Network Discovery Protocol LLDP and LLDP-MED

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Abstract

Various devices are connected in network to each other. It becomes a tedious task to keep track of all the devices for network administrator. Checking links physically are also not a good option for network administrator. In case of network consisting of devices from same vendors it may becomes possible to keep track of devices and manage network, but in multi vendor scenario it becomes more difficult. Solution to this is use of Network Discovery Protocol. Network discovery protocol help administrator to find devices connected over network but also helps to find information related to devices. Various vendors have designed their own proprietary discovery protocols, but they are not interoperable in case of devices from different vendors. Here comes the Link Layer Discovery Protocol (LLDP) which is IEEE 802.3ab standard for network discovery over link layer. Link Layer Discovery Protocol-Media Endpoint Discovery (LLDP-MED) is extension to LLDP which is specially designed for multimedia devices and IP Phones, Video Phones etc. LLDP and LLDP-MED helps to achieve discovery in multi-vendor environment also. Here this paper discusses the need, basics and implementation of LLDP and LLDP-MED over a network switch.

1   Introduction

Today's network management solutions are required to add expanded functionality and, at the same time, reduce complexity. Deployment, configuration, monitoring and other management disciplines must accommodate new technologies and network changes that are necessary to support new applications. We can try to simplify today's expanding network environment and management challenges by improving intelligence and automation throughout the network by incorporating the recently finalized Link Layer Discovery Protocol (LLDP) - IEEE standard, 802.1AB into its infrastructure products. LLDP was recently accepted as the standard open protocol for discovering network topologies and information concerning devices on the network. LLDP promises to simplify troubleshooting of enterprise networks and enhance the ability of network management tools to discover and maintain accurate network topologies in multi-vendor environments. It serves to reduce the complexities and expenses involved with convergence driven network changes by greatly simplifying management and connectivity issues. The new standard sets the stage for convergence applications by allowing enterprises to add new access devices in a non-disruptive Plug and Play fashion. Voice and wireless services can be easily implemented without major network upgrades. LLDP-MED is an extension to LLDP which provides additional voice, power and inventory related functions. The Link Layer Discovery Protocol (LLDP) stations attached to an IEEE 802 LAN to advertise, to other stations attached to the same IEEE 802 LAN, the major capabilities provided by the system incorporating that station, the management address or addresses of the entity or entities that provide management of those capabilities, and the identification of the station's point of attachment to the IEEE 802 LAN required by those management entity or entities. The information distributed via this protocol is stored by its recipients in a standard Management Information Base (MIB), making it possible for the information to be accessed by a Network Management System (NMS) using a management protocol such as the Simple Network Management Protocol (SNMP).

Routing protocols allow routers to learn about each other dynamically as a network expands and changes. However, these protocols run over Layer 3 of the Open Systems Interconnection (OSI) model. Devices such as switches, which operate on Layer 2, do

not participate. Networks expand all the time; switches are moved, and new ones are added. Devices need to stay up to date on these changes. Link Layer Discovery Protocol (LLDP), which runs over OSI Layer 2 as shown in Figure 2, allows locally attached devices in a network, such as switches and routers, to advertise information about themselves to listening devices. (See Figure 1.) Because devices continually broadcast and listen for LLDP messages, they can discover when a new device is added or one removed. In this way, they maintain an accurate picture of a dynamic network.
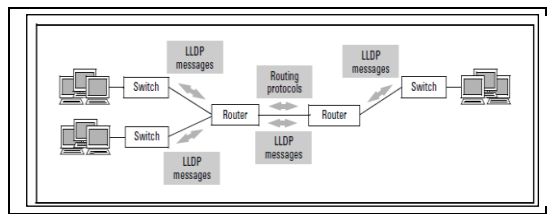

Figure 1:LLDP Message Flow

1.1 Device Discovery Protocols

Device discovery protocols enable directly connected devices to discover information about each other. They advertise information about the device over every interface, allowing any device in the network to "know" everything it is connected to. Examples of applications that use the information conveyed by discovery protocols include:

Network topology: A network management system (NMS) can accurately represent a map of the network topology.

Inventory: A management system can query a switch to learn about all the devices connected to that switch.

Emergency services: Location of a phone can be determined by the switch port to which it is connected.

VLAN configuration: The switch can tell the phone which VLAN to use for voice.

Power negotiation: The phone and the switch can negotiate the power that the phone can consume.

1.2 LLDP

LLDP functions over any Data Link Layer network. Nodes transmit information about them and listen for information about the devices on each connection. With this information, they compile a picture of the network and of the neighbors that they can reach. Nodes identify neighbors according to the information (such as MAC address and system name) they receive in LLDP messages. LLDP messages also include a network address where a management process such as a Simple Network Management Protocol (SNMP) server can reach the endpoint. LLDP runs over the Data Link Layer, so devices that use different Network Layer protocols can still identify each other. The switch is supposed to participate automatically so that a router can learn about the devices to which it connects and so that it can inform other devices of its presence.

