INTERNET MANAGEMENT PROTOCOLS

THE SIMPLE NETWORK MANAGEMENT PROTOCOL

TUTORIAL
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OVERVIEW

INTRODUCTION
- SNMP GOALS
- SNMP STRUCTURE

STRUCTURE OF MANAGEMENT INFORMATION
- SCALARS
- TABLES
- SMI

MANAGEMENT INFORMATION BASE
- MIB-II

SIMPLE NETWORK MANAGEMENT PROTOCOL
- SNMP

FURTHER INFORMATION

SNMP GOALS

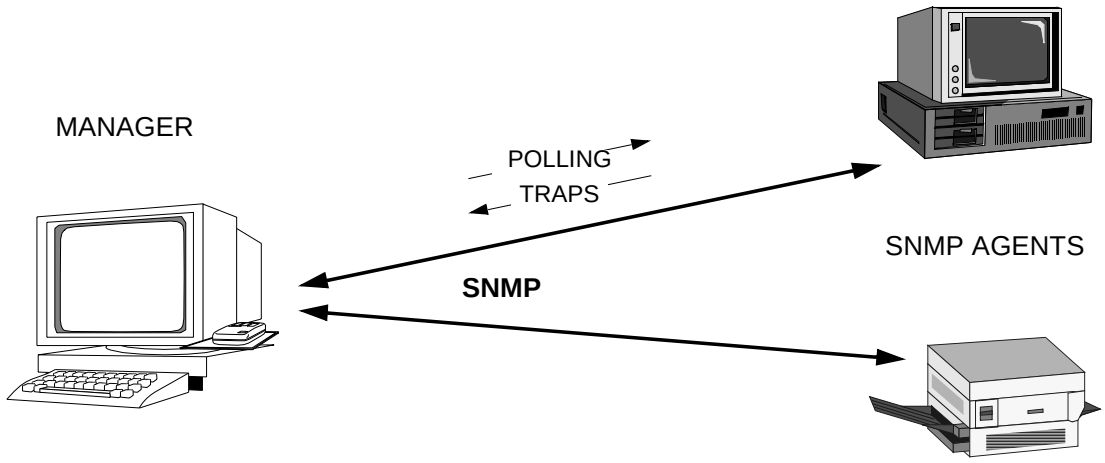
UBIQUITY
• PCs AND CRAYs

INCLUSION OF MANAGEMENT
SHOULD BE INEXPENSIVE
• SMALL CODE
• LIMITED FUNCTIONALITY

MANAGEMENT EXTENSIONS
SHOULD BE POSSIBLE
• NEW MIBs

MANAGEMENT SHOULD BE ROBUST
• CONNECTIONLESS TRANSPORT

STRUCTURE



STRUCTURE OF MANAGEMENT INFO

SMI

STRUCTURE OF MANAGEMENT INFORMATION
RFC 1155

CONCISE MIB DEFINITIONS
RFC 1212

MAKES THE DEFINITION OF (NEW) MIBs EASIER

SMI

MANAGEMENT INFORMATION WITHIN MANAGED SYSTEMS
MUST BE REPRESENTED AS:

- SCALARS
- TABLES

(= TWO DIMENSIONAL ARRAYS OF SCALARS)

