware presence server
- Call Control server

2. Client sends presence status update with LLDP chassis/port ID

UC client
with LLDP user agent

LLDP Applicability to VoWLAN

LLDP benefits

- LLDP operates above the MAC service layer, and as such can be easily implemented, without requiring any driver modifications
- Reduced complexity with high interoperability potential
- Easily extensible for future needs
- *Applicable to all IEEE 802 networks and would provide common interface across many networking technologies for ECS capable software applications*

LLDP applicability

- Industry accepted solution, already deployed in wired IP phones
- Believed all interfaces required for ECS location delivery are defined today
- As currently defined, LLDP-MED can provide physical location of AP, which is suitable for many ECS requirements

LLDP Multicast Limitation

- 802.1AB-2009 has removed LLDP multicast limitation specifically for wireless, which can now support client specific physical location

Competitive Landscape

	LLDP-MED	Cisco CDP	Nortel NDP	Enterasys CDP
Industry Standards Based	Y	N	N	N
Multi-Vendor Network Support	Y	N	N	N
Chassis & Port ID	Y	Y	Y	Y
Port Description	Y	Y	Y	Y
System Name	Y	Y	Y	Y
System Description	Y	Y	N	N
System Capabilities	Y	Y	N	N
Management Address	Y	Y	Y	Y
VLAN ID	Y	Y	N	N
Voice VLANs	Y	N	N	N
Network Policy	Y	N	N	N
Auto Negotiation Requirements	Y	N	N	N
Power Information (PoE Capable)	Y	Y	N	N
Frame Size Requirements	Y	N	N	N
Location Advertisements (E911 capable)	Y	Y	N	N

Source: LLDP White Paper available on Avaya Web site

LLDP Business Benefits

Lower Operational Cost

- Accurate physical topology and device inventory simplifies management and maintenance
- Plug-and-play provisioning speeds up deployments and reduces QoS and VLAN configuration errors for IP phones
- Automatic location services for E-911
- Enables consolidated management tools with visibility of networking, telephony, and more...

Improved Security over Proprietary Solutions

- Runs after 802.1X, to prevent unauthenticated devices from gaining access to the voice network

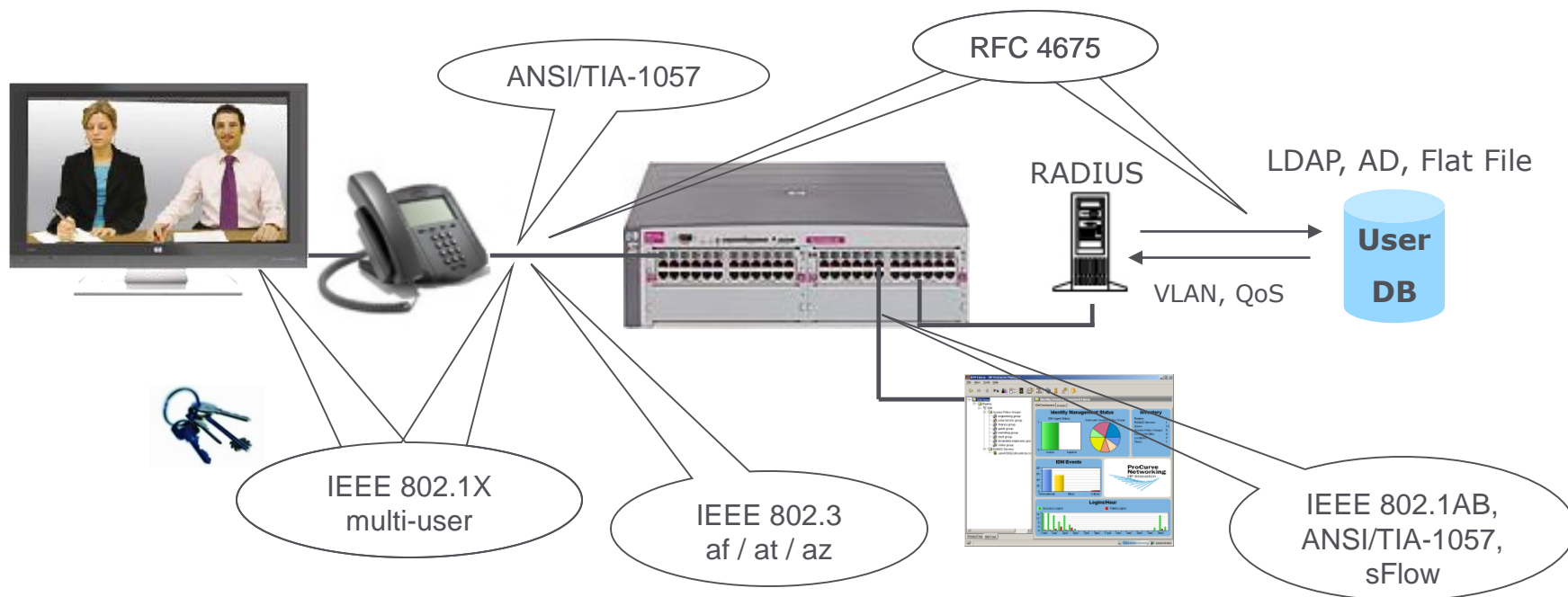**Open standard enables the market and customer choice**