1.3 LLDP-MED

LLDP got its start in an IETF Working Group (PTOPOMIB), which focused on a common framework or model to describe physical topology. This group published an informational MIB, RFC 2922, in September 2000. Cisco then worked with the IEEE to create 802.1AB, which was published in May 2005. This protocol provides standards-based discovery for vendor interoperability. It was recognized that additional capabilities were needed specific to VoIP, and this work was assumed by the Telecommunications Industry Association (TIA) TR-41.4 subcommittee. This committee developed LLDP-MED, which defines extensions to LLDP. LLDPMED is specified to operate only between endpoint devices such as IP phones and network connectivity devices such as switches.

While LLDP can provide base discovery capabilities, it is not adequate for use by IP telephony and video. These devices require a protocol that offers features such as plug-and-play provisioning, simplified management and accurate network topology, precise device tracking for use by Emergency Call Service, and rapid identification and troubleshooting of call quality issues. VoIP, moreover, needs specific inventory management. Another challenge is that the protocol must allow IP telephony systems from different vendors to interoperate on one network. In April, 2006, the TIA (Telecommunications Industry Association) comes up with Link Layer Discovery Protocol-Media Endpoint Discovery standard. According to some industry experts "The LLDP-MED standard is an important milestone toward simplifying the deployment and management of multi-vendor VoIP environments. This supports our long-standing belief that networks should be based on open industry standards — to enable the market and give customers the choice to select best-in-breed solutions. There should be no proprietary restrictions."

2 Survey of current implementations

Cisco is first to implement LLDP and LLDP-MED on network devices. Now there are very few companies which support LLDP-MED on their network devices. Cisco has a similar discovery protocol known as Cisco Discovery Protocol (CDP) which is slightly similar to LLDP but a proprietary of Cisco. Cisco currently supports CDP and LLDP, LLDP-MED both. Nortel Networks also has a discovery protocol for network topology discovery. But all these protocols are not capable to interoperate among manufacturers. Following figure shows similar Discovery protocols from a number of vendors. Problem with various discovery protocols is that it is not possible to have vendor independents support. In case of multiple vendors devices network it is not possible to manage networks using their proprietary discovery protocol.

Vendor	Acronym	Name
Cisco Systems	CDP	Cisco Discovery Protocol
Extreme	EDP	Extreme Discovery Protocol
Foundry	FDP	Foundry Discovery Protocol
Nortel	NDP	Nortel Discovery Protocol
Enterasys	CDP	Cabletron Discovery Protocol

Table 1: Discovery Protocols from Various Vendors.

OpenLLDP is a open source implementation available for LLDP. The OpenLLDP project aims to bring an Open Source LLDP agent to various platforms, including Mac OS X, Windows, and Linux. OpenLLDP can send and receive LLDP messages. Limitation of OpenLLDP is that it supports only a subset of TLVs. Current version of OpenLLDP does not supports Organization specific TLVs and LLDP-MED TLVs.

3 Link Layer Discovery Protocol

LLDP is a data-link layer protocol that is an optional part of the protocol stack of an IEEE 802 LAN station. It operates above the MAC service layer and can be used in any networking device that implements MAC service layer.

It is a one way protocol. An LLDP agent can transmit information about the capabilities and current status of the system associated with its interfaces. It also receives similar information from its neighbors. LLDP cannot solicit such info from its neighbors.

LLDP can be enabled in different modes: Tx only enabled, Rx only enabled and RxTx enabled. LLDP transmits the information using LLDPDU which is a sequence of short, variable length, informational elements known as TLV that each include type, length and value fields.

- Type identifies the kind of information that is sent
- Length indicates the length of the information in octets
- Value is the actual information for the parameter mentioned in the type field (could be string, bitmap, integer value etc)

3.1 LLDP Protocol Data Unit (LLDPDU)

A single LLDPDU is transmitted in a single 802.3 Ethernet frame which consists of Destination MAC address, Source MAC address, Ether type and LLDPDU. Destination MAC address used by LLDP is 01-80-C2-00-00-0E. This address is within the range reserved by IEEE STD 802.1D 2004. LLDPDU will not be forwarded by the MAC bridges that conform to IEEE STD 802.1D 2004. Ether type used by LLDPDU will be "88-CC" as defined by the IEEE Standard.

Chassis ID TLV	Port ID TL	TTL TLV	Optional TLV	. . . . . .	Optional TLV	End of LLDP DU

Figure 2: LLDPDU Format

Each LLDPDU includes four mandatory TLVs plus optional TLVs as selected by the admin:

- A Chassis ID TLV (Mandatory)
- A Port ID TLV (Mandatory)
- A Time-To-Live TLV (Mandatory)
- From zero to n optional TLVs
- An End of LLDPDU TLV (Mandatory)

3.2 Type-Length-Value (TLV)

Type Length Value also known as TLV is the basic unit to send information

are defined in standards or by organizations and are optional to LLDPDUs.