THE SNMP PROTOCOL CAN ONLY EXCHANGE
(A LIST OF) SCALARS

DEFINED IN TERMS OF ASN.1 CONSTRUCTS

SMI: DATA TYPES FOR SCALARS

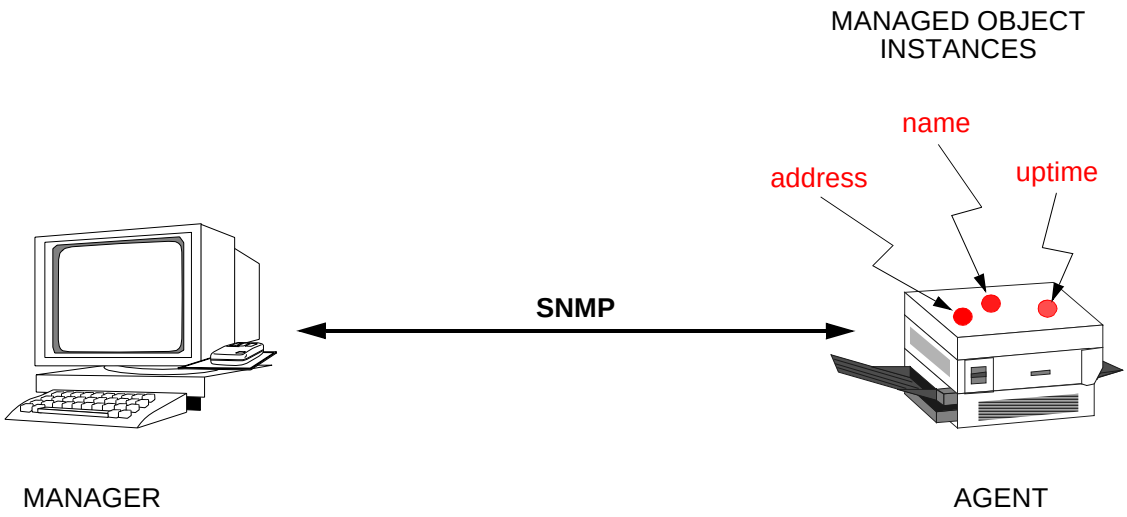
SIMPLE TYPES

- INTEGER
- OCTET STRING
- OBJECT IDENTIFIER
- NULL

APPLICATION-WIDE TYPES

- IpAddress
- NetworkAddress
- Counter
- Gauge
- TimeTicks
- Opaque

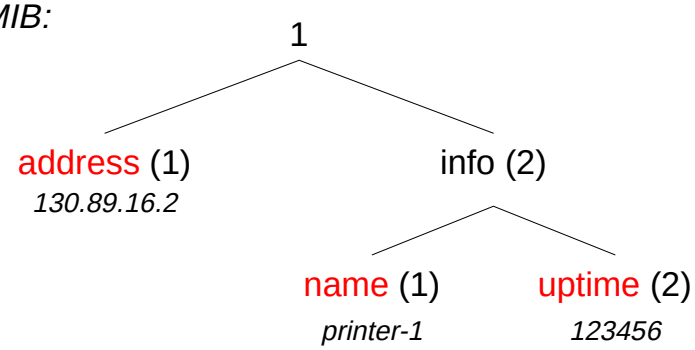
EXAMPLE OF SCALAR OBJECTS



OBJECT NAMING

INTRODUCE NAMING TREE

new-MIB:



THE LEAVES OF THE TREE REPRESENT THE MANAGED OBJECTS

NODES ARE INTRODUCED FOR NAMING PURPOSES

OBJECT NAMING

• address
Object ID = 1.1
Object Instance = 1.1.0
Value of Instance = *130.89.16.2*

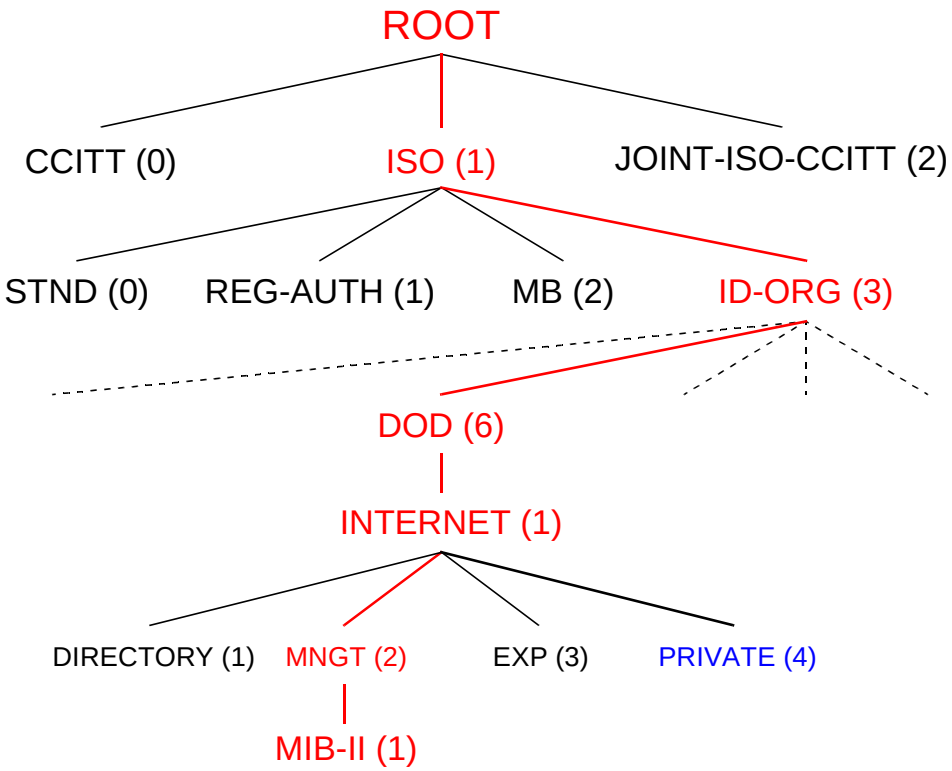
• info
Object ID = 1.2

• name
Object ID = 1.2.1
Object Instance = 1.2.1.0
Value of Instance = *printer-1*

• uptime
Object ID = 1.2.2
Object Instance = 1.2.2.0
Value of Instance = *123456*