- Best-in-breed multi-vendor solutions - no proprietary "lock-in"
- More capital expense choices

Human error is the biggest contributor to downtime[1]

1. Source: Gartner Group, CNET 2001

HP Driving Multivendor Standards to enable UC&C

Open standard multi-vendor solutions – no proprietary "lock-in"

- Power negotiation using 802.3af PoE and 802.3at PoE+

- Energy Efficiency with 802.3az to reduce power consumption when idle

- Secure authentication of phone and PC with a single network connection

- RFC 4675 for dynamic assignment of tagged voice VLAN and untagged PC VLAN

- LLDP-MED auto-provision phone with voice VLAN, QoS policy, and E911 location

- Detailed Topology, IP Phone inventory management, and more...

Outcomes that matter.

Back-up

Wireshark Example

Display Filter → (points to) Filter: lldp

Packet Summary → (points to)

No. ▾	Time	Source	Destination	Protocol	Info
53	1.653838	HewlettP_57:ca:7f	LLDP_Multicast	LLDP	Chassis Id = 00:13:21:
424	7.417745	Mitel_14:de:f2	LLDP_Multicast	LLDP	Chassis Id = 192.168.10
863	17.417948	Mitel_14:de:f2	LLDP_Multicast	LLDP	Chassis Id = 192.168.10
1266	27.417915	Mitel_14:de:f2	LLDP_Multicast	LLDP	Chassis Id = 192.168.10
1437	31.653118	HewlettP_57:ca:7f	LLDP_Multicast	LLDP	Chassis Id = 00:13:21:

⊞ Frame 53 (268 bytes on wire, 268 bytes captured)
⊞ Ethernet II, Src: HewlettP_57:ca:7f (00:13:21:57:ca:7f), Dst: LLDP_Multicast (01:80:
⊟ Link Layer Discovery Protocol
　⊞ Chassis Subtype = MAC address
　⊞ Port Subtype = Locally assigned
　⊞ Time To Live = 120 sec
　⊞ Port Description = 1
　⊞ System Name = ProCurve Switch 2600-8-PWR
　⊞ System Description = ProCurve J8762A Switch 2600-8-PWR, revision H.08.89, ROM H.08
　⊞ Capabilities
　⊞ Management Address
　⊞ IEEE 802.3 - MAC/PHY Configuration/Status
　⊞ TIA - Media Capabilities

Detailed TLV Breakdown → (points to)

　⊟ TIA - Network Policy
　　1111 111. .... = TLV Type: Organization Specific (127)
　　.... ...0 0000 1000 = TLV Length: 8
　　Organization Unique Code: TIA (0x0012bb)
　　Media Subtype: Network Policy (0x02)
　　Applicaton Type: Voice (1)
　　0... .... = Policy: Defined
　　.1.. .... = Tagged: Yes
　　...0 0000 0110 010. = VLAN Id: 50
　　.... ...1 10.. .... = L2 Priority: 6
　　..10 1110 = DSCP Value: 46
　⊞ TIA - Location Identification