4 Experiment

Following are the things done while working on Network discovery protocol LLDP and LLDP-MED.

4.1 Packet Transmission

In this phase I have started with LLDP packets. As a first step I implemented all LLDP packets so that they can be transmitted from machine over network. Following figure shows the packet capture for all LLDP frames transmitted over network.

After successful transmission of LLDP packets I started with creating LLDP-MED packets. Following figure shows a packet capture which shows LLDP as well as LLDP-MED packets are transmitted over network.

TLV Type	TLV Name	Usage in LLDPDU
0	End of LLDPDU	Mandatory
1	Chassis ID	Mandatory
2	Port ID	Mandatory
3	Time To Live	Mandatory
4	Port Description	Optional
5	System Name	Optional
6	System Description	Optional
7	System Capabilities	Optional
8	Management Address	Optional
9-129	Reserved	Optional
127	Organizationally specific TLVs	Optional

TLV Type (7	TLV Info string length (9 bits)	TLV information string
TLV		TLV

Figure 3:TLV Format

Time-To-Live field tells receiving LLDP agent how long this information pertaining to neighbor will be valid. After this time the
Table 2: Discovery Protocols from Various Vendors.

LLDP agent should discard this entry if receiving agent does not receive the updated info from the neighbor in this time period.
Time-To-Live value of zero tells the recipient that all the system information associated with the LLDPDU's MSAP identified needs to be deleted immediately.
End of LLDPDU TLV marks the end of the LLDPDU.

3.3 TLV Types

TLVs encapsulated in LLDPDUs fall into these categories: basic TLV, organization defined TLV, and MED (media endpoint discovery) related TLV. Basic TLVs are the base of device management. Organization specific TLVs and MED related TLVs are used for enhanced device management. They

Figure 4:Packet capture showing LLDP and LLDP-MED packets

4.2 Receiving Packets

After successful transmission next challenge was to receive packets and to decode them. So I initially started with reception of LLDP packets and decoding them appropriately.

After successful decoding of LLDP packets I proceeded with decoding LLDP-MED packets. Following figure shows snapshot for decoded LLDP packet.

```
TLV Type is :    MAC Address - 00 15 75
TLV Type is :    Interface Name - eth2
TLV Type is :    90 seconds
TLV Type is : eth2
TLV Type is :    Sushil-R2#12.(none)
TLV Type is : i686/Linux 2.4.28
TLV Type is :
                                    Station
TLV Type is : IPv4 - 0.0.0.0 (System Po
VLAN Name TLV
 Port and Protocol VLAN ID TLV
Port VLAN ID TLV
Power via MDI TLV
Maximum Frame Size TLV
MAC PHY Configuration/Status TLV
Link Aggregation TLV
MED capabililties TLv
MED Network POlicy TLV
MED Extended Power TLV
MED Hardware TLV
MED Software Revison TLV
MED Firmaware TLV
MED Serial Number TLV
MED Manufacturer TLV
 MED MOdel Name TLv
MED Model Name String : Lan Enforcer 1(
Asset ID TLV
```

Figure 5:Decoding Received Packets

4.3   Porting Process to Switch

All previous tasks were done on a Linux host machine. Now time was to port this process to actual working environment i.e. to switch. Switch has got its own operating system and its own process environment which is not exactly as Linux but similar to Linux. So I need to start listening for processor boot up messages and other events. Also many events are generated in system which is needed to be handled.

4.4   Command Line Interface

During this phase, modifications are made so as to make it more user friendly for the switch. It involved writing command lines for performing various functions like to display neighbors in various formats, defining various controls like Transmit, Receive enable/disable and many more.

4.5   Testing

This task involves testing of complete system as a whole. System will be tested against working of protocol in various test cases. During this step various tests are carried out like changing transmit interval, changing TTL value, deleting local information when Shutdown packet is received, receiving multiple packets on a port at the same time. All these tests involved a test setup consisting of 2 multi port host machine, 8 port hub and Network switch.

4.6   Implementing Debug support

During this phase efforts were made to make this program programmer friendly. Debug support is implemented for LLDP process so that programmers can trace flow of packets through   the   system   during   runtime. Implementing will made it easy to solve of any problems or bugs that may come into picture in future. Debug support is implemented with different levels of debug so that it is easy to debug problems and not too many messages are displayed on the screen.

5   Conclusion

 Implementing LLDP and LLDP-MED will lead to more easily manageable networks and will make a difference in the successful implementation of an IP telephony solution. Implementing LLDP and LLDP-MED will lead to more multi vendor support over networks than ever before. LLDP and LLDP-MED simplify discovery at Link layer (Layer 2) and added location based services to a network which helps a lot in services such as emergency 911 services.

6   References

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