Data Communications and Networking Fourth Edition

Forouzan

Chapter 28

Network Management: SNMP

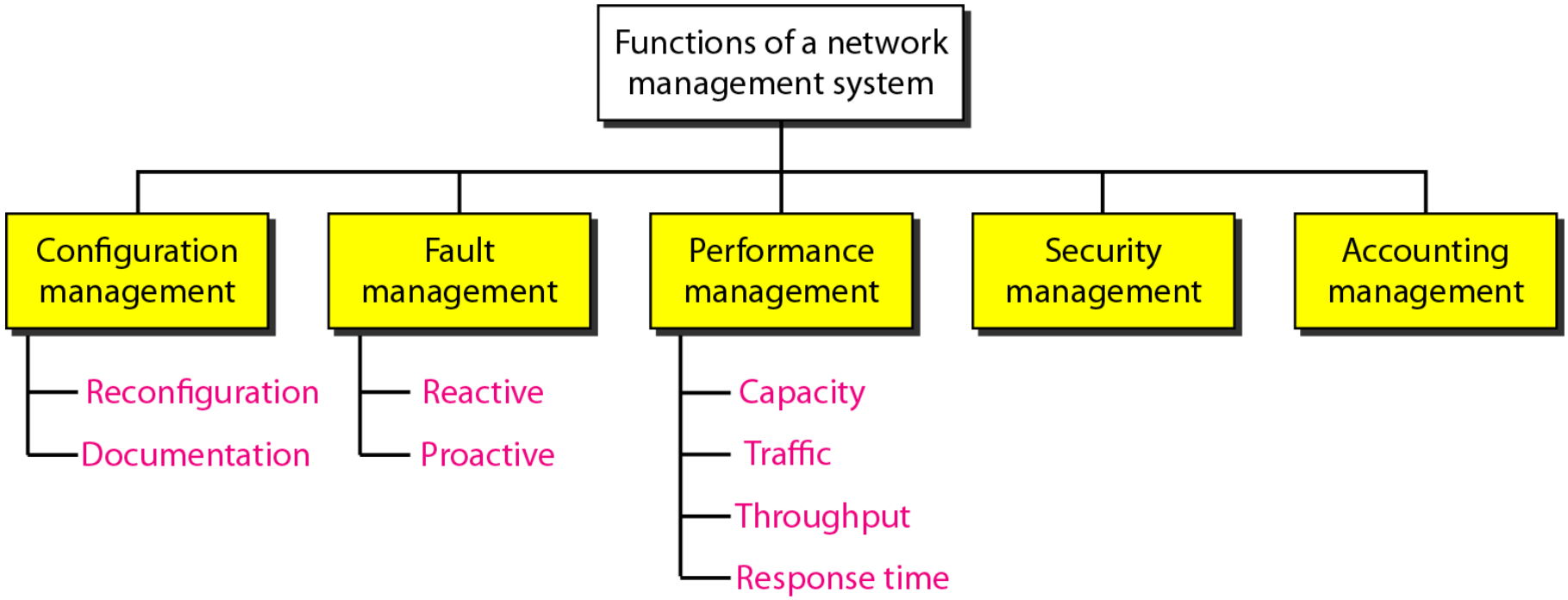
28-1 NETWORK MANAGEMENT SYSTEM

We can say that the functions performed by a network management system can be divided into five broad categories: configuration management, fault management, performance management, security management, and accounting management.

Topics discussed in this section:

Configuration Management
Fault Management
Performance Management
Security Management
Accounting Management

Figure 28.1 *Functions of a network management system*



28-2 SIMPLE NETWORK MANAGEMENT PROTOCOL (SNMP)

The Simple Network Management Protocol (SNMP) is a framework for managing devices in an internet using the TCP/IP protocol suite. It provides a set of fundamental operations for monitoring and maintaining an internet.

Topics discussed in this section:

Concept
Management Components
Structure of Management Information (SMI)
Management Information Base (MIB)
SNMP

Figure 28.2 *SNMP concept*

SNMP defines the format of packets exchanged between a manager and an agent. It reads and changes the status (values) of objects (variables) in SNMP packets.

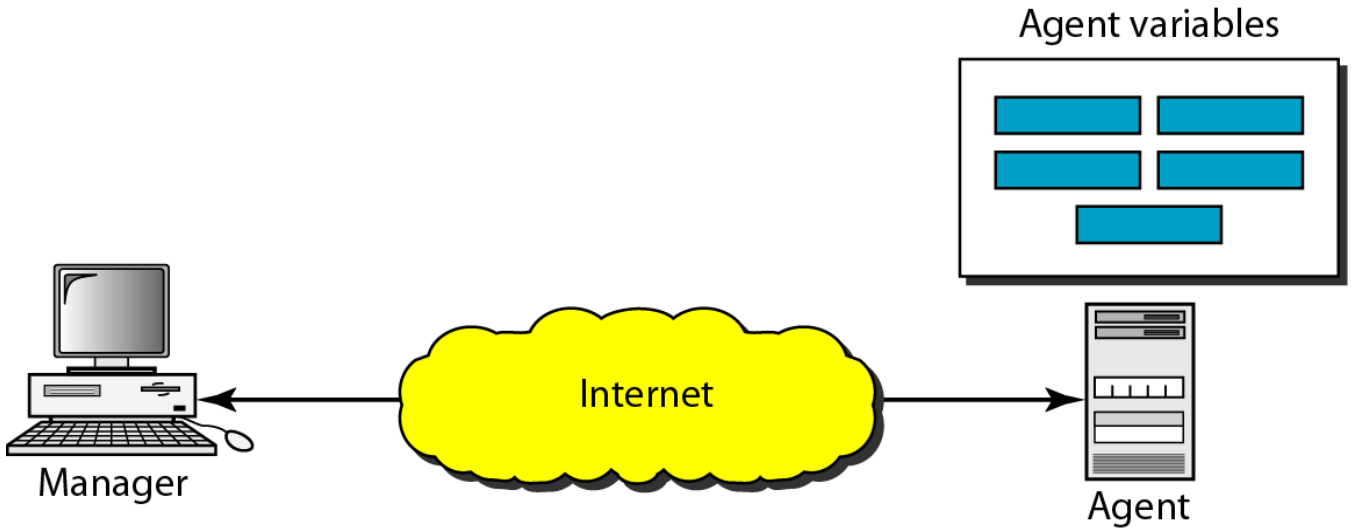
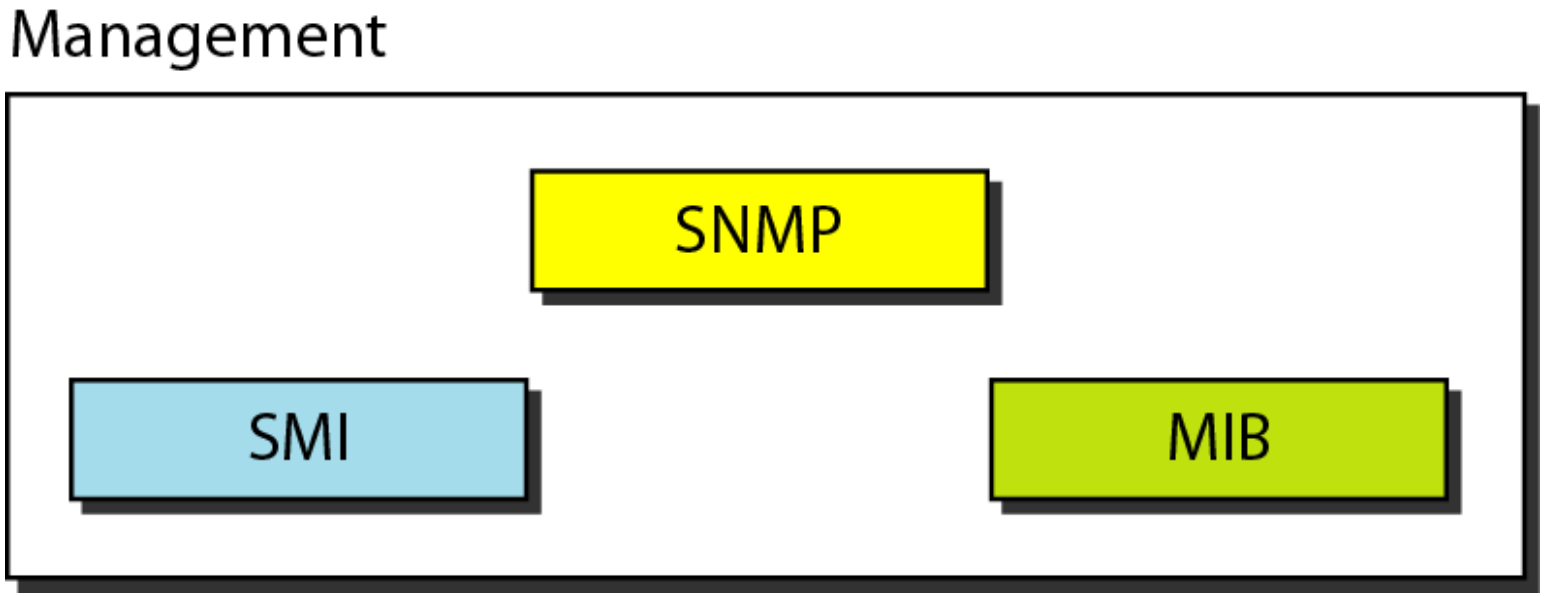


Figure 28.3 *Components of network management on the Internet*

Define mechanism for remote management of network devices (routers, bridges, etc.)