33

Open Source and Diagnostic Tools

OpenLLDP

- Open source implementation of LLDP and LLDP-MED
  http://sourceforge.net/projects/openlldp

Wireshark (formerly Ethereal)

- Popular open source protocol analyzer and troubleshooting tool
- Provides detailed decodes for all LLDP & LLDP-MED TLVs
  http://www.wireshark.org/download.html

Network Management Tools

- NetDisco Network Management
  http://www.netdisco.org
- NetDi Network Discovery Suite
  http://www.netdi.ch

Wiki

- LLDP primer that includes useful links and sample captures:
  http://wiki.wireshark.org/LinkLayerDiscoveryProtocol

LLDP-MED Industry Momentum

Initial vendors supporting standardization...

LLDP-MED Location TLV

TLV Type = 127	Location ID String Length	TIA OUI 00-12-BB	Location ID Subtype = 3	Location Data Format	Location ID
7 bits	9 bits	3 octets	1 octet	1 octet	Variable size

TLV Header — MED Header
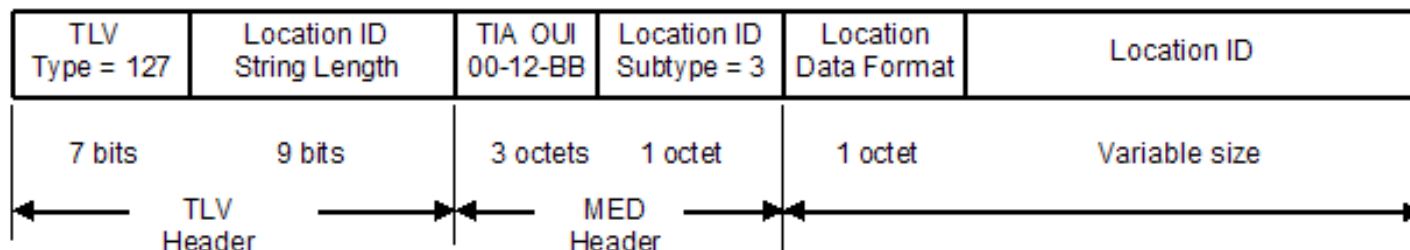
Enables Physical Location Services, including Emergency Call Service (ECS)

- Supports E911 and other location services (for example NENA TID 07-501)

Currently supported location formats

- Coordinate-based LCI subtype as defined by IETF RFC 3825
- Civic Address LCI subtype as defined by draft-ietf-geopriv-dhcp-civil-09
- ELIN subtype, to support traditional PSAP-based Emergency Call
- One or more methods may be used simultaneously for different endpoint requirements

Two ECS methods supported (End-device & Notification based)

- Switch advertises periodic location info for endpoint to use
- Switch sends notification when a new endpoint is detected or endpoint moves