ALTERNATIVE:
Object ID = new-MIB info uptime

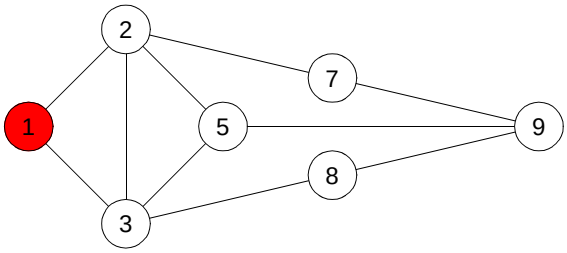
OBJECT NAMING: MIBs



TABLES

EXAMPLE: ROUTING TABLE

destination	next
2	2
3	3
5	2
7	2
8	3
9	3



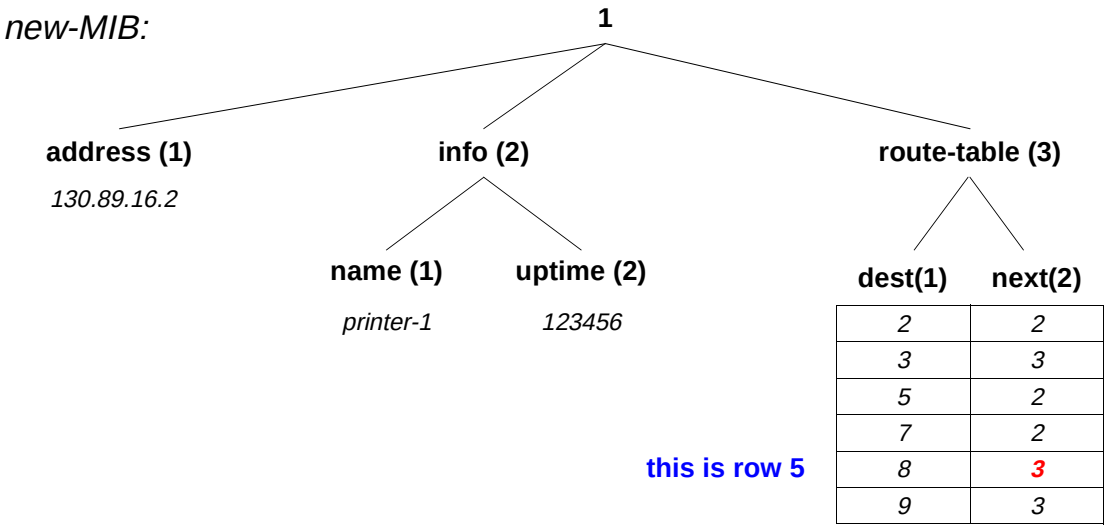
TO RETRIEVE INDIVIDUAL TABLE ENTRIES

EACH ENTRY SHOULD GET A NAME

NAMING OF TABLE ENTRIES - I

POSSIBILITY 1 (NOT BEING USED BY SNMP): USE ROW NUMBERS

new-MIB:



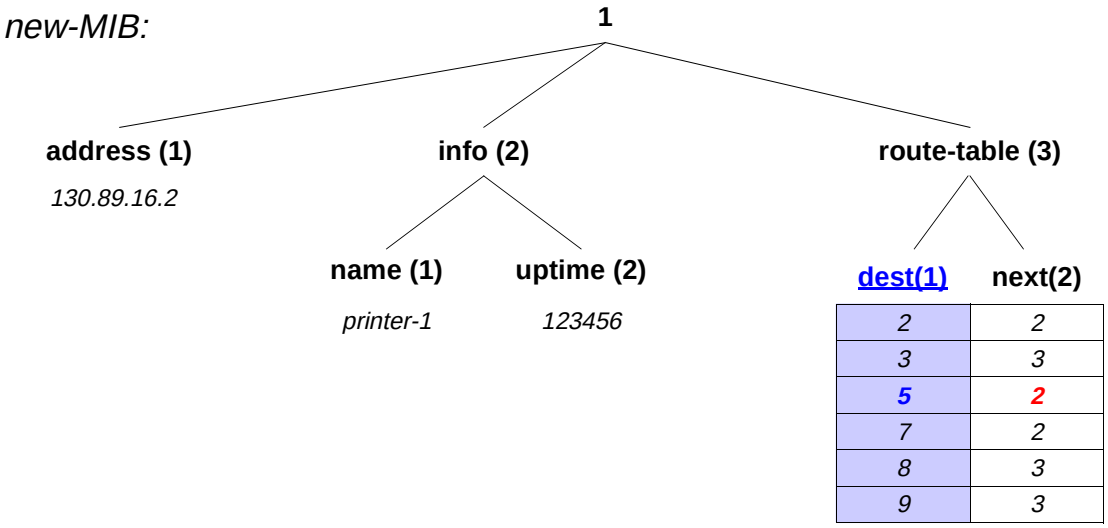
dest(1)	next(2)
2	2
3	3
5	2
7	2
8	3
9	3

EXAMPLE: THE VALUE OF *new-MIB route-table next 5* IS *3*

NAMING OF TABLE ENTRIES - II

POSSIBILITY 2 (USED BY SNMP): INTRODUCE AN INDEX COLUMN

new-MIB:



dest(1)	next(2)
2	2
3	3
5	2
7	2
8	3
9	3

EXAMPLE: THE VALUE OF *new-MIB route-table next 5* IS *2*

TABLE INDEXING

GENERAL SCHEME

X.C.I

OID of Table Column number Index value

EXAMPLES:

OID of Table = 1.3
1.3.1.5 => *5*
1.3.2.5 => *2*
1.3.1.9 => *9*
1.3.2.9 => *3*
1.3.2.7 => *2*
1.3.1.1 => *entry does not exist*
1.3.2.1 => *entry does not exist*

TABLE INDEXING - NON-INTEGER INDEX

AN INDEX NEED NOT BE AN INTEGER

route-table (3)

dest (1)	next (2)
130.89.16.1	*130.89.16.1*
130.89.16.4	*130.89.16.4*
130.89.16.23	*130.89.16.1*
130.89.19.121	*130.89.16.1*
192.1.23.24	*130.89.16.4*
193.22.11.97	*130.89.16.4*

