CURSUS

NETWERK MANAGEMENT

ENERTEL

12 en 13 mei 1998

Aiko Pras

INFORMATIE CURSUSLEIDER

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Telematics Systems and Services
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TELEMATICA EN DE UT

TSS

• Prof. dr. ir. I.G.M.M. NIEMEGEERS

⇩

• SAMENWERKINGSVERBAND VAN HOOGLERAREN
• FACULTEITEN INFORMATICA EN ELEKTROTECHNIEK
• ONDERWIJS EN ONDERZOEK

CTIT

• Prof. dr. ir. I.G.M.M. NIEMEGEERS

⇩

• ONDERZOEKSINSTITUUT VAN DE UT
• COORDINEERT TELEMATICA ONDERZOEK
VAN DE VERSCHILLENDE UT FACULTEITEN

TELEMATICA INSTITUUT (TI)

• Prof. dr. ir. C.A. VISSERS
http://www.trc.nl/

⇩

• OVERHEID, BEDRIJFSLEVEN EN UT

TSS

QUANTITATIEVE ANALYSE & METHODEN
Prof. dr. ir. I.G.M.M. Niemegeers
Dr. ir. V.F. Nicola

ARCHITECTUUR
Prof. dr. ir. C.A. Vissers
dr. ir. M.J. van Sinderen

APPLICATIE PROTOCOLLEN
Prof. ir. E.F. Michiels
dr. V.M. Jones

COMMUNICATIE PROTOCOLLEN
Prof. dr. ir. I.G.M.M. Niemegeers
Dr. P.F. Chimento

MANAGEMENT
Prof. ir. B.L. de Goede
Dr. ir. A. Pras
Dr. ir. B.J.F. van Beijnum
ir. R.A.M. Sprenkels
Ir. B.D. van der Waaij

TSS: MANAGEMENT GROEP

Externe projecten

- UT-ATM
- UT-WWW

Interne projecten

- Accounting
- Management Hierarchies
- UT-SNMPv2
- Damocles
- SMASH
- LaForge

CTIT: INBEDDING EN SAMENWERKING

Faculteiten:

- Informatica
- Elektrotechniek
- Toegepaste Wiskunde
- Toegepaste Onderwijskunde
- Technologie en Management
- Bestuurskunde
- Wijsbegeerte en Maatschappijwetenschappen

Telematics Graduate School

Telematica Instituut

Bedrijven

- KPN, Ericsson, Lucent, SURFnet, ...

CTIT: ONDERZOEKPROGRAMMA - 1

Information Technology

- Language, speech and information engineering
- Software engineering
- Database technology
- Signal processing

Telematics Systems

Application systems

- Telematics services and protocols
- Distributed databases
- Mobile & nomadic computing

Systems Management

- Network & service management

Communication systems

- Photonic networks
- Communication networks

Use of Telematics

Human and societal aspects

- Human - computer interfaces
- Models for human collaboration

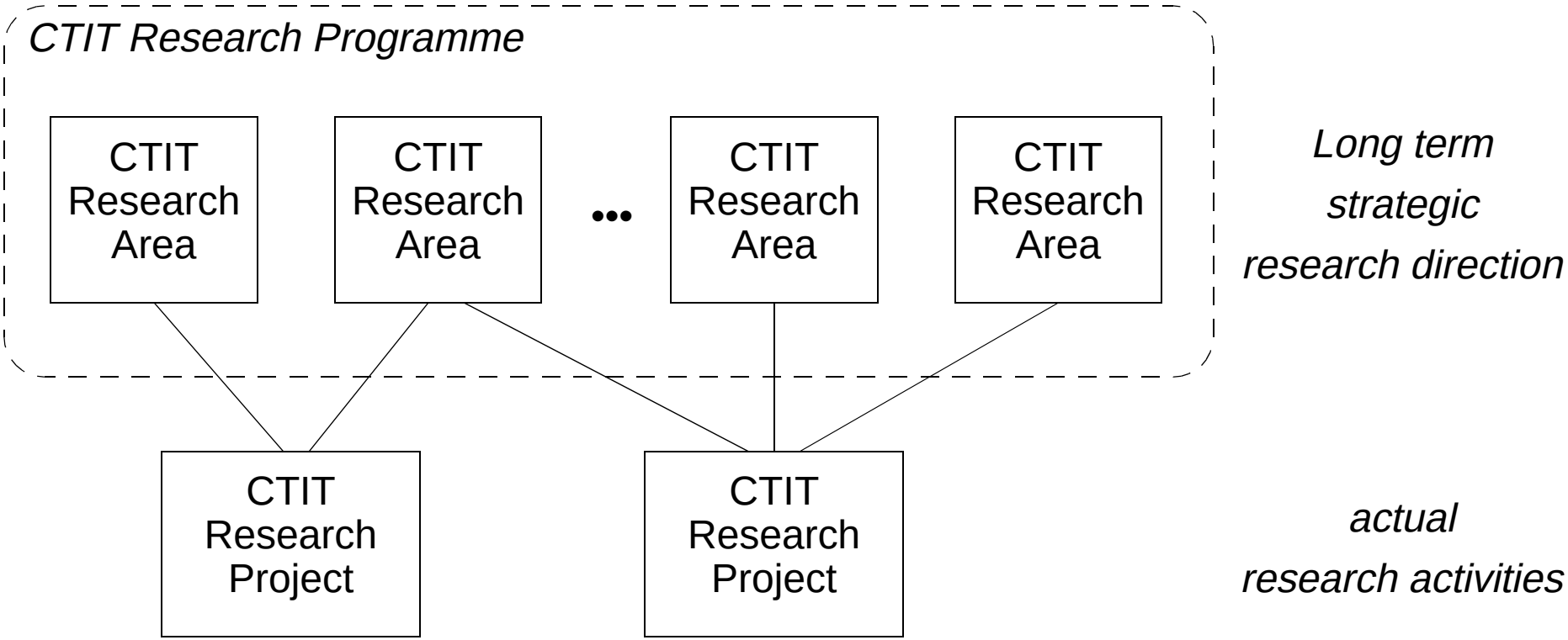
Business, industry and government

- Public administration
- Education and training
- Logistics
- Business

Methods, Techniques and Tools

- Design methods and concepts
- Performance and reliability analysis
- Formal methods
- Software tools

CTIT: ONDERZOEKPROGRAMMA - 2



CTIT: ONDERZOEKPROJECTEN

EUROPEES:

• INSIGNIA, TOBASCO, PRISMA, RAINBOW, WIDE, TWENTY ONE, ...

NATIONAAL:

• MESH, TESTBED, SURFNET4, IMPACT, FLAMINGO, OPTICAL NETW., ...

UT:

• IDYLLE, OVERHEIDSLOKET-2000, ...

TELEMATICA INSTITUUT:

• DMW, MERITS, AMIDST, DRUID, INTERNET NEXT GENERATION, ...

OVERZICHT VAN DE CURSUS

Dinsdag 12 mei

9:30	Algemene Inleiding
10:10	Enige theorie
11:30	Normering: TMN, ISO, Internet, ...
12:30	Lunch
13:30	TMN
15:00	OSI Management
16:30	OSI Management - vervolg

Woensdag 13 mei

9:00	Introduktie SNMP
9:20	Structuur van Management Informatie (SMI)
10:45	Internet Management Information Base (MIB-II)
12:15	Lunch
13:15	Het SNMP protocol
14:00	SNMPv2
14:45	SNMPv3
15:30	Overige MIBs
16:00	Extensible agent technology
16:25	TMN / OSI versus SNMP
16:45	Slot opmerkingen
17:00	Einde

A LITTLE BIT OF THEORY ...

WHAT IS MANAGEMENT?

- DEFINITIONS

- AUTOMATIC VERSUS OPERATOR INITIATED MANAGEMENT

- DISTRIBUTION OF MANAGEMENT FUNCTIONALITY

- MANAGER-AGENT RELATIONSHIP

- MANAGEMENT INTERACTIONS

- MANAGEMENT INFORMATION BASE

MANAGEMENT DEFINITIONS

OSI Management Framework:
The facilities to control, coordinate and monitor
the resources
which allow communications to take place
in the OSI environment

ITU-T E.410:
The function of supervising the network and taking action when necessary to control
the flow of traffic

ITU-T M.3010 (TMN):
Plan, provision, install, maintain, operate and administer telecommunication networks and services

MANAGEMENT DEFINITIONS

PTT Nederland

Het begrip netwerkmanagement is de verzamelnaam voor het op een bepaald service niveau en tegen bepaalde kosten verzorgen van activiteiten - al dan niet geautomatiseerd - die voor het plannen, installeren, bewaken, observeren en werkend houden van een netwerk met alle netwerkcomponenten nodig zijn

Centrale Commissie Overheidsinformatievoorziening

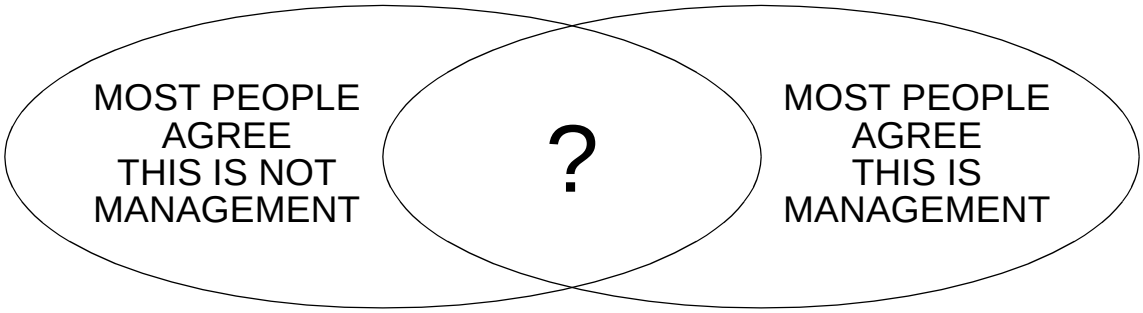
De activiteiten die nodig zijn voor het plannen, installeren, bemeten en onderhouden van alle componenten van een datacommunicatie-netwerk, teneinde een gagarandeerd niveau van ondersteuning te bieden tegen acceptabele en overeengekomen kosten

RACE CFS A150

The set of functions which has been designed to get maximum benefit in operating a telecommunication network or services. Network management includes subscriber and network administration, quality of service management (incl. system reconfiguration)

WHAT IS MANAGEMENT

DEFINITIONS NOT REALLY CLEAR



ITU:

- USER PLANE
- CONTROL PLANE
- MANAGEMENT PLANE

BUT:
IS THIS DIVISION PRACTICAL?

WHAT IS MANAGEMENT

CHANGING IDEAS

E.G.

- PROTOCOLS TO MAINTAIN ROUTING TABLES

- PROTOCOLS TO INITIALIZE ADDRESSES

- PROTOCOLS TO DETECT IF SYSTEMS ARE ACTIVE

WHAT IS MANAGEMENT

MANUAL VERSUS AUTOMATIC

MANUAL:
PERFORMED BY OPERATOR

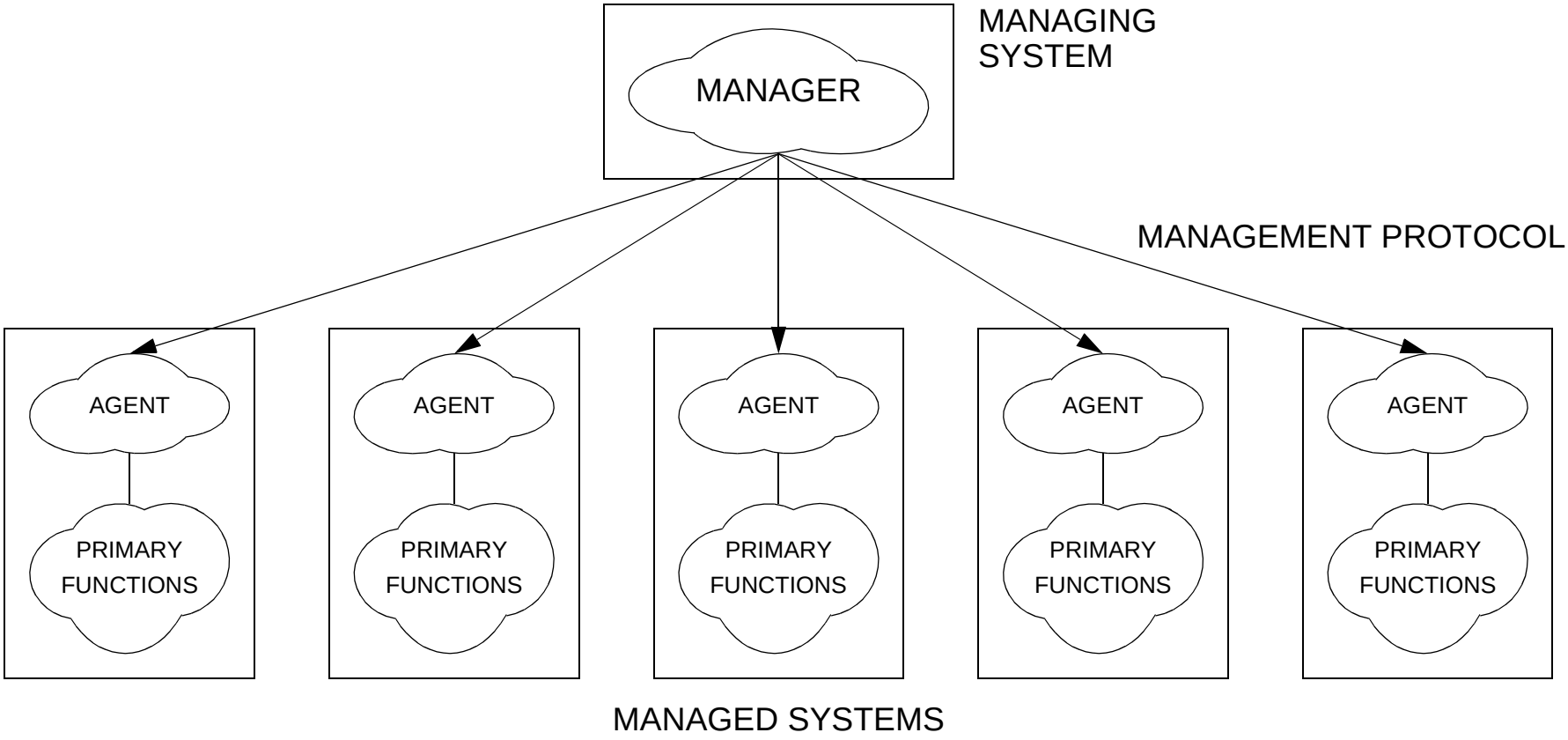
AUTOMATIC:
PERFORMED BY MANAGEMENT FUNCTIONS
THAT ARE IMPLEMENTED
WITHIN THE NETWORK EQUIPMENT

