

NET311
Computer Network Management
SNMPv1
Organization and Information Models

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Acknowledgements

- Notes are based on slides of:
 - Network Management: Principles and Practice, 2E, Mani Subramanian.

Overview

- IETF SNMP standard
- Organization Model
 - 2- and 3-tier models
 - Manager and agent
- Management messages
- Structure of management information, SMI
- Object type and instance
- Scalar and aggregate managed objects
- Management information base, MIB
- IETF MIB-2 standard

Managed LAN

- NMS on subnet 192.168.252.1 manages the router and the hubs on subnet 172.16.46.1 across the backbone network

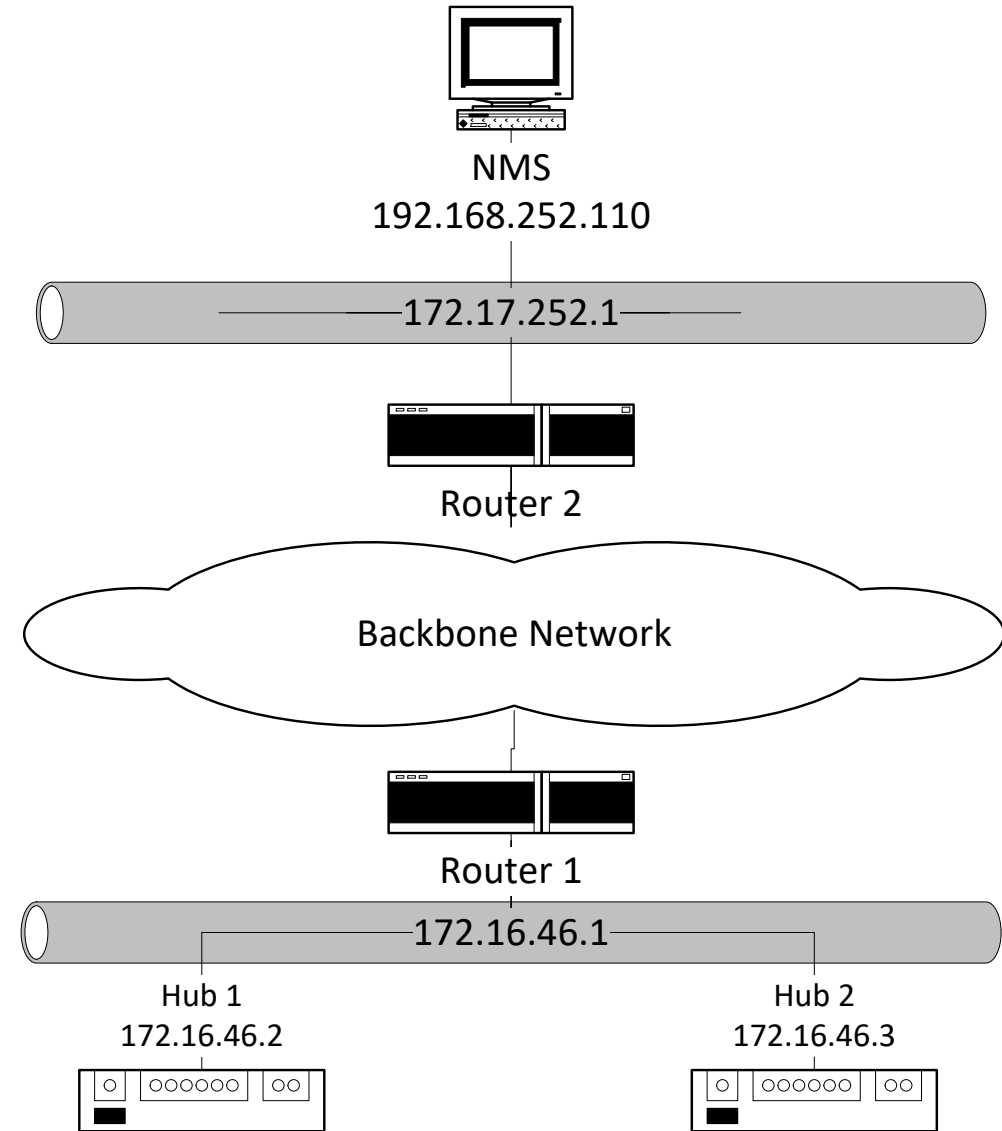


Figure 4.1 Managed LAN Network

Managed Hub: System Information

- Information obtained querying the hub
- Data truly reflects what is stored in the hub

Title: System Information: 172.16.46.2

Name or IP Address: 172.16.46.2

System Name:

System Description: 3Com LinkBuilder FMS, SW version:3.02

System Contact:

System Location:

System Object ID:

iso.org.dod.internet.private.enterprises.43.1.8.5

System Up Time: (2475380437) 286 days, 12:03:24.37

Figure 4.2(a) System Information on 172.16.46.2 Hub

Managed Router: System Information

Title: System Information: router1.gatech.edu

Name or IP Address: 172.16.252.1

System Name : router1.gatech.edu

System Description : Cisco Internetwork Operating System Software

: IOS (tm) 7000 Software (C7000-JS-M), Version

: 11.2(6),RELEASE SOFTWARE (ge1)

: Copyright (c) 1986-1997 by Cisco Systems, Inc.

: Compiled Tue 06-May-97 19:11 by kuong

System Contact

System Location :

System Object ID : iso.org.dod.internet.private.enterprises.cisco.ciscoProducts.
cisco 7000

System Up Time : (315131795) 36 days, 11:21:57.95

Figure 4.2(c) System Information on Router

Managed Hub: Port Addresses

Index	Interface	IP address	Network Mask	Network Address	Link Address
1	3Com	172.16.46.2	255.255.255.0	172.16.46.0	0x08004E07C25C
2	3Com	192.168.101.1	255.255.255.0	192.168.101.0	<none>

- Information acquired by the NMS on hub interfaces
- Index refers to the interface on the hub
- Link address is the MAC address
- The second row data is a serial link