EXAMPLES:
OID of Table = 1.3
1.3.1.130.89.16.23 => *130.89.16.23*
1.3.2.130.89.16.23 => *130.89.16.1*
1.3.1.193.22.11.97 => *193.22.11.97*
1.3.2.193.22.11.97 => *130.89.16.4*
1.3.2.130.89.19.121 => *130.89.16.1*

TABLE INDEXING - MULTIPLE INDEX FIELDS

USE OF MULTIPLE INDEX FIELDS

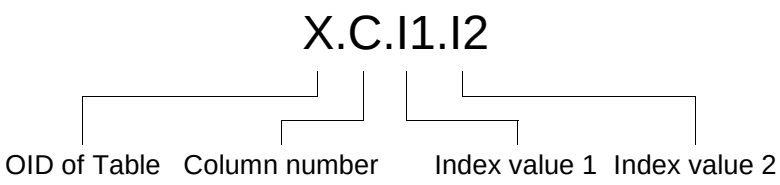


TABLE INDEXING - MULTIPLE INDEX FIELDS: EXAMPLE

EXAMPLE:

1 = low costs
2 = high reliability

route-table (3)

dest (1)	policy (2)	next (3)
130.89.16.23	*1*	*130.89.16.23*
130.89.16.23	*2*	*130.89.16.23*
130.89.19.121	*1*	*130.89.16.1*
192.1.23.24	*1*	*130.89.16.1*
192.1.23.24	*2*	*130.89.16.4*
193.22.11.97	*1*	*130.89.16.1*