Fundamental principle: all device management done by simple variable value manipulation

Approach: standard means for specifying quantities recognized by devices
protocol for requesting, returning, notifying of changes of values



SNMP SMI (Structure of Management Information)

SMI defines the general rules for naming objects, defining object types (including range and length), and showing how to encode objects and values. SMI does not define the number of objects an entity should manage or name the objects to be managed or define the association between the objects and their values.

- Variables recognized by device supplied in MIB (Management Information Base)
  - text file giving variables and data structures defined using ASN.1
  - standard variable sets often provided as RFC's
  - device-specific sets provided by vendors
- Management stations parse MIB's to determine variables available for management
  - obtain both data structure and management information

Note

MIB creates a collection of named objects, their types, and their relationships to each other in an entity to be managed.

Note

We can compare the task of network management to the task of writing a program.

- Both tasks need rules. In network management this is handled by SMI.
- Both tasks need variable declarations. In network management this is handled by MIB.
- Both tasks have actions performed by statements. In network management this is handled by SNMP.

Figure 28.4 *Management overview*

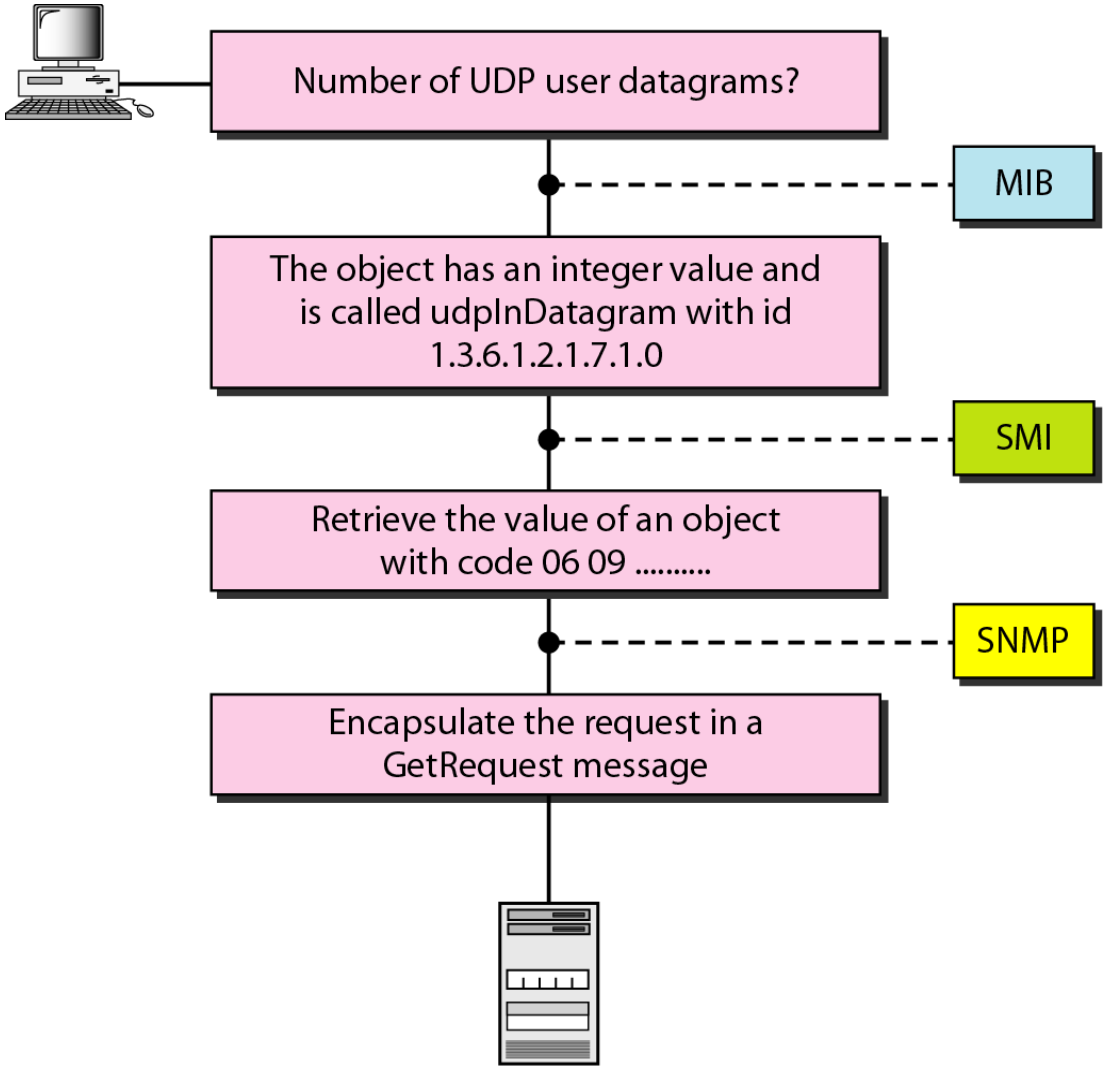


Figure 28.5 *Object attributes*

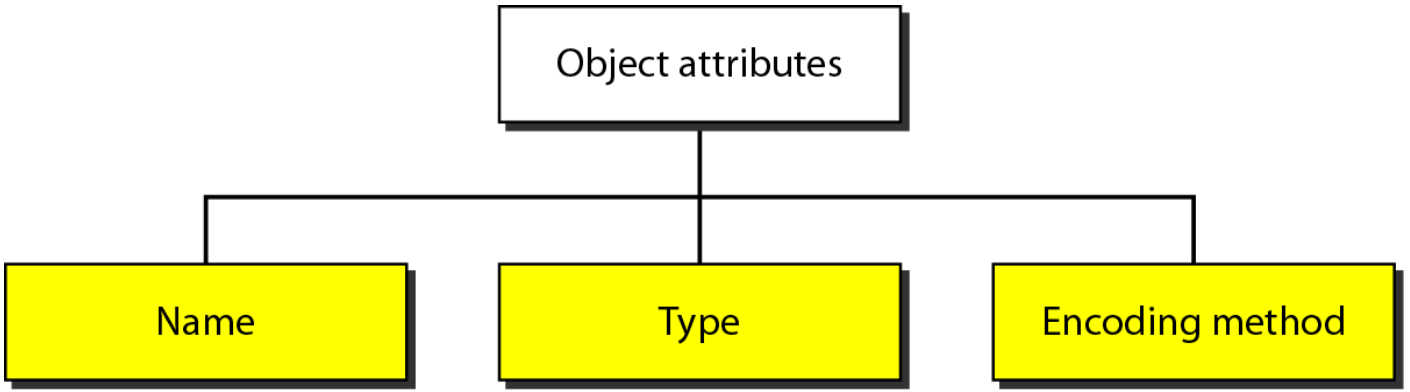
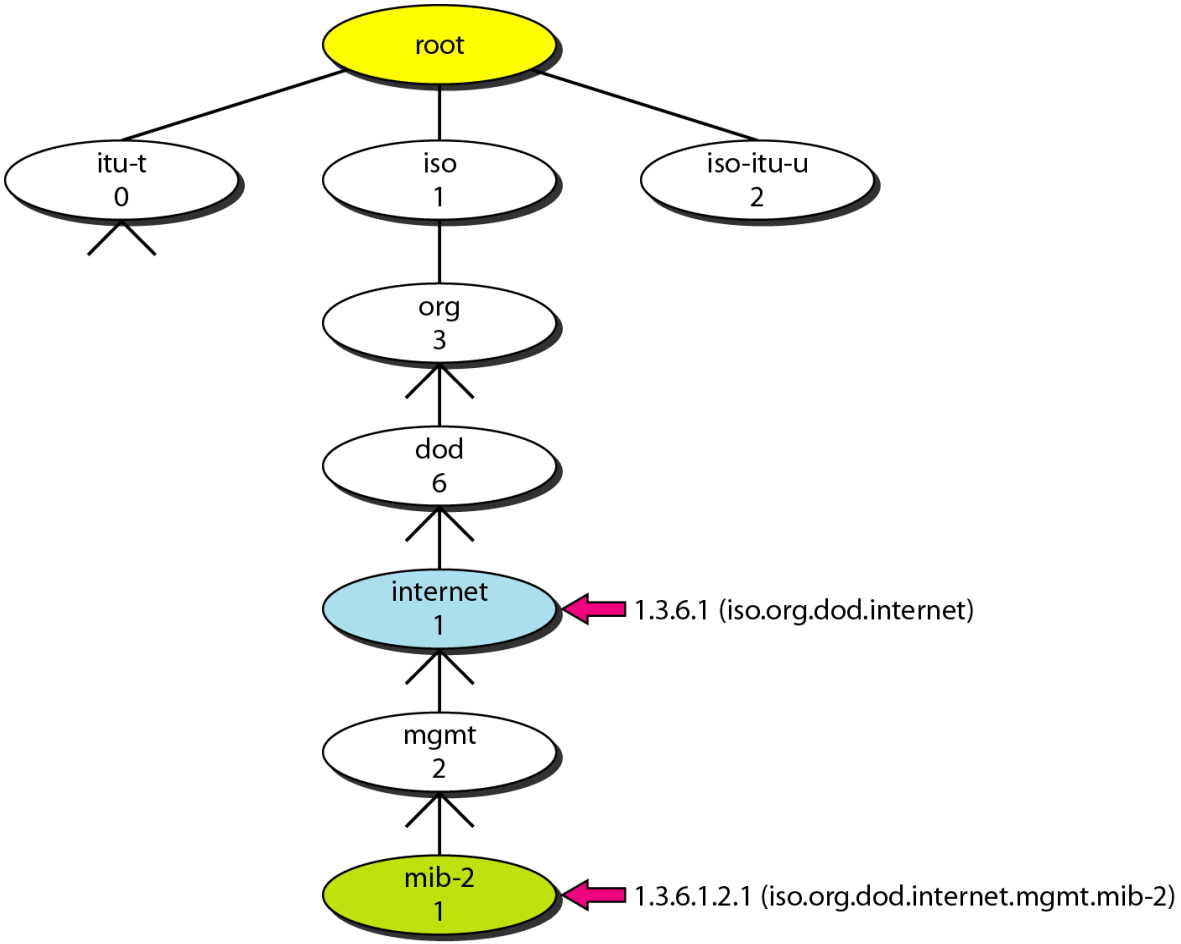


Figure 28.6 *Object identifier*

All objects managed by SNMP are given an object identifier. The object identifier always starts with 1.3.6.1.2.1.



ASN.1 Object Identifiers

- Variables identified by globally unique strings of digits
  - ex: 1.3.6.1.4.1.3.5.1.1
  - name space is hierarchical; tree on next slide
    - in above, 1 stands for iso, 3 stands for org, 6 stands for dod, 1 stands for internet, 4 stands for private, etc.
- Variable names are aliases for digit strings (within MIB)
  - From previous page: ifNumber ::= { interfaces 1 }
  - interfaces was previously defined in MIB as 1.3.6.1.2.1.2, so ifNumber = 1.3.6.1.2.1.2.1

Figure 28.7 *Data type*

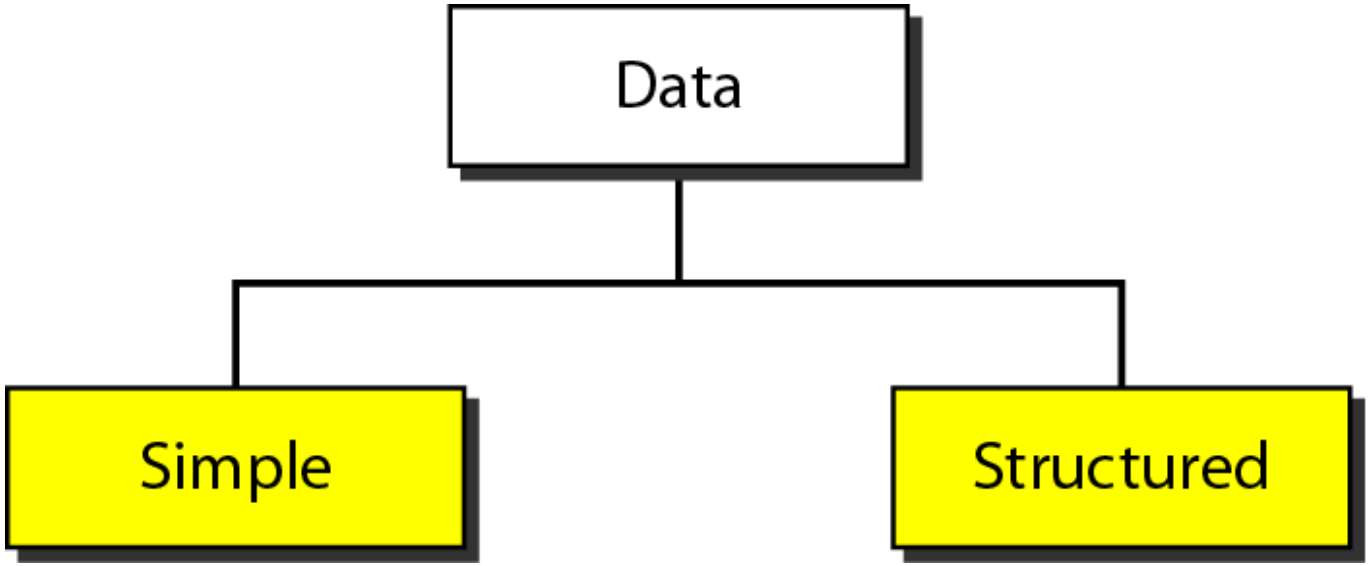


Table 28.1 *Data types*

Type	*Size*	*Description*
INTEGER	4 bytes	An integer with a value between -2^{31} and $2^{31} - 1$
Integer32	4 bytes	Same as INTEGER
Unsigned32	4 bytes	Unsigned with a value between 0 and $2^{32} - 1$
OCTET STRING	Variable	Byte string up to 65,535 bytes long
OBJECT IDENTIFIER	Variable	An object identifier
IPAddress	4 bytes	An IP address made of four integers
Counter32	4 bytes	An integer whose value can be incremented from 0 to 2^{32}; when it reaches its maximum value, it wraps back to 0.
Counter64	8 bytes	64-bit counter
Gauge32	4 bytes	Same as Counter32, but when it reaches its maximum value, it does not wrap; it remains there until it is reset
TimeTicks	4 bytes	A counting value that records time in $\frac{1}{100}$ s
BITS		A string of bits
Opaque	Variable	Uninterpreted string