Managed Router: Port Addresses

Index	Interface	IP address	Network Mask	Network Address	Link Address
23	LEC.1.0	192.168.3.1	255.255.255.0	192.168.3.0	0x00000C3920B4
25	LEC.3.9	192.168.252.15	255.255.255.0	192.168.252.0	0x00000C3920B4
13	Ethernet 2/0	172.16..46.1	255.255.255.0	172.16..46.0	0x00000C3920AC
16	Ethernet 2/3	172.16.49.1	255.255.255.0	172.16.49.0	0x00000C3920AF
9	Ethernet 1/2	172.16.55.1	255.255.255.0	172.16.55.0	0x00000C3920A6

- Information acquired by NMS on the router interfaces
- Index refers to the interface on the router
- LEC is the LAN emulation card
- Ethernet 2/0 refers to interface card 2 and port 0 in that card

Internet SNMP Management

- Internet Engineering Task Force (IETF)
 - 1990 SNMPv1
 - 1995 SNMPv2
 - 1998 SNMPv3
- Internet documents:
 - Request for Comments (RFC)
 - IETF STD Internet Standard

SNMPv1 and SNMPv2 Documents

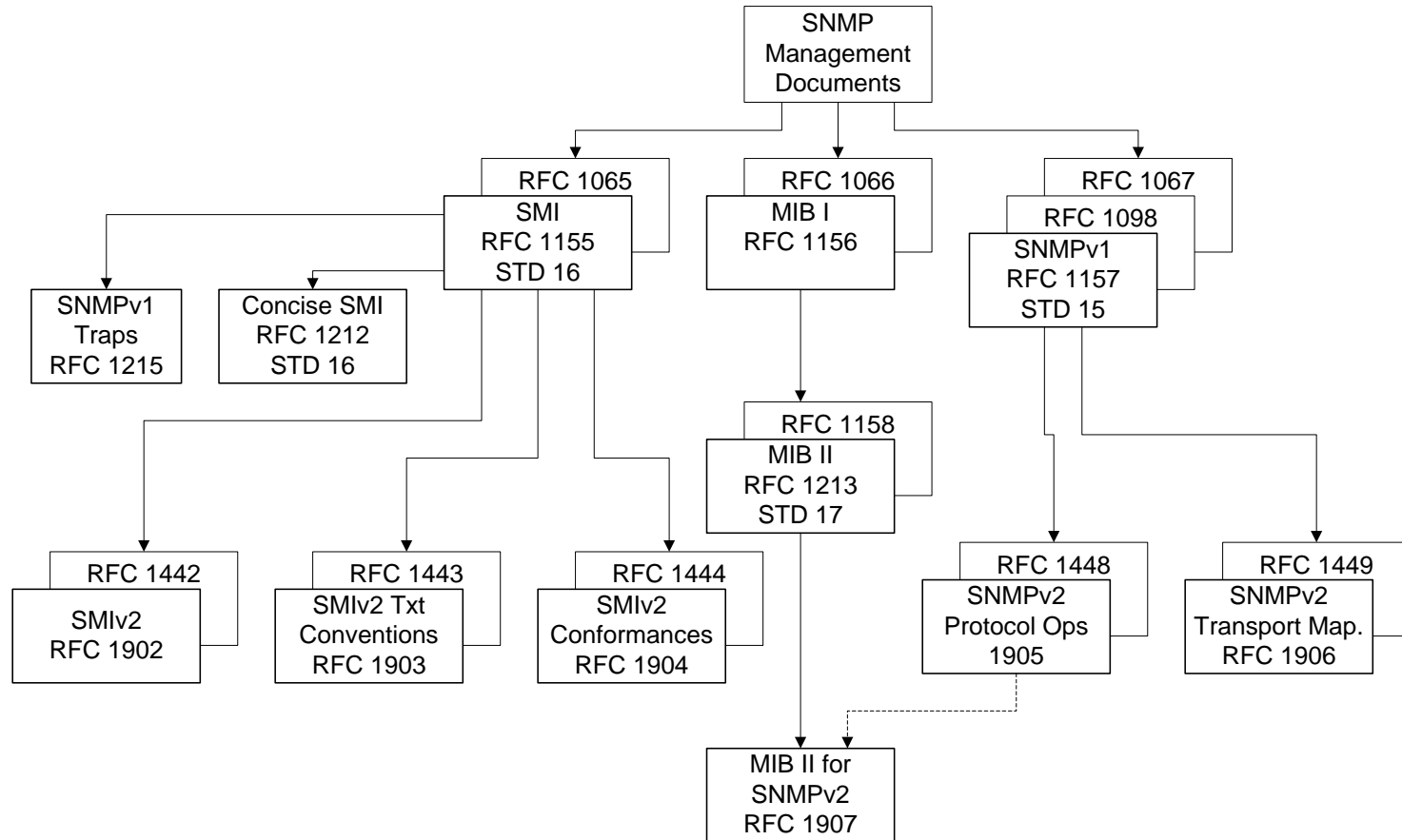
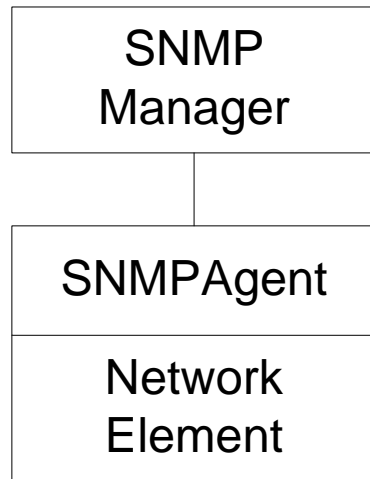


Figure 4.4 SNMP Document Evolution

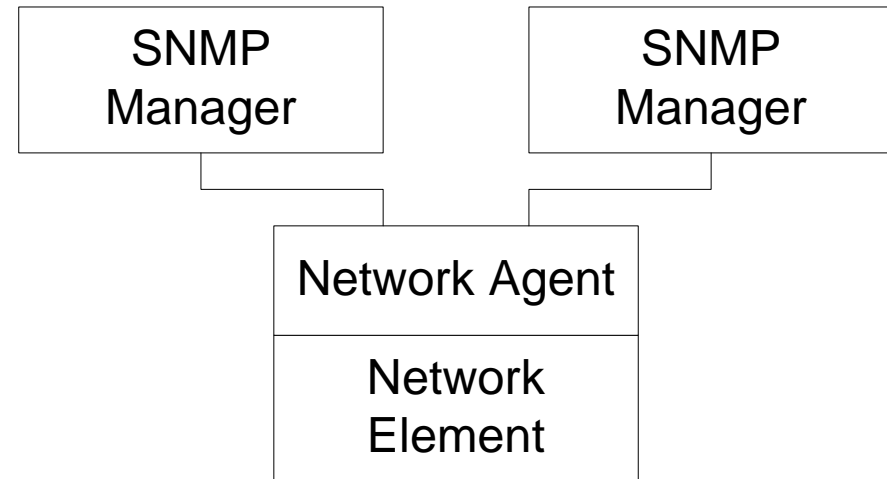
SNMP Model

- Organization Model
 - Relationship between network element, agent, and manager
 - Hierarchical architecture
- Information Model
 - Uses ASN.1 syntax
 - SMI (Structure of Management Information)
 - MIB (Management Information Base)
- Communication Model
 - Transfer syntax
 - SNMP over TCP/IP
 - Communication services addressed by messages
 - Security framework community-based model