NENA - National Emergency Number Association
PSAP - Public Service Access Point

End-device based location
Method 1 - Ideal for smart clients (e.g. SIP phones)
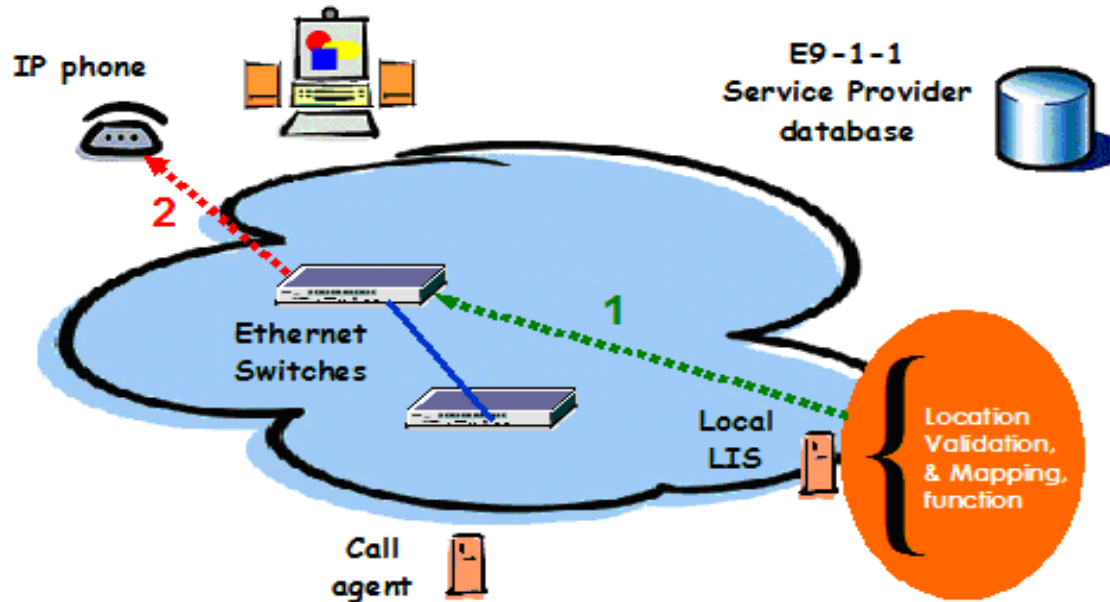
1. A management application or an LIS (Location Information Server) programs the location into network devices using SNMP and LLDP-MED MIB
   - Every port may advertise a unique coordinate based, civic based, and/or ELIN location value

2. Network devices advertise periodic LLDP-MED frames containing the location identifier
   - Endpoint has location information to use immediately in the call setup

Notification based ECS (E-911)
Method 2 - Infrastructure Based for smart management tools
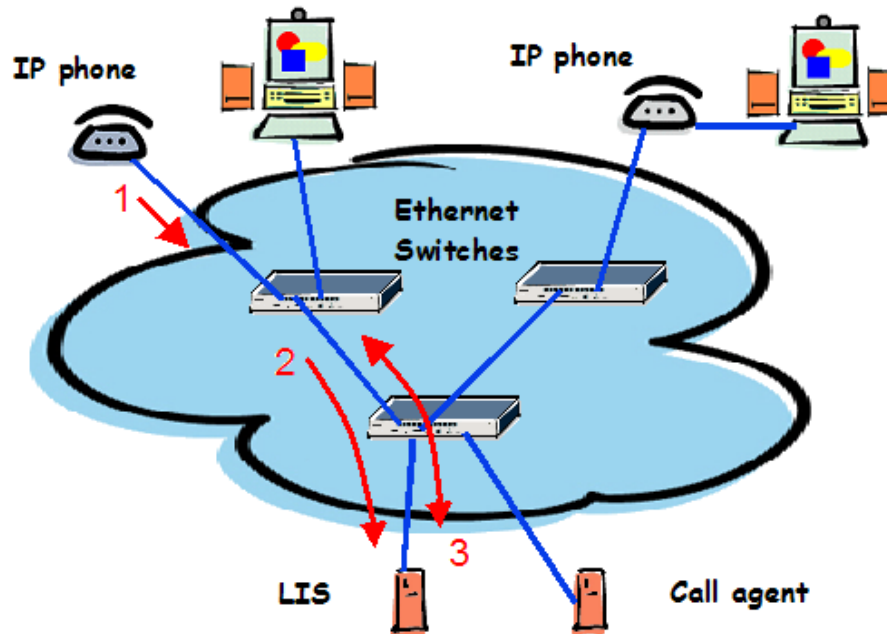
1. IP phones advertises their MAC/IP, and telephone capability to network device via periodic LLDP frames

2. Network device send an SNMP event notification to a management application or an LIS whenever a new IP phone has directly connected

3. A management application or LIS will poll the IP phone information from network devices using the LLDP-MED MIB, to insure integrity