

**ANALYSIS OF OPERATIONAL CHARACTERISTICS AND
COMPATIBILITY ISSUES OF THE LLDP PROTOCOL ACROSS VARIOUS
VENDOR DEVICES.**

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Abstract: *In this thesis, the implementation characteristics of the LLDP protocol on network devices from various manufacturers are analyzed. The operating principles of the LLDP protocol based on the IEEE 802.1AB standard and the differences in vendor devices are examined. The research analyzes methods for collecting LLDP data via SNMP. As a result, proposals were developed for identifying and resolving compatibility issues between devices from different vendors.*

Keywords: *LLDP, IEEE 802.1AB, SNMP, network protocols, heterogeneous networks, vendor devices, network monitoring, interoperability.*

Introduction

The use of network devices produced by various manufacturers (vendors) is widespread in modern corporate networks. In such heterogeneous network environments, standard protocols play a crucial role in ensuring information exchange between devices. One such protocol is the Link Layer Discovery Protocol (LLDP), which operates based on the IEEE 802.1AB standard. It enables the exchange of service information about network devices and the discovery of network topology. However, there are certain differences in the implementation of the LLDP protocol across various vendor devices. Although vendors develop based on the standard, they may introduce additional functional capabilities or specific configuration mechanisms. This can lead to interoperability issues between devices and complicate the network management process. Therefore, analyzing the implementation characteristics of the LLDP protocol in various vendor devices is considered a relevant task.

Software implementation of LLDP data collection via SNMP.

Obtaining practical data is crucial when analyzing the operational characteristics of the LLDP protocol across different vendor devices. To achieve this, methods for automatically collecting LLDP data from network devices are employed. In practice,

SNMP (Simple Network Management Protocol) is widely used to retrieve data from network devices.

Within the scope of the research, a software solution based on the SNMP protocol was developed to retrieve LLDP data from network devices. This program was developed using the Python programming language and an SNMP library, enabling the automatic collection of data from LLDP MIB tables. A fragment of the program developed to implement this process is presented below.

To simplify the analysis and processing of the obtained results, the data was converted into JSON format. This method enables the systematization, storage, and automation of

```
def snmp_walk(oid, ip, community, mibBuilder):
    results = []
    yxat yaratish

    for (errorIndication, errorStatus, errorIndex, varBinds) in nextCmd(
        SnmpEngine(),
        CommunityData(community),
        UdpTransportTarget((ip, 161)),
        ContextData(),
        ObjectType(ObjectIdentity('LLDP-MIB', oid, 1)),
        lexicographicMode = False):

        if errorIndication:
            print(errorIndication)
            break
        elif errorStatus:
            print('%s at %s' % (errorStatus.prettyPrint(), errorIndex and varBinds[int(
            break
        else:
            for varBind in varBinds:
                results.append(' = '.join([x.prettyPrint() for x in varBind]))
```

subsequent analysis processes.