Two-Tier Organization Model



(a) One Manager - One Agent Model



(b) Multiple Managers - One Agent Model

Figure 4.5 Two-Tier Organization Model

Any host that could query an agent is a manager.

Three-Tier Organization Model: RMON

- Managed object comprises network element and management agent
- RMON acts as an agent and a manager
- RMON (Remote Monitoring) gathers data from MO, analyses the data, and stores the data
- Communicates the statistics to the manager

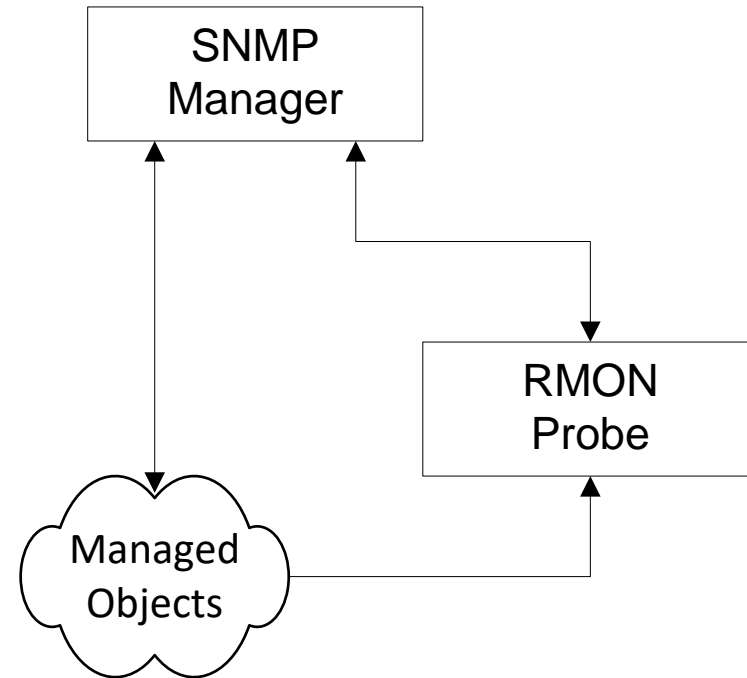


Figure 4.6 Three-Tier Organization Model

Three-Tier Organization Model: Proxy Server

- Proxy server converts non-SNMP data from non-SNMP objects to SNMP compatible objects and messages