1.3.3.192.1.23.24.1 => *130.89.16.1*

1.3.3.192.1.23.24.2 => *130.89.16.4*

MIB-II

DEFINES THE VARIABLES
TO MANAGE THE
TCP/IP PROTOCOL STACK

170 VARIABLES

RFC 1213

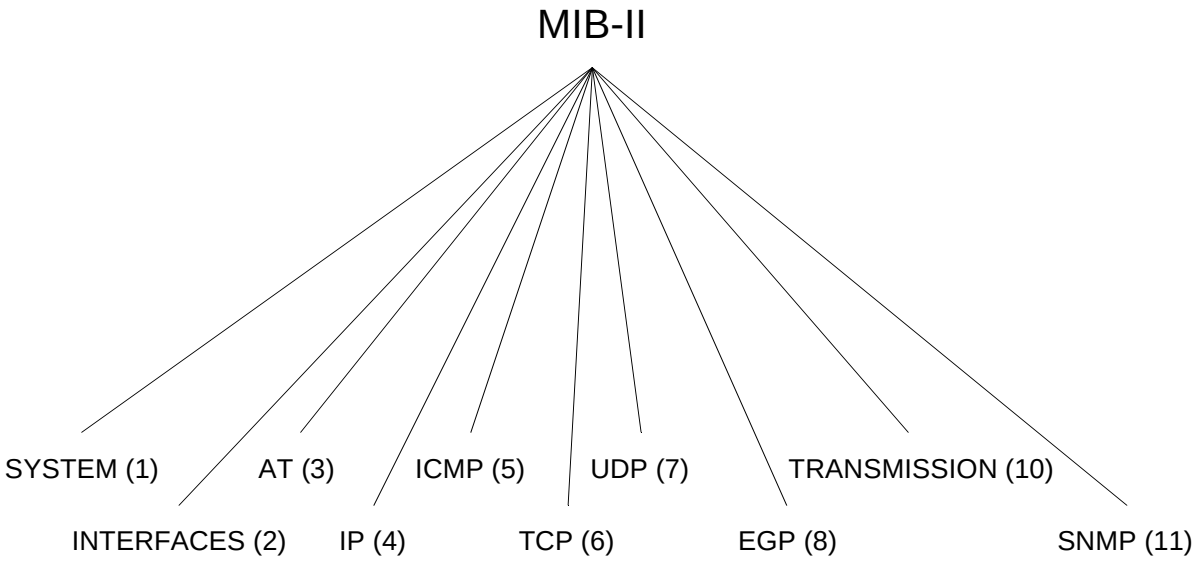
ENHANCEMENT OF MIB-I

RFC 1156

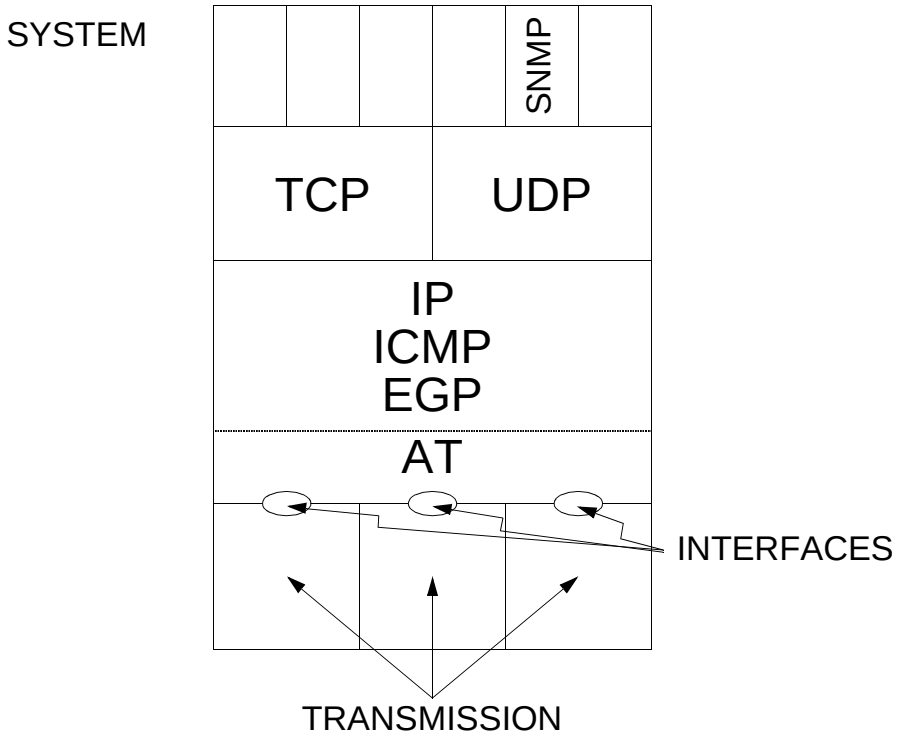
DESIGN CRITERIA

- ESSENTIAL FOR FAULT OR CONFIGURATION MANAGEMENT
- ONLY WEAK CONTROL OBJECTS
- SMALL NUMBER OF OBJECTS
- AVOID REDUNDANCY
- EVIDENCE OF UTILITY
- DO NOT DISTURB NORMAL OPERATION
- NO IMPLEMENTATION SPECIFIC ISSUES

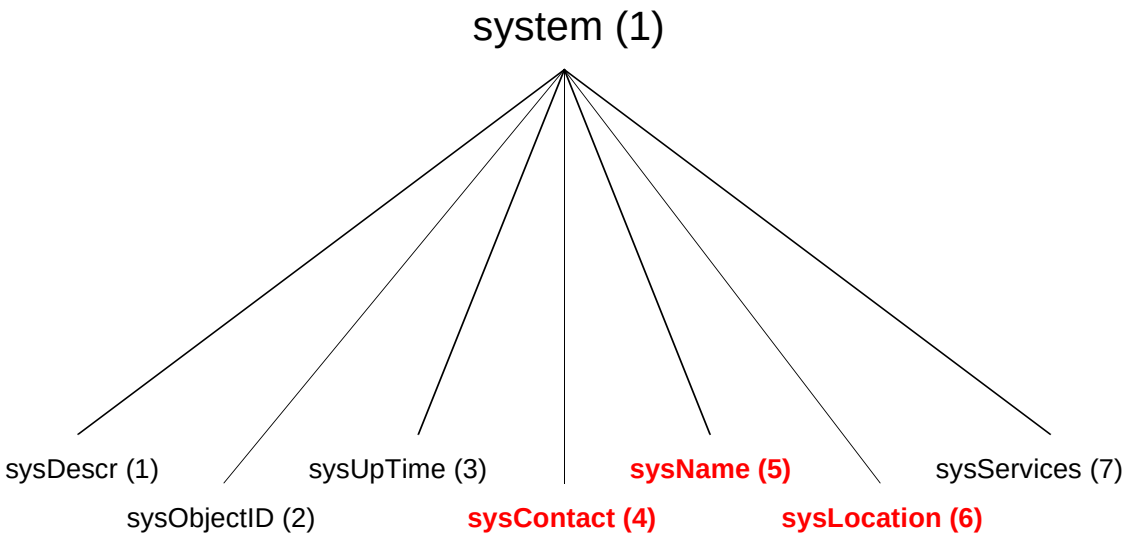
STRUCTURE



MIB-II GROUPS IN A PROTOCOL STACK



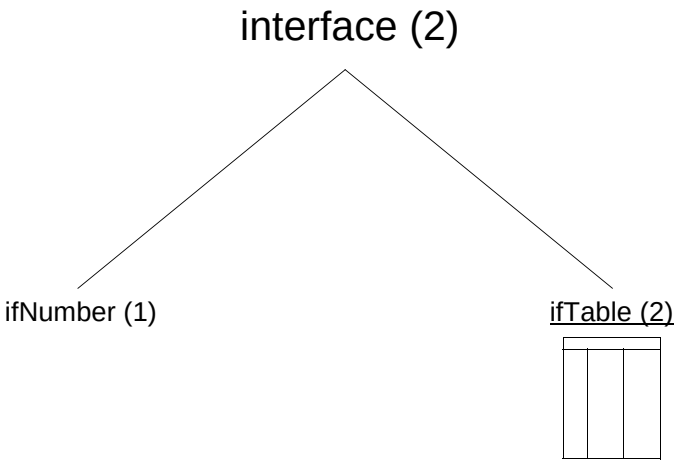
SYSTEM GROUP



EXAMPLE

sysDescr:	"**Cisco Gateway**"
sysObjectID:	**1.3.6.1.4.1.9.1.1**
sysUpTime:	**37153422** *(4 days, 7 h, 12 min, 14.22 s)*
sysContact:	"**helpdesk@cs.utwente.nl**"
sysName:	"**utic01.cs.utwente.nl**"
sysLocation:	"**near logica meeting room**"
sysServices:	**6** *(bridge and router functions)*