During the research, a query was sent via SNMP to the LLDP MIB tables on an customer network device. According to the obtained results, the device did not return data for the lldpRemManAddrTable. However, the following data was obtained from the query regarding the lldpRemTable.

```
["LLDP-MIB::lldpRemChassisIdSubtype.4500.1.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221557700.15.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221567600.36.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221588400.38.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221596300.12.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221618600.46.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221622600.40.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221627700.44.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221644400.39.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221659700.37.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221724000.24.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222060500.41.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222092700.7.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222096900.45.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222130900.21.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222151700.23.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222154300.35.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222158200.42.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222162900.11.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222172700.47.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222239800.10.1 = macAddress",
"LLDP-MIB::lldpRemChassisId.4500.1.1 = 0x8f0827c2a03",
"LLDP-MIB::lldpRemChassisId.221557700.15.1 = 0x00e04cf16cd3",
"LLDP-MIB::lldpRemChassisId.221567600.36.1 = 0x00e04cf17066",
"LLDP-MIB::lldpRemChassisId.221588400.38.1 = 0x00e04cf0c612",
"LLDP-MIB::lldpRemChassisId.221596300.12.1 = 0x48ba4e27f069",
"LLDP-MIB::lldpRemChassisId.221618600.46.1 = 0x00e04cf0e018",
"LLDP-MIB::lldpRemChassisId.221622600.40.1 = 0x00e04cf0de71",
"LLDP-MIB::lldpRemChassisId.221627700.44.1 = 0x00e04cf0dfc5",
"LLDP-MIB::lldpRemChassisId.221644400.39.1 = 0x00e04cf0dfc6",
"LLDP-MIB::lldpRemChassisId.221659700.37.1 = 0x00e04cf0dddc",
"LLDP-MIB::lldpRemChassisId.221724000.24.1 = 0x00e04cf1716f",
"LLDP-MIB::lldpRemChassisId.222060500.41.1 = 0x00e04cf0e0f3",
"LLDP-MIB::lldpRemChassisId.222092700.7.1 = 0x00e04cf0de7f",
"LLDP-MIB::lldpRemChassisId.222096900.45.1 = 0x00e04cf0c531",
"LLDP-MIB::lldpRemChassisId.222130900.21.1 = 0x00e04cf0ddde",
"LLDP-MIB::lldpRemChassisId.222151700.23.1 = 0x00e04cf1717e",
"LLDP-MIB::lldpRemChassisId.222154300.35.1 = 0x00e04cf0c50a",
"LLDP-MIB::lldpRemChassisId.222158200.42.1 = 0x00e04cf0ddf0",
"LLDP-MIB::lldpRemChassisId.222162900.11.1 = 0x00e04cf0dddd",
"LLDP-MIB::lldpRemChassisId.222172700.47.1 = 0x00e04cf0dddb",
"LLDP-MIB::lldpRemChassisId.222239800.10.1 = 0x00e04cf0dc65",
"LLDP-MIB::lldpRemPortIdSubtype.4500.1.1 = local",
"LLDP-MIB::lldpRemChassisIdSubtype.4500.1.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221557700.15.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221567600.36.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221588400.38.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221596300.12.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221618600.46.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221622600.40.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221627700.44.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221644400.39.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221659700.37.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.221724000.24.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222060500.41.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222092700.7.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222096900.45.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222130900.21.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222151700.23.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222154300.35.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222158200.42.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222162900.11.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222172700.47.1 = macAddress",
"LLDP-MIB::lldpRemChassisIdSubtype.222239800.10.1 = macAddress",
"LLDP-MIB::lldpRemChassisId.4500.1.1 = 0x8f0827c2a03",
"LLDP-MIB::lldpRemChassisId.221557700.15.1 = 0x00e04cf16cd3",
"LLDP-MIB::lldpRemChassisId.221567600.36.1 = 0x00e04cf17066",
"LLDP-MIB::lldpRemChassisId.221588400.38.1 = 0x00e04cf0c612",
"LLDP-MIB::lldpRemChassisId.221596300.12.1 = 0x48ba4e27f069",
"LLDP-MIB::lldpRemChassisId.221618600.46.1 = 0x00e04cf0e018",
"LLDP-MIB::lldpRemChassisId.221622600.40.1 = 0x00e04cf0de71",
"LLDP-MIB::lldpRemChassisId.221627700.44.1 = 0x00e04cf0dfc5",
"LLDP-MIB::lldpRemChassisId.221644400.39.1 = 0x00e04cf0dfc6",
"LLDP-MIB::lldpRemChassisId.221659700.37.1 = 0x00e04cf0dddc",
"LLDP-MIB::lldpRemChassisId.221724000.24.1 = 0x00e04cf1716f",
"LLDP-MIB::lldpRemChassisId.222060500.41.1 = 0x00e04cf0e0f3",
"LLDP-MIB::lldpRemChassisId.222092700.7.1 = 0x00e04cf0de7f",
"LLDP-MIB::lldpRemChassisId.222096900.45.1 = 0x00e04cf0c531",
"LLDP-MIB::lldpRemChassisId.222130900.21.1 = 0x00e04cf0ddde",
"LLDP-MIB::lldpRemChassisId.222151700.23.1 = 0x00e04cf1717e",
"LLDP-MIB::lldpRemChassisId.222154300.35.1 = 0x00e04cf0c50a",
"LLDP-MIB::lldpRemChassisId.222158200.42.1 = 0x00e04cf0ddf0",
"LLDP-MIB::lldpRemChassisId.222162900.11.1 = 0x00e04cf0dddd",
"LLDP-MIB::lldpRemChassisId.222172700.47.1 = 0x00e04cf0dddb",
"LLDP-MIB::lldpRemChassisId.222239800.10.1 = 0x00e04cf0dc65",
"LLDP-MIB::lldpRemPortIdSubtype.4500.1.1 = local",
```

When analyzing the LLDP data obtained via SNMP, it was determined that the lldpRemTable contained service information about neighboring network devices. It was observed that LLDP MIB parameters, including the lldpRemChassisIdSubtype and lldpRemChassisId fields, were returned in the table results. These parameters allow for the determination of identification data of neighboring devices, specifically MAC addresses. The obtained results indicated the presence of several neighboring devices in the network and that their identification data is being successfully transmitted via the LLDP protocol. This is considered of significant importance in discovering network topology, monitoring connections between devices, and optimizing network management processes. At the same time, the results show that there may be differences in the presentation format and coverage level of LLDP data across devices from different vendors. This situation confirms the necessity of applying additional processing mechanisms during the process of generalizing and analyzing LLDP data in heterogeneous network environments.