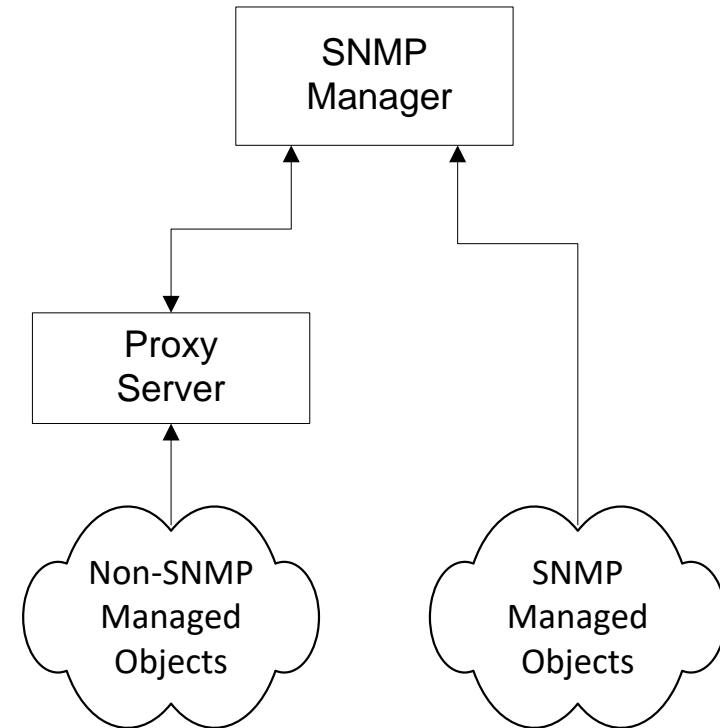


Figure 4.7 Proxy Server Organization Model

Managed Object

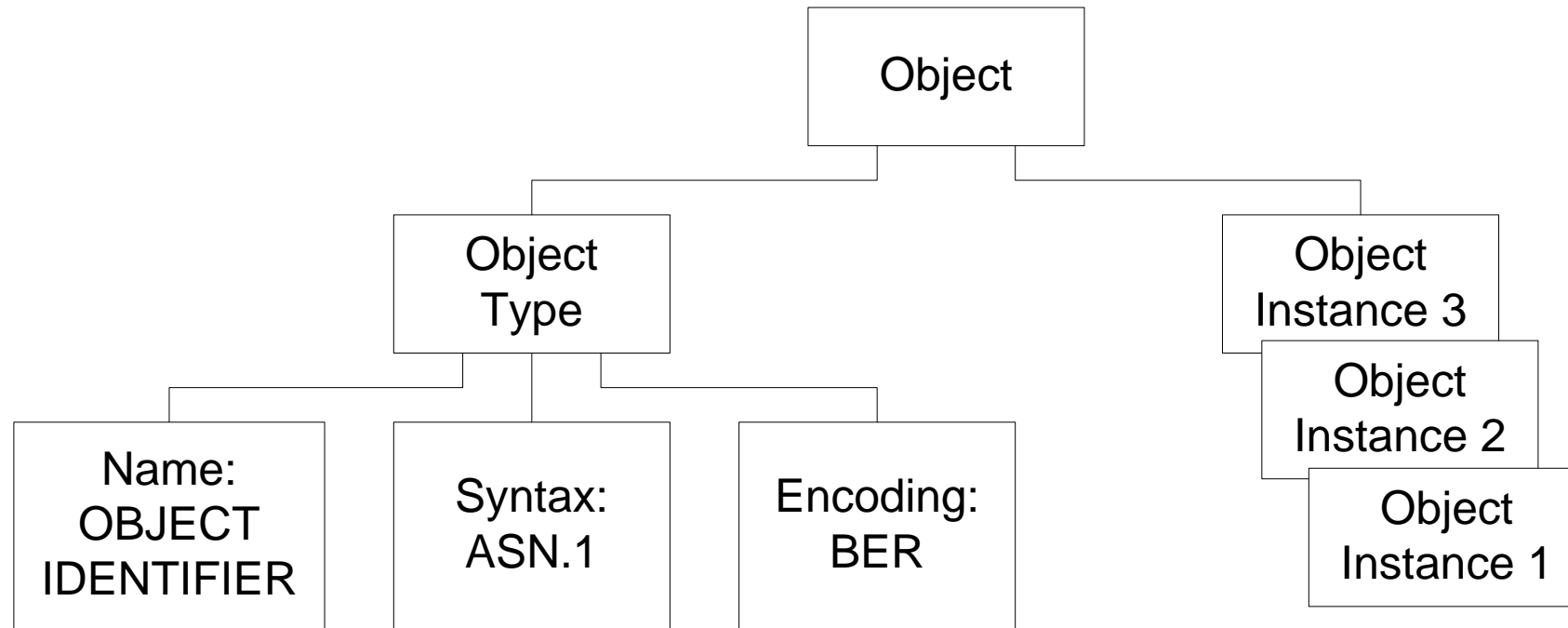


Figure 4.11 Managed Object : Type with Multiple Instances

Managed Object

- Object type and data type are synonymous
- Object identifier is data type, not instance
- Object instance IP address (See Figure 4.2)
- All hubs of the same version have identical identifier
- They are distinguished by the IP address
- Each IP address is an instance of the object

Name

- Uniquely defined by
 - DESCRIPTOR
 - OBJECT IDENTIFIER
- Examples
 - internet OBJECT IDENTIFIER ::= {iso org(3) dod(6) 1 }.
 - internet OBJECT IDENTIFIER ::= {iso(1) standard(3) dod(6) internet(1)}
 - internet OBJECT IDENTIFIER ::= {1 3 6 1}
 - internet OBJECT IDENTIFIER ::= {iso standard dod internet }
 - internet OBJECT IDENTIFIER ::= { iso standard dod(6) internet(1) }
 - internet OBJECT IDENTIFIER ::= { iso(1) standard(3) 6 1 }

Internet Subnodes

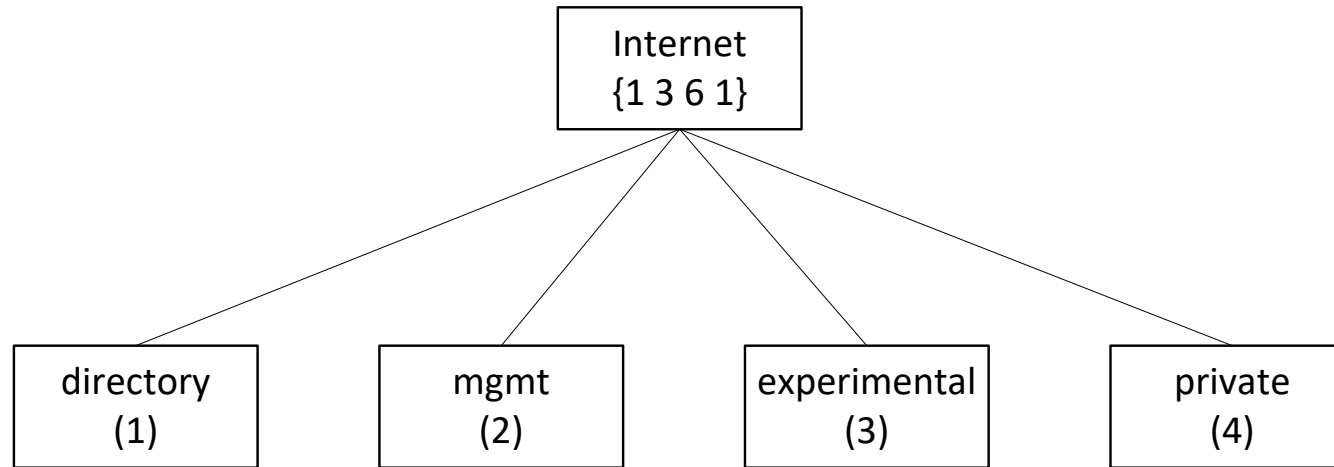


Figure 4.13 Subnodes under Internet Node in SNMPv1

directory	OBJECT IDENTIFIER ::= {internet 1}
mgmt	OBJECT IDENTIFIER ::= {internet 2}
experimental	OBJECT IDENTIFIER ::= {internet 3}
private	OBJECT IDENTIFIER ::= {internet 4}

Private MIB Example

Notes

- *private* MIB intended for vendor equipment
- IANA (Internet Assigned Numbers Authority) assigns identifiers