INTERFACES GROUP



ifTable

ifIndex	ifDescr	ifType	ifMtu	ifSpeed	ifPhysAddress	**ifAdminStatus**	ifOperstatus	ifLastChange	ifInOctets	ifInUcastPkts	ifInNUcastPkts	ifInDiscards	ifInErrors	ifInUnknownProtos	ifOutOctets	ifOutUcastPkts	ifOutNUcastPkts	ifOutDiscards	ifOutErrors	ifOutQLen	ifSpecific
1																					●
2																					●
n																					●

ifType and ifStatus

• ifType

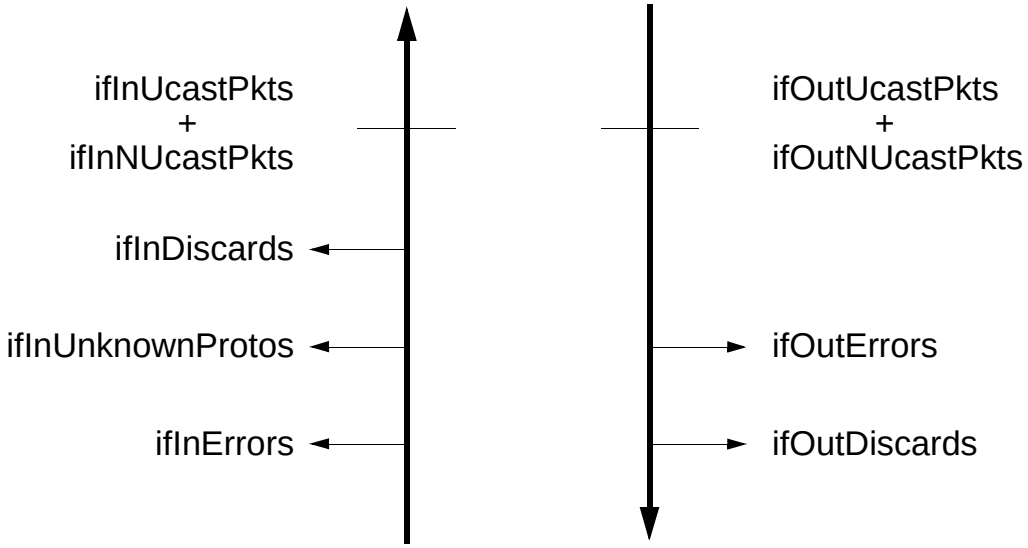
EXAMPLES:

1	Undefined	16	LAPB
6	Ethernet	20	ISDN Basic
7	IEEE 802.3	21	ISDN Primary
8	IEEE 802.4	23	PPP
9	IEEE 802.5	24	Loopback
10	IEEE 802.6	28	SLIP
15	FDDI	32	Frame Relay

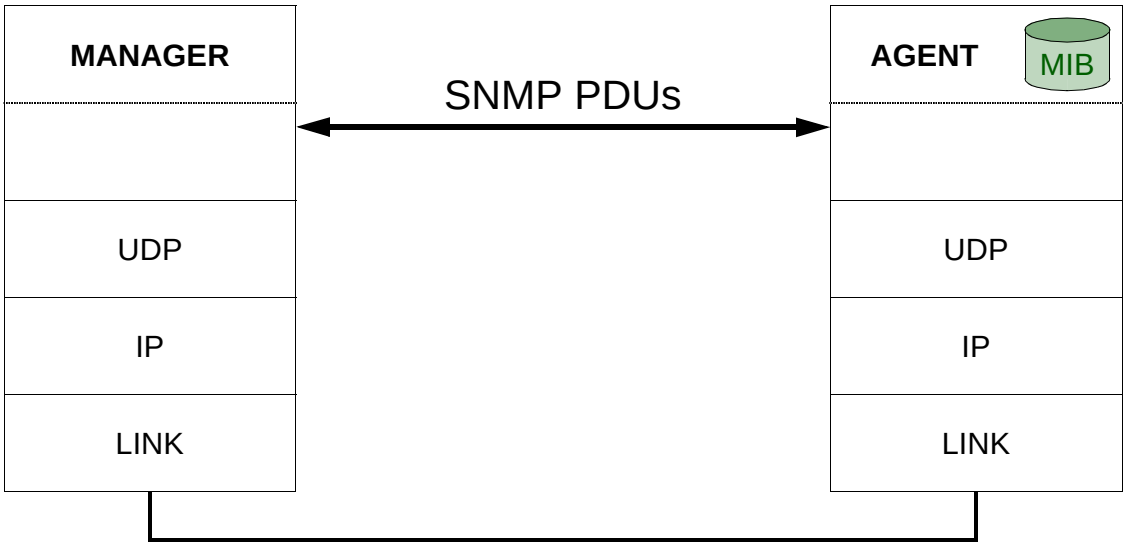
• ifAdminStatus / ifOperStatus

1 = up
2 = down
3 = testing

IF PACKET COUNT



SNMP PROTOCOL



MESSAGE & PDU STRUCTURE

variable bindings:

NAME *1*	VALUE *1*	NAME *2*	VALUE *2*	•••	•••	NAME *n*	VALUE *n*

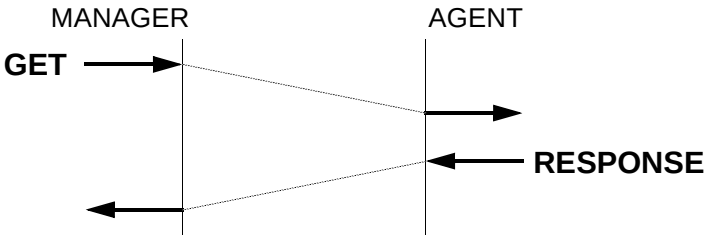
SNMP PDU:

PDU TYPE*	REQUEST ID	ERROR STATUS	ERROR INDEX	VARIABLE BINDINGS

SNMP message:

VERSION	COMMUNITY	SNMP PDU

GET

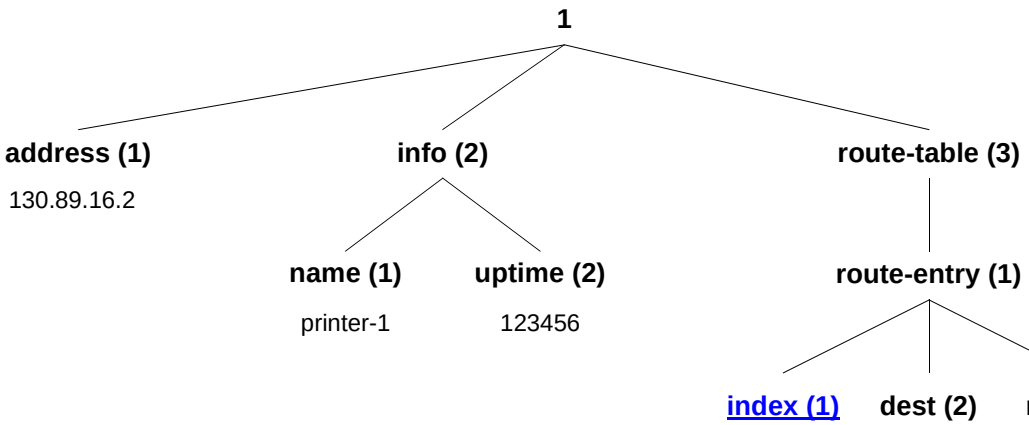


TO REQUEST THE VALUE OF 1 OR MORE VARIABLES

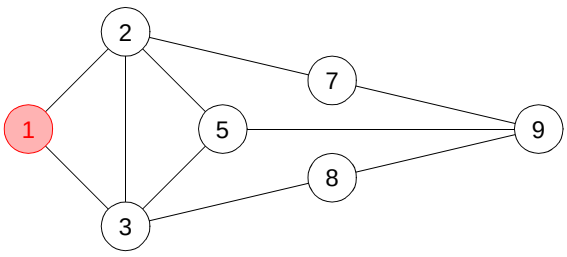
POSSIBLE ERRORS:

- NoSuchName ⇨ Object does not exist / Object is not a leaf
- tooBig ⇨ Result does not fit in Response PDU
- genErr ⇨ All other causes

EXAMPLE MIB



index (1)	dest (2)	next (3)
1	2	2
2	3	3
3	5	2
4	7	2
5	8	3
6	9	3



GET EXAMPLES

GET(1.1.0)
RESPONSE(1.1.0 => *130.89.16.2*)

GET(1.2.0)
RESPONSE(ErrorStatus = NoSuchName)

GET(1.1)
RESPONSE(ErrorStatus = NoSuchName)

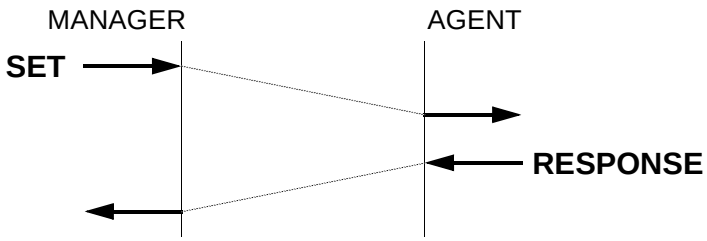
GET(1.1.0; 1.2.2.0)
RESPONSE(1.1.0 => *130.89.16.2*; 1.2.2.0 => *123456*)

GET(1.3.1.1.4)
RESPONSE(1.3.1.1.4 => *4*)

GET(1.3.1.3.4)
RESPONSE(1.3.1.3.4 => *2*)

GET(1.3.1.2.4, 1.3.1.3.4)
RESPONSE(1.3.1.2.4 => *7*, 1.3.1.3.4 => *2*)

SET



SET(1.2.1.0 => *my-printer*)
RESPONSE(noError; 1.2.1.0 => *my-printer*)

POSSIBLE ERRORS:

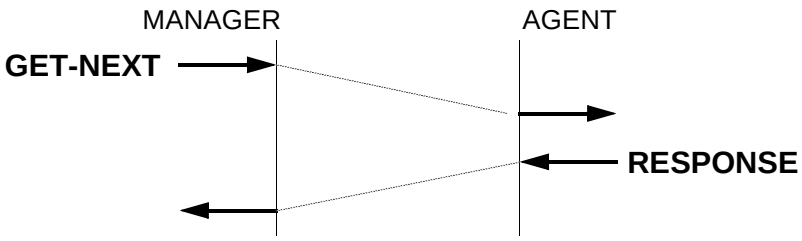
- noSuchName
- badValue
- genErr
- tooBig