Analysis of ifTable query results. As a result of the query sent to the ifTable via the SNMP protocol, service information about the network device's interfaces was obtained. It was observed that IF-MIB parameters, including the ifIndex and ifDescr fields, were returned in the obtained results. While the ifIndex parameter represents the unique identifier of network interfaces, the ifDescr parameter indicates the interface naming, i.e., Ethernet port numbers. According to the analysis results, the presence of multiple Ethernet interfaces on the device was determined, and separate identification data was returned for each of them. These data are considered of

```
"IF-MIB::ifIndex.40 = 40",
"IF-MIB::ifIndex.41 = 41",
"IF-MIB::ifIndex.42 = 42",
"IF-MIB::ifIndex.43 = 43",
"IF-MIB::ifIndex.44 = 44",
"IF-MIB::ifIndex.45 = 45",
"IF-MIB::ifIndex.46 = 46",
"IF-MIB::ifIndex.47 = 47",
"IF-MIB::ifIndex.48 = 48",
"IF-MIB::ifIndex.49 = 49",
"IF-MIB::ifIndex.50 = 50",
"IF-MIB::ifIndex.51 = 51",
"IF-MIB::ifIndex.52 = 52",
"IF-MIB::ifIndex.11001 = 11001",
"IF-MIB::ifDescr.1 = Ethernet1/0/1",
"IF-MIB::ifDescr.2 = Ethernet1/0/2",
"IF-MIB::ifDescr.3 = Ethernet1/0/3",
"IF-MIB::ifDescr.4 = Ethernet1/0/4",
"IF-MIB::ifDescr.5 = Ethernet1/0/5",
"IF-MIB::ifDescr.6 = Ethernet1/0/6",
"IF-MIB::ifDescr.7 = Ethernet1/0/7",
"IF-MIB::ifDescr.8 = Ethernet1/0/8",
"IF-MIB::ifDescr.9 = Ethernet1/0/9",
"IF-MIB::ifDescr.10 = Ethernet1/0/10",
"IF-MIB::ifDescr.11 = Ethernet1/0/11"
```

```
"IF-MIB::ifIndex.40 = 40",
"IF-MIB::ifIndex.41 = 41",
"IF-MIB::ifIndex.42 = 42",
"IF-MIB::ifIndex.43 = 43",
"IF-MIB::ifIndex.44 = 44",
"IF-MIB::ifIndex.45 = 45",
"IF-MIB::ifIndex.46 = 46",
"IF-MIB::ifIndex.47 = 47",
"IF-MIB::ifIndex.48 = 48",
"IF-MIB::ifIndex.49 = 49",
"IF-MIB::ifIndex.50 = 50",
"IF-MIB::ifIndex.51 = 51",
"IF-MIB::ifIndex.52 = 52",
"IF-MIB::ifIndex.11001 = 11001",
"IF-MIB::ifDescr.1 = Ethernet1/0/1",
"IF-MIB::ifDescr.2 = Ethernet1/0/2",
"IF-MIB::ifDescr.3 = Ethernet1/0/3",
"IF-MIB::ifDescr.4 = Ethernet1/0/4",
"IF-MIB::ifDescr.5 = Ethernet1/0/5",
"IF-MIB::ifDescr.6 = Ethernet1/0/6",
"IF-MIB::ifDescr.7 = Ethernet1/0/7",
"IF-MIB::ifDescr.8 = Ethernet1/0/8",
"IF-MIB::ifDescr.9 = Ethernet1/0/9",
"IF-MIB::ifDescr.10 = Ethernet1/0/10",
"IF-MIB::ifDescr.11 = Ethernet1/0/11"
```

significant importance in monitoring the status of network device ports, analyzing network topology, and coordinating data regarding interfaces in network management systems.

Conclusion

The research results demonstrated the existence of differences in the implementation of the LLDP protocol across network devices from various vendors. Data obtained via SNMP allowed for the analysis of LLDP and interface information, although it was

observed that data regarding certain MIB tables was not fully returned. The obtained results indicated the necessity of employing additional analysis methods to generalize LLDP data in heterogeneous network environments. Future automation of network monitoring and management is considered a significant direction in this field.

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