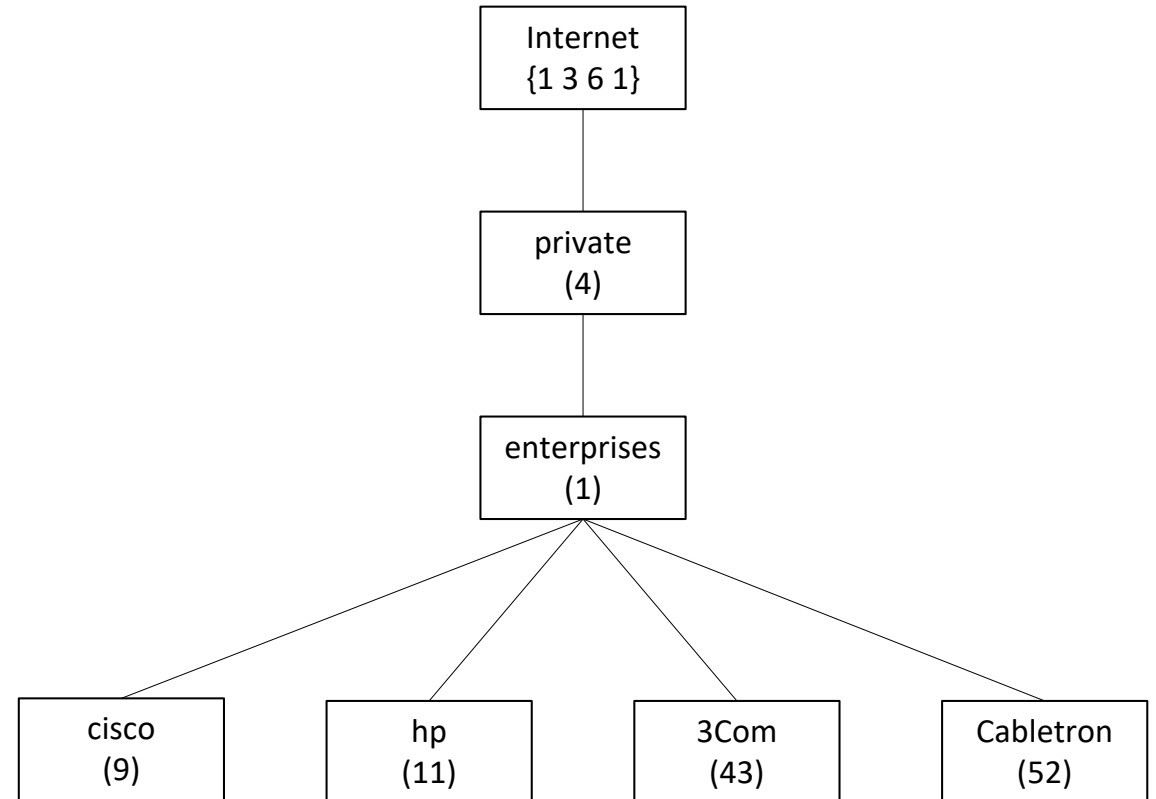


Figure 4.14 Private Subtree for Commercial Vendors

SNMP ASN.1 Data Type

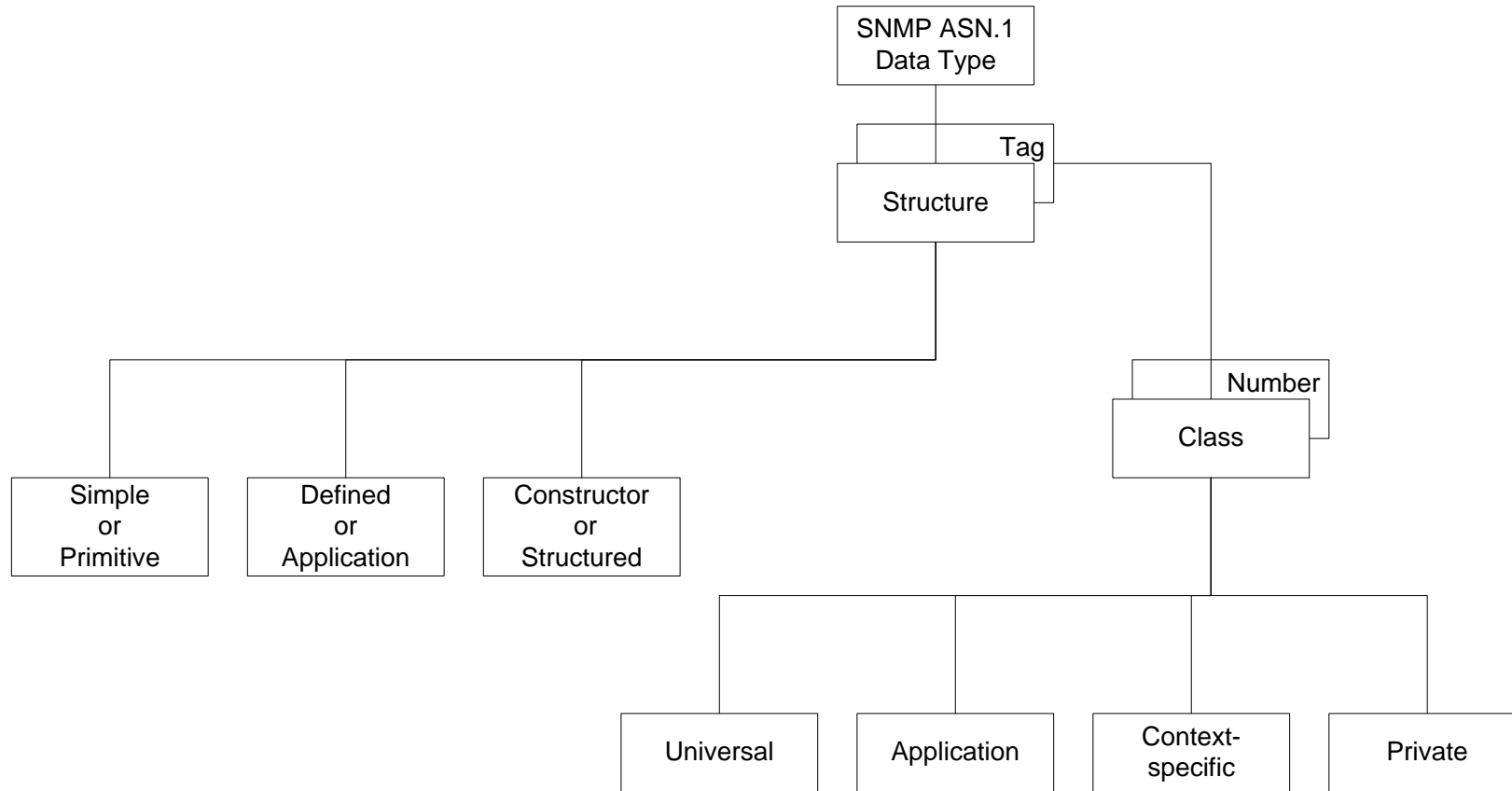


Figure 4.15 SNMP ASN.1 Data Type

Primitive Data Types

Data Type	Comments
INTEGER	Subtype INTEGER (n1..nN) Special case: Enumerated INTEGER type
OCTET STRING	8-bit bytes binary and textual data Subtypes can be specified by either range or fixed
OBJECT IDENTIFIER	Object position in MIB
NULL	Placeholder