EXPLICIT VERSUS IMPLICIT

MIXED APPROACHES:
- ARTIFICIAL INTELLIGENCE
- EXPERT SYSTEMS
- SCRIPTS

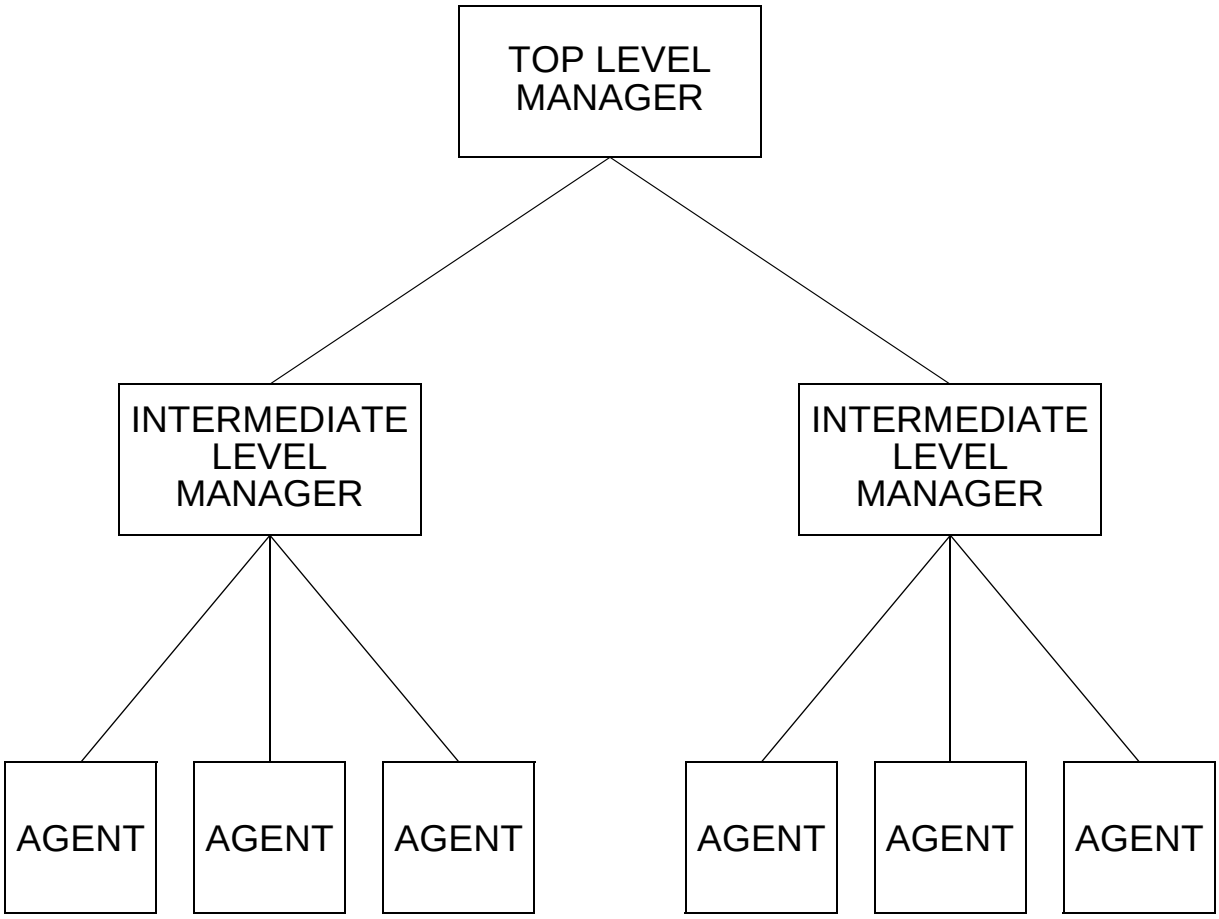
MANAGEMENT DISTRIBUTION

CENTRALIZED APPROACH



MANAGEMENT DISTRIBUTION

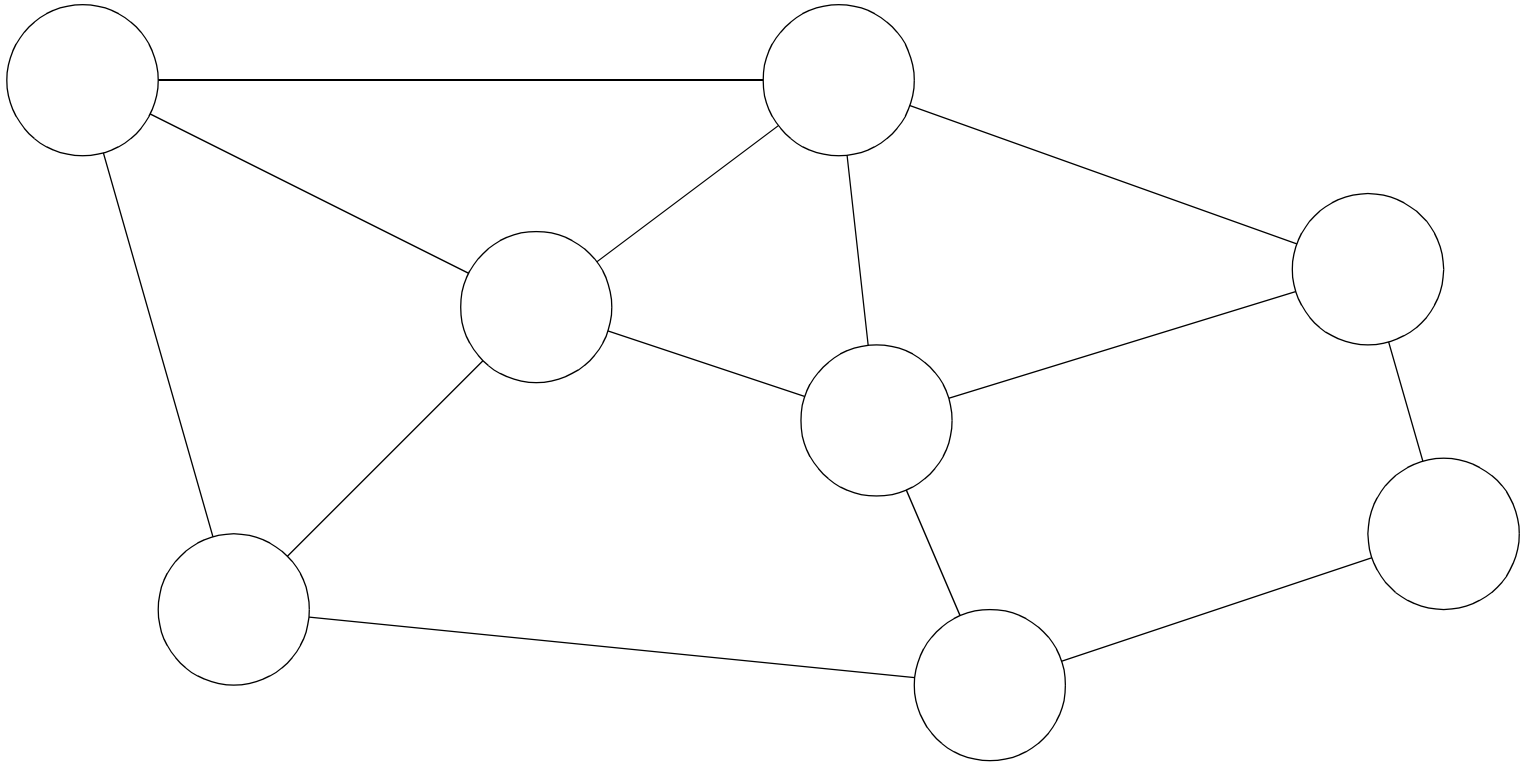
CENTRALIZED APPROACH



MANAGEMENT HIERARCHY

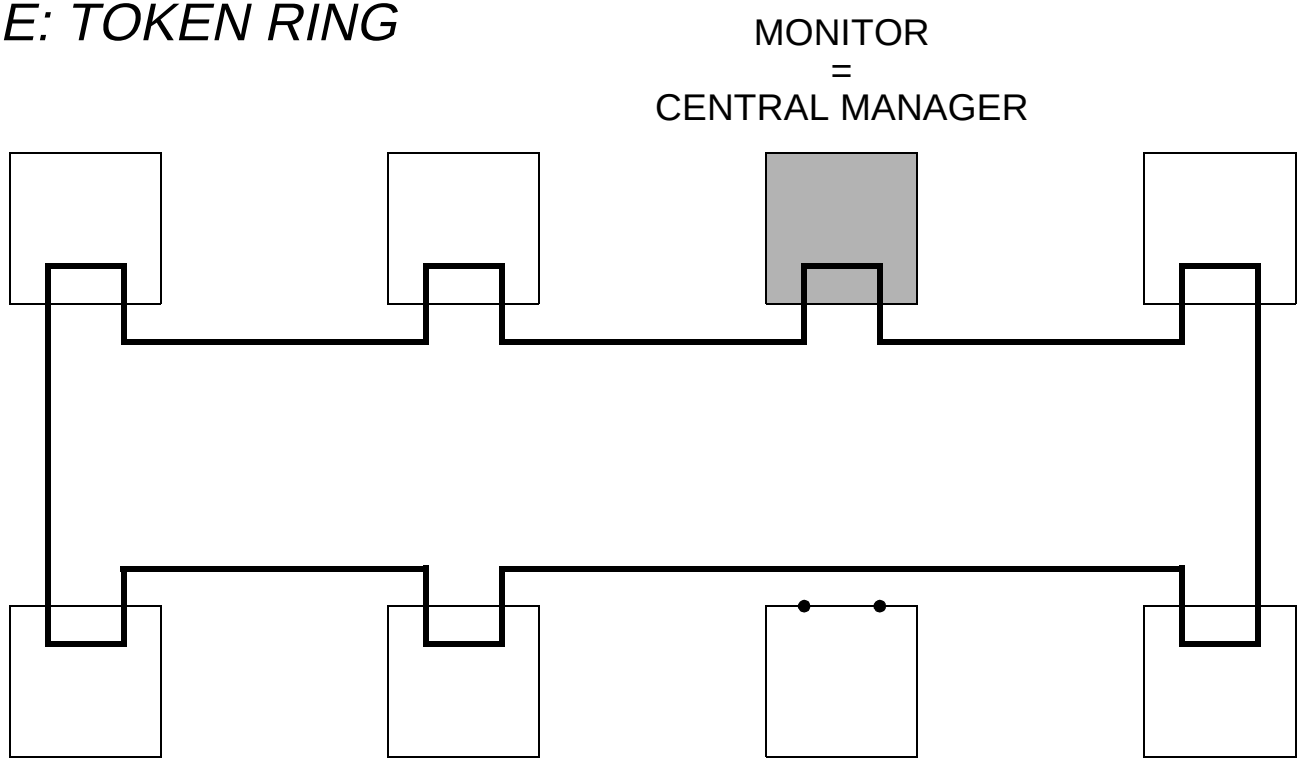
MANAGEMENT DISTRIBUTION

DISTRIBUTED APPROACH



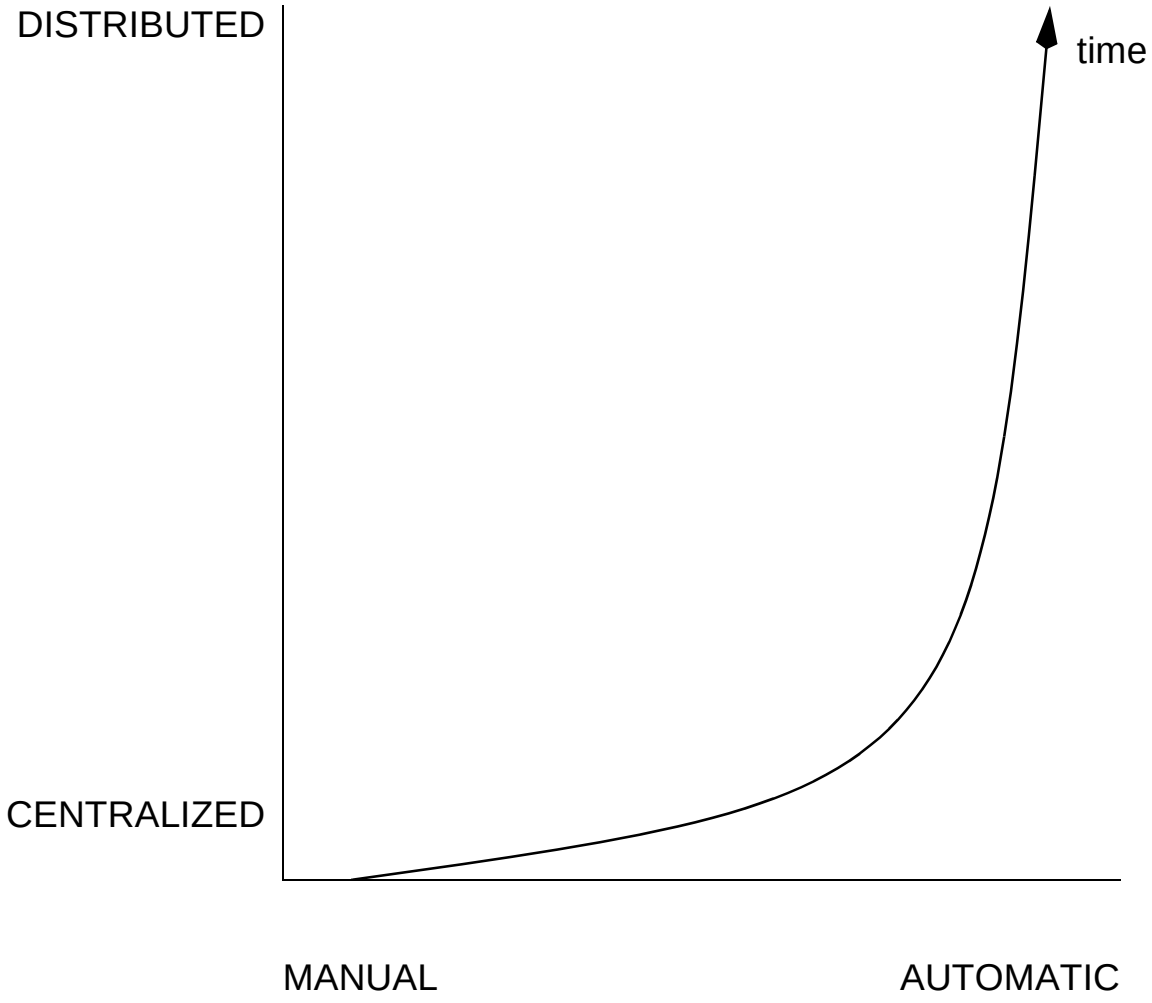
MANAGEMENT DISTRIBUTION

EXAMPLE: TOKEN RING



EVERY STATION HAS THE POTENTIAL TO BECOME CENTRAL MANAGER

FROM MANUAL TO AUTOMATIC



CERTAIN MANAGEMENT TASKS
(EG. FAULT MANAGEMENT)
MAY ALWAYS DEMAND
A MANUAL & CENTRALIZED APPROACH

MANAGEMENT APPROACHES

VARIABLE ORIENTED APPROACH

CHANGE THE *VARIABLES*
WITHIN THE MANAGED SYSTEM

- READ AND WRITE OPERATIONS
- MIBs
- REMOTE DEBUGGING
- EXAMPLE: SNMP

COMMAND ORIENTED APPROACH

SEND IMPERATIVE *COMMANDS*
TO THE MANAGED SYSTEM

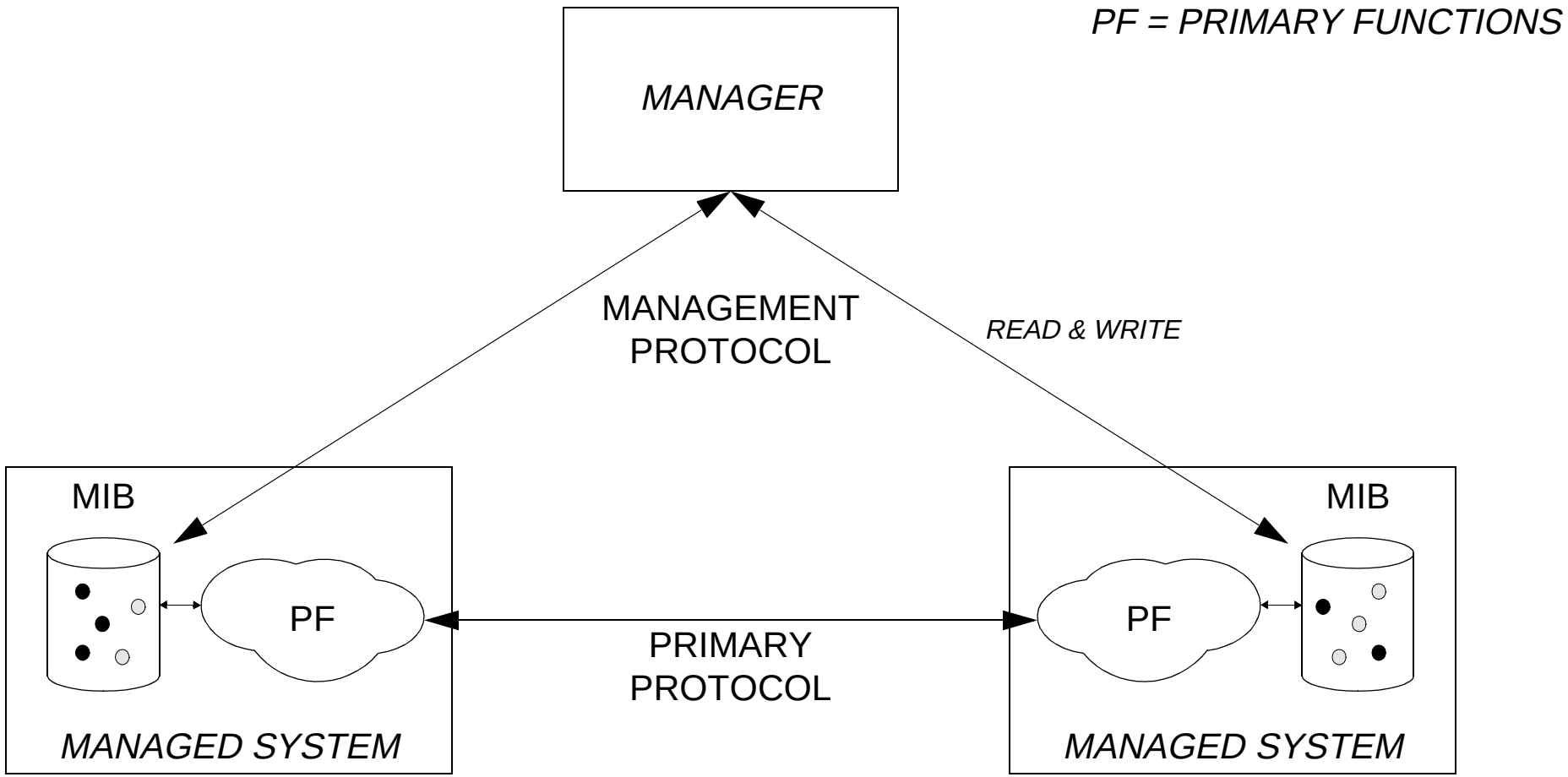
- E.G. REBOOT
- EXAMPLE: TOKEN RING

OBJECT ORIENTED APPROACH

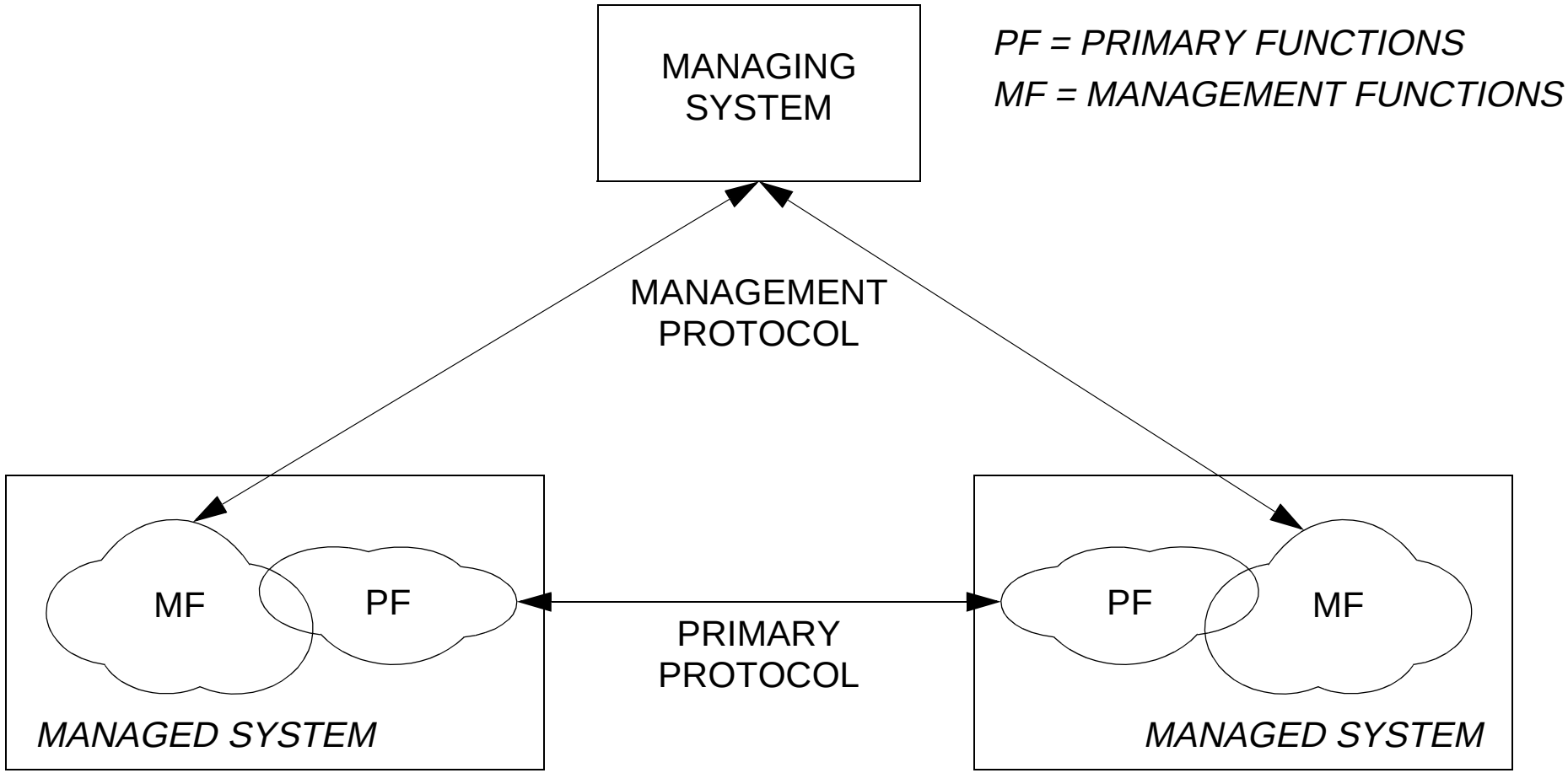
A COMBINATION
OF BOTH APPROACHES

- EXAMPLE: OSI

VARIABLE ORIENTED APPROACH

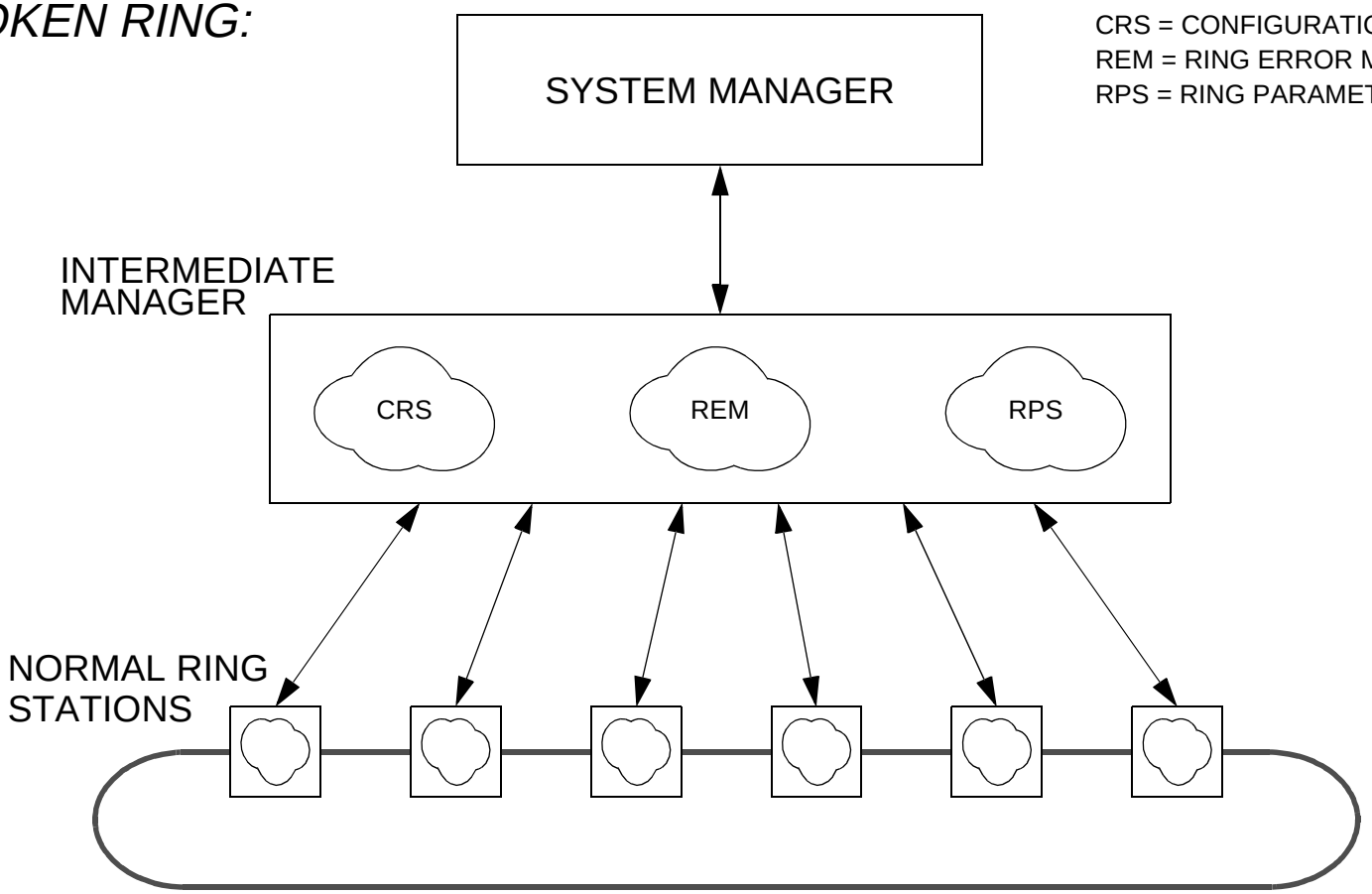


COMMAND ORIENTED APPROACH



COMMAND ORIENTED APPROACH: EXAMPLE

TOKEN RING:



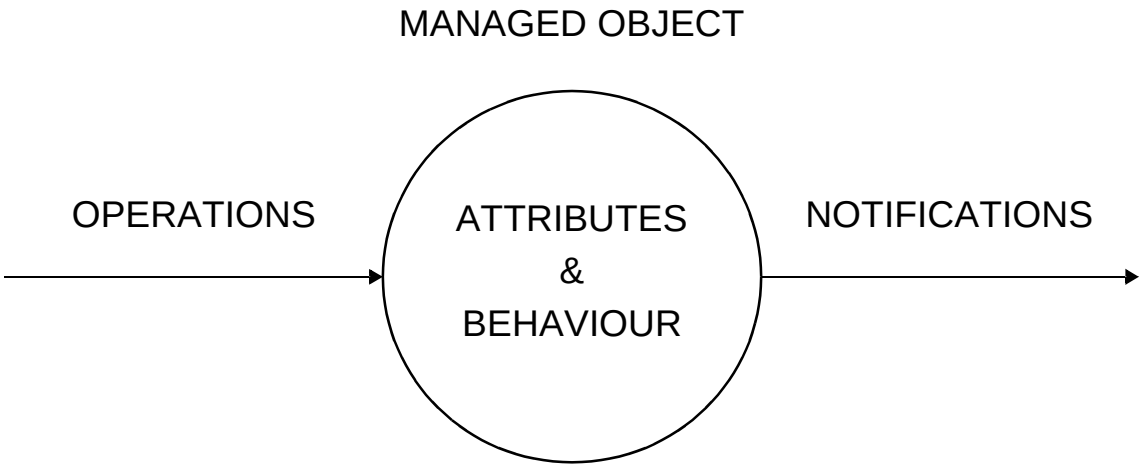
CRS = CONFIGURATION REPORT SERVER
REM = RING ERROR MONITOR
RPS = RING PARAMETER SERVER

EXAMPLE (CONT.)

MANAGEMENT COMMANDS
TOKEN RING:

NAME	DESCRIPTION
Remove Ring Station	Sent by the CRS to a specific ring station causing unconditional removal
Request Ring Station Address	Issued by RPS, REM or CRS to obtain the address(es) of a specific station
Report Ring Station Address	Sent by a station as a response to the RPS, REM or CRS
Request Ring Station Attachments	Issued by RPS, REM or CRS to obtain information on the functions active in a specific station
Report Ring Station Attachments	Sent by a station as a response to the RPS, REM or CRS
Request Ring Station State	Issued by RPS, REM or CRS to obtain state information of a specific station
Report Ring Station State	Sent by a station as a response to the RPS, REM or CRS
Request Initialization	Issued by the station that has just entered the ring. It informs the RPS that it has been inserted and wants new parameters
Initialize Ring Station	Issued by the RPS as a response to a previous Request Initialization.
Change Parameters	Sent by the CRS to set parameters
Report Error	Sent by a station to the REM
Report SUA Change	Sent by a station to the CRS when a change in station's Stored Upstream neighbour Address is detected

OBJECT ORIENTED APPROACH



READ AND WRITE OPERATIONS
ON ATTRIBUTES

IMPERATIVE COMMANDS
TO OBTAIN SPECIFIC BEHAVIOUR

- E.G. REBOOT
- VIA 'ACTION' PDU

MANAGEMENT STANDARDS

INTERNET

- INTERNET ENGINEERING TASK FORCE (IETF)
- OPERATIONS AND MANAGEMENT AREA
- SNMP

ISO

- ISO-IEC/JTC 1/WG 4
- OSI
- CMIP-CMIS

ITU-T

- THE FORMER CCITT
- SG IV
- TMN

OTHERS

- IEEE
- NM FORUM
- OMG
- TINA-C
- ACTS
- OPEN GROUP
- DMTF

CHARACTERISTICS

IETF

• MANAGEMENT SHOULD BE SIMPLE
• VARIABLE ORIENTED APPROACH
• MANAGEMENT INFORMATION EXCHANGES MAY BE UNRELIABLE

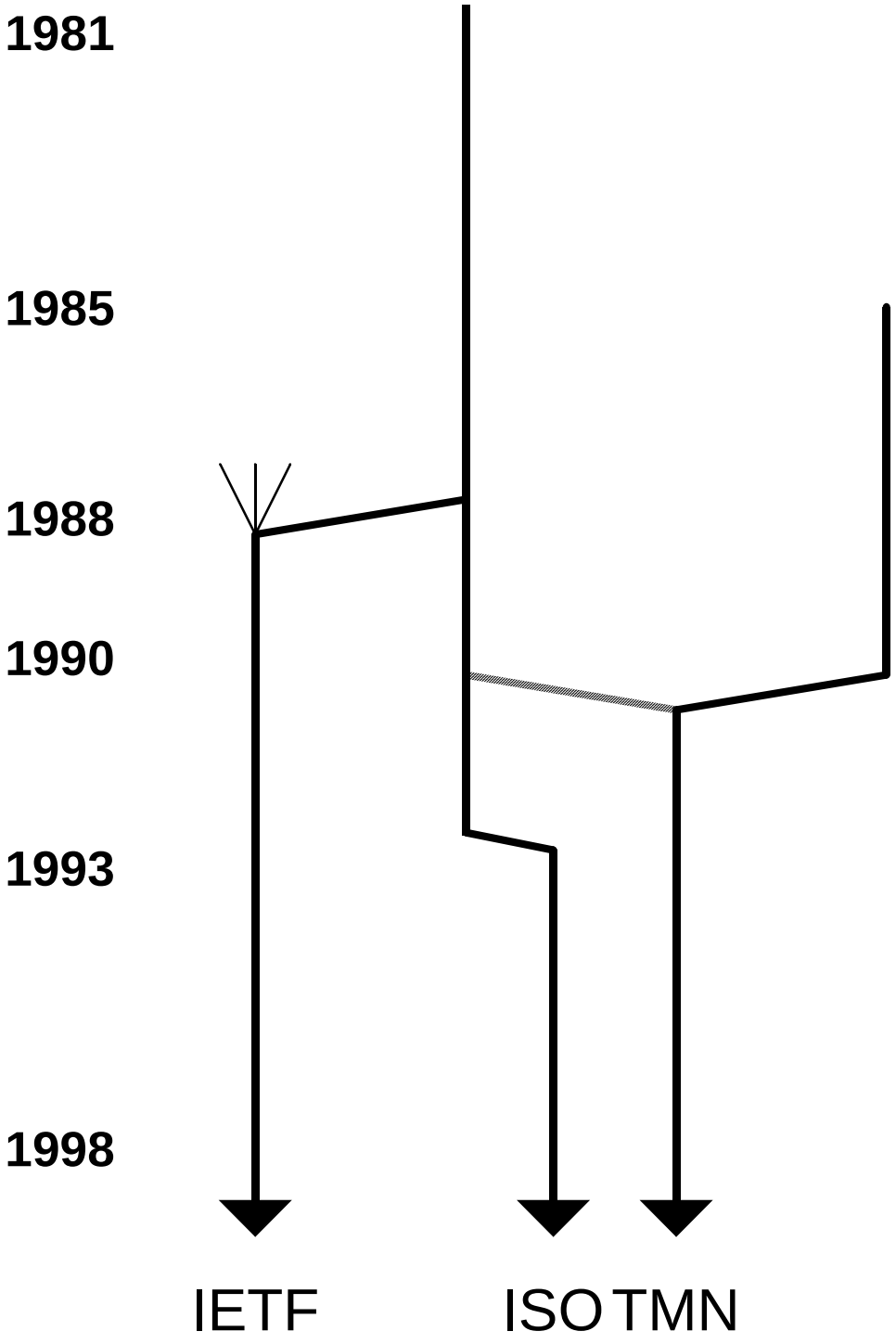
ISO

• MANAGEMENT SHOULD BE POWERFUL
• OBJECT ORIENTED APPROACH
• MANAGEMENT INFORMATION MUST BE EXCHANGED IN A RELIABLE FASHION

TMN

• DEFINES ONLY A MANAGEMENT *ARCHITECTURE*
• THE ACTUAL PROTOCOLS ARE THOSE OF OSI
• OUT-OF-BAND MANAGEMENT

HISTORY



MARKET SHARE

NUMBER OF AGENTS?

NUMBER OF MANAGERS?

MONEY?

FOR SPECIFIC ENVIRONMENTS?

- IBM MAIN-FRAMES
- PRIVATE DATA LANs
- PRIVATE DATA WANs
- PABX
- PUBLIC VOICE NETWORKS
- PUBLIC DATA NETWORKS

WHY DID SNMP SUCCEED?

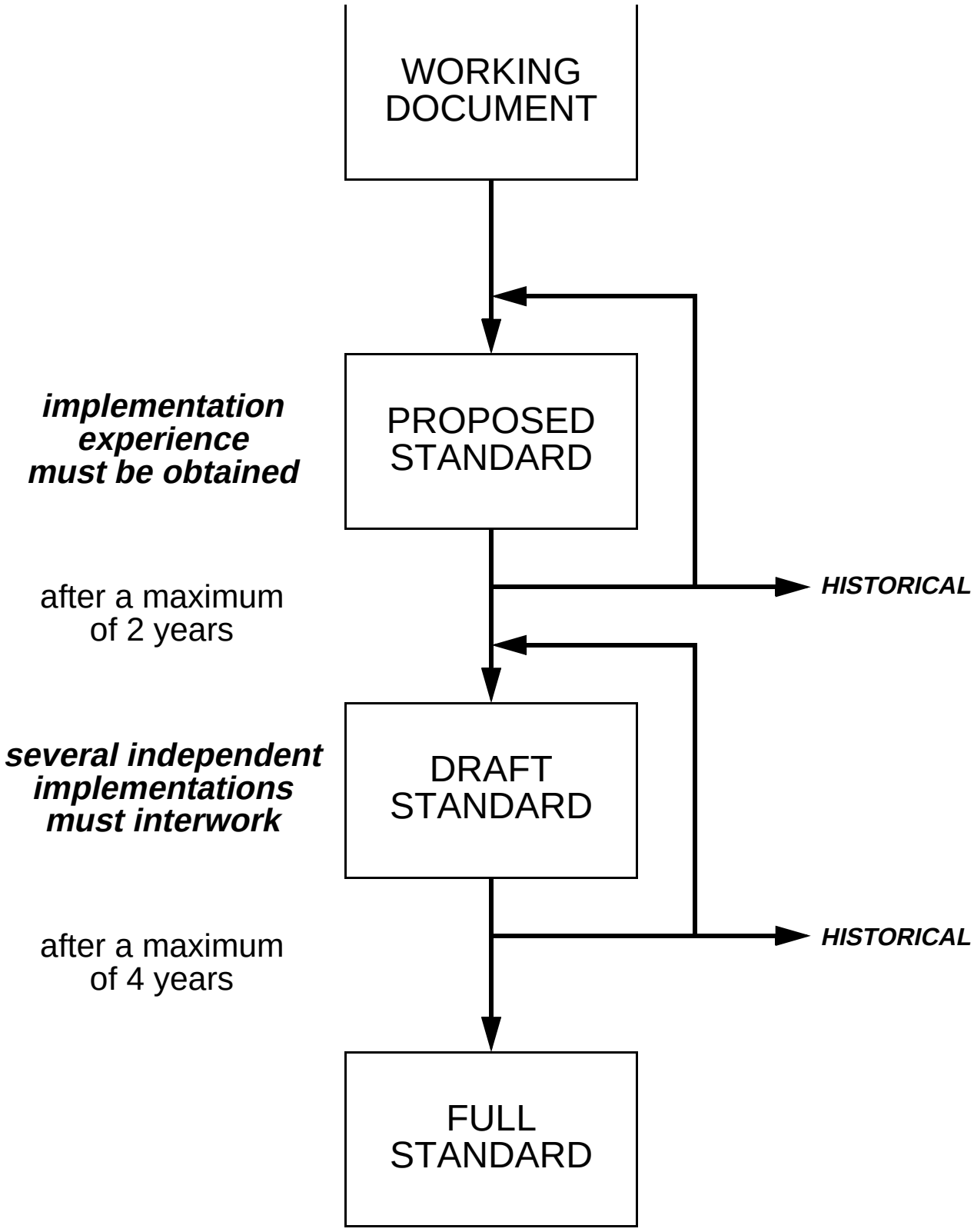
• STANDARDS CAN BE OBTAINED FOR FREE

• STANDARDS ARE AVAILABLE
ON FTP-SERVERS
IN AN ELECTRONIC FORM

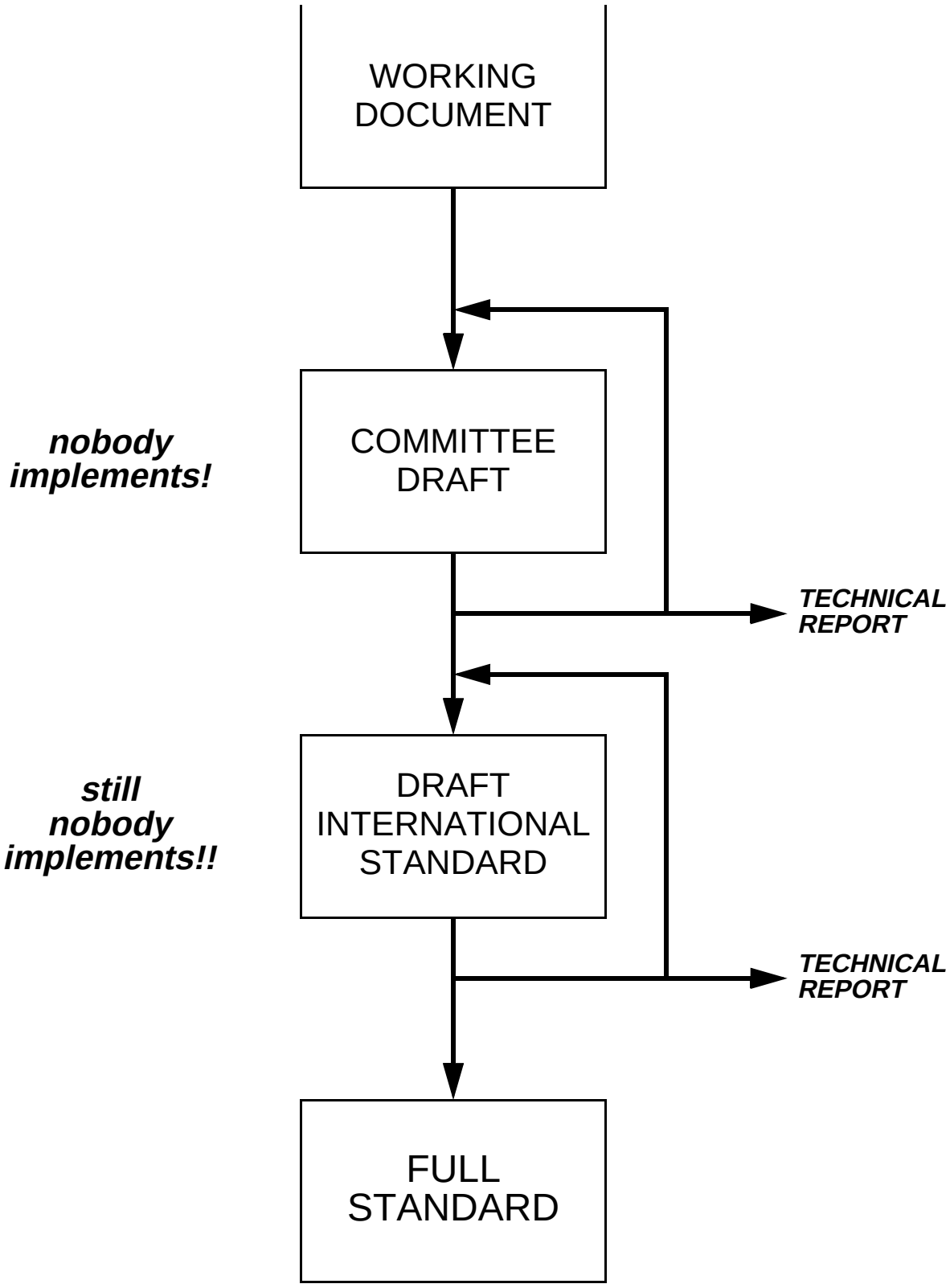
• RAPID DEVELOPMENT OF STANDARDS

• PROTOTYPES MUST DEMONSTRATE
THE NEED FOR, AND
THE FEASIBILITY OF STANDARDS

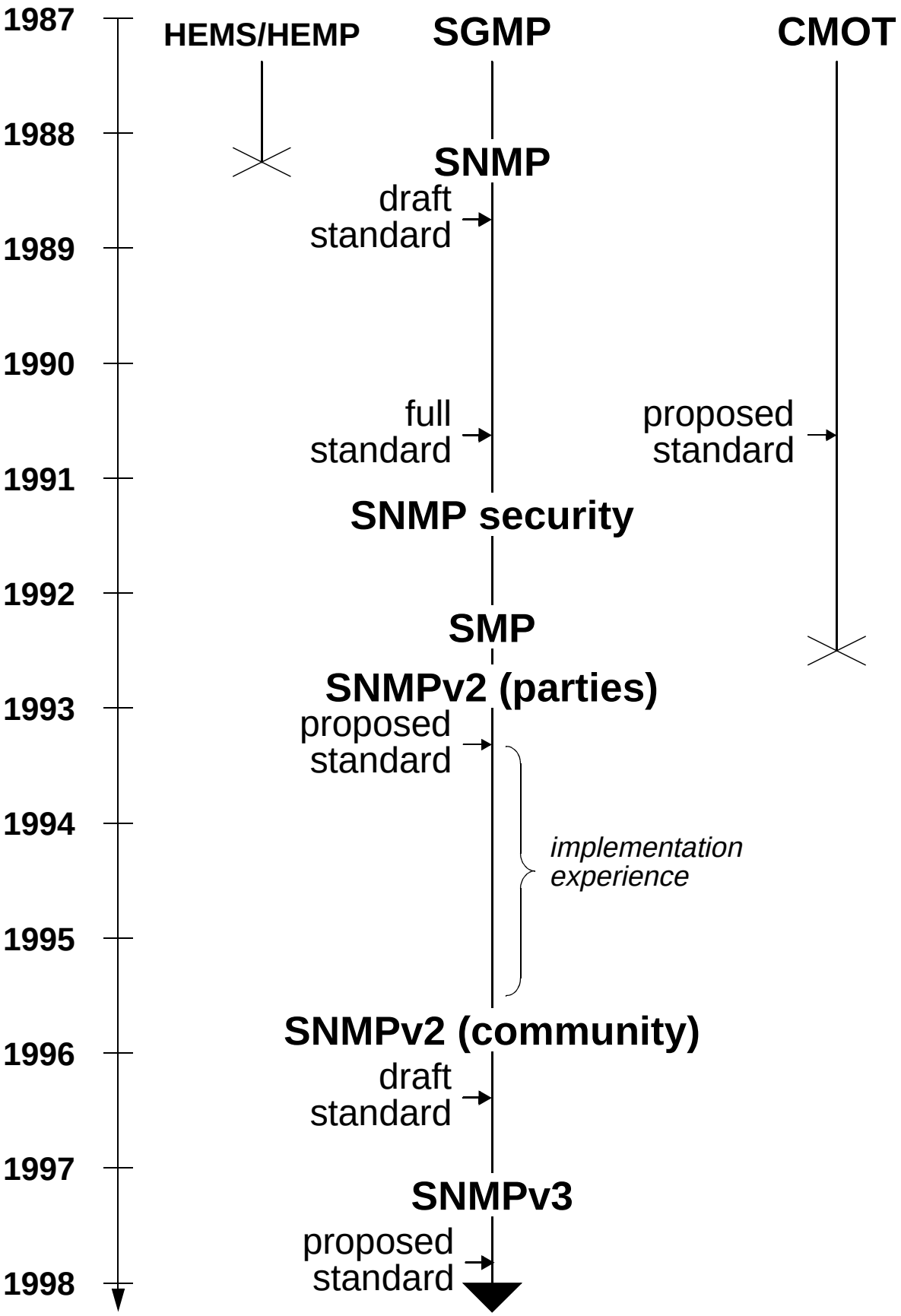
IETF STANDARDIZATION



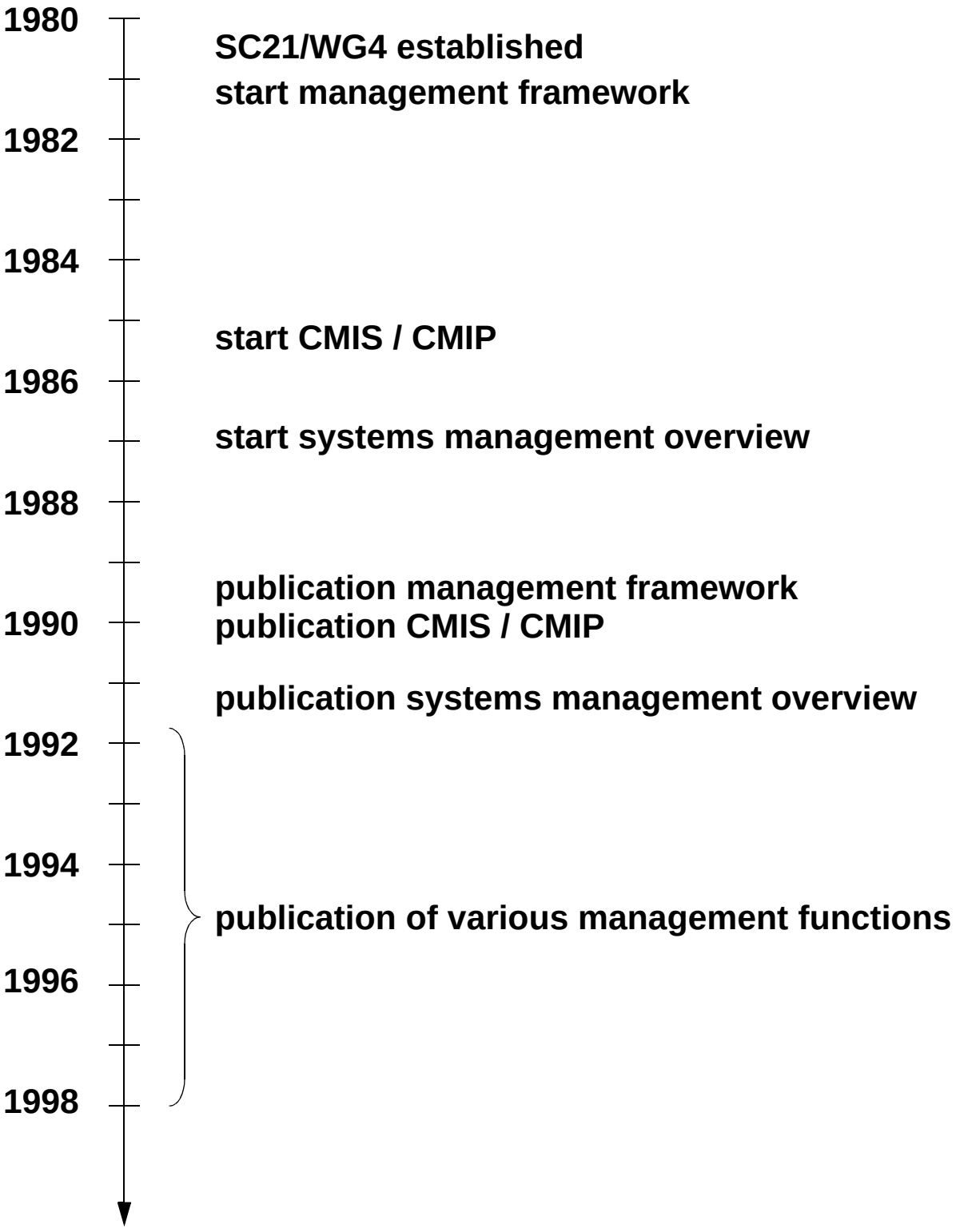
ISO STANDARDIZATION



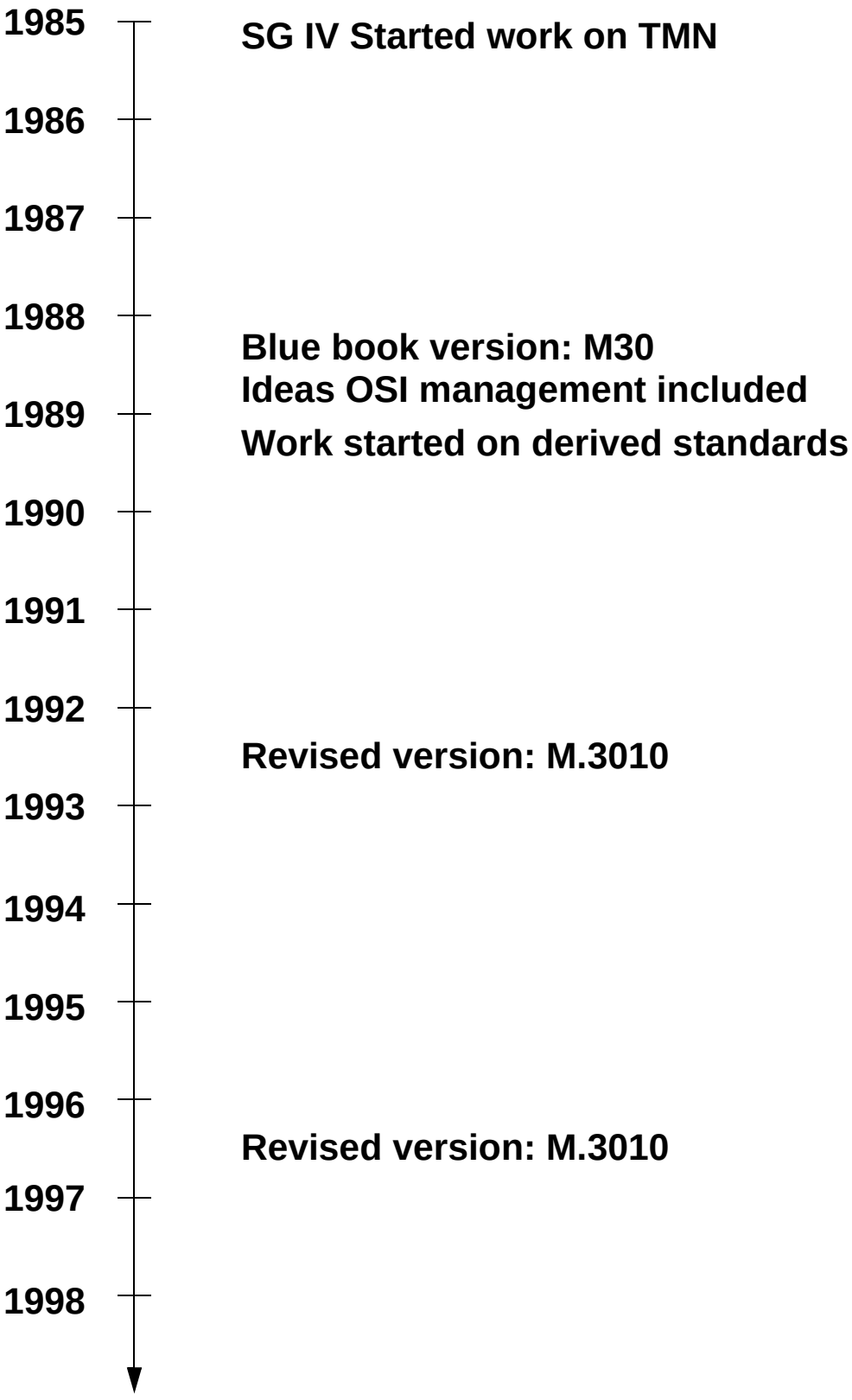
HISTORY IETF



HISTORY ISO


1980
SC21/WG4 established
start management framework
1982
1984
start CMIS / CMIP
1986
start systems management overview
1988
publication management framework
1990
publication CMIS / CMIP
publication systems management overview
1992
1994
publication of various management functions
1996
1998

HISTORY ITU-T



OTHER APPROACHES

IEEE

BASED ON OSI

COMMON MANAGEMENT OVER LLC
CMOL

CANNOT OPERATE ACROSS
LAYER 3 ROUTERS

PROMOTED BY IBM

NO AGENT IMPLEMENTATIONS

OTHER APPROACHES

NM-FORUM

FORMED IN 1988

OMNI*POINT*

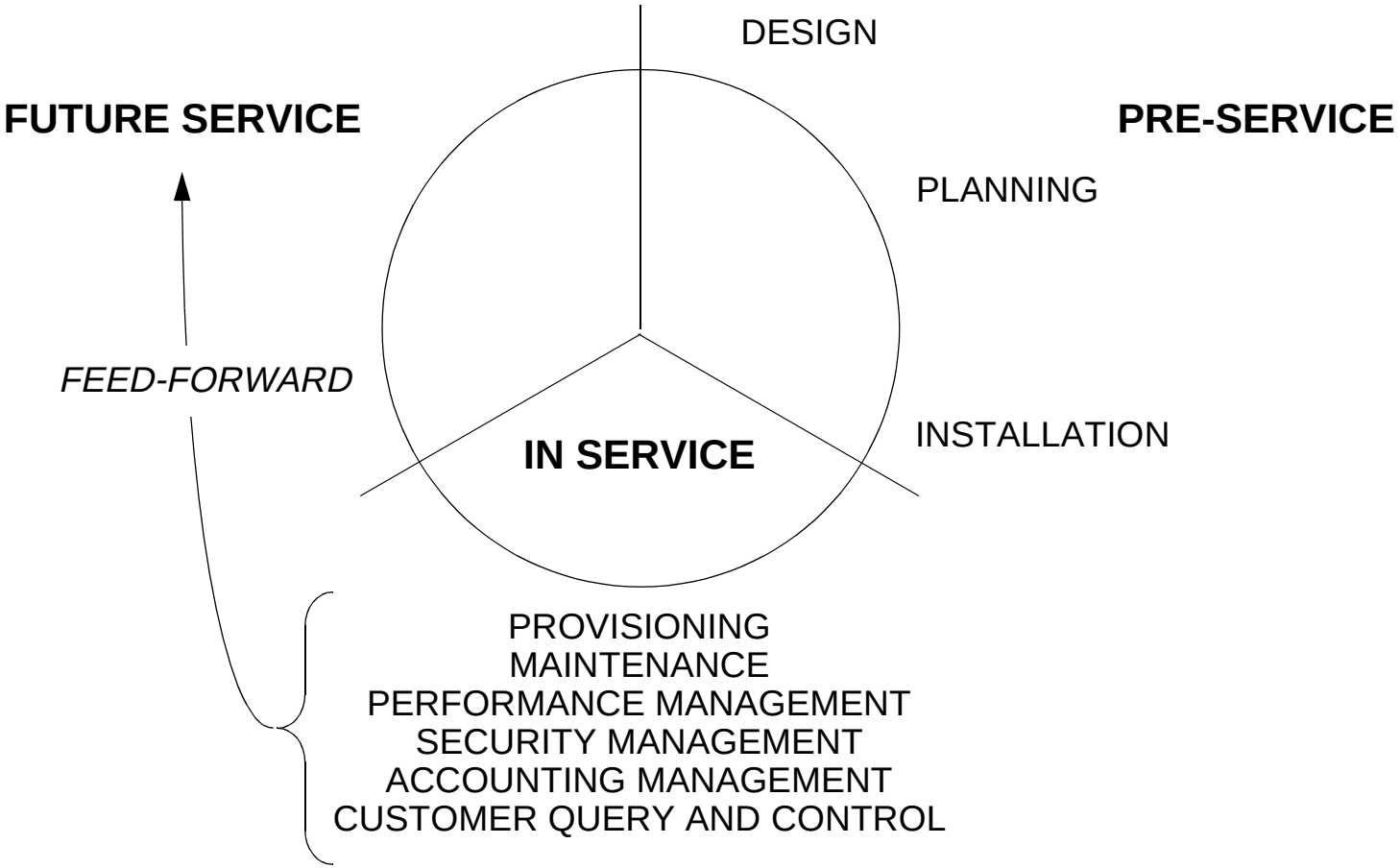
ORIGINALLY BASED ON OSI

NOWADAYS ALSO IETF

XMP & XOM
FROM X/OPEN

CORBA
FROM OMG

RACE


DESIGN
FUTURE SERVICE
PRE-SERVICE
PLANNING
FEED-FORWARD
IN SERVICE
INSTALLATION
PROVISIONING
MAINTENANCE
PERFORMANCE MANAGEMENT
SECURITY MANAGEMENT
ACCOUNTING MANAGEMENT
CUSTOMER QUERY AND CONTROL

TMN

TELECOMMUNICATIONS MANAGEMENT NETWORK

ITU-T
(CCITT)

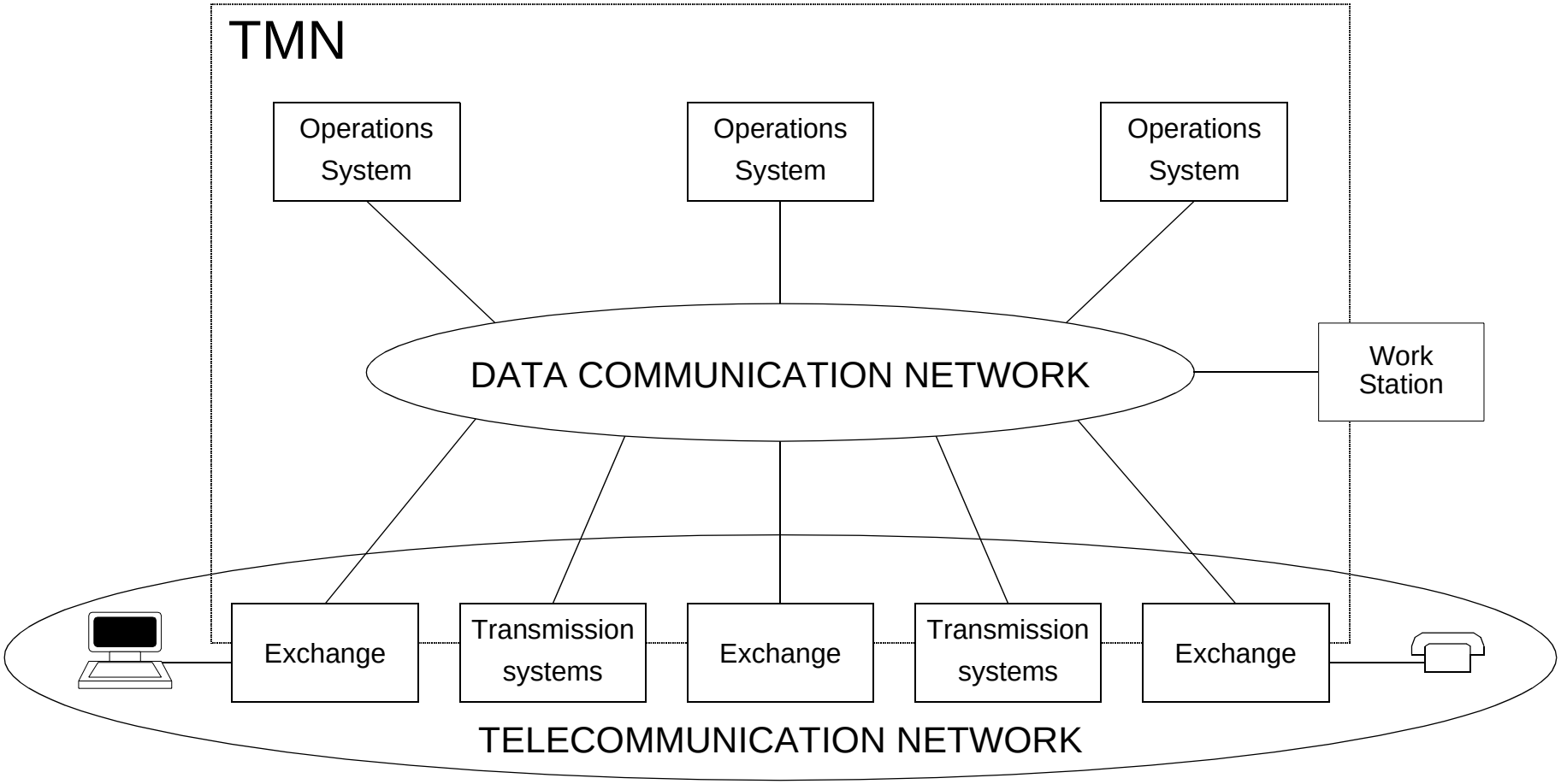
DEFINITION STARTED 1985

DEFINED IN M-SERIES
- M.3010

USES
OSI SYSTEMS MANAGEMENT

FAMOUS FOR ITS
MANAGEMENT HIERARCHY
CONCEPT

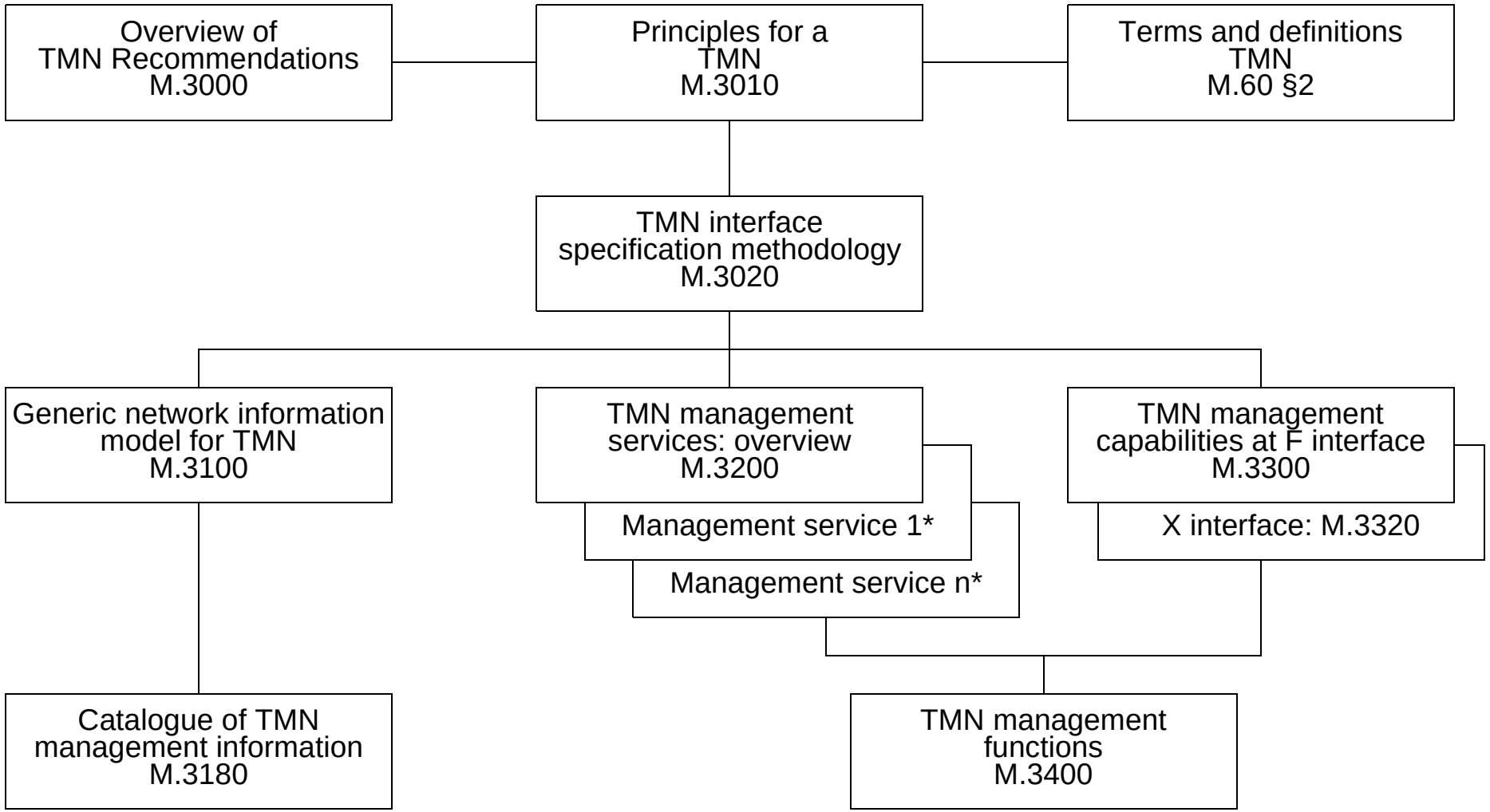
STRUCTURE


TMN
Operations System
Operations System
Operations System
DATA COMMUNICATION NETWORK
Work Station
Exchange
Transmission systems
Exchange
Transmission systems
Exchange
TELECOMMUNICATION NETWORK

STANDARDS - I

Title	NUMBER	DATE
Overview of TMN Recommendations	M.3000	10/94
Principles for a TMN	M.3010	05/95
TMN interface specification methodology	M.3020	07/95
Generic network information model	M.3100	07/95
Managed object conformance statements for the generic network inf. model	M.3101	07/95
Catalogue of TMN management information	M.3180	10/92
TMN Management Services: Overview	M.3200	10/92
TMN management Services: Maintenance aspects of B-ISDN management	M.3207.1	05/96
TMN management Services: Fault and performance mgt. of the ISDN access	M.3211.1	05/96
TMN management capabilities presented at the F interface	M.3300	10/92
Management requirements framework for the TMN X-interface	M.3320	04/97
TMN management functions	M.3400	04/97

STANDARDS - II



TMN-ISDN STANDARDS

Title	NUMBER	DATE
Principles for the management of ISDNs	M.3600	10/92
Application of maintenance principles to ISDN subscriber installations	M.3602	10/92
Application of maintenance principles to ISDN basic rate access	M.3603	10/92
Application of maintenance principles to ISDN primary rate access	M.3604	10/92
Application of maintenance principles to static multiplexed basic rate access	M.3605	10/92
Principles for applying the TMN concept to the management of B-ISDN	M.3610	05/96
Test management of the B-ISDN ATM layer using the TMN	M.3611	04/97
Principles for the use of ISDN test calls, systems and responders	M.3620	10/92
Integrated management of the ISDN customer access	M.3621	07/95
Management of the D-channel - Data link layer and network layer	M.3640	10/92
Management information model for the management of the data link and network layer of the ISDN D channel	M.3641	10/94
Network performance measurements of ISDN calls	M.3650	04/97
ISDN interface management services	M.3660	10/92

RELATION WITH ISO

REFERENCE TO ISO MANAGEMENT STANDARDS

- SAME VIEW OF MANAGER-AGENT CONCEPT

- SAME OO APPROACH

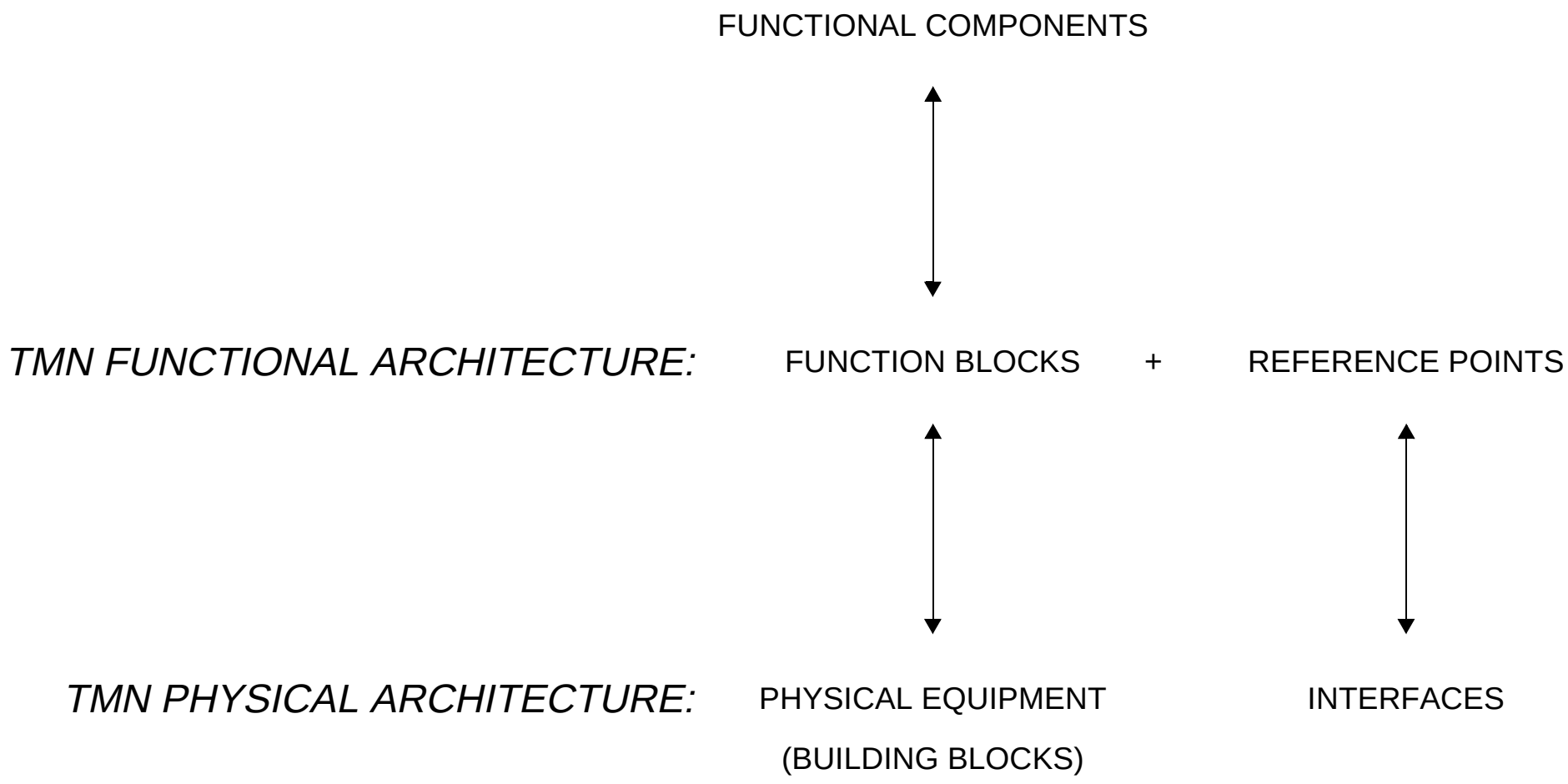
- SAME MANAGEMENT INFORMATION MODEL (INFORMATION ARCHITECTURE)

- SAME PROTOCOLS (CMIP)

TMN ARCHITECTURES

- FUNCTIONAL ARCHITECTURE
- PHYSICAL ARCHITECTURE
- INFORMATION ARCHITECTURE
- LOGICAL LAYERED ARCHITECTURE

FUNCTIONAL AND PHYSICAL ARCHITECTURE



FUNCTIONAL COMPONENTS

- MAF

MANAGEMENT APPLICATION FUNCTION

- ICF

INFORMATION CONVERSION FUNCTION

- WSSF

WORKSTATION SUPPORT FUNCTION

- UISF

USER INTERFACE SUPPORT FUNCTION

- MCF

MESSAGE COMMUNICATION FUNCTION

- DSF

DIRECTORY SYSTEM FUNCTION

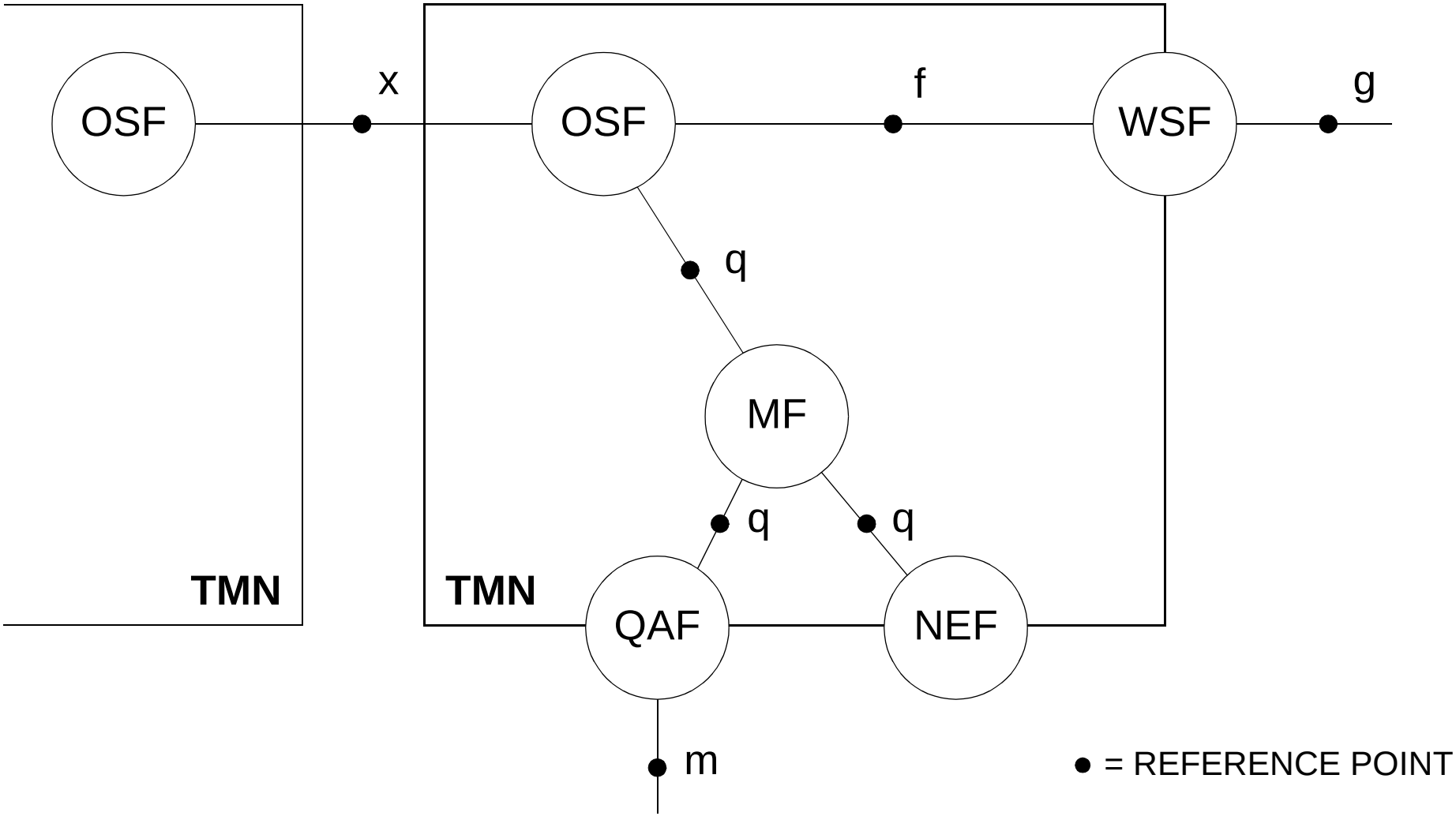
- DAF

DIRECTORY ACCESS FUNCTION

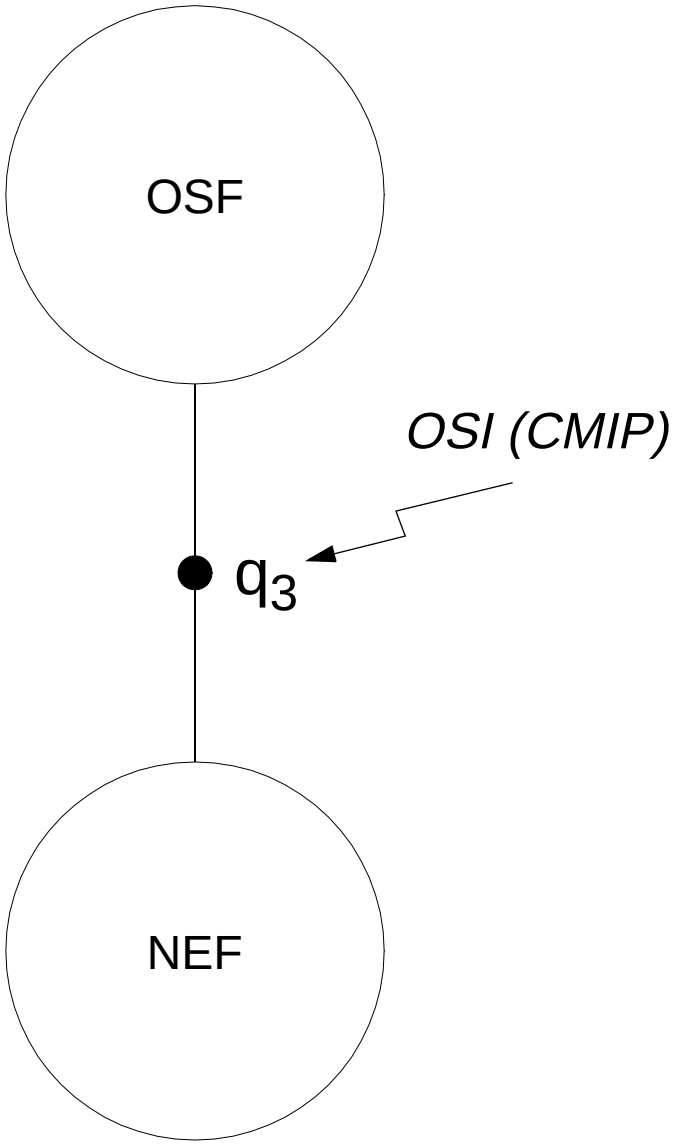
- SF

SECURITY FUNCTION

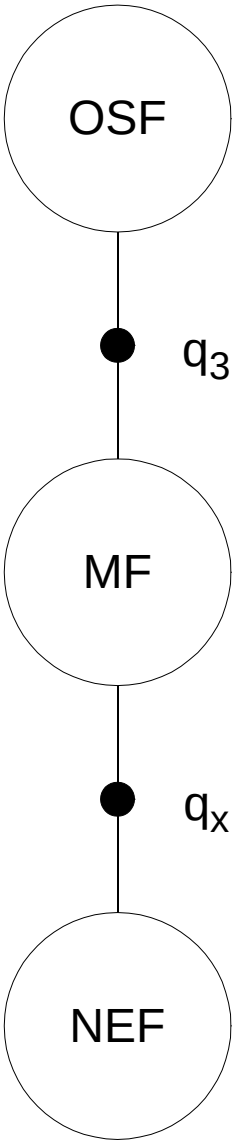
FUNCTIONAL ARCHITECTURE



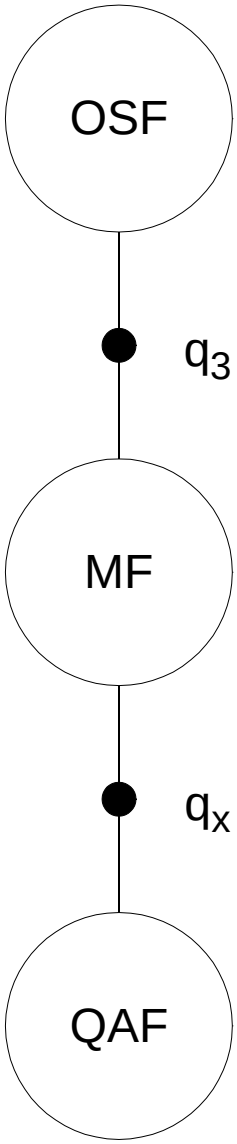
OSF AND NEF



MEDIATION FUNCTIONS

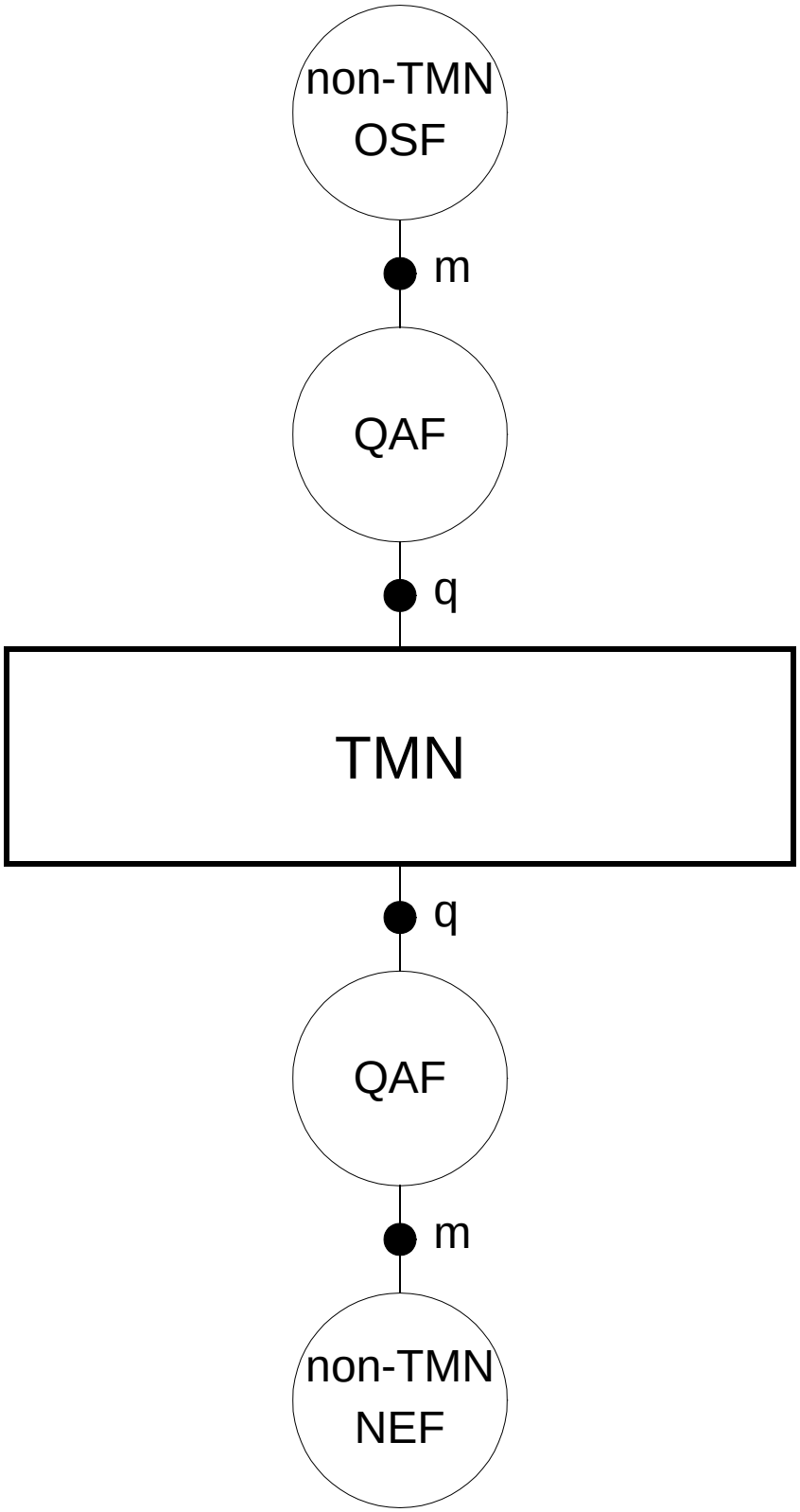


MF BETWEEN
NEF AND OSF



MF BETWEEN
QAF AND OSF

Q ADAPTOR FUNCTIONS

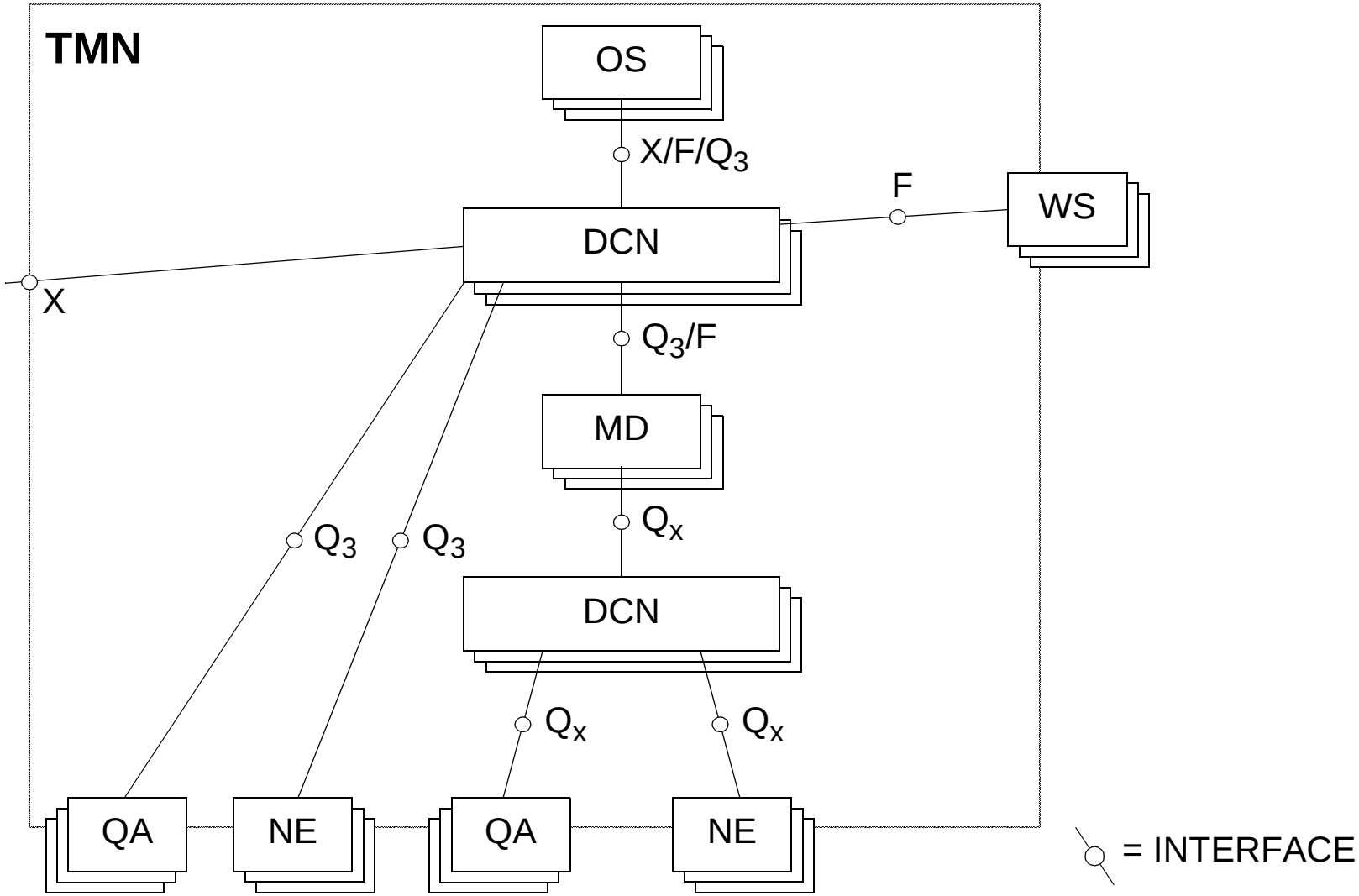


FUNCTIONAL COMPONENTS & FUNCTION BLOCKS

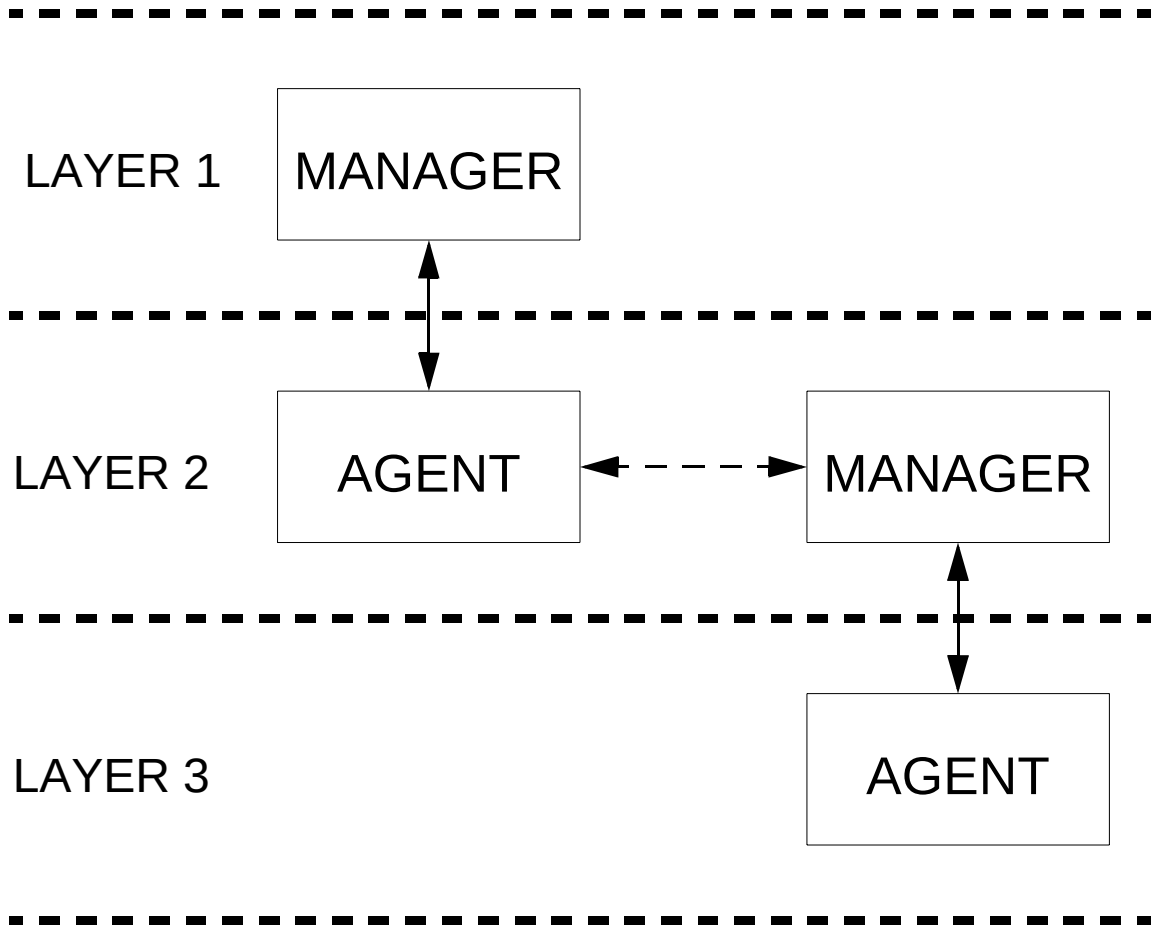
	MAF[1]	ICF	WSSF	UISF	DSF	DAF	SF
OSF	M	O	O		O	O	O
WSF	[2]	[2]		M		O	O
NEFq_3	M				O	O	O
NEFq_x	O				O	O	O
MF	O	M	O		O	O	O
QAFq_3	O	M			O	O	O
QAFq_x	O	M			O	O	O

1: MAF is considered to be additional to any Agent or Manager activities and may be inconflict with ISO definitions
2: These functions (or equivalent) may be considered to be as part of the UISF

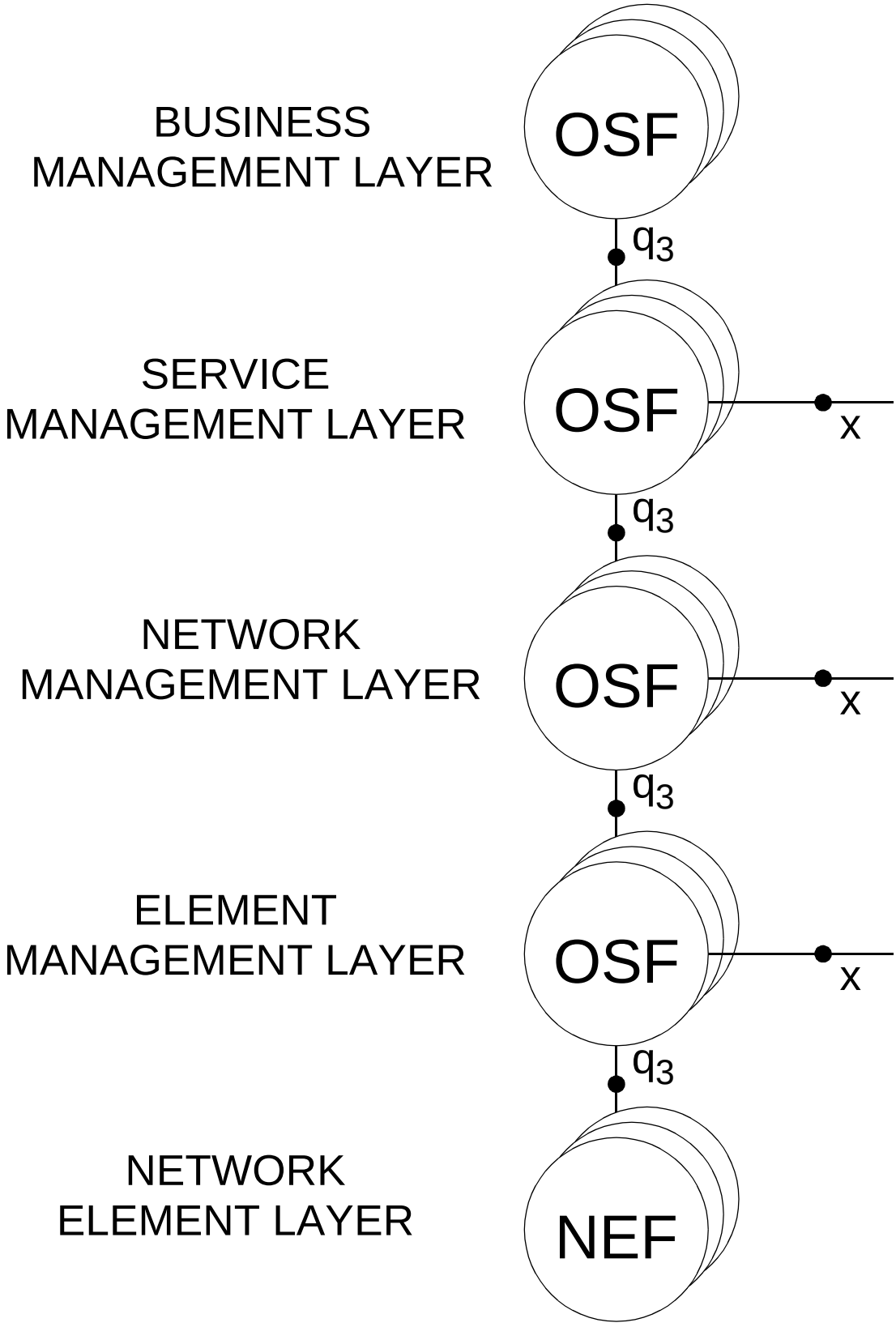
PHYSICAL ARCHITECTURE



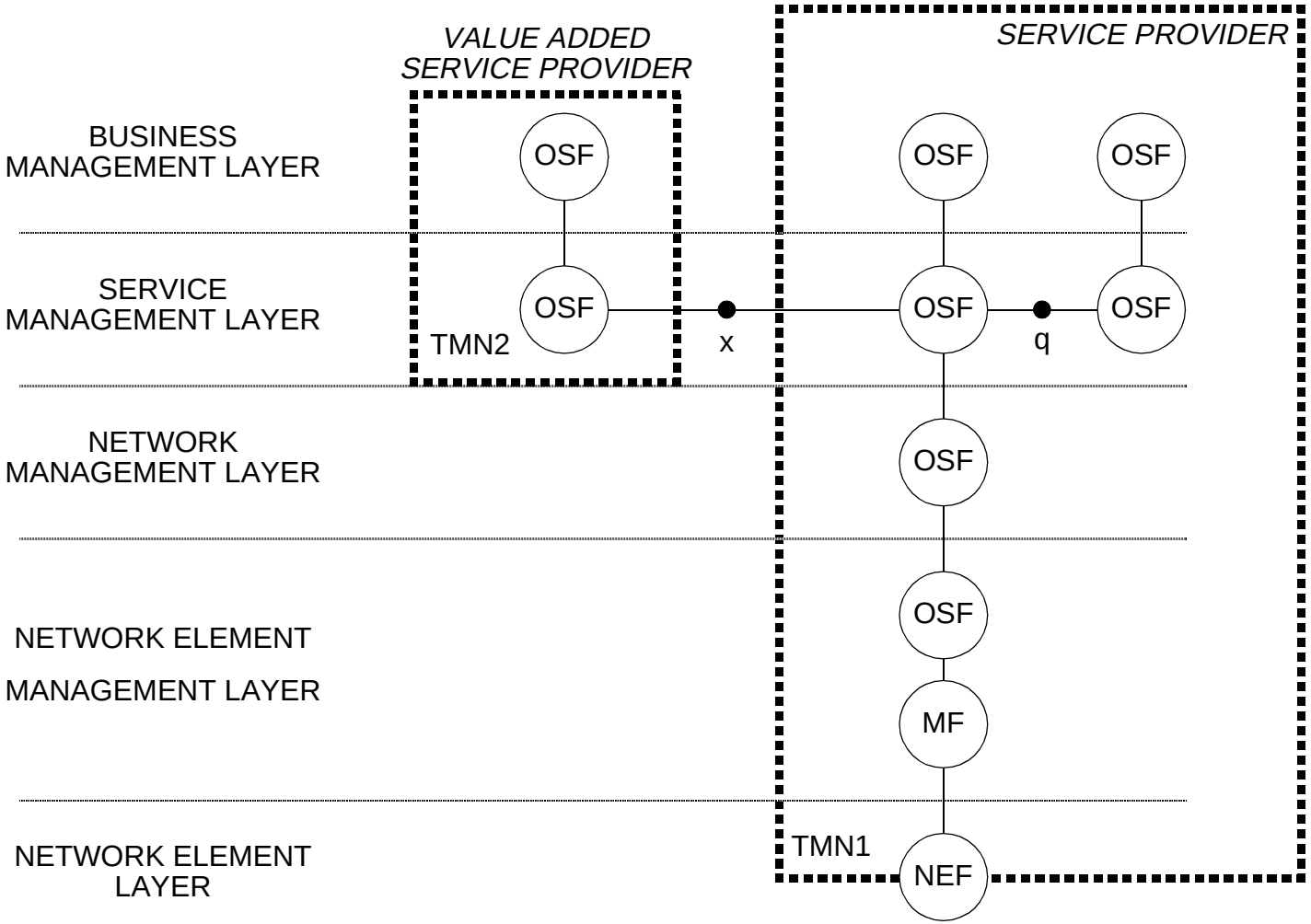
LOGICAL LAYERED ARCHITECTURE



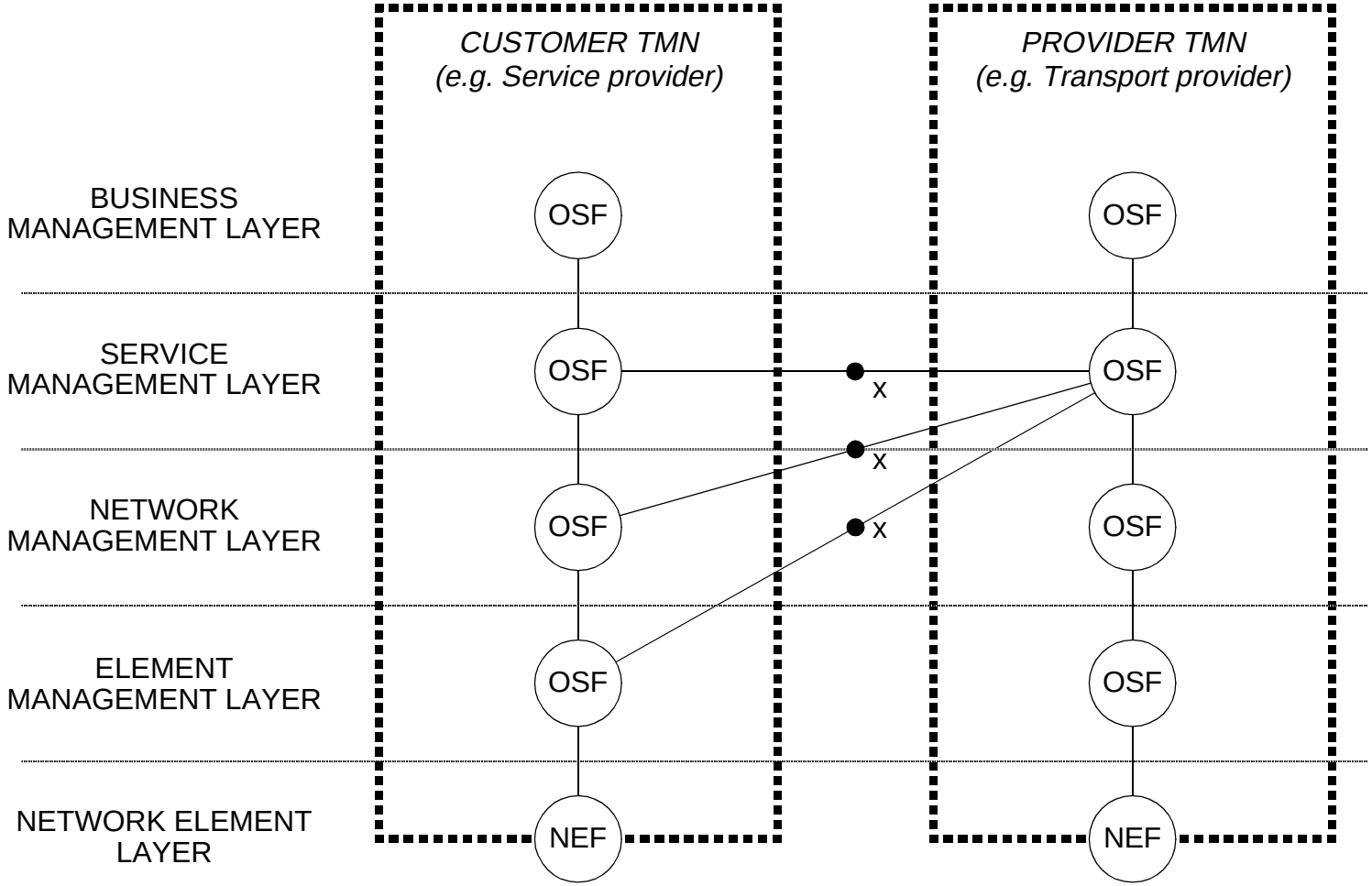
LOGICAL LAYERED ARCHITECTURE



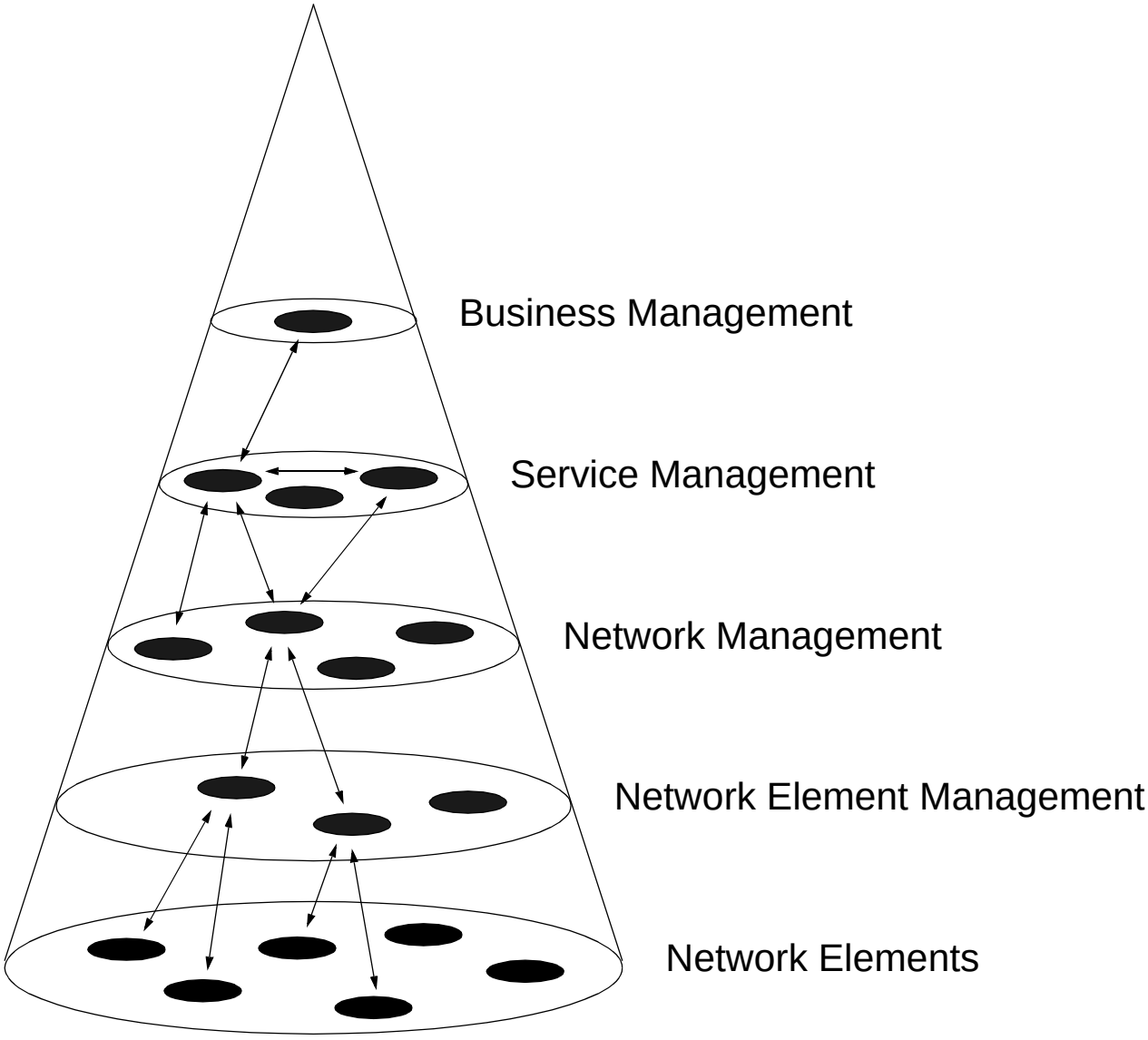
MANAGEMENT HIERARCHY: EXAMPLE - I



MANAGEMENT HIERARCHY: EXAMPLE - II



RESPONSIBILITY MODEL



DEVELOPED BY BT

OSI MANAGEMENT

STANDARDS

BASIC CONCEPTS
OSI MANAGEMENT FRAMEWORK

INFORMATION ASPECTS

ORGANISATIONAL ASPECTS

FUNCTIONAL ASPECTS

COMMUNICATION ASPECTS

COMPARISON TO SNMP

STANDARDS

PRINCIPLES

• MANAGEMENT FRAMEWORK
manager-agent concept
managed object concept
functional areas
systems mngt, layer mngt & layer operation
• SYSTEMS MANAGEMENT OVERVIEW

MANAGED OBJECTS

• SMI
• GDMO
• LAYER OBJECT DEFINITIONS

MANAGEMENT APPLICATIONS

• MIS

COMMUNICATION

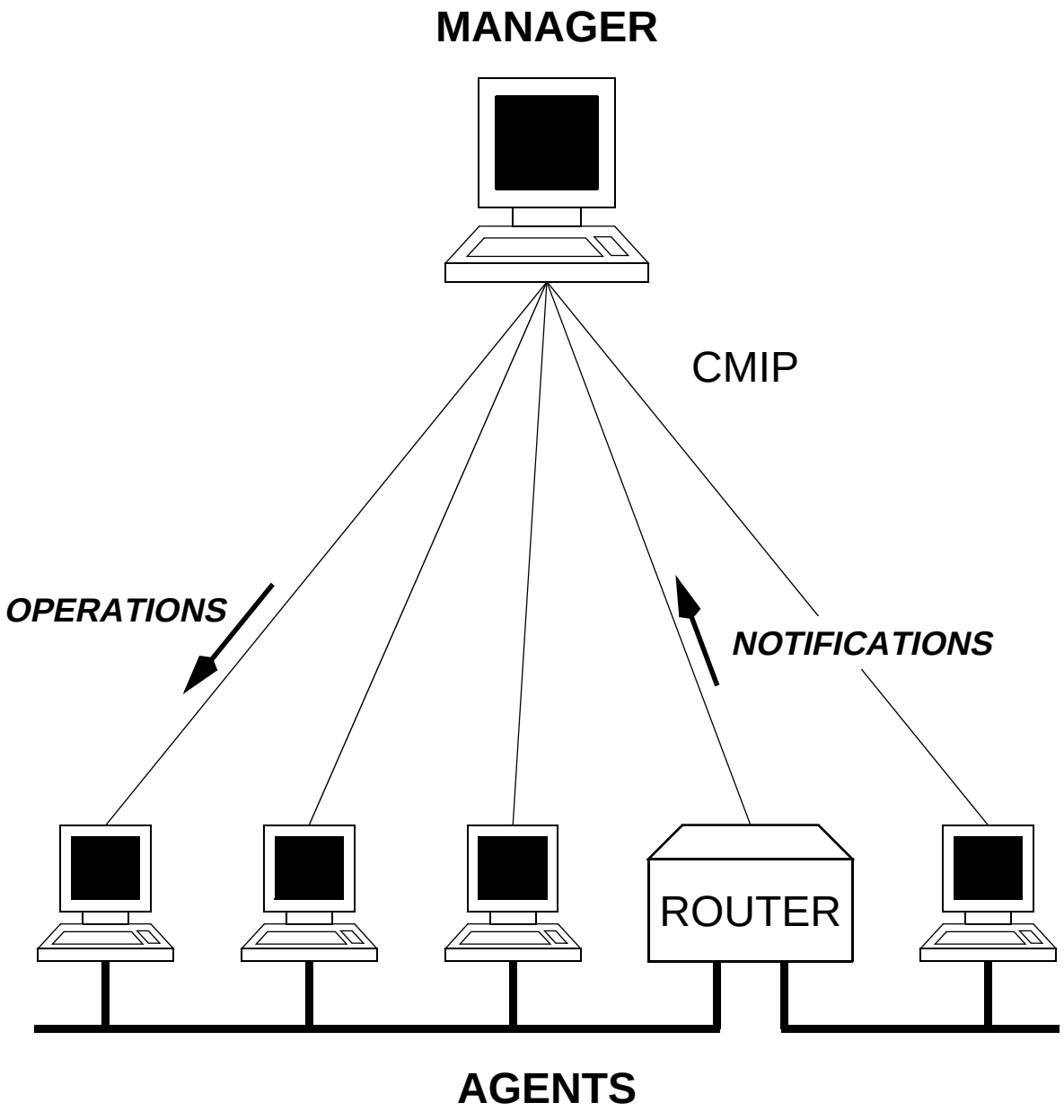
• CMIP / CMIS

STANDARDS

Title	ISO/IEC	ITU-T
MANAGEMENT FRAMEWORK	7498/4	X.700
SMO SYSTEMS MANAGEMENT OVERVIEW	10040	X.701
CMIS COMMON MANAGEMENT INFORMATION SERVICE	9595	X.710
CMIP COMMON MANAGEMENT INFORMATION PROTOCOL	9596	X.711
SMF SYSTEMS MANAGEMENT FUNCTIONS	10164x	X73x - X75x
SMI STRUCTURE OF MANAGEMENT INFORMATION	10165x	X72x

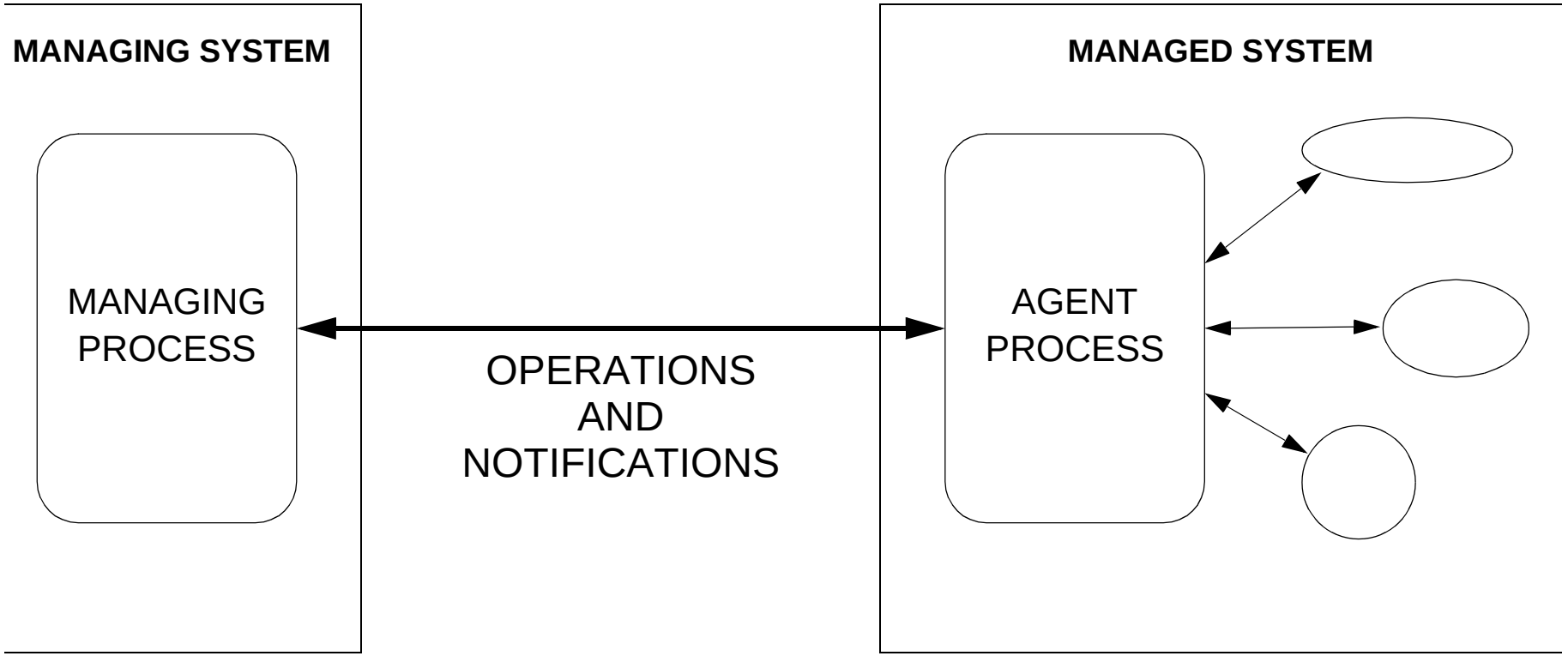
MANAGEMENT FRAMEWORK

MANAGER-AGENT CONCEPT



MANAGEMENT FRAMEWORK

MANAGED-OBJECT CONCEPT



MANAGEMENT FRAMEWORK

FUNCTIONAL AREA'S

FAULT MANAGEMENT

CONFIGURATION MANAGEMENT

ACCOUNTING MANAGEMENT

PERFORMANCE MANAGEMENT

SECURITY MANAGEMENT

MANAGEMENT FRAMEWORK

MANAGEMENT INFORMATION EXCHANGE

SYSTEMS MANAGEMENT

- USE ALL 7 LAYERS
- ROYAL ROUTE
- PREFERRED APPROACH
- EXPLICIT MANAGEMENT APPROACH

LAYER MANAGEMENT

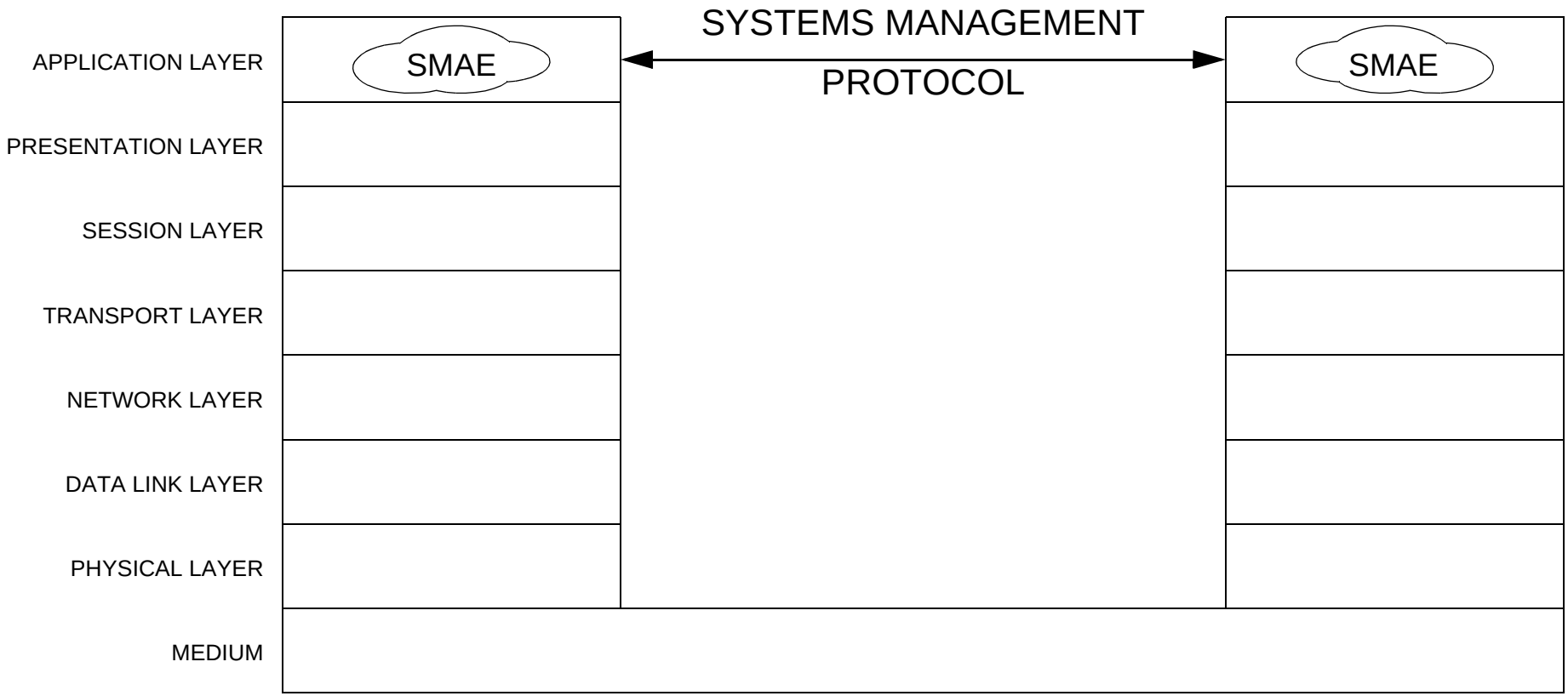
- USE UNDERLYING LAYERS
- DEFINED IN SEPARATE STANDARD
- IMPLICIT MANAGEMENT APPROACH

LAYER OPERATION

- USE UNDERLYING LAYERS
- DEFINED AS PART OF LAYER STANDARD
- IMPLICIT MANAGEMENT APPROACH

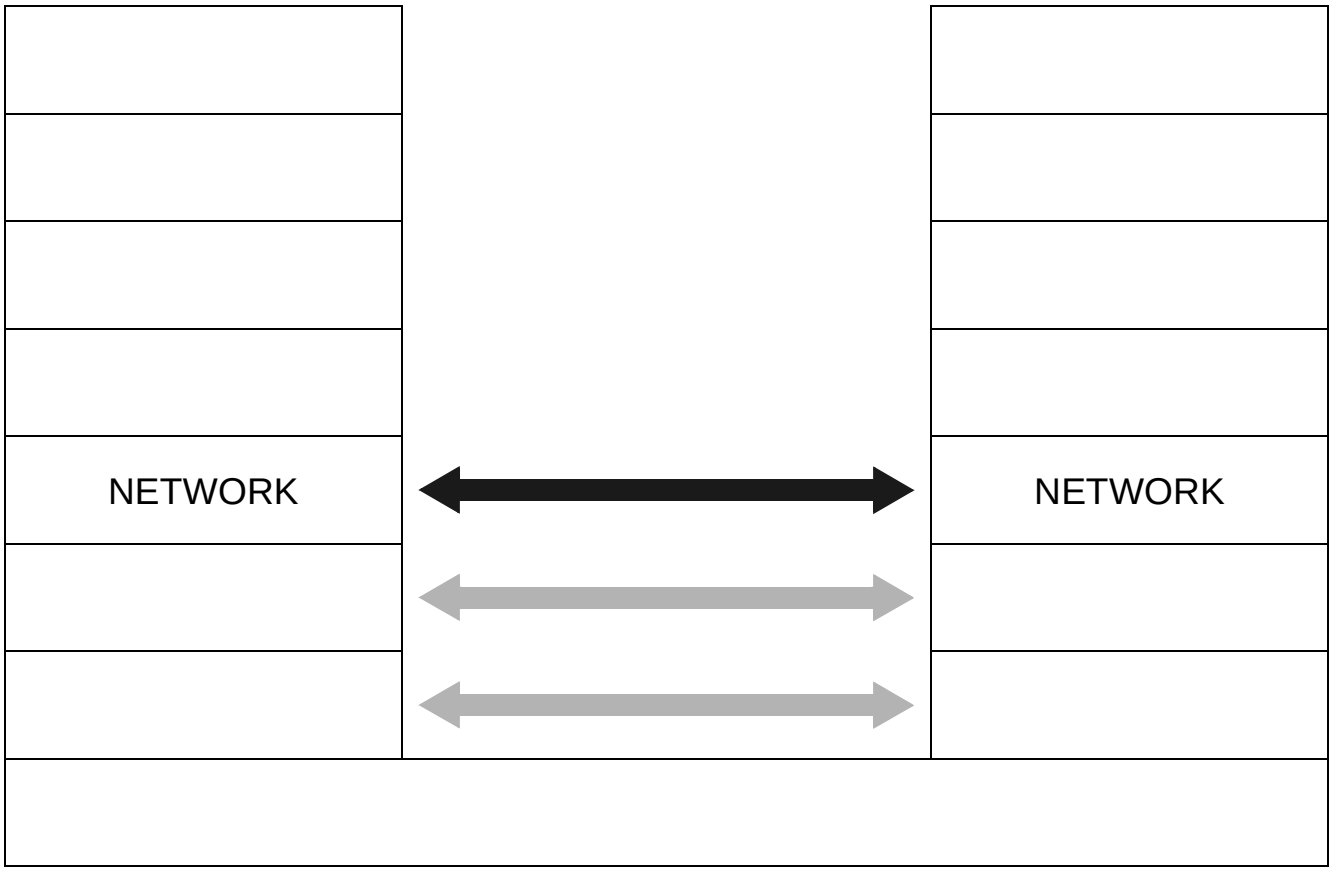
MANAGEMENT FRAMEWORK

SYSTEMS MANAGEMENT



MANAGEMENT FRAMEWORK

LAYER MANAGEMENT

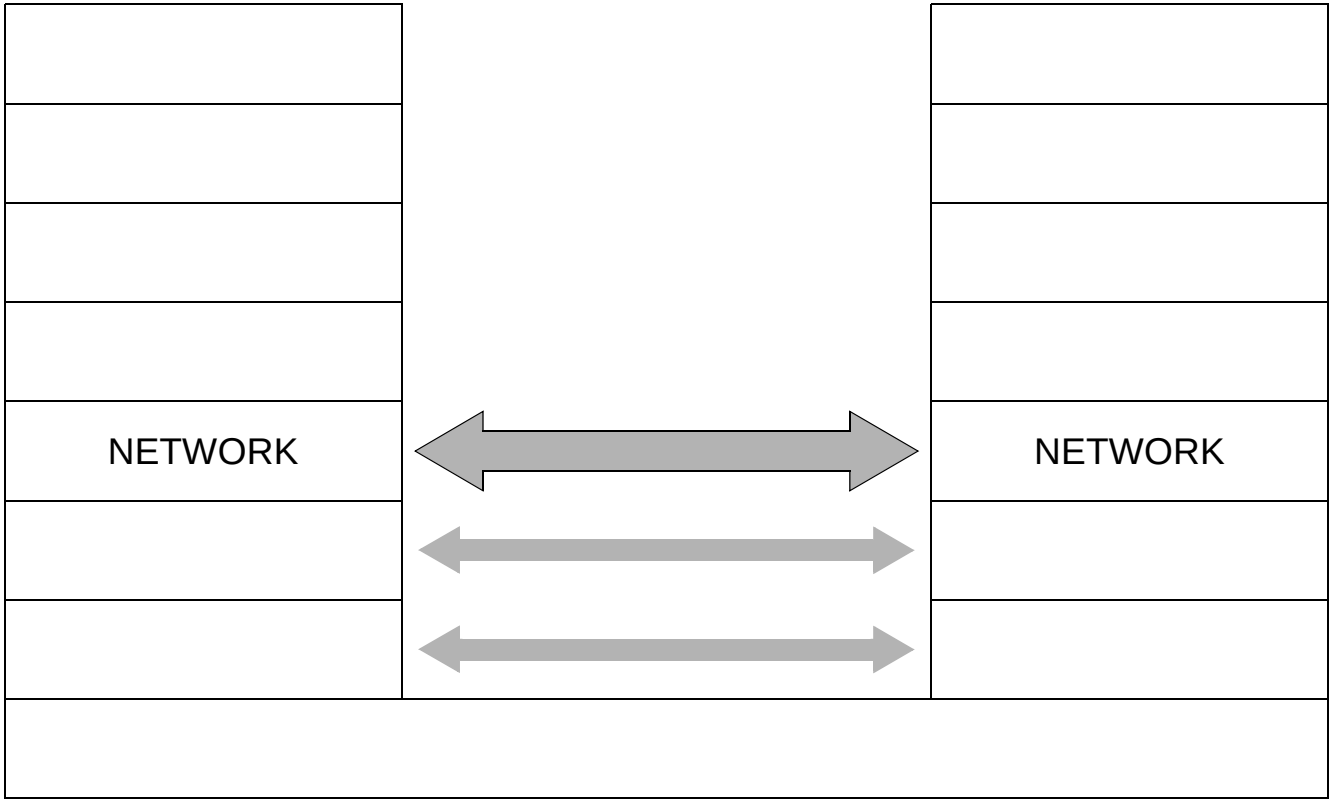


SPECIAL PURPOSE LAYER MANAGEMENT PROTOCOL

NORMAL COMMUNICATIONS PROTOCOL

MANAGEMENT FRAMEWORK

LAYER OPERATION



NORMAL COMMUNICATIONS PROTOCOL CARRYING 'LAYER OPERATION' INFORMATION

NORMAL COMMUNICATIONS PROTOCOL

INFORMATION ASPECTS

SINCE 1988:

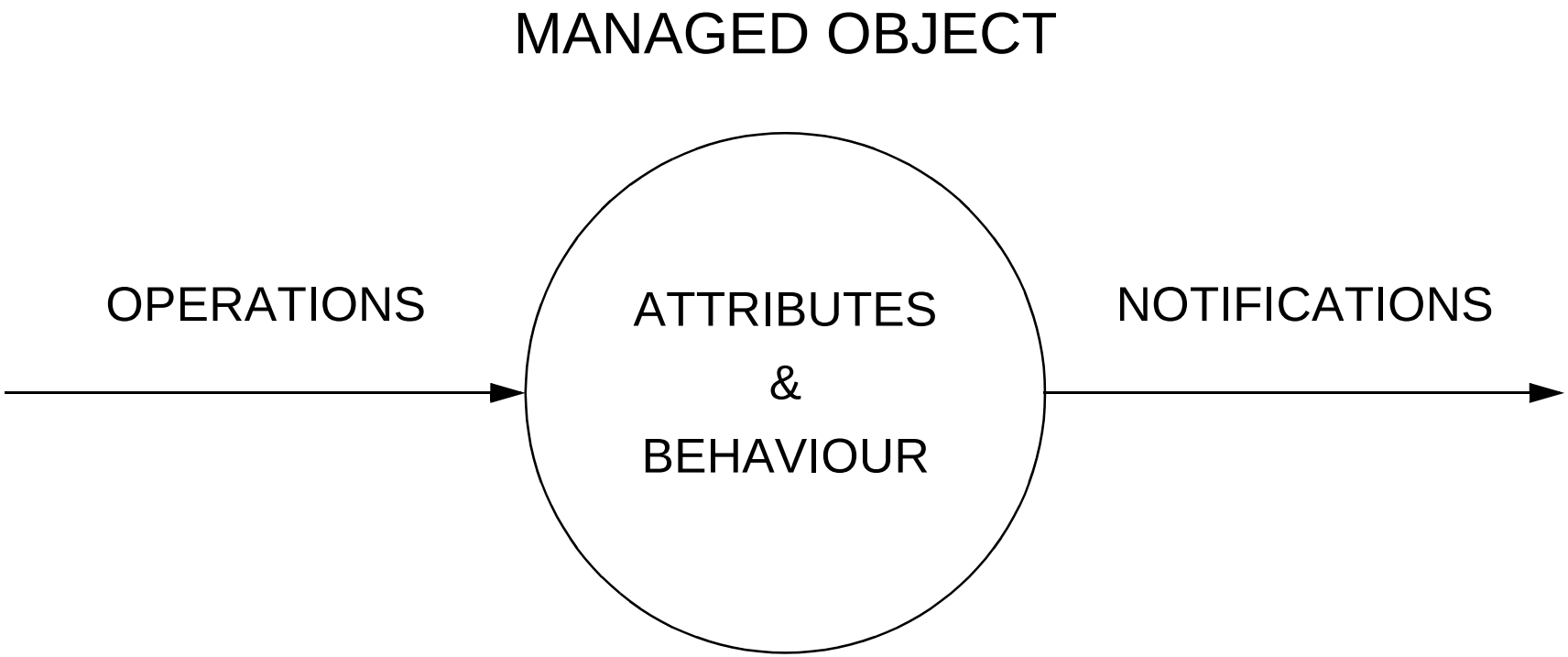
OBJECT ORIENTED APPROACH

OO-APPROACH

- ENCAPSULATION
- CONTAINMENT
- OBJECT CLASSES & INHERITANCE
- ALLOMORPHISM

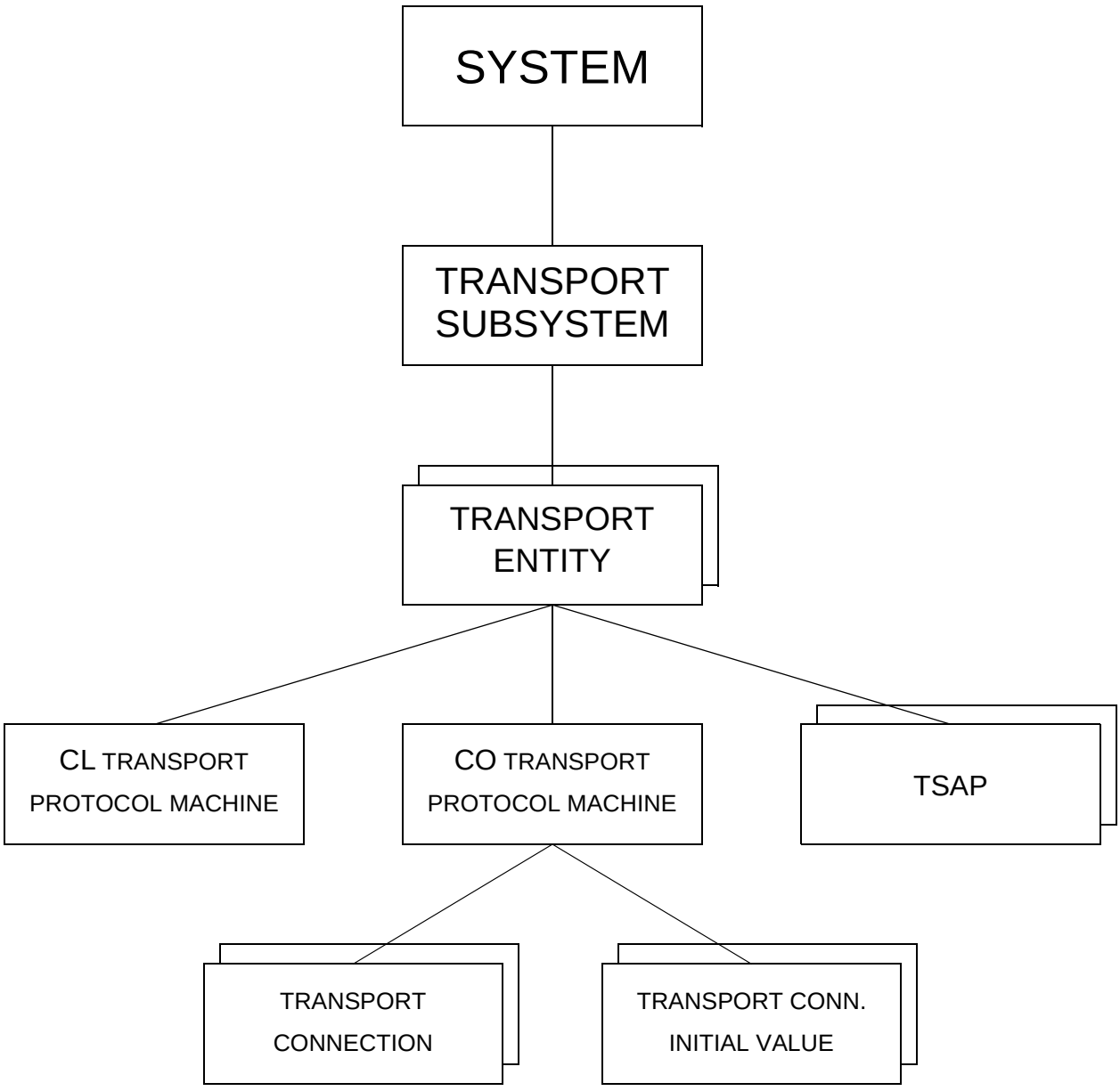
RELATED STANDARDS

ENCAPSULATION



CONTAINMENT

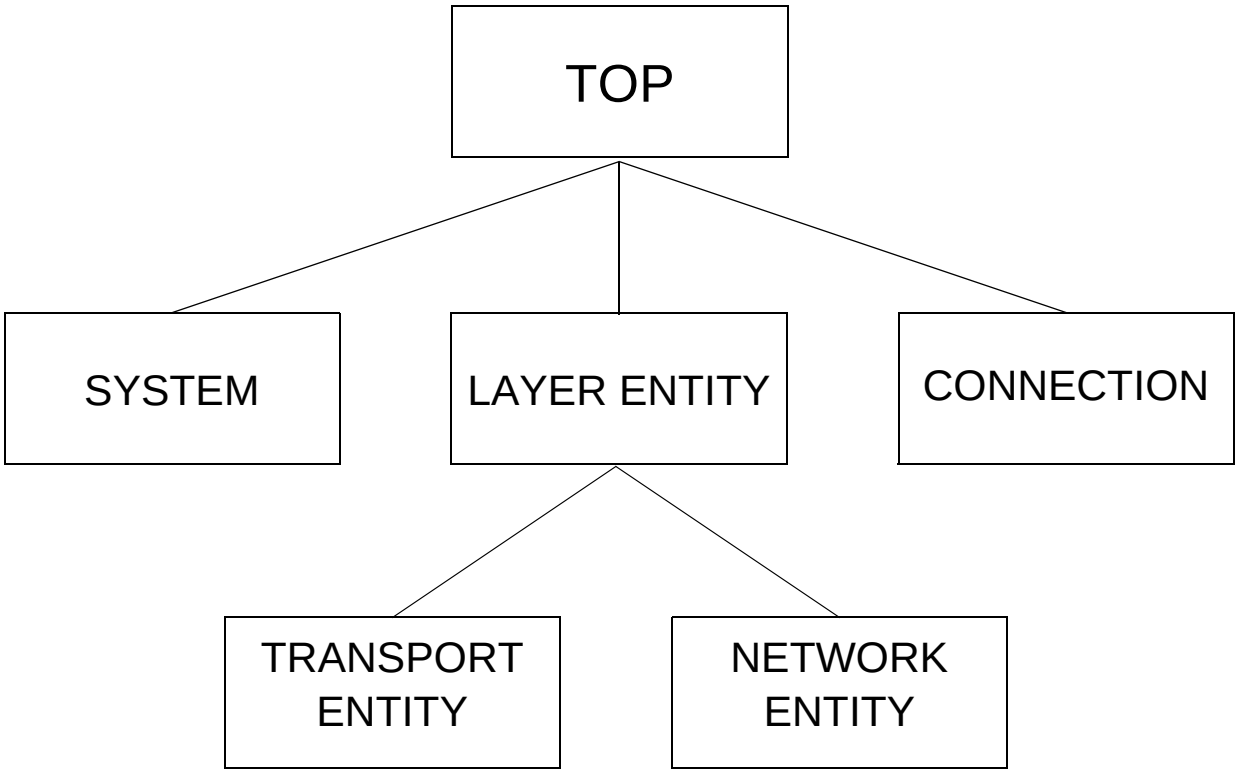
OBJECT MAY **CONTAIN**
ONE OR MORE SMALLER OBJECTS



RESULTS INTO A *MANAGED OBJECT* TREE

CLASSES AND INHERITANCE

SUBCLASS INHERITS CHARACTERISTICS
(= ATTRIBUTES, BEHAVIOUR, OPERATIONS AND NOTIFICATIONS)
OF SUPERCLASS



RESULTS INTO A TREE
OF MANAGED OBJECT *CLASSES*

ALLOMORPHISM

"THE ABILITY OF A MANAGED OBJECT
TO ACT AS IF IT BELONGS
TO ANOTHER MANAGED OBJECT CLASS"

POLYMORPHISM

USEFUL TO:

- UPDATE A MIB

- EXTEND A MIB
WITH PROPRIETARY FEATURES

- CUSTOMIZE MIB VIEWS
FOR DIFFERENT MANAGERS

OSI MANAGEMENT TREES

• INHERITANCE TREE

SHOWS THE RELATION BETWEEN *OBJECT CLASSES*

• CONTAINMENT TREE

SHOWS THE RELATION BETWEEN *OBJECT INSTANCES*

• REGISTRATION TREE

ASSIGNS NAMES
TO *DEFINITIONS* OF
OBJECT CLASSES, ATTRIBUTES, ACTIONS
NOTIFICATIONS AND PACKAGES

USEFUL DURING THE DESIGN PHASE
TO REGISTER *DEFINITIONS*

STANDARDS FOR MANAGEMENT INFORMATION - 1

Title	ISO/IEC	ITU-T
MANAGEMENT INFORMATION MODEL	10165-1	X.720
DEFINITION OF MANAGEMENT INFORMATION	10165-2	X.721
GDMO: GUIDELINES TO THE DEFINITION OF MANAGED OBJECTS	10165-4	X.722
GENERIC MANAGEMENT INFORMATION	10165-5	X.723
GUIDELINES FOR CONFORMANCE PROFORMAS	10165-6	X724
GENERAL RELATIONSHIP MODEL	10165-7	X725

STANDARDS FOR MANAGEMENT INFORMATION - 2

Title	ISO/IEC	ITU-T
TRANSPORT LAYER MANAGEMENT INFORMATION	10737	X.284
NETWORK LAYER MANAGEMENT INFORMATION	10733	X.283
DATA LINK LAYER MANAGEMENT INFORMATION	10742	X.282
PHYSICAL LAYER MANAGEMENT INFORMATION	13642	X.281

ORGANISATIONAL ASPECTS

MANAGER-AGENT CONCEPT

THERE IS A NEED TO DEFINE
MANAGEMENT HIERARCHIES

MANAGEMENT DOMAINS

- MANAGEMENT POLICIES

POSSIBLE PARTITIONING CRITERIA:

- MANAGEMENT FUNCTIONS
- GEOGRAPHICAL AREAS
- ORGANISATIONS
- ETC.

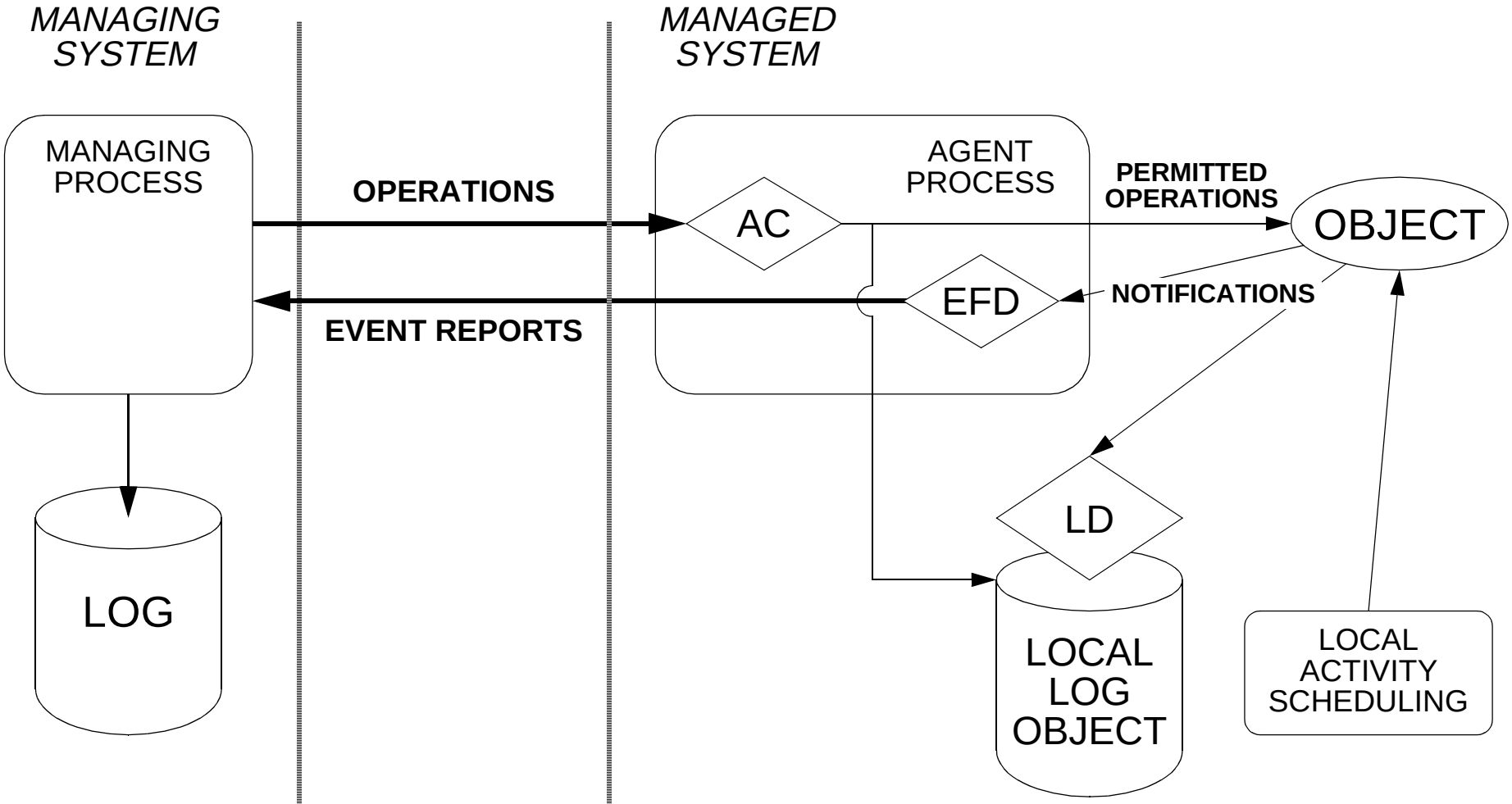
FUNCTIONAL ASPECTS

AS OPPOSED TO SNMP,
OSI HAS DEFINED A LARGE NUMBER OF MANAGEMENT FUNCTIONS

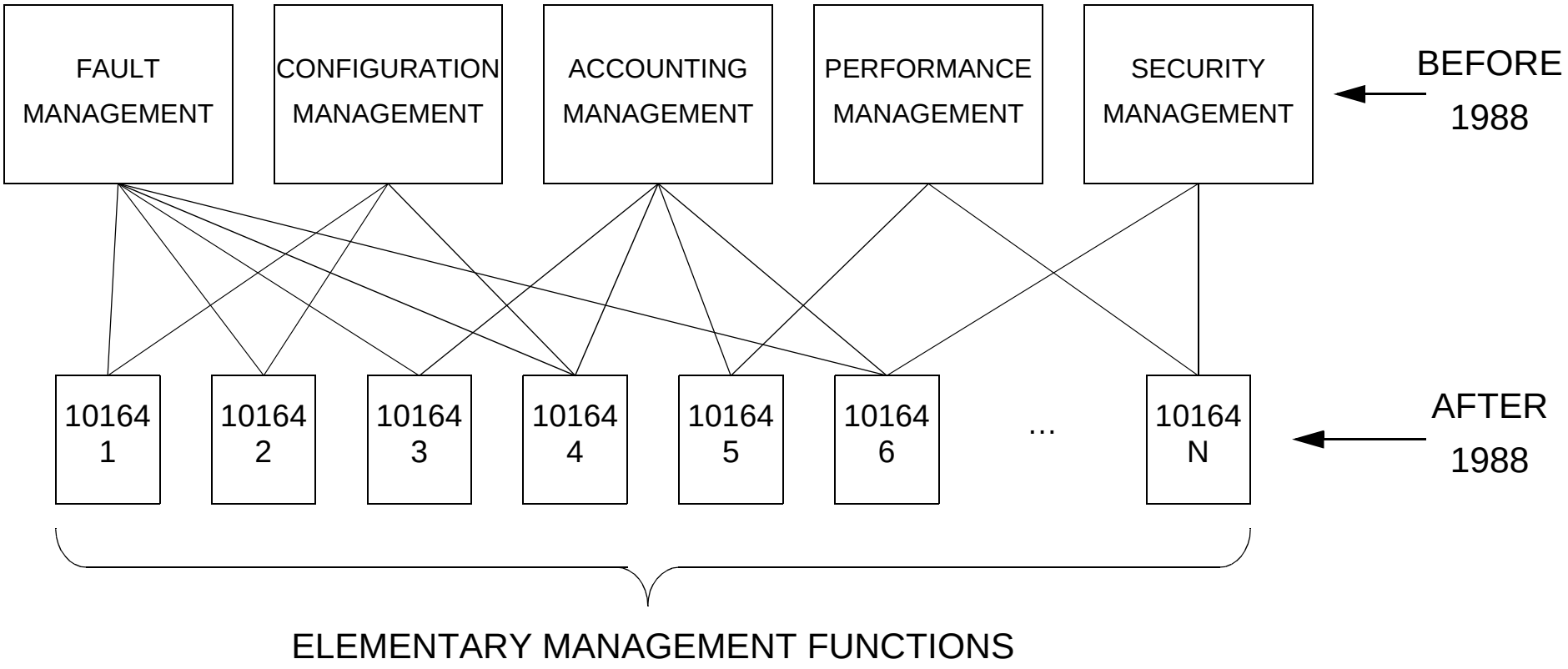
MANY OF THESE FUNCTIONS
SHOULD BE PERFORMED
BY AGENTS

AGENTS BECOME COMPLEX

MANAGEMENT FUNCTIONS



MANAGEMENT FUNCTIONS VERSUS FUNCTIONAL AREAS



STANDARDS FOR MANAGEMENT FUNCTIONS

Title	ISO/IEC	ITU-T
Object Management Function	10164-1	X.730
State Management Function	10164-2	X.731
Attributes for representing Relationships	10164-3	X.732
Alarm Reporting Function	10164-4	X.733
Event Report Management Function	10164-5	X.734
Log Control Function	10164-6	X.735
Security Alarm Reporting Function	10164-7	X.736
Security Audit Trail Function	10164-8	X.740
Objects and Attributes for Access Control	10164-9	X.741
Accounting Meter Function	10164-10	X.742
Workload Monitoring Function	10164-11	X.739
Test Management Function	10164-12	X.745
Measurement Summarization Function	10164-13	X.738
Confidence and Diagnostic Test Classes	10164-14	X.737
Scheduling Function	10164-15	X.746
Management Knowledge Management Function	10164-16	X.750
Time Management Function		X.743
Software Management Function		X.744
General Relationship Model		X.747
Response Time Monitoring Function		X.748
Management Domain Management Function		X.749
Changeover Function		X.751
Enhanced Event Control Function		X.752

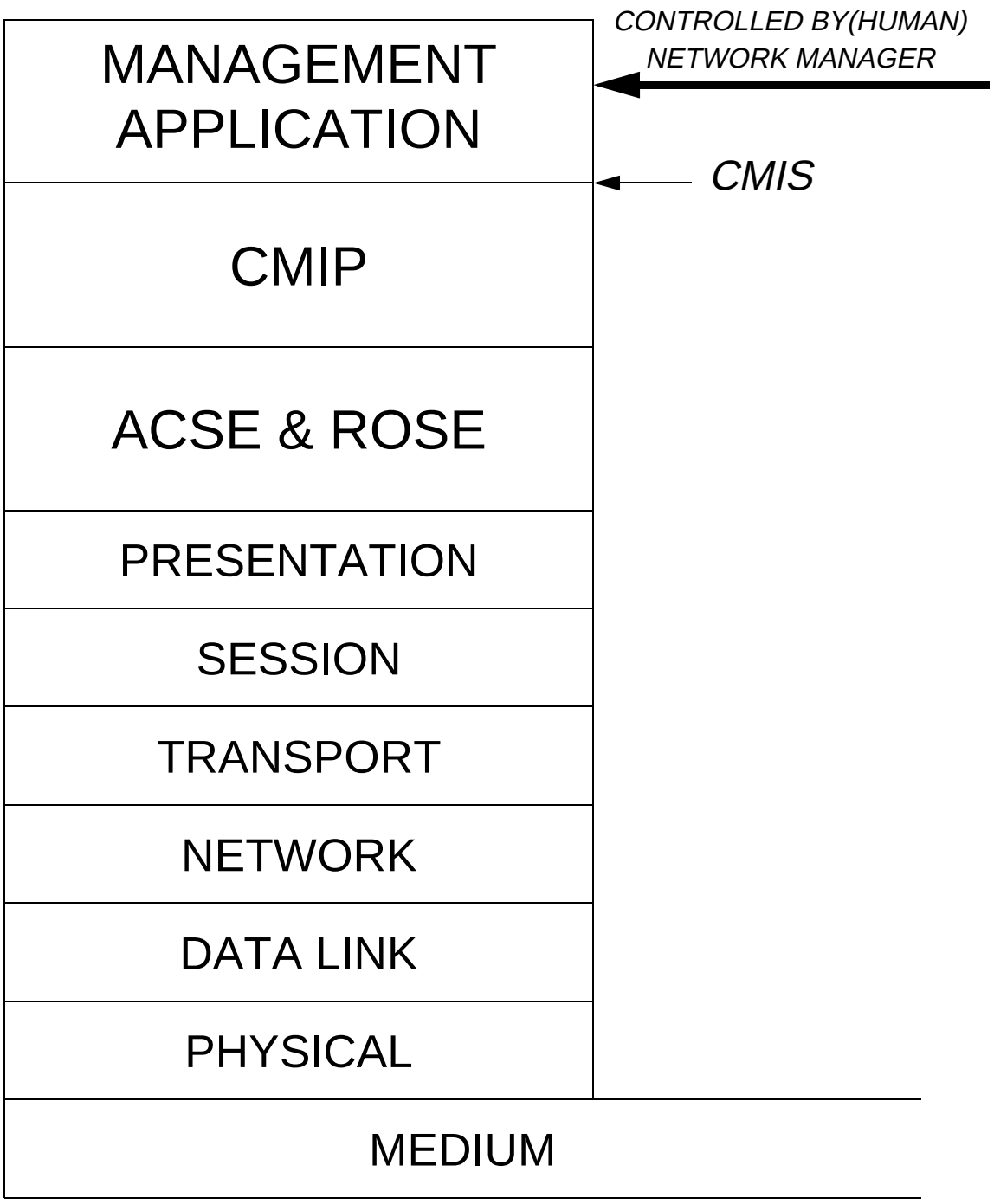
COMMUNICATION ASPECTS

CMIP / CMIS

USES A
CONNECTION ORIENTED
UNDERLYING SERVICE

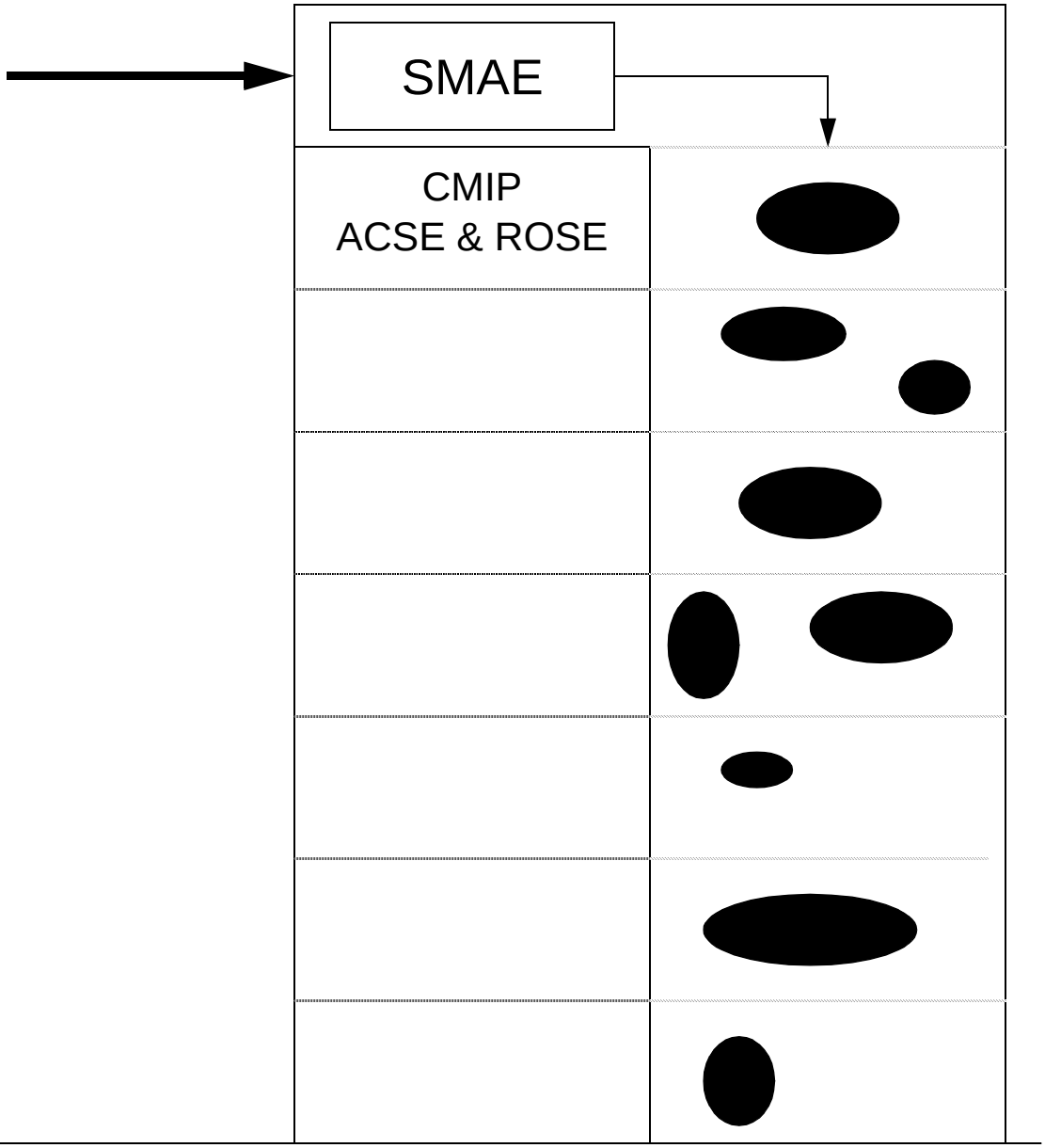
ALLOWS FOR
- SCOPING
- FILTERING

LAYERED STRUCTURE



ACSE - ASSOCIATION CONTROL SERVICE ELEMENT
ROSE = REMOTE OPERATION SERVICE ELEMENT

AGENT STRUCTURE



SMAE = SYSTEMS MANAGEMENT APPLICATION ENTITY

OPERATION SERVICES:

- M-GET (C)
- M-CANCEL-GET (C)
- M-SET (C/U)
- M-ACTION (C/U)
- M-CREATE (C)
- M-DELETE (C)

NOTIFICATION SERVICES:

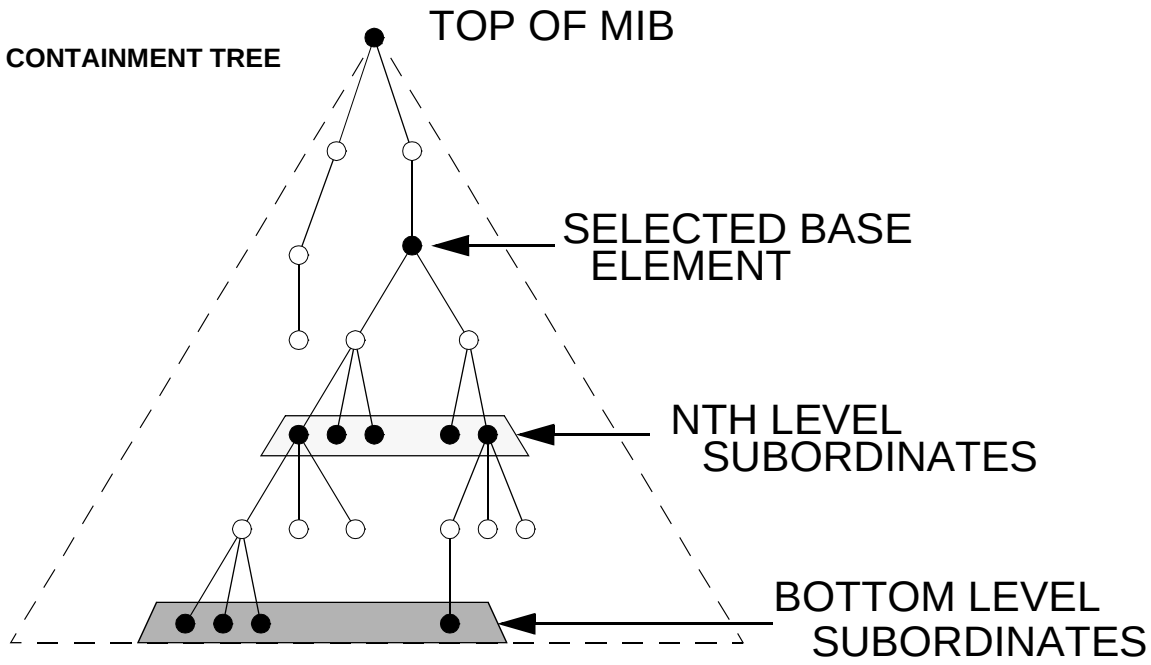
- M-EVENT-REPORT (C/U)

CONNECTION ESTABLISHMENT USES ACSE:

- A-ASSOCIATE
- A-RELEASE
- A-ABORT

SCOPING

ALLOWS THE CREATION OF A *SET* OF OBJECTS



THE SET MAY CONSIST OF:

- THE BASE OBJECT

- ALL N^{th} LEVEL SUBORDINATES

- THE BASE OBJECT
PLUS THE FIRST LEVEL SUBORDINATES
PLUS THE SECOND LEVEL SUBORDINATES
UNTIL THE N^{th} LEVEL SUBORDINATES

- THE BASE OBJECT
PLUS *ALL* SUBORDINATES

FILTERING

TO FURTHER LIMIT THE SET

CHECKS ATTRIBUTE VALUES

- EQUALITY
- GREATER OR EQUAL
- LESS OR EQUAL
- PRESENT
- SUBSTRING
- SUBSET
- SUPERSET
- NON-NULL-SET INTERSECTION

SYNCHRONIZATION

MANAGEMENT OPERATIONS
MAY BE PERFORMED:

- ATOMIC

ALL OR NOTHING
SIMILAR TO SNMP

- BEST EFFORT

INTERNET MANAGEMENT

- INTRODUCTION
- STANDARDS
- STRUCTURE OF MANAGEMENT INFORMATION SMI
- STANDARD MANAGEMENT INFORMATION BASE MIB-II
- SNMP PROTOCOL OPERATIONS
- SNMPv2
- SNMPv3
- PROXIES
- OTHER MIBs
- EXTENSIBLE AGENT TECHNOLOGY
- REMOTE MONITORING RMON
- MANAGEMENT HIERARCHIES

SNMP GOALS

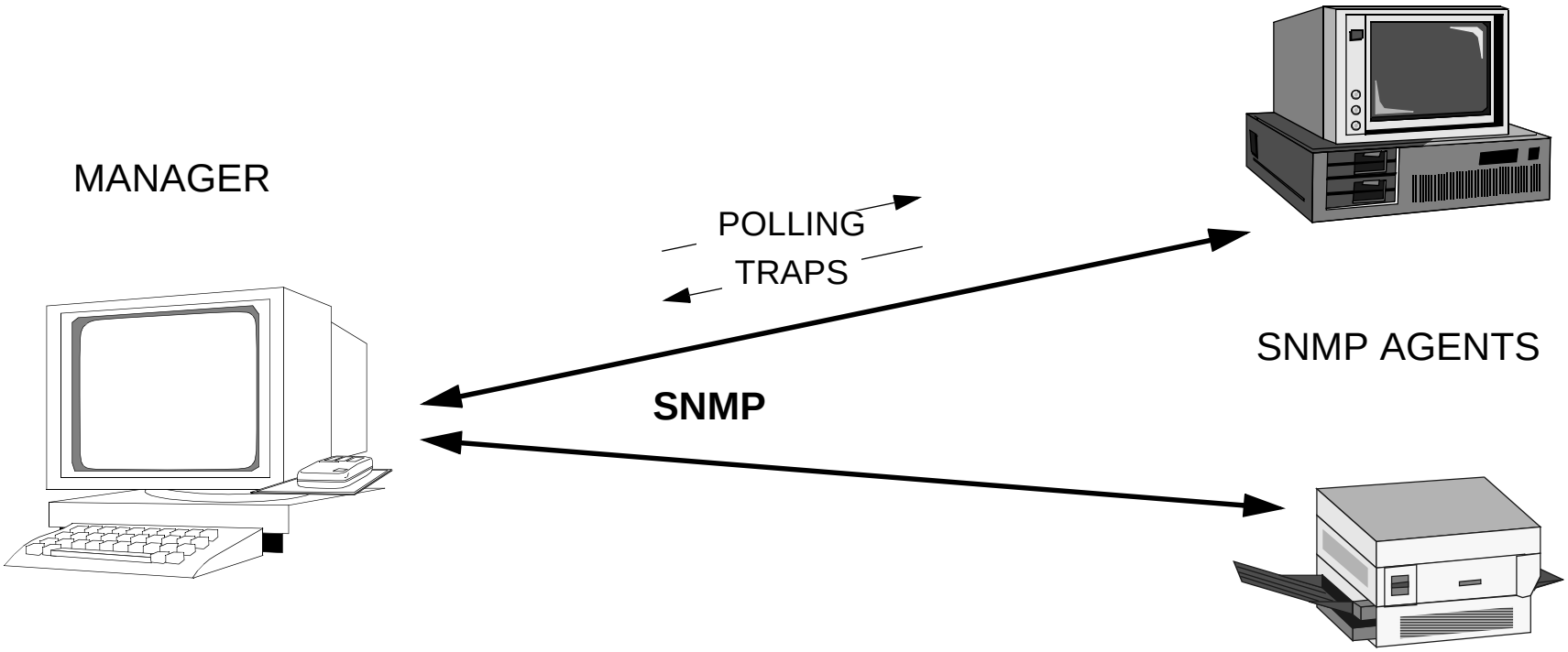
UBIQUITY
• PCs AND CRAYs

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

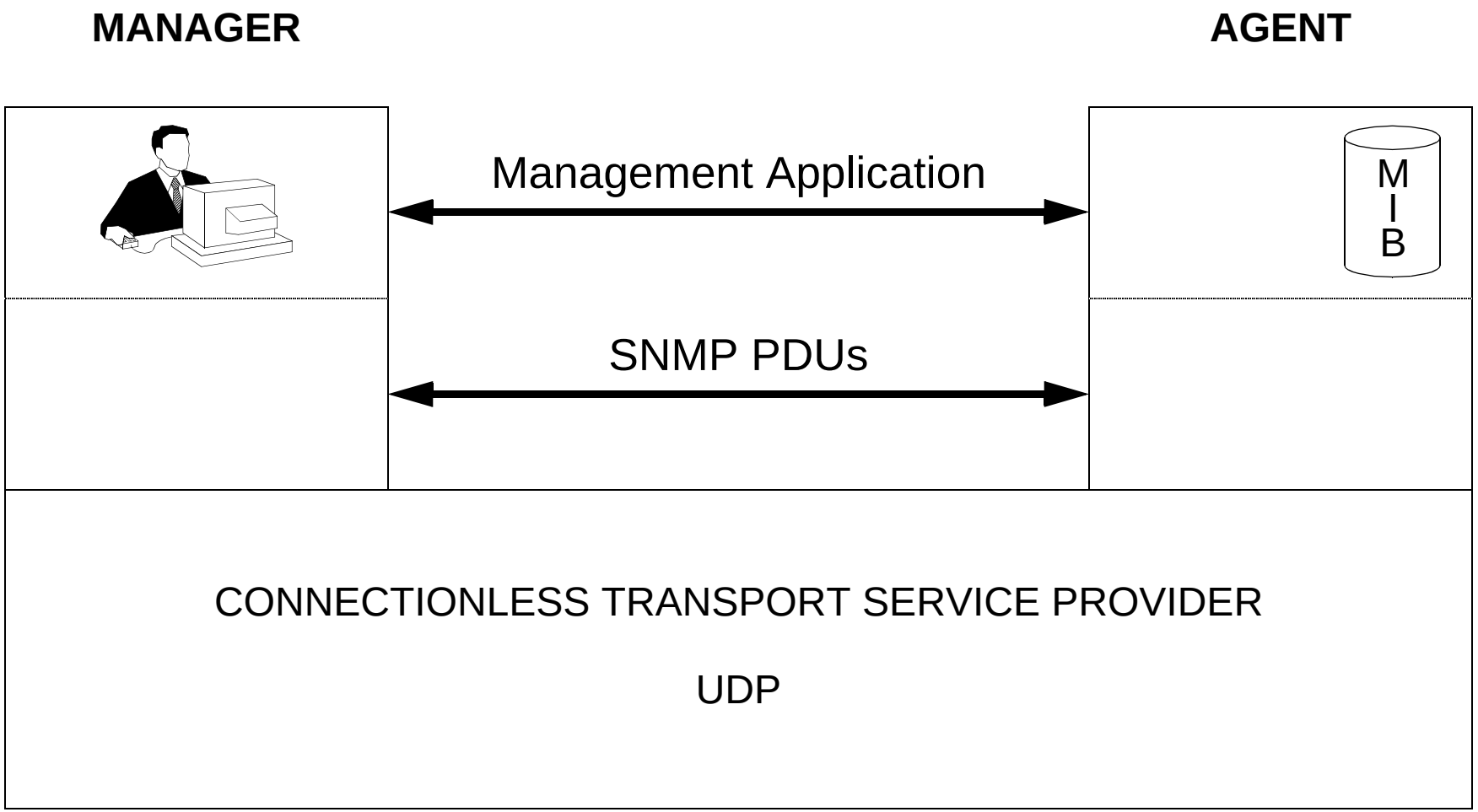
MANAGEMENT EXTENSIONS SHOULD BE POSSIBLE
• NEW MIBs

MANAGEMENT SHOULD BE ROBUST
• CONNECTIONLESS TRANSPORT

SNMP STRUCTURE



SNMP STRUCTURE



STANDARDS

SMI

• STRUCTURE OF MANAGEMENT INFORMATION
• RFC 1155

MIB-II

• MANAGEMENT INFORMATION BASE
• RFC 1213
• A LARGE NUMBER OF ADDITIONAL MIBs EXIST

SNMP

• SIMPLE NETWORK MANAGEMENT PROTOCOL
• RFC 1157
• NAME IS USED IN A MORE GENERAL SENSE

NEW VERSIONS: SNMPv2 & SNMPv3

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

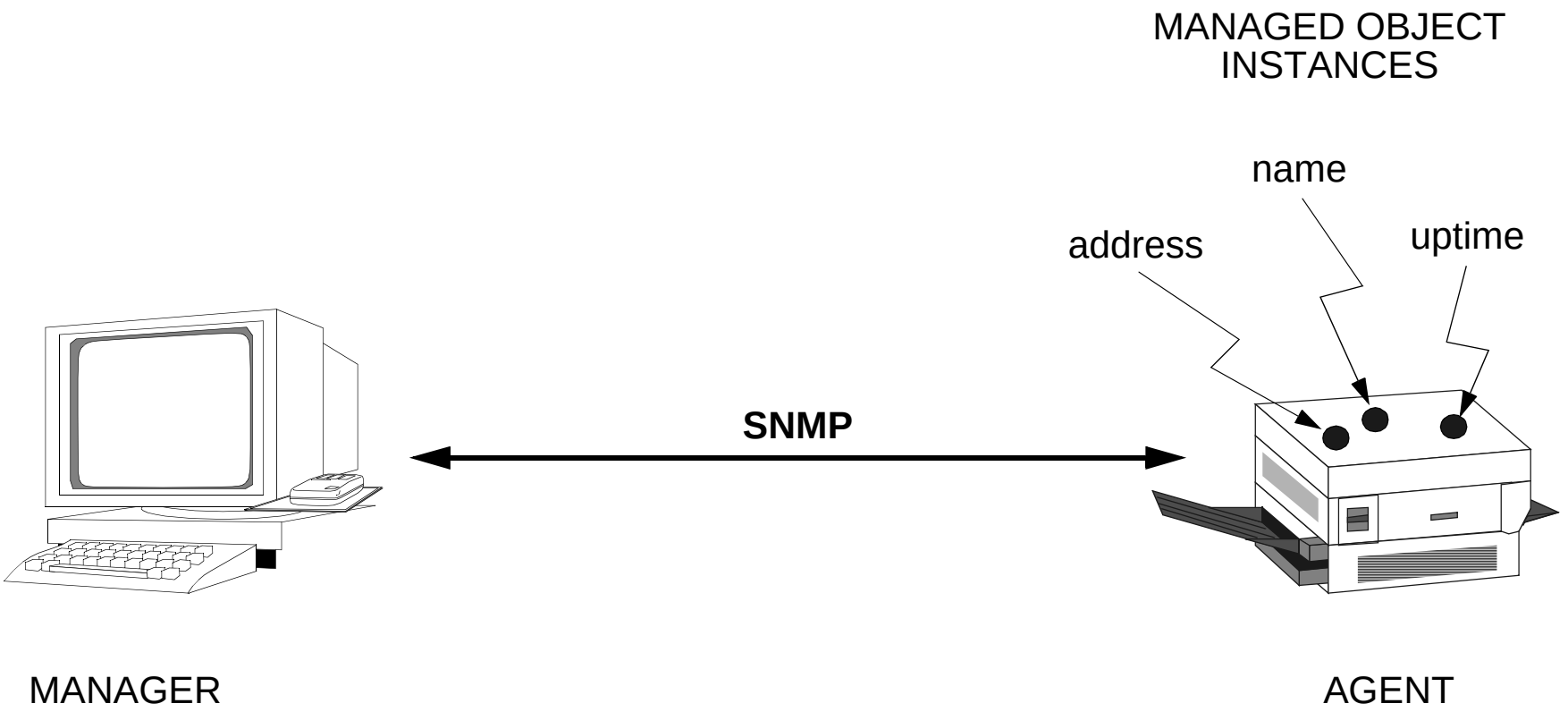
SIMPLE TYPES

- INTEGER
- OCTET STRING
- OBJECT IDENTIFIER
- NULL

APPLICATION-WIDE TYPES

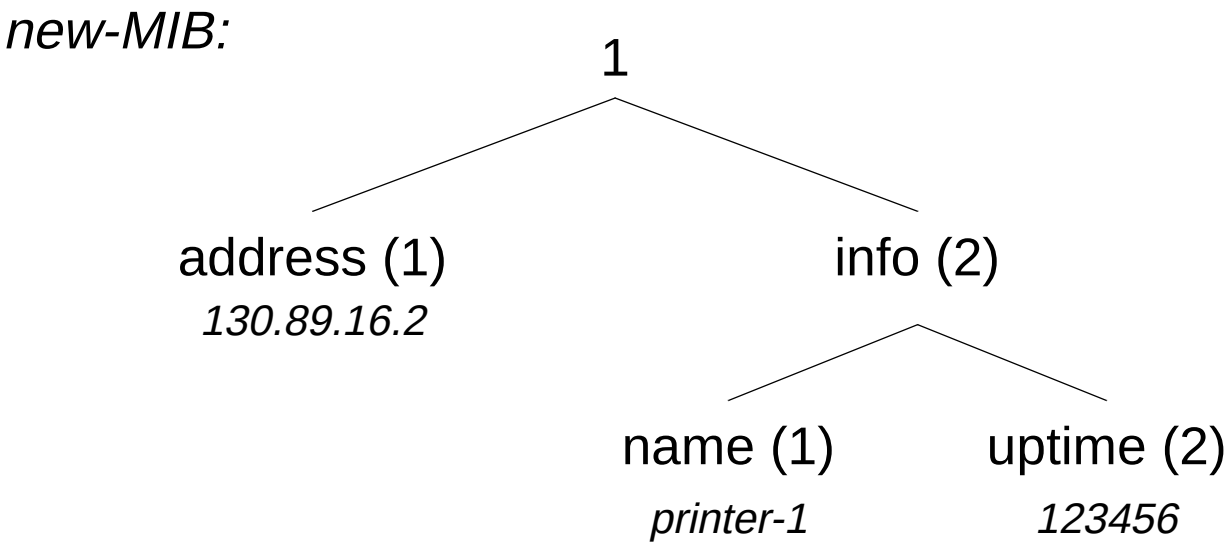
- IpAddress
- NetworkAddress
- Counter
- Gauge
- TimeTicks
- Opaque

EXAMPLE OF SCALAR OBJECTS



OBJECT NAMING

INTRODUCE NAMING TREE



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*

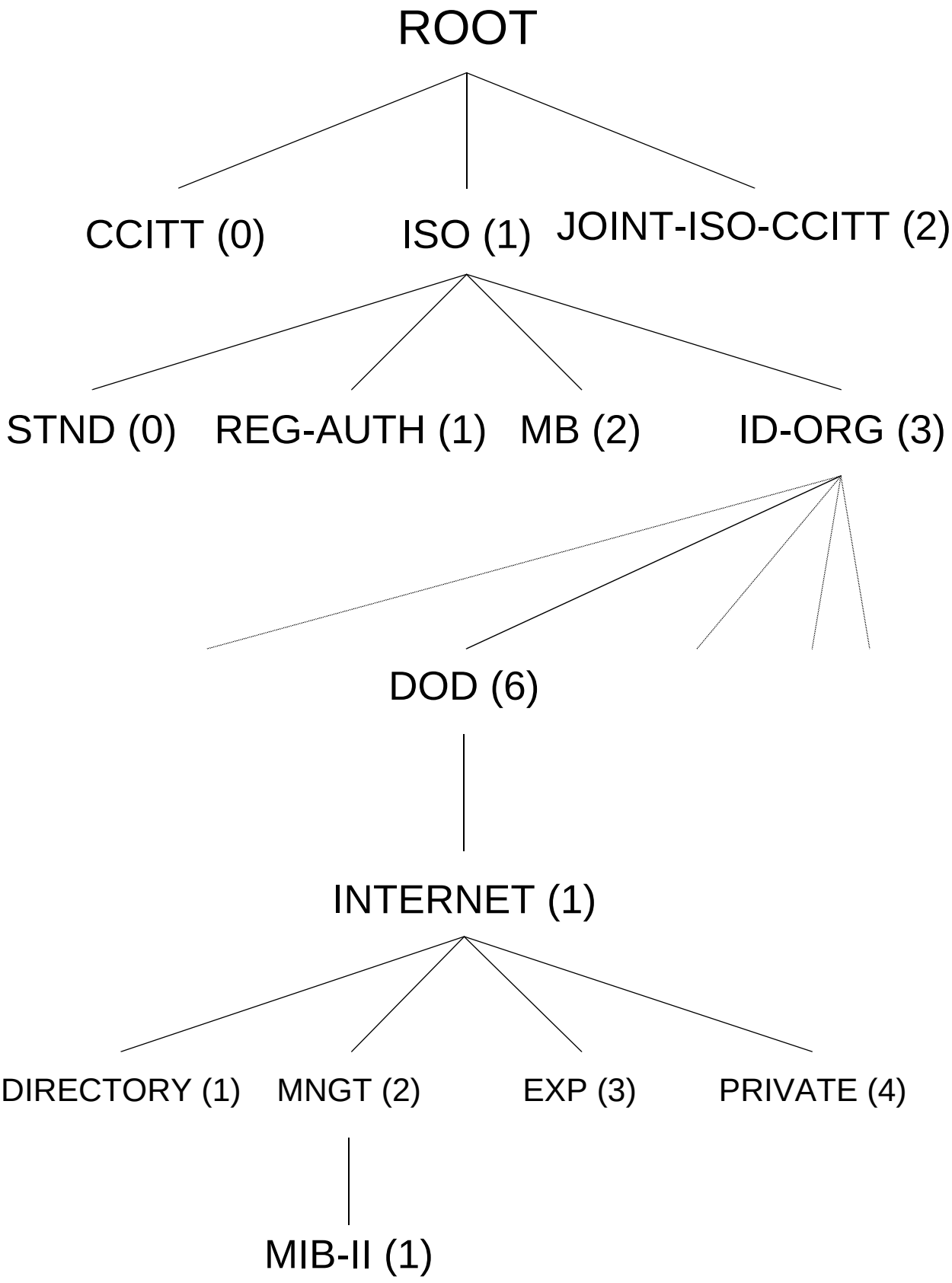
• info
Object ID = 1.2

• 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



OBJECT TYPE DEFINITION

OBJECT-TYPE:

SYNTAX	INTEGER OCTET STRING OBJECT IDENTIFIER NULL IpAddress NetworkAddress Counter Gauge TimeTicks Opaque New Type
ACCESS	read-only read-write write-only not-accessible
STATUS	mandatory optional obsolete deprecated
DESCRIPTION	""

-- Definition of address

address **OBJECT-TYPE**
SYNTAX IpAddress
ACCESS read-write
STATUS mandatory
DESCRIPTION "The Internet address of this system"
::= {new-MIB 1**}**

DEFINITION OF NON-LEAF ‘OBJECTS’

Name **OBJECT IDENTIFIER ::= {**...**}**

EXAMPLE:

info **OBJECT IDENTIFIER ::= {**new-MIB 2**}**

DEFINITION OF A MIB

Mib DEFINITIONS **::=**
BEGIN

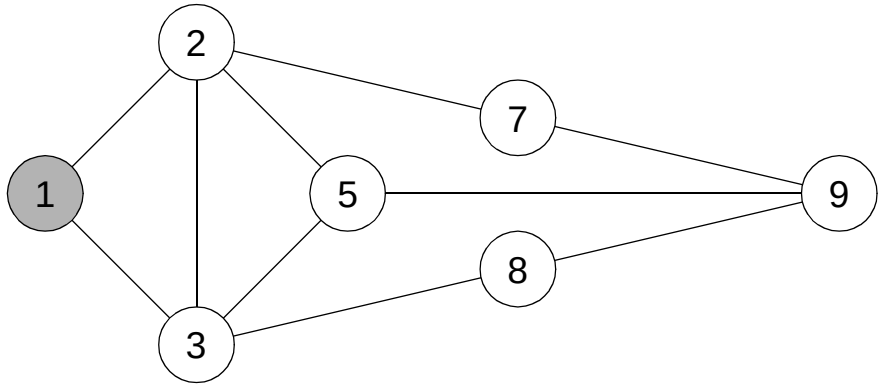
definition of the root's OID
definition of all node and leaf objects

END

TABLES

EXAMPLE: ROUTING TABLE

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



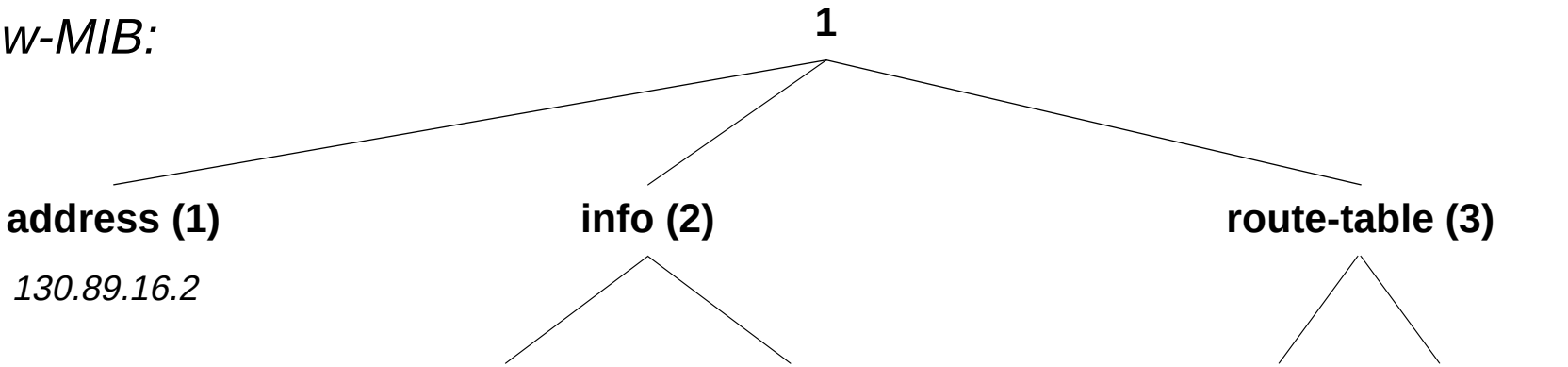
TO RETRIEVE INDIVIDUAL TABLE ENTRIES

EACH ENTRY SHOULD GET A NAME

NAMING OF TABLE ENTRIES - I

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

new-MIB:



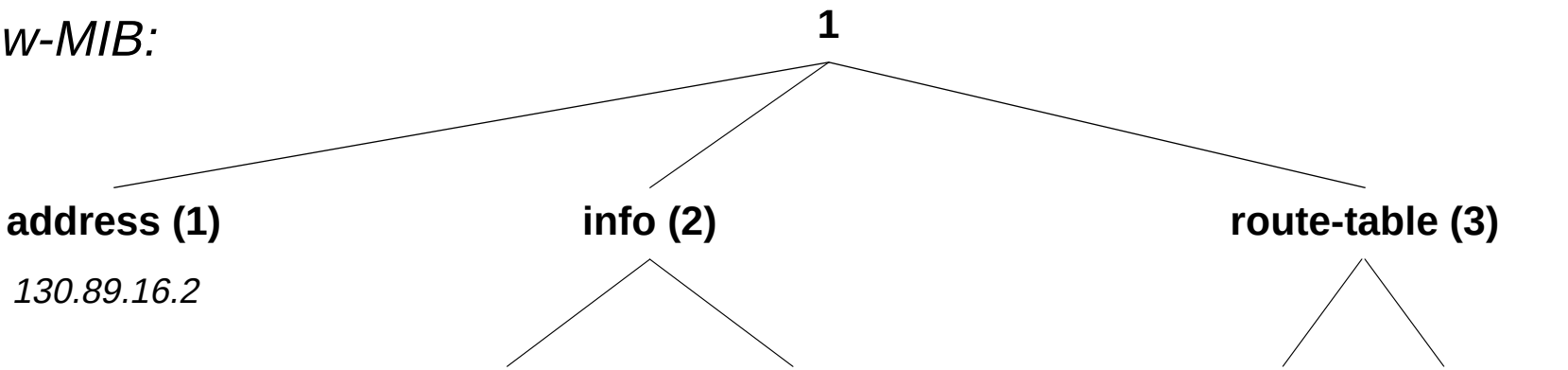
dest(1)	next(2)
2	*2*
3	*3*
5	*2*
7	*2*
8	***3***
9	*3*

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 INDEX - I

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 INDEX - II

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 INDEX - III

USE OF MULTIPLE INDEX FIELDS

X.C.I1.I2

OID of Table | Column number | Index value 1 | Index value 2

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*

TABLE DEFINITION - 1

-- Definition of the route-table

```
route-table          OBJECT-TYPE
    SYNTAX           SEQUENCE OF route-entry
    ACCESS           not-accessible
    STATUS           mandatory
    DESCRIPTION      "This entity's routing table"
    ::= {new-MIB  3}
```

```
route-entry          OBJECT-TYPE
    SYNTAX           Route-entry      -- this is a new type!
    ACCESS           not-accessible
    STATUS           mandatory
    DESCRIPTION      "A route to a particular destination"
    INDEX            {dest, policy}
    ::= {route-table  1}
```

```
Route-entry ::=
    SEQUENCE     {
                 dest      ipAddress,
                 policy    INTEGER,
                 next      ipAddress
                 }
```

TABLE DEFINITION - 2

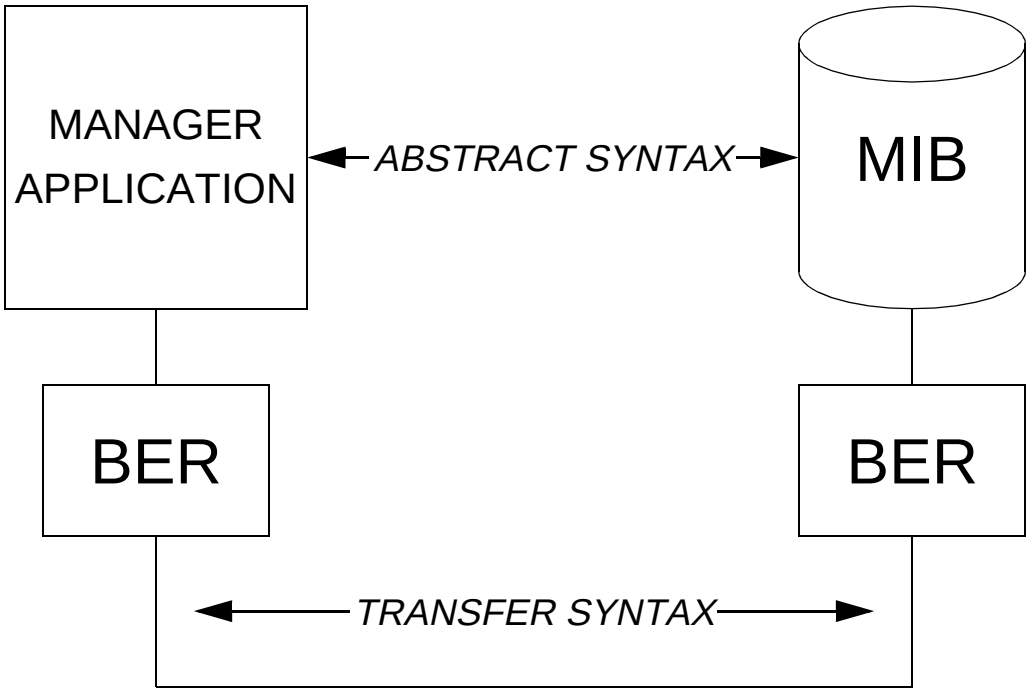
```
dest        OBJECT-TYPE
     SYNTAX         ipAddress
     ACCESS         read-write
     STATUS         mandatory
     DESCRIPTION    "The address of a particular destination"
     ::= {route-entry  1}


policy      OBJECT-TYPE
     SYNTAX         INTEGER {
                       costs(1)         -- lowest delay
                       reliability(2) }  -- highest reliability
     ACCESS         read-write
     STATUS         mandatory
     DESCRIPTION    "The routing policy to reach that destination"
     ::= {route-entry  2}


next        OBJECT-TYPE
     SYNTAX         ipAddress
     ACCESS         read-write
     STATUS         mandatory
     DESCRIPTION    "The internet address of the next hop"
     ::= {route-entry  3}
```

ASN.1 & BER - 1

MIB DEFINITIONS
ARE DESCRIBED IN TERMS OF
THE ASN.1 LANGUAGE



THE MAPPING FROM THIS
ABSTRACT SYNTAX
UPON A
TRANSFER SYNTAX
IS DEFINED BY THE
BASIC ENCODING RULES

BER

ASN.1 & BER - 2

EACH ASN.1 VALUE
IS ENCODED
AS AN OCTET STRING

THIS ENCODING RESULTS INTO
A SEQUENCE OF
TAG, LENGTH, VALUE
STRUCTURES

tag	length	value

TAG FIELD

primitive (=simple) / constructed (=structured)

0 0 = universal tag
0 1 = application-wide tag
1 0 = (context specific tag)
1 1 = (private tag)

Universal tags

f	tag number	bit pattern	hex code	ASN.1 type
0	2	0000 0010	02_H	INTEGER
0	4	0000 0100	04_H	OCTET STRING
0	5	0000 0101	05_H	NULL
0	6	0000 0110	06_H	OBJECT IDENTIFIER
1	16	0011 0000	30_H	SEQUENCE SEQUENCE OF

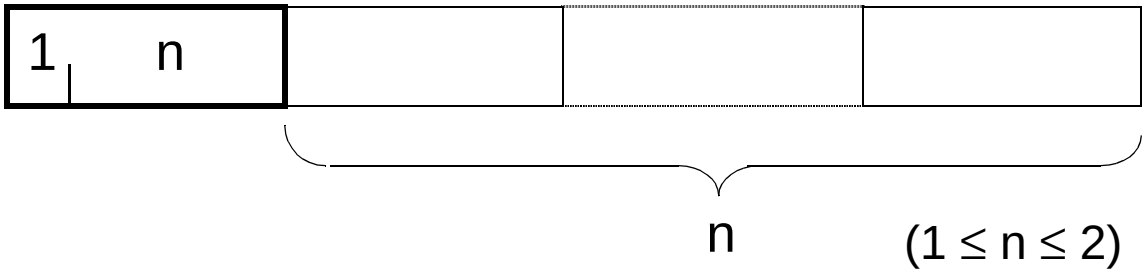
Application-wide tags

IpAddress
NetworkAddress
Counter
Gauge
TimeTicks
Opaque

LENGTH FIELD

SHORT FORM:

LONG FORM:



MIB-II

DEFINES THE VARIABLES
TO MANAGE THE
TCP/IP PROTOCOL STACK

170 VARIABLES

RFC 1213

ENHANCEMENT OF MIB-I

RFC 1156

MIB-II

• ESSENTIAL FOR
FAULT OR CONFIGURATION MANAGEMENT

• ONLY WEAK CONTROL OBJECTS

• SMALL NUMBER OF OBJECTS

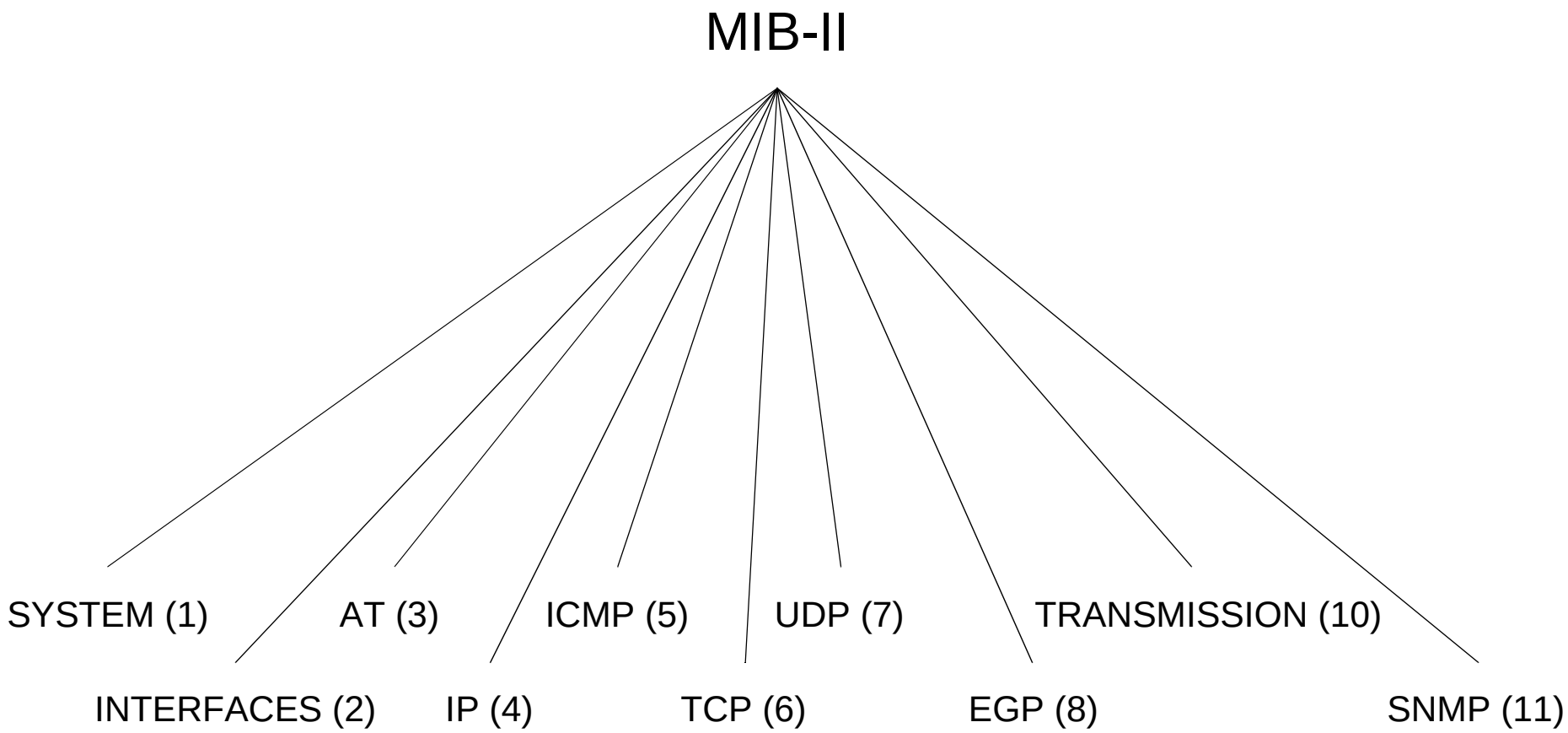
• AVOID REDUNDANCY

• EVIDENCE OF UTILITY

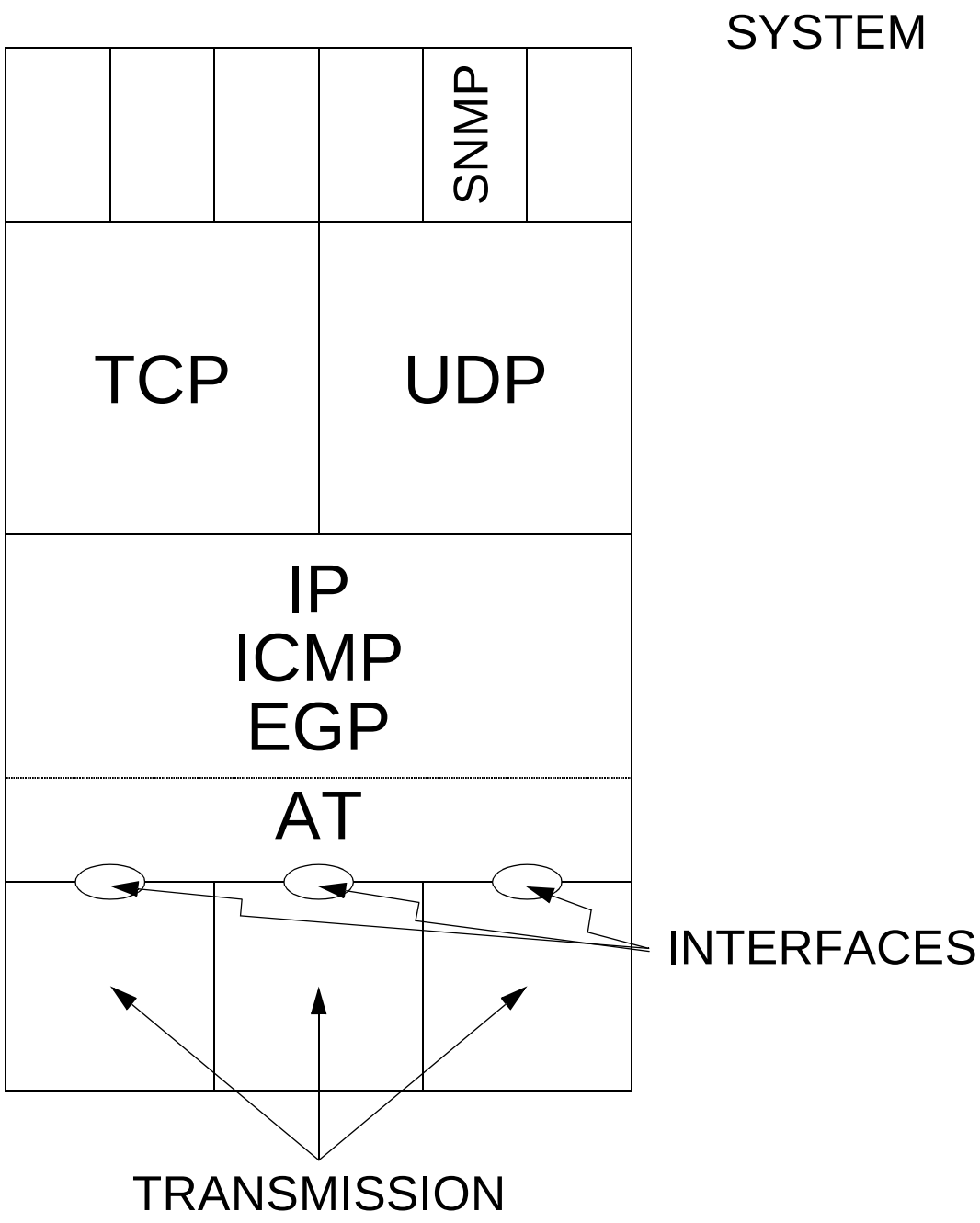
• DO NOT DISTURB NORMAL OPERATION

• NO IMPLEMENTATION SPECIFIC ISSUES

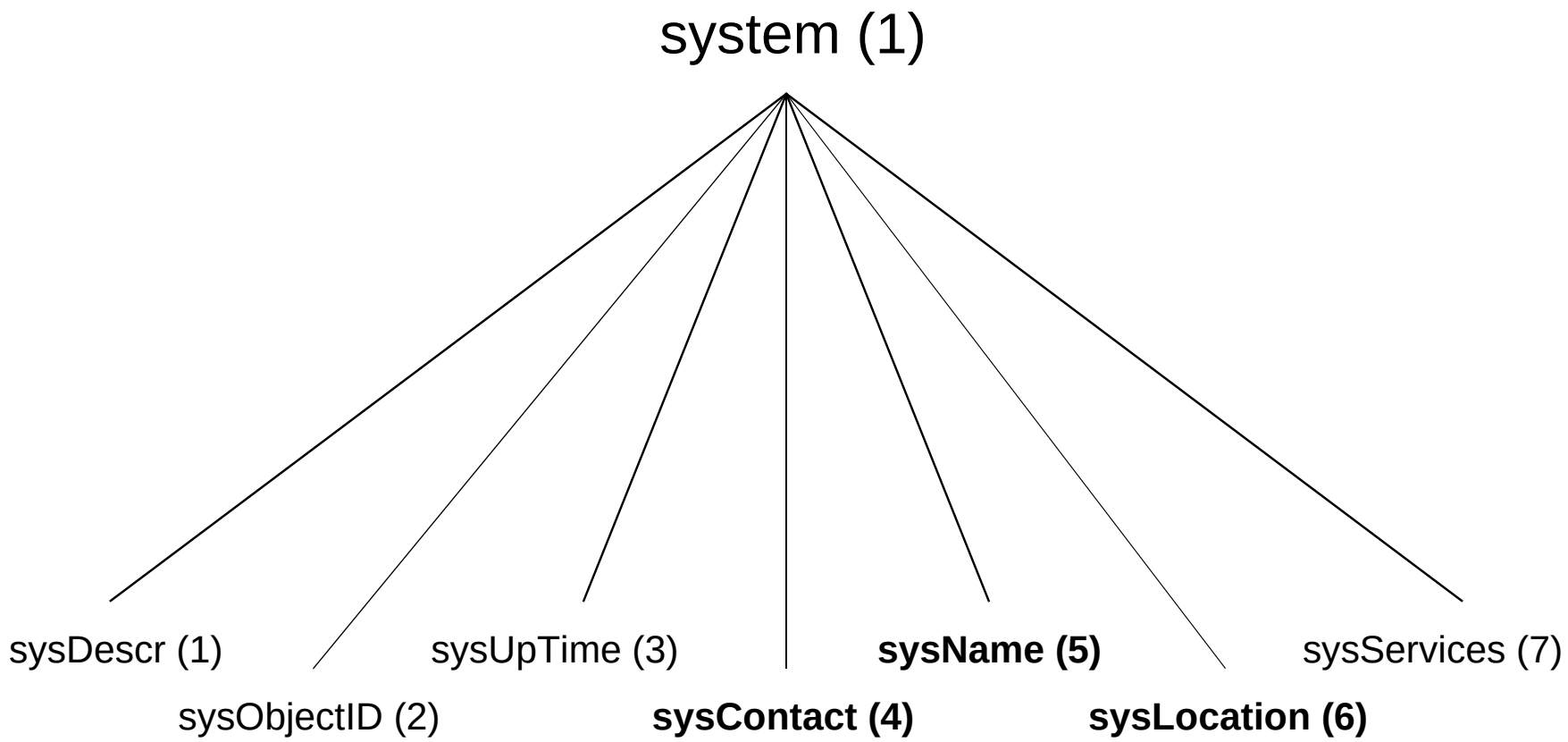
MIB-II


MIB-II
SYSTEM (1)
INTERFACES (2)
AT (3)
IP (4)
ICMP (5)
TCP (6)
UDP (7)
EGP (8)
TRANSMISSION (10)
SNMP (11)

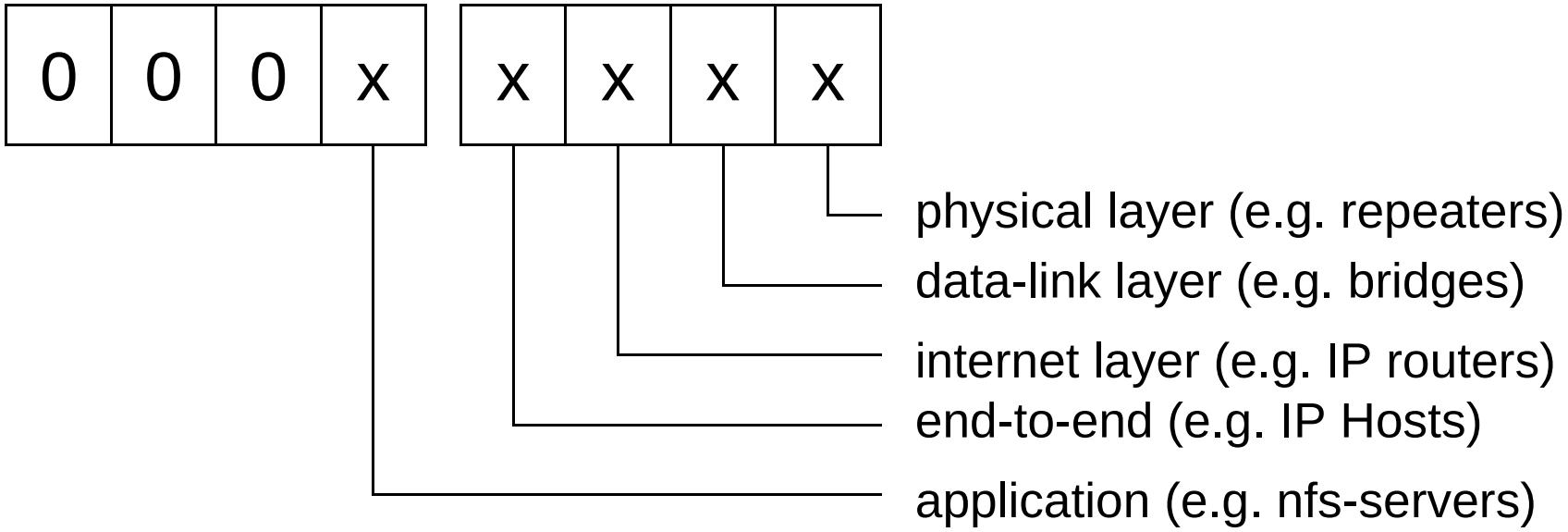
MIB-II GROUPS



SYSTEM GROUP



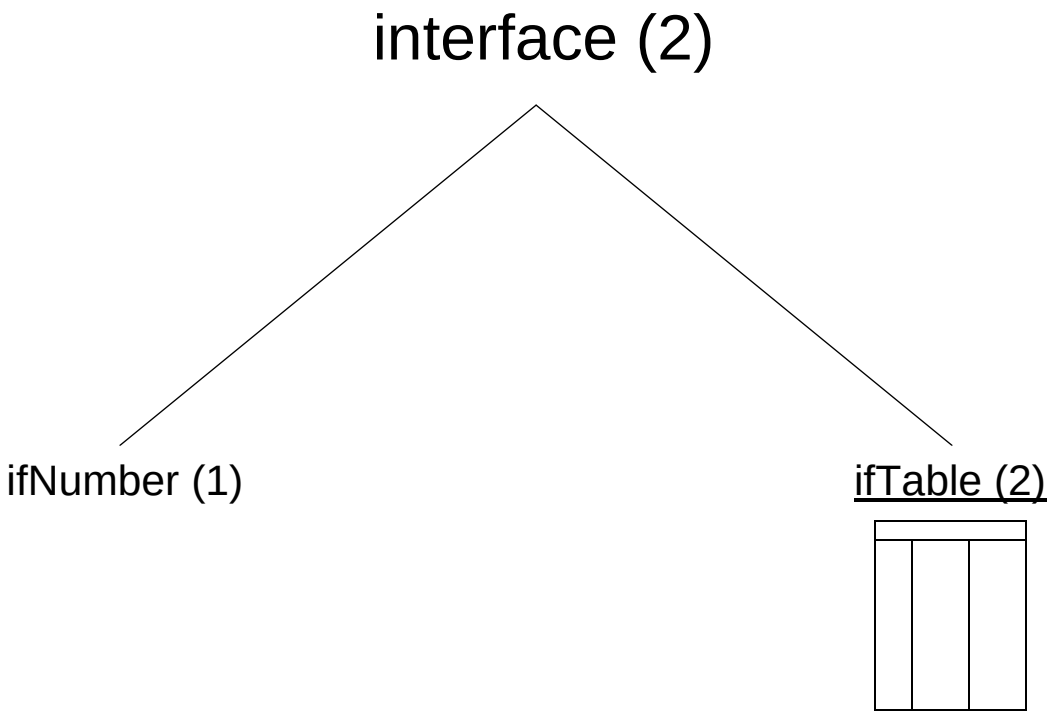
sysServices



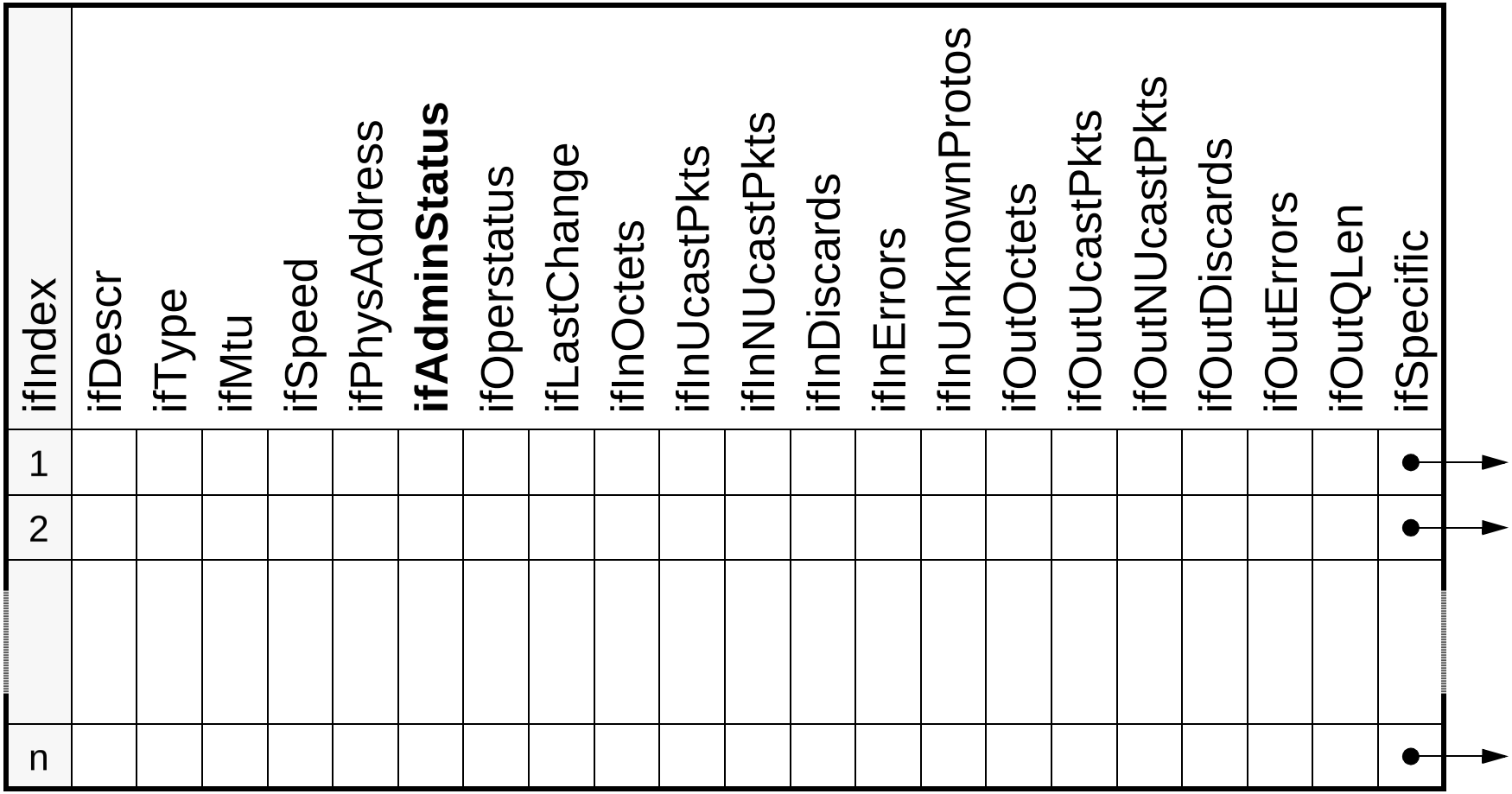
EXAMPLE

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

ifTable

- ifAdminStatus / ifOperStatus

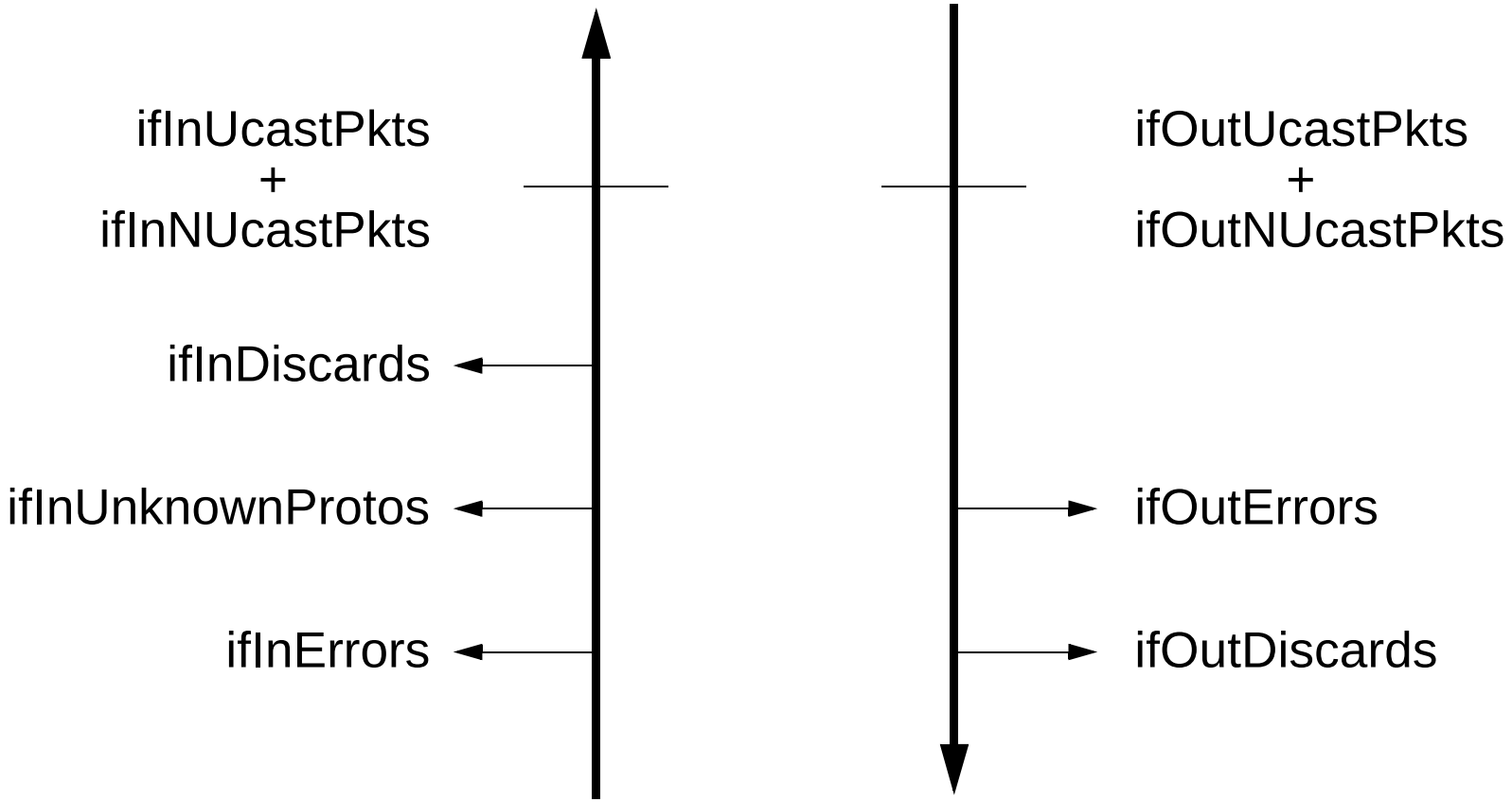
1 = up
2 = down
3 = testing

- 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

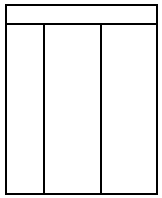
IF PACKET COUNT



ADDRESS TRANSLATION GROUP

at (3)

atTable (1)