ATOMICITY

THE SET REQUEST IS
ATOMIC

SET(1.2.1.0 => *my-printer*, 1.2.2.0 => *0*)
RESPONSE(ErrorStatus = noSuchName; ErrorIndex = 2)

GET-NEXT



RETRIEVES THE INSTANCE NAME AND VALUE OF THE **NEXT** MIB ELEMENT

TO DISCOVER MIB STRUCTURES

TO RETRIEVE TABLE ROWS

POSSIBLE ERRORS:

- noSuchName (= END OF MIB)
- genErr
- tooBig

GET-NEXT EXAMPLES

GET-NEXT(1.1.0)
RESPONSE(1.2.1.0 => *printer-1*)

GET-NEXT(1.2.1.0)
RESPONSE(1.2.2.0 => *123456*)

GET-NEXT(1.1)
RESPONSE(1.1.0 => *130.89.16.2*)

GET-NEXT(1.3.1.1.1)
RESPONSE(1.3.1.1.2 => *2*)

GET-NEXT(1.3.1.1.6)
RESPONSE(1.3.1.2.1 => *2*)

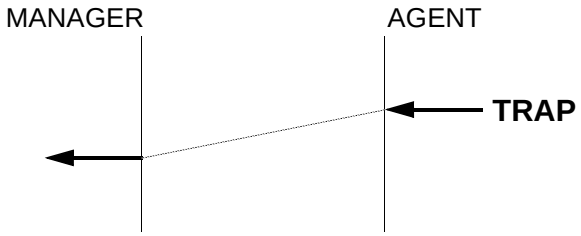
GET-NEXT(1.3.1.1.1; 1.3.1.2.1; 1.3.1.3.1)
RESPONSE(1.3.1.1.2 => *2*; 1.3.1.2.2 => *3*; 1.3.1.3.2 => *3*)

LEXICOGRAPHICAL ORDERING

THE MIB CAN BE CONSIDERED AS AN ORDERED LIST

INSTANCE ID	INSTANCE VALUE
1.1.0	130.89.16.2
1.2.1.0	printer-1
1.2.2.0	123456
1.3.1.1.1	1
1.3.1.1.2	2
1.3.1.1.3	3
1.3.1.1.4	4
1.3.1.1.5	5
1.3.1.1.6	6
1.3.1.2.1	2
1.3.1.2.2	3
1.3.1.2.3	5
1.3.1.2.4	7
1.3.1.2.5	8
1.3.1.2.6	9
1.3.1.3.1	2
1.3.1.3.2	3
•••	•••

TRAP



TRAP RECEPTION IS NOT CONFIRMED
(THUS UNRELIABLE)

POLLING REMAINS NECESSARY

AGENTS MAY BE CONFIGURED
TO DISCARD TRAPS

DEFINED TRAPS

- COLDSTART
- WARMSTART
- LINKDOWN
- LINKUP
- AUTHENTICATION FAILURE
- EGPNEIGHBOURLOSS
- ENTERPRISESPECIFICTRAP

TRAP - PDU FORMAT

ENTERPRISE
AGENT-ADDRESS
GENERIC-TRAP
SPECIFIC-TRAP
TIME-STAMP
VARIABLE-BINDINGS

CONCLUSIONS

COMMERCIAL SNMP SOFTWARE

FREE SNMP SOFTWARE

WWW SERVERS

BOOKS

COMMERCIAL SNMP SOFTWARE

BULL OPENMASTER
http://www.openmaster.com/ism

HP OPENVIEW
http://www.openview.hp.com/

SNMP RESEARCH
http://www.snmp.com/

CABLETRON SPECTRUM
http://www.cabletron.com/spectrum/

SUN SOLSTICE
http://www.sun.com/solstice/

TIVOLI
http://www.tivoli.com/

FREE SNMP SOFTWARE

CMU
http://www.net.cmu.edu/groups/netdev/software.html

UCD
http://ucd-snmp.ucdavis.edu/

Scotty
http://wwwhome.cs.utwente.nl/~schoenw/scotty/

JMAPI
http://java.sun.com/products/JavaManagement/

Advent
http://www.adventnet.com/

ModularSnmp
http://www.teleinfo.uqam.ca/snmp/

WWW SERVERS

• IETF
http://www.ietf.org/

• The SimpleWeb
http://www.simpleweb.org/

• The Simple Times
http://www.simple-times.org/

• The Smurfland NM Web Server
http://netman.cit.buffalo.edu/

BOOKS

• W. Stallings
SNMP, SNMPv2, SNMPv3 and RMON1 and 2
Third edition, Addison-Wesley, 1999
ISBN: 0-201-48534-6

• D. Zeltserman
A Practical Guide to SNMPv3 and Network Management
Prentice Hall, 1999
ISBN: 0-13-021453-1

• D. Perkins, E. McGinnis
Understanding SNMP MIBs
Prentice Hall, 1996
ISBN: 0-13-437708-7