Notes

- *get-request* message has NULL for value fields and *get-response* from agent has the values filled in subtype:
 - INTEGER (0..255)
 - OCTET STRING (SIZE 0..255)
 - OCTET STRING (SIZE 8)

Defined or Application Data Type

Data Type	Comments
NetworkAddress	Not used
IpAddress	Dotted decimal IP address
Counter	Wrap-around, non-negative integer, monotonically increasing, max $2^{32} - 1$
Gauge	Capped, non-negative integer, increase or decrease
TimeTicks	Non-negative integer in hundredths of second units
Opaque	Application-wide arbitrary ASN.1 syntax, double wrapped OCTET STRING

Notes

- Defined data types are simple or base types
- Opaque is used to create data types based on previously defined data types

Constructor or Structured Data Type: SEQUENCE

SEQUENCE { <type1>, <type2>, ..., <typeN> }

Object	OBJECT IDENTIFIER	ObjectSyntax
ipAddrEntry	{ipAddrTable 1}	SEQUENCE
ipAdEntAddr	{ipAddrEntry 1}	IpAddress
ipAdEntIfIndex	{ipAddrEntry 2}	INTEGER
ipAdEntNetMask	{ipAddrEntry 3}	IpAddress
ipAdEntBcastAddr	{ipAddrEntry 4}	INTEGER
ipAdEntReasmMaxSize	{ipAddrEntry 5}	INTEGER

```
IpAddrEntry ::= SEQUENCE {  
    ipAdEntAddr      IpAddress  
    ipAdEntIfIndex   INTEGER  
    ipAdEntNetMask   IpAddress  
    ipAdEntBcastAddr INTEGER  
    ipAdEntReasmMaxSize INTEGER (0..65535)  
}
```

Managed Object IpAddrEntry as a **list**

Constructor or Structured Data Type: SEQUENCE OF

SEQUENCE OF <entry>

where <entry> is a list constructor

Object Name	OBJECT IDENTIFIER	Syntax
ipAddrTable	{ip 20}	SEQUENCE OF

IpAddrTable ::= SEQUENCE OF IpAddrEntry

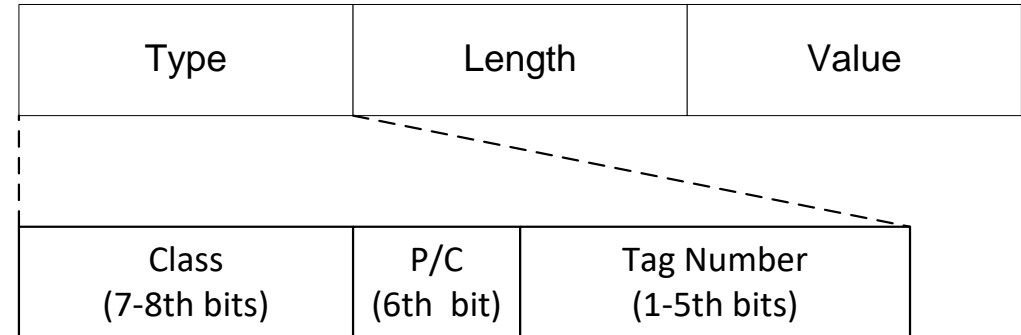
Managed Object ipAddrTable as a table

Encoding

SNMP Data Types and Tags

Type	Tag
OBJECT IDENTIFIER	UNIVERSAL 6
SEQUENCE	UNIVERSAL 16
IpAddress	APPLICATION 0
Counter	APPLICATION 1
Gauge	APPLICATION 2
TimeTicks	APPLICATION 3
Opaque	APPLICATION 4

Basic Encoding Rules (BER) Tag, Length, and Value (TLV)



Class	8th bit	7th bit
Universal	0	0
Application	0	1
Context-specific	1	0
Private	1	1

Managed Object: Macro

Managed Object: Macro

OBJECT-TYPE MACRO ::=

BEGIN

TYPE NOTATION ::= "SYNTAX" type(TYPE ObjectSyntax)

"ACCESS" Access

"STATUS" Status

VALUE NOTATION ::= value(VALUE ObjectName)

Access ::= "read-only" | "read-write" | "write-only" | "not-accessible"

Status ::= "mandatory" | "optional" | "obsolete"

END

Figure 4.18(a) OBJECT-TYPE Macro [RFC 1155]

Managed Object: Macro

`sysDescr OBJECT-TYPE`

`SYNTAX DisplayString (SIZE (0..255))`

`ACCESS read-only`

`STATUS mandatory`

`DESCRIPTION`

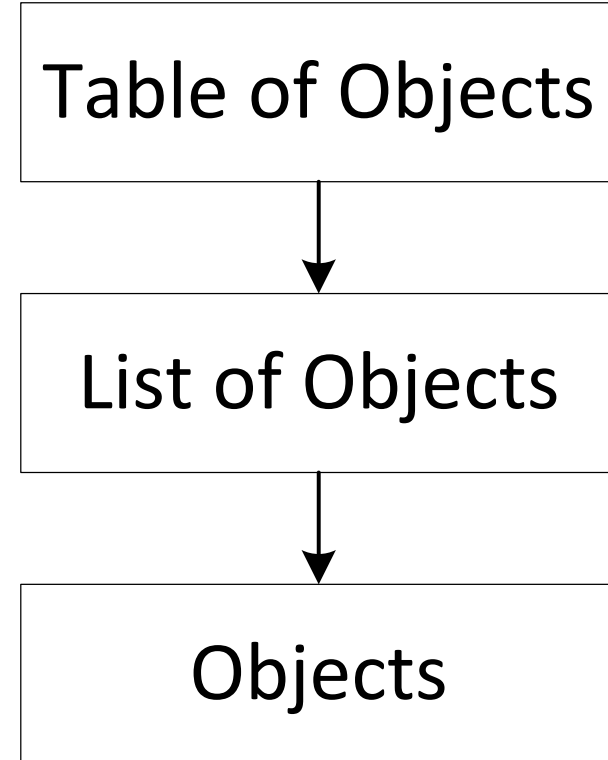
"A textual description of the entity. This value should include the full name and version identification of the system's hardware type, software operating-system, and networking software. It is mandatory that this only contain printable ASCII characters."

`::= {system 1 }`

Figure 4.18(b) Scalar or Single Instance Macro: sysDescr [RFC 1213]

Aggregate Object

- A group of objects
- Also called tabular objects
- Can be represented by a table with
 - Columns of objects
 - Rows of instances
- Example: IP address table
 - Consists of objects:
 - IP address
 - Interface
 - Subnet mask
 - Broadcast address
 - Largest IP datagram



Tabular Representation of Aggregate Object

- TABLE T and ENTRY E are objects that are logical objects
- They define the grouping and are not accessible
- Columnar objects are objects that represent the attributes and hence are accessible
- Each instance of E is a row of columnar objects 1 through 5
- Multiple instances of E are represented by multiple rows

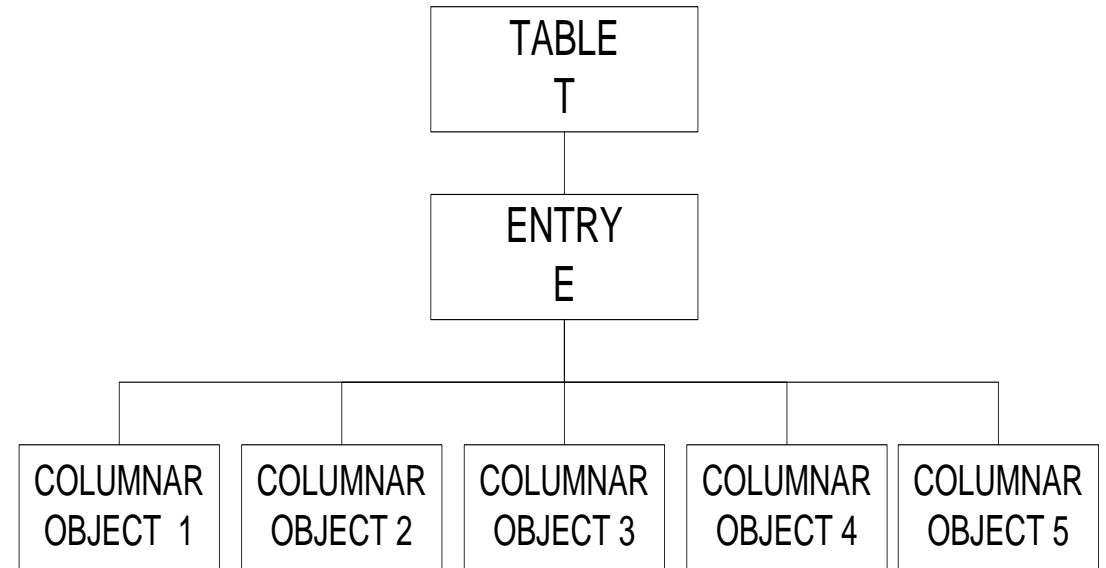


Figure 4.22(a) Multiple Instance Managed Object

Tabular Representation of Aggregate Object

- Notice the column-row numeric designation
- Is reverse of what we are used to as row-column

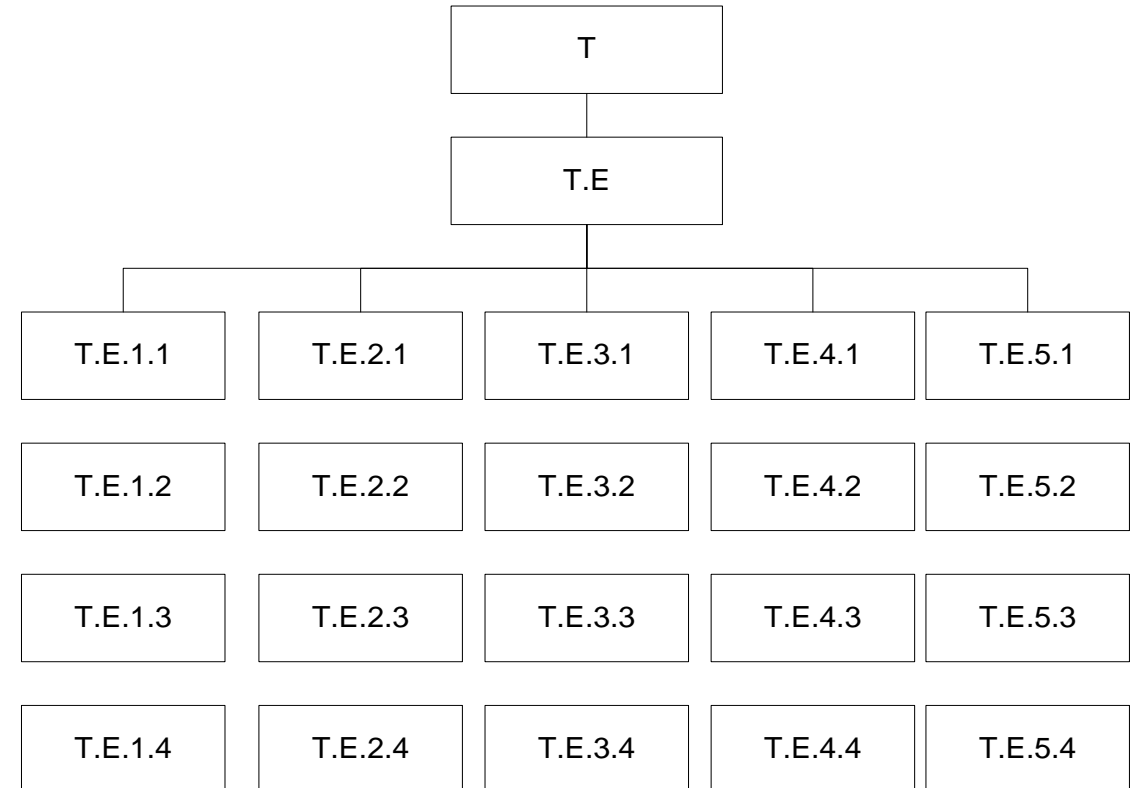


Figure 4.22(b) Example of 5 Columnar Object with 4 Instances (rows)

Multiple Instances of Aggregate Managed Object

```
+- -ipAddrTable (1.3.6.1.2.1.4.20)
|
+- -ipAddrEntry(1)
|   Index: ipAdEntAddr
|
+- - -R-- IpAddr      ipAdEntAddr(1)
+- - -R-- INTEGER     ipAdEntIfIndex(2)      Range: 1..2147483647
+- - -R-- IpAddr      ipAdEntNetMask(3)
+- - -R-- INTEGER     ipAdEntBcastAddr(4)     Range: 0..1
+- - -R-- INTEGER     ipAdEntReasmMaxSize(5)  Range: 0..65535
```

Columnar object ID of ipAdEntBcastAddr is (1.3.6.1.2.1.4.20.1.4):

iso	org	dod	internet	mgmt	mib	ip	ipAddrTable	ipAddrEntry	ipAdEntBcastAddr
1	3	6	1	2	1	4	20	1	4

Figure 4.23(a) Columnar objects under ipAddrEntry

Multiple Instances of Aggregate Managed Object

Figure 4.23(b) Object instances of ipAddrTable (1.3.6.1.2.1.4.20)

ipAdEntAddr	ipAdEntIfIndex	IpAdEntNetMask	IpAdEntBcastAddr	IpAdEntReasmMaxSize
123.45.2.1	1	255.255.255.0	0	12000
123.45.3.4	3	255.255.0.0	1	12000
165.8.9.25	2	255.255.255.0	0	10000
9.96.8.138	4	255.255.255.0	0	15000

Object Identifier for Specific Instance

{1.3.6.1.2.1.4.20.1.1.123.45.3.4}

{1.3.6.1.2.1.4.20.1.2.165.8.9.25}

{1.3.6.1.2.1.4.20.1.4.123.45.2.1}

{1.3.6.1.2.1.4.20.1.5.9.96.8.138}

SMI Definition STD 16 / 1155 RFC

```
SMI DEFINITIONS ::= BEGIN
    EXPORTS -- EVERYTHING
        internet, directory, mgmt, experimental, private, enterprises,
        OBJECT-TYPE, ObjectName, ObjectSyntax, SimpleSyntax,
        ApplicationSyntax, NetworkAddress, IpAddress, Counter, Gauge,
        TimeTicks, Opaque;

    -- the path to the root

    internet      OBJECT IDENTIFIER ::= { iso org(3) dod(6) 1 }
    directory     OBJECT IDENTIFIER ::= { internet 1 }
    mgmt          OBJECT IDENTIFIER ::= { internet 2 }
    experimental  OBJECT IDENTIFIER ::= { internet 3 }
    private       OBJECT IDENTIFIER ::= { internet 4 }
    enterprises   OBJECT IDENTIFIER ::= { private 1 }
```

Notes

- EXPORTS identifies the objects that any other module could import

MIB

- MIB-II (RFC 1213) is superset of MIB-I
- Related objects grouped into object groups
- MIB module comprises module name, imports from other modules, and definitions of current module
- RFC 1213 defines 11 groups

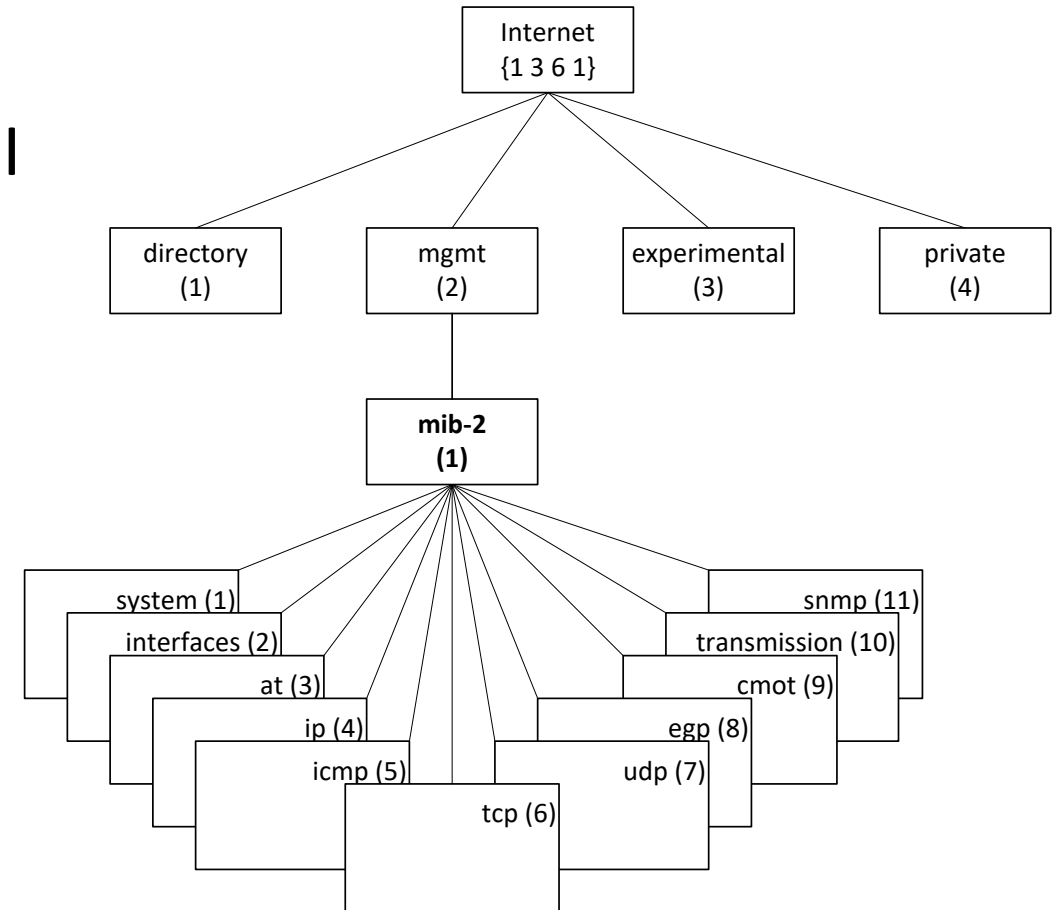


Figure 4.26 Internet MIB-II Group