Figure 28.8 *Conceptual data types*

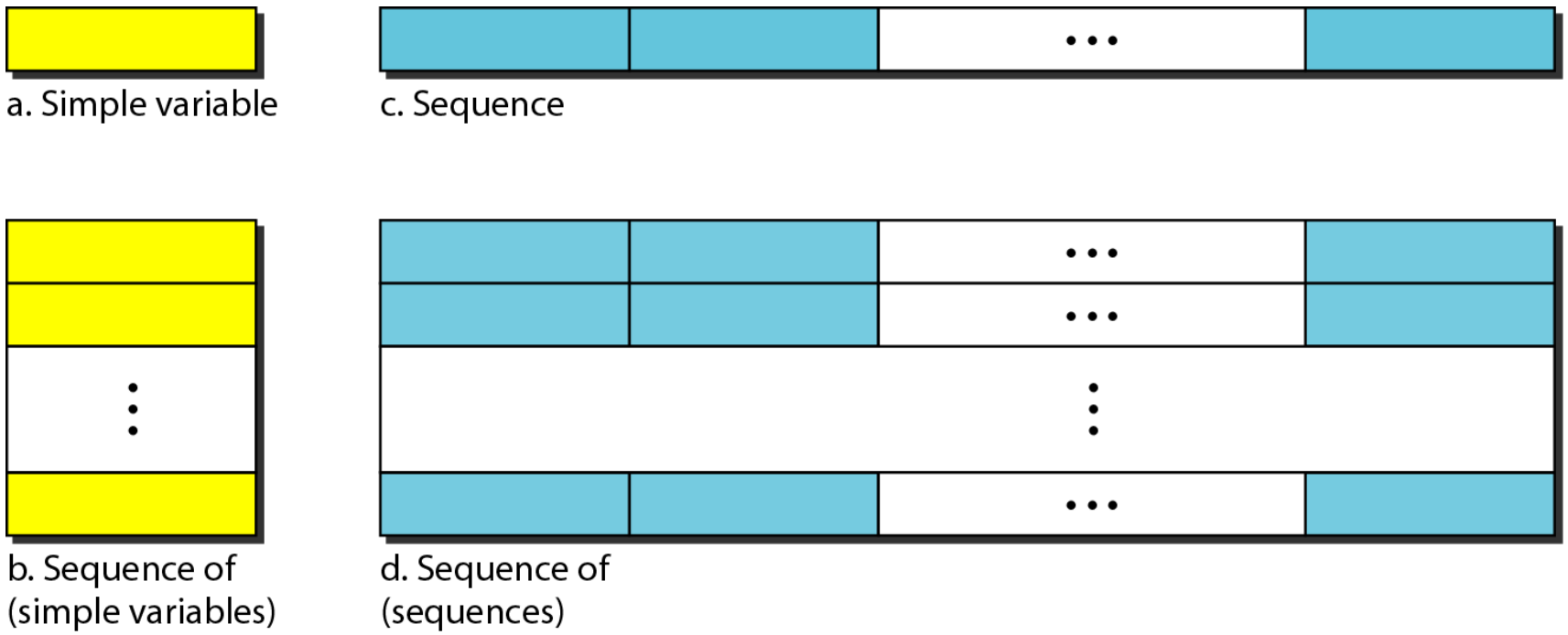


Figure 28.9 *Encoding format*

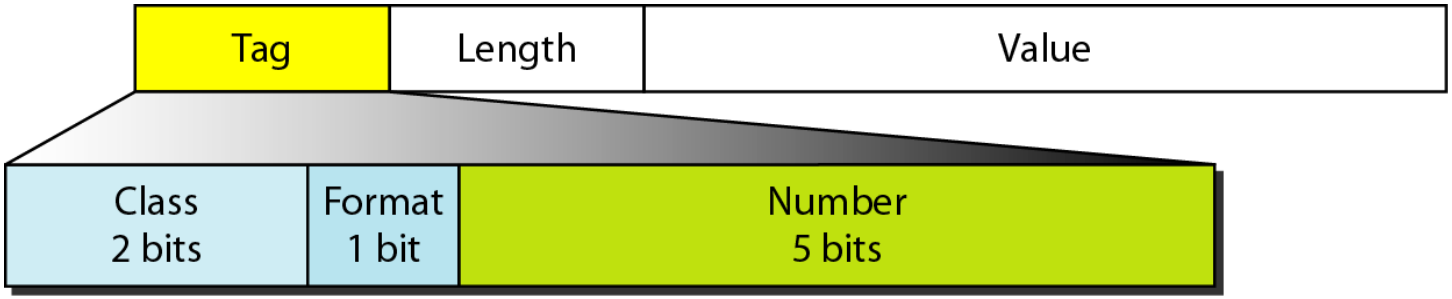
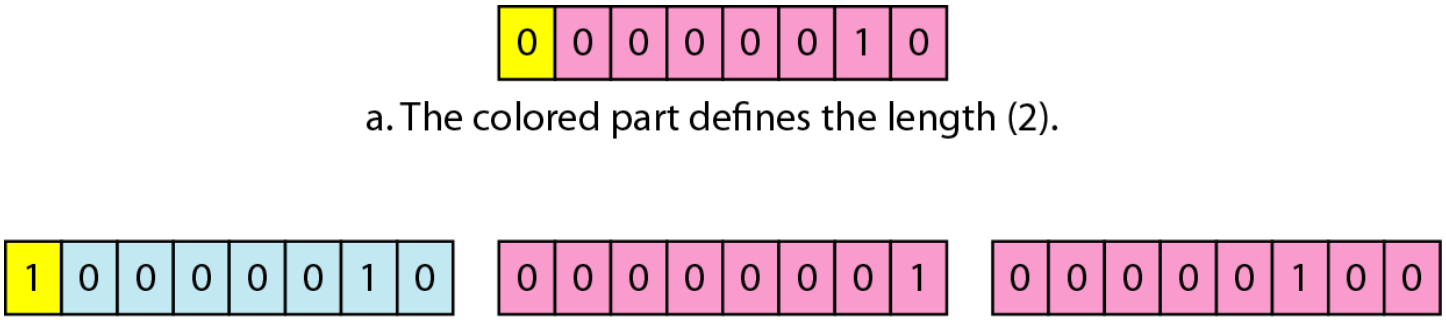


Table 28.2 *Codes for data types*

Data Type	*Class*	*Format*	*Number*	*Tag (Binary)*	*Tag (Hex)*
INTEGER	00	0	00010	**00000010**	**02**
OCTET STRING	00	0	00100	**00000100**	**04**
OBJECT IDENTIFIER	00	0	00110	**00000110**	**06**
NULL	00	0	00101	**00000101**	**05**
Sequence, sequence of	00	1	10000	**00110000**	**30**
IPAddress	01	0	00000	**01000000**	**40**
Counter	01	0	00001	**01000001**	**41**
Gauge	01	0	00010	**01000010**	**42**
TimeTicks	01	0	00011	**01000011**	**43**
Opaque	01	0	00100	**01000100**	**44**

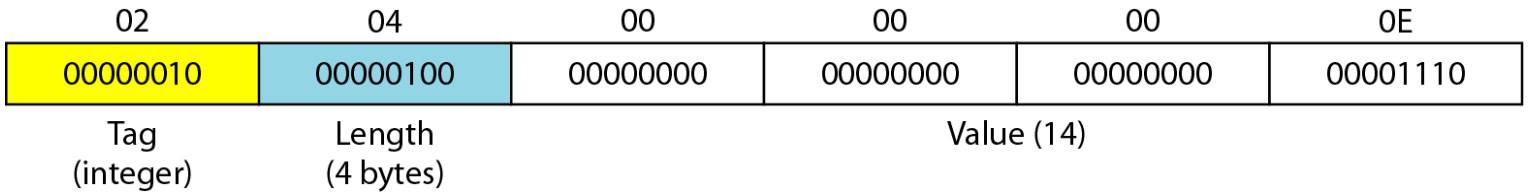
Figure 28.10 *Length format*



Example 28.1

Figure 28.11 shows how to define INTEGER 14.

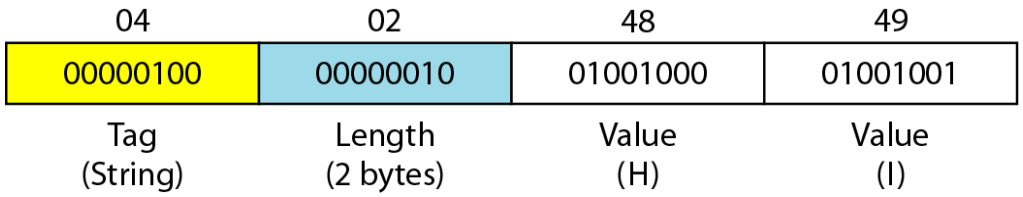
Figure 28.11 *Example 28.1, INTEGER 14*



Example 28.2

Figure 28.12 shows how to define the OCTET STRING "HI".

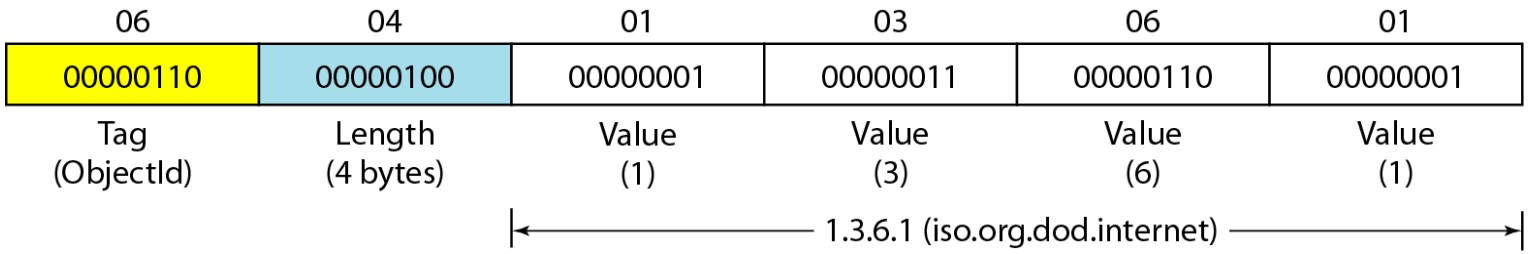
Figure 28.12 *Example 28.2, OCTET STRING "HI"*



Example 28.3

Figure 28.13 shows how to define ObjectIdentifier 1.3.6.1 (iso.org.dod.internet).

Figure 28.13 *Example 28.3, ObjectIdentifier 1.3.6.1*



Example 28.4

Figure 28.14 shows how to define IPAddress 131.21.14.8..

Figure 28.14 *Example 28.4, IPAddress 131.21.14.8.*

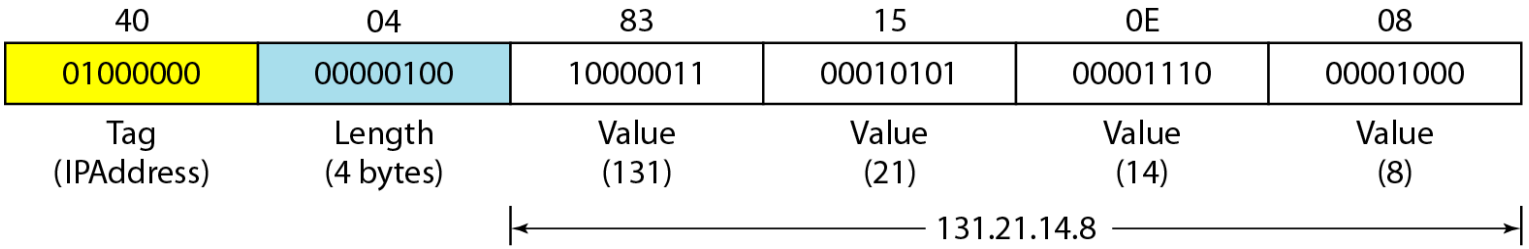


Figure 28.15 *mib-2*

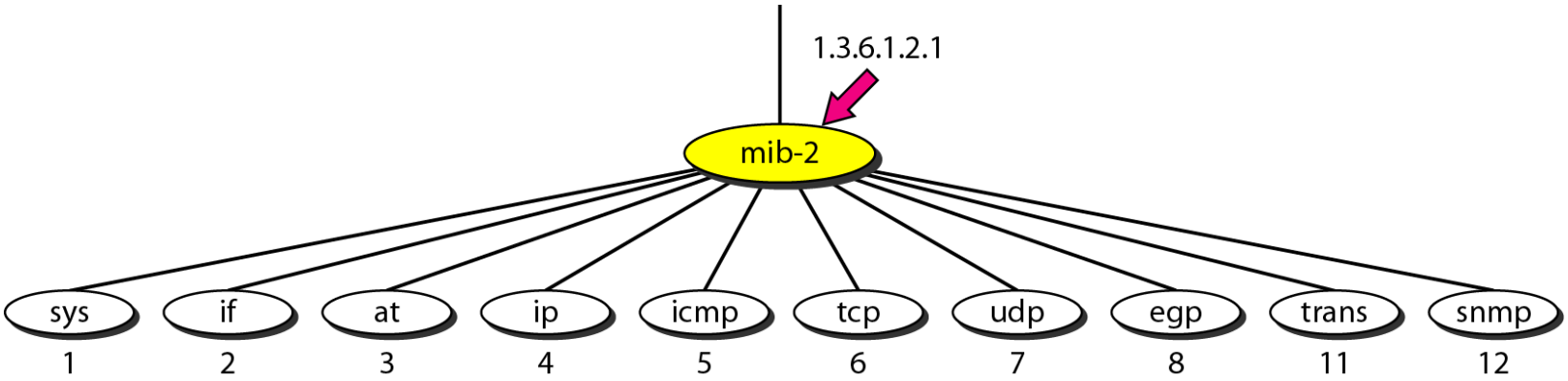


Figure 28.16 *udp group*

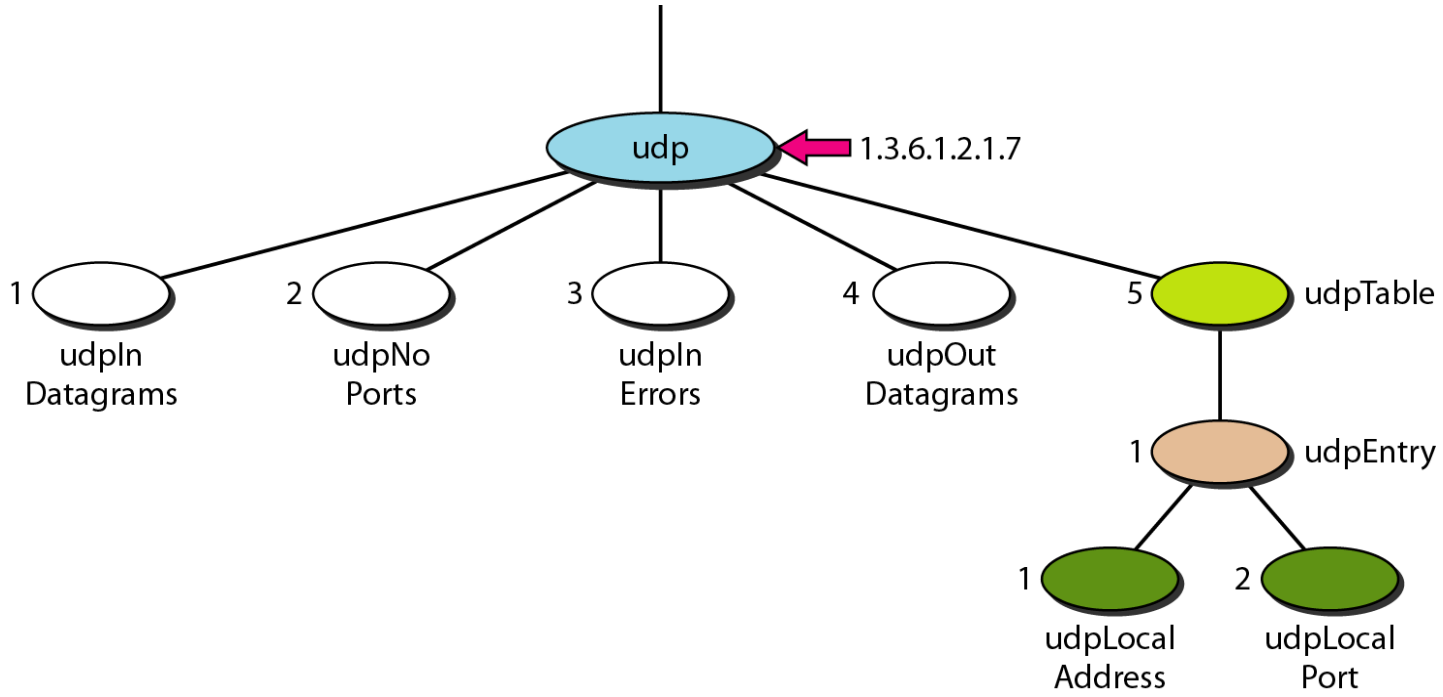


Figure 28.17 *udp variables and tables*

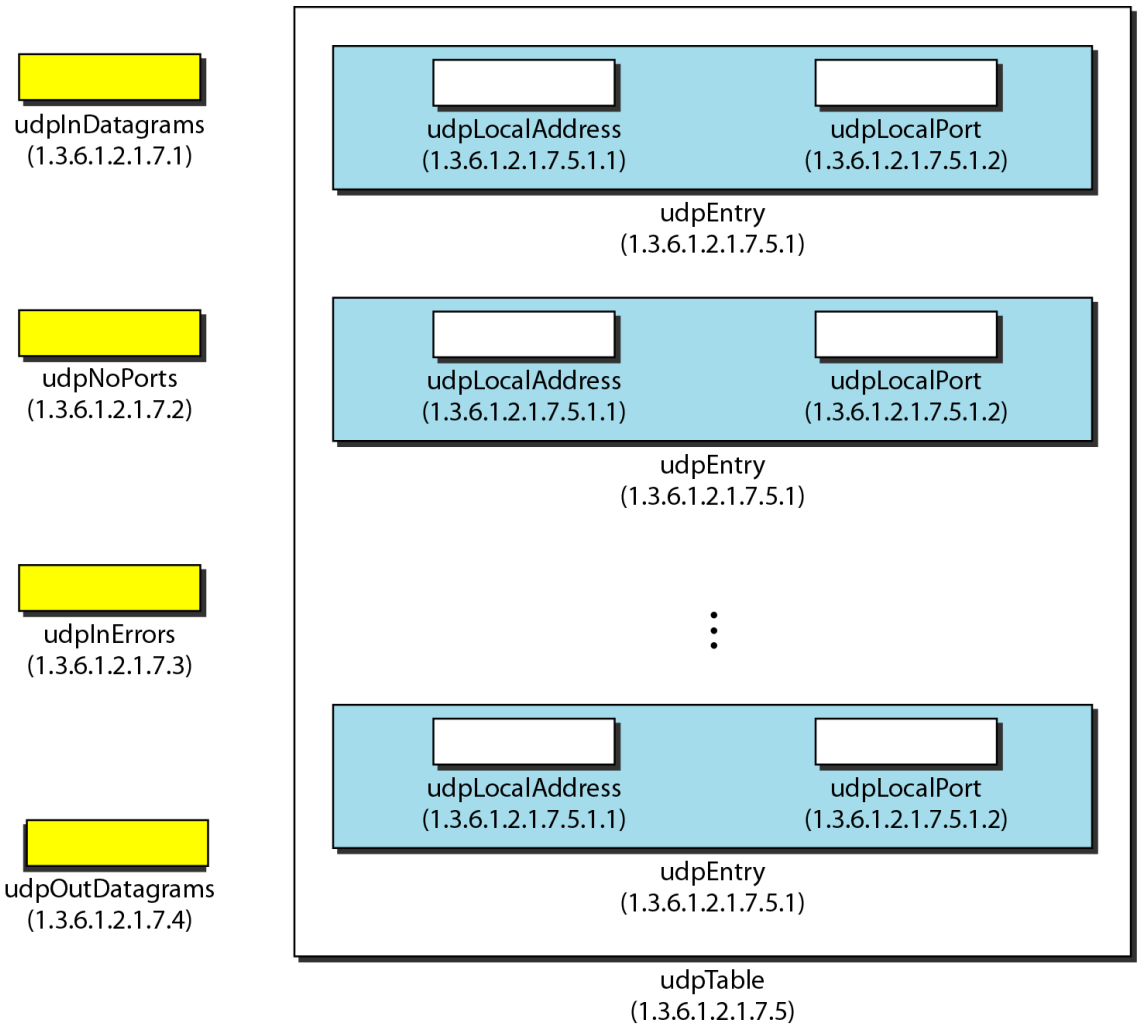


Figure 28.18 *Indexes for udpTable*

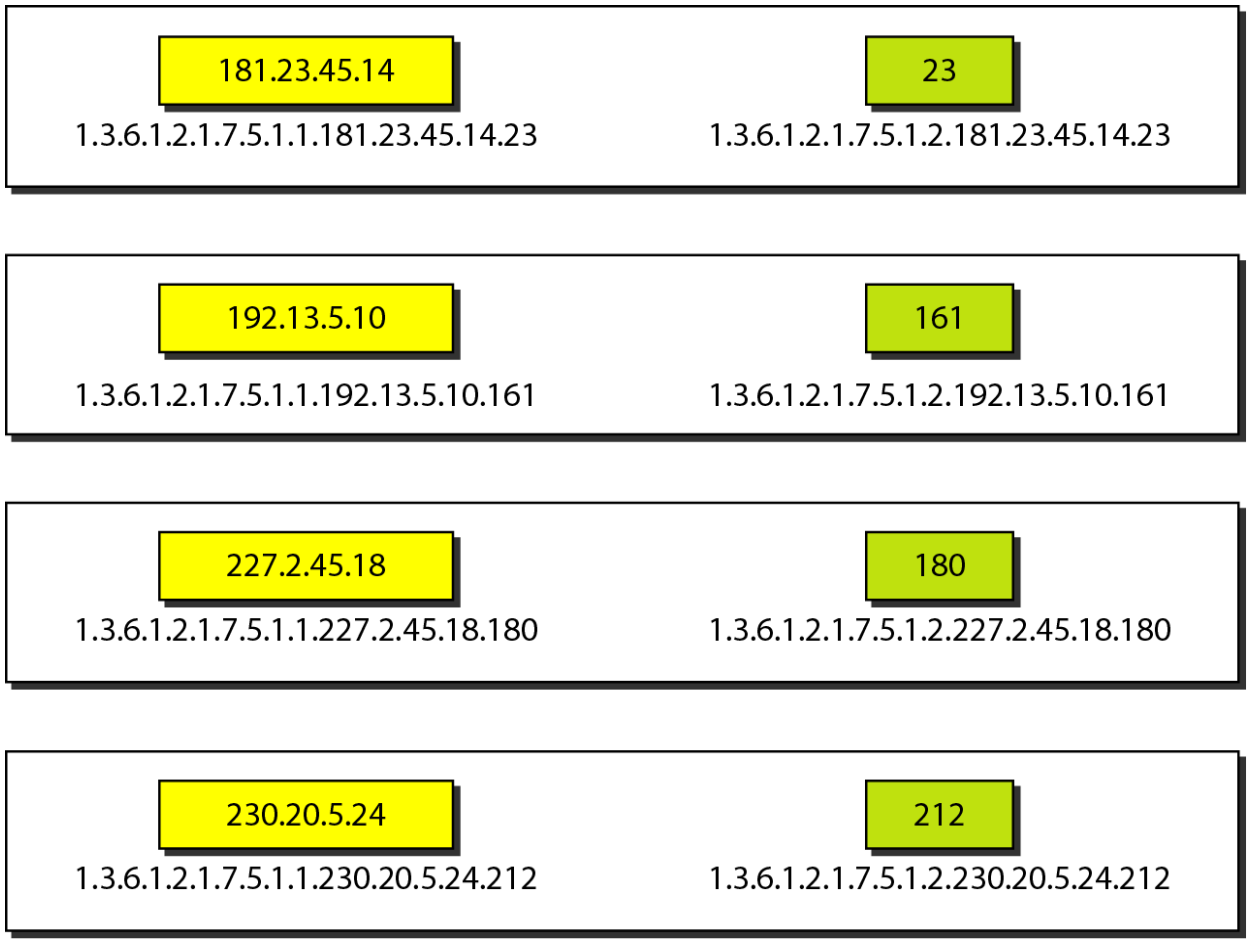


Figure 28.19 *Lexicographic ordering*

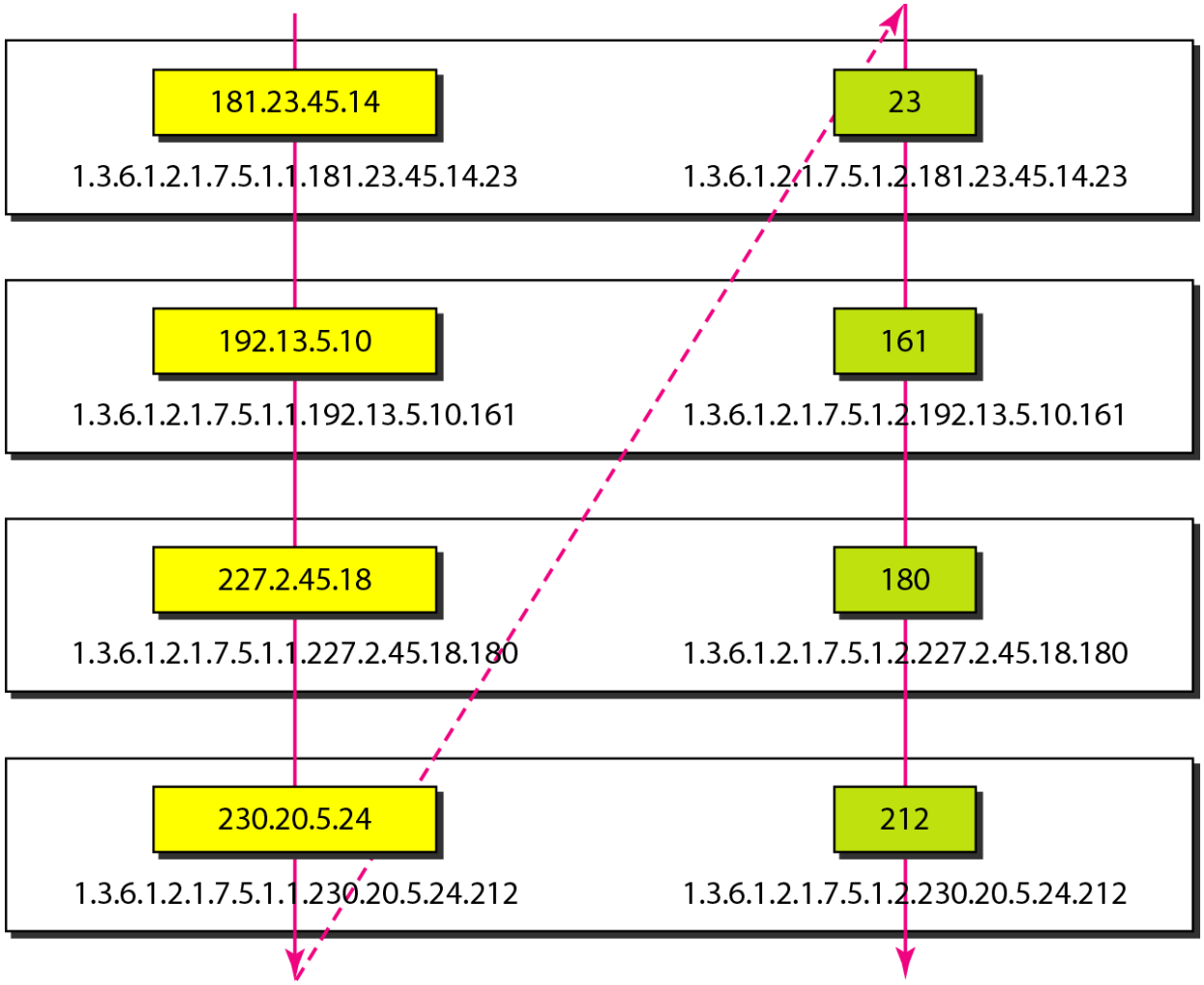


Figure 28.20 *SNMP PDUs*

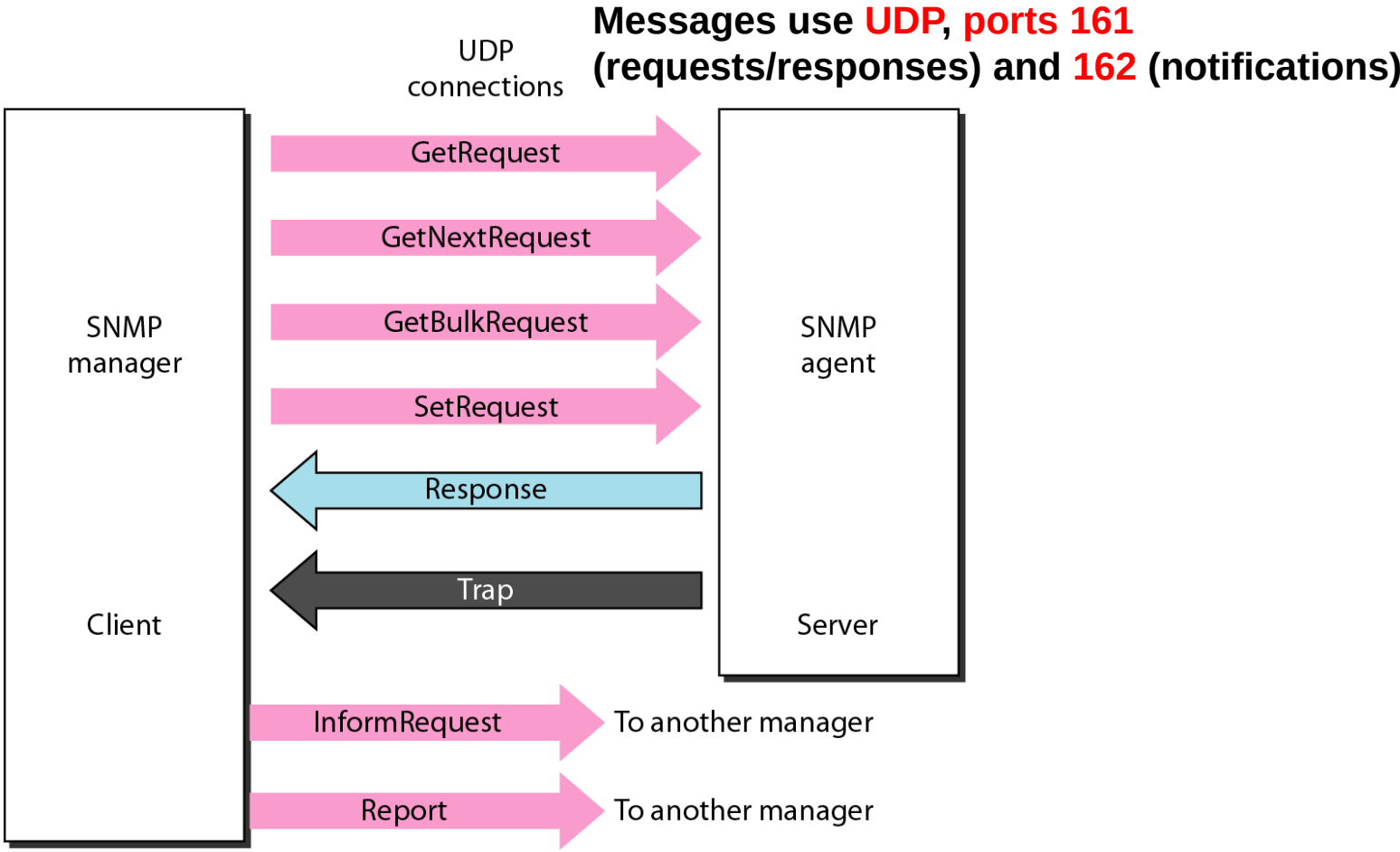
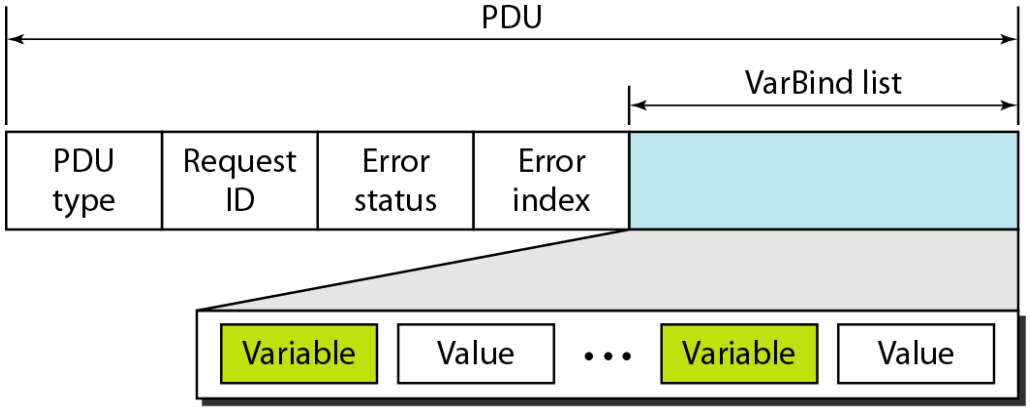


Figure 28.21 *SNMP PDU format*



Differences:

1. Error status and error index values are zeros for all request messages except GetBulkRequest.
2. Error status field is replaced by nonrepeater field and error index field is replaced by max-repetitions field in GetBulkRequest.

SNMP Message Encoding

- Encode message as byte stream using ASN.1 BER (Abstract Syntax Notation 1 Basic Encoding Rules)
- Quantites encoded as Type,Length,Value triples
- Types
  - Subset of basic ASN.1 types used in SNMP: integer, octet string, object identifier ("variable name"), sequence
  - SNMP-defined types: gauge, counter, IP address, etc.
- Values
  - weirdly encoded!! (see ASN.1 specs)

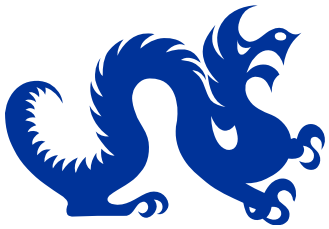


Table 28.3 ***Types of errors***

Status	*Name*	*Meaning*
0	noError	No error
1	tooBig	Response too big to fit in one message
2	noSuchName	Variable does not exist
3	badValue	The value to be stored is invalid
4	readOnly	The value cannot be modified
5	genErr	Other errors

Figure 28.22 *SNMP message*

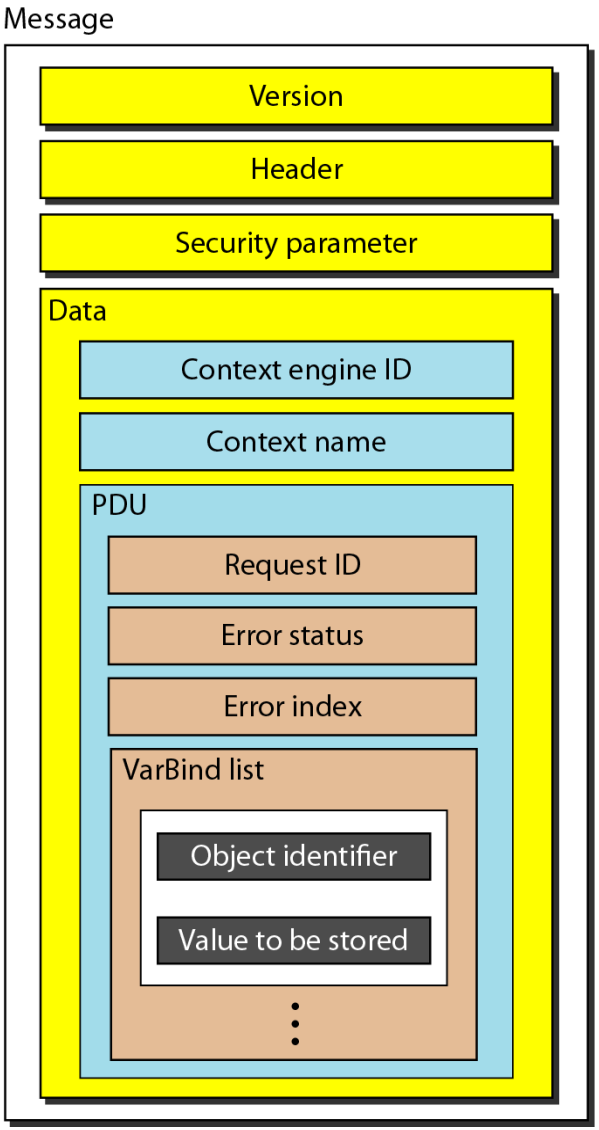


Table 28.4 *Codes for SNMP messages*

Data	*Class*	*Format*	*Number*	*Whole Tag (Binary)*	*Whole Tag (Hex)*
GetRequest	10	1	00000	**10100000**	**A0**
GetNextRequest	10	1	00001	**10100001**	**A1**
Response	10	1	00010	**10100010**	**A2**
SetRequest	10	1	00011	**10100011**	**A3**
GetBulkRequest	10	1	00101	**10100101**	**A5**
InformRequest	10	1	00110	**10100110**	**A6**
Trap (SNMPv2)	10	1	00111	**10100111**	**A7**
Report	10	1	01000	**10101000**	**A8**

Example 28.5

In this example, a manager station (SNMP client) uses the GetRequest message to retrieve the number of UDP datagrams that a router has received. There is only one VarBind entity. The corresponding MIB variable related to this information is udpInDatagrams with the object identifier 1.3.6.1.2.1.7.1.0. The manager wants to retrieve a value (not to store a value), so the value defines a null entity. Figure 28.23 shows the conceptual view of the packet and the hierarchical nature of sequences. We have used white and colored boxes for the sequences and a gray one for the PDU. The VarBind list has only one VarBind.

Example 28.5 (continued)

The variable is of type 06 and length 09. The value is of type 05 and length 00. The whole VarBind is a sequence of length 0D (13). The VarBind list is also a sequence of length 0F (15). The GetRequest PDU is of length ID (29). Now we have three OCTET STRINGs related to the security parameter, security model, and flags. Then we have two integers defining maximum size (1024) and message ID (64). The header is a sequence of length 12, which we left blank for simplicity. There is one integer, version (version 3). The whole message is a sequence of 52 bytes. Figure 28.24 shows the actual message sent by the manager station (client) to the agent (server).

Figure 28.23 *Example 28.5*

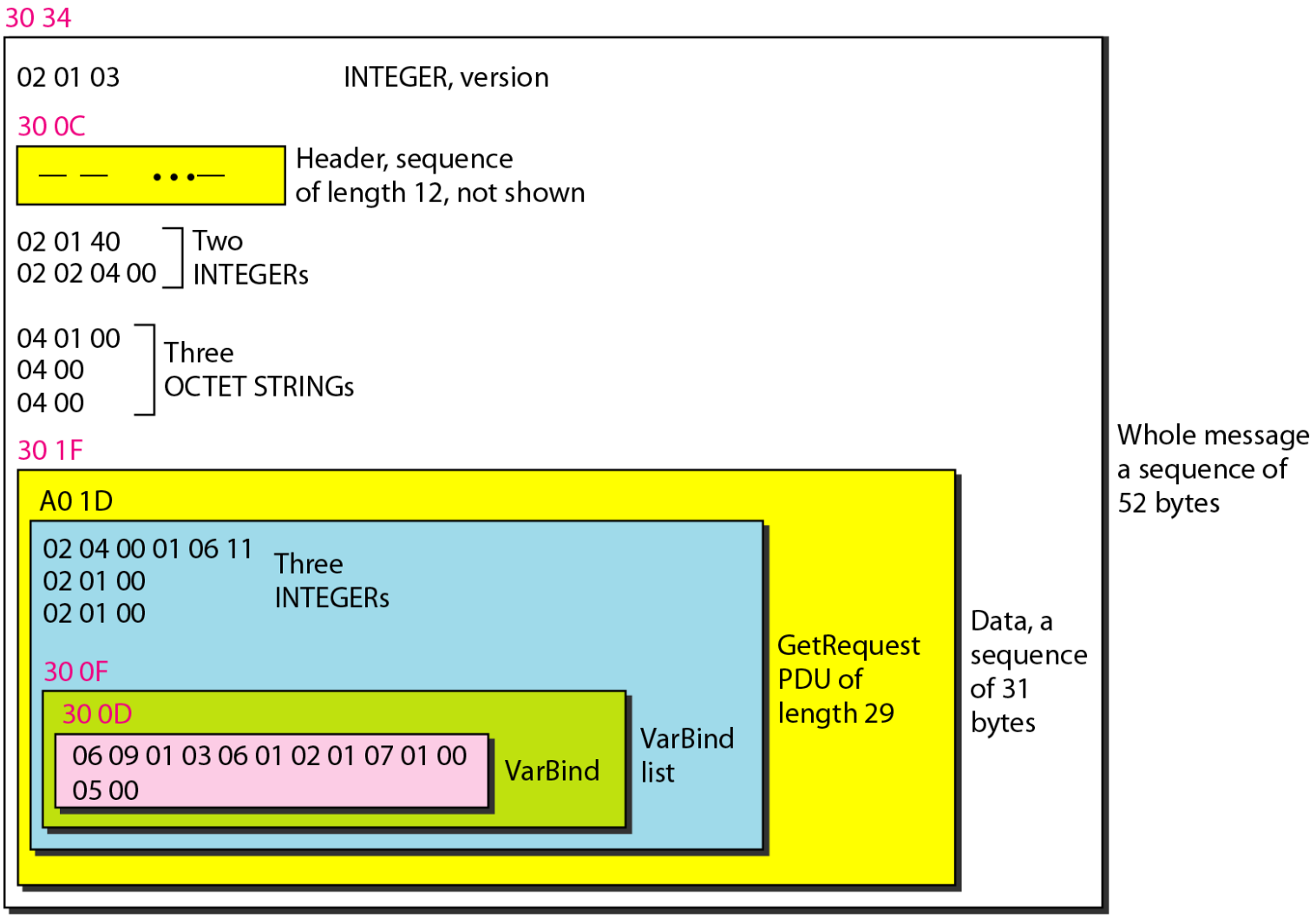


Figure 28.24 *GetRequest message*

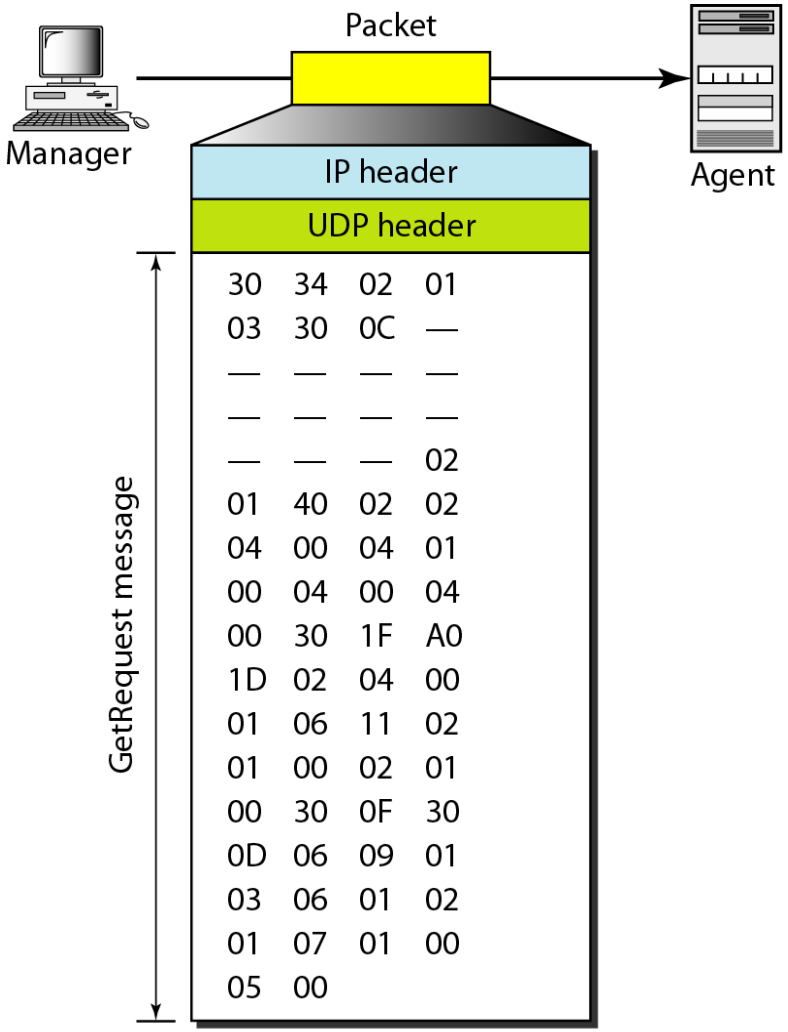
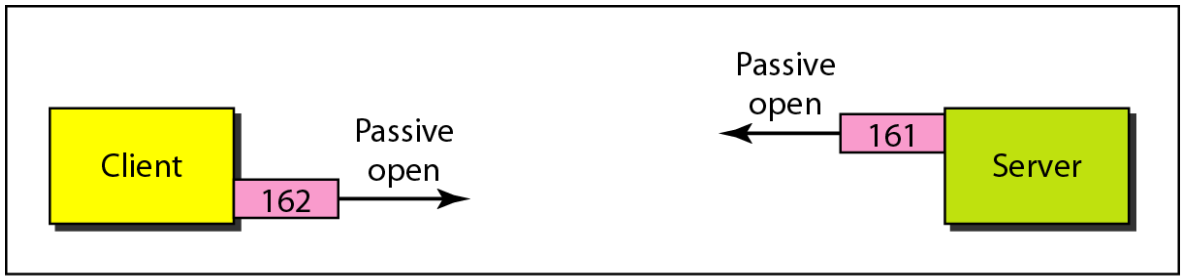
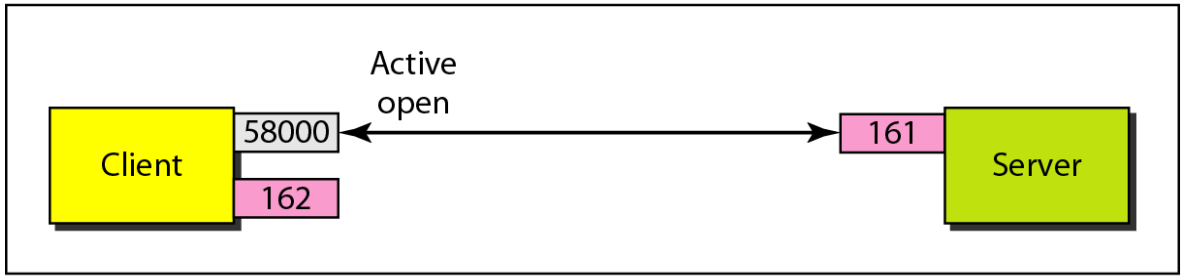


Figure 28.25 *Port numbers for SNMP*



a. Passive open by both client and server



b. Exchange of request and response messages

c. Server sends trap message

Application: GICL SNMP Monitor

- Java-based SNMP application
  - Query devices for available MIB variables
  - Set desired variable values
- Current status
  - retrieve and display all values from device
  - automatically build data structures to hold retrieved values
- Future work
  - incorporate MIB information via MIB parser
  - auto-generate GUI display
  - implement device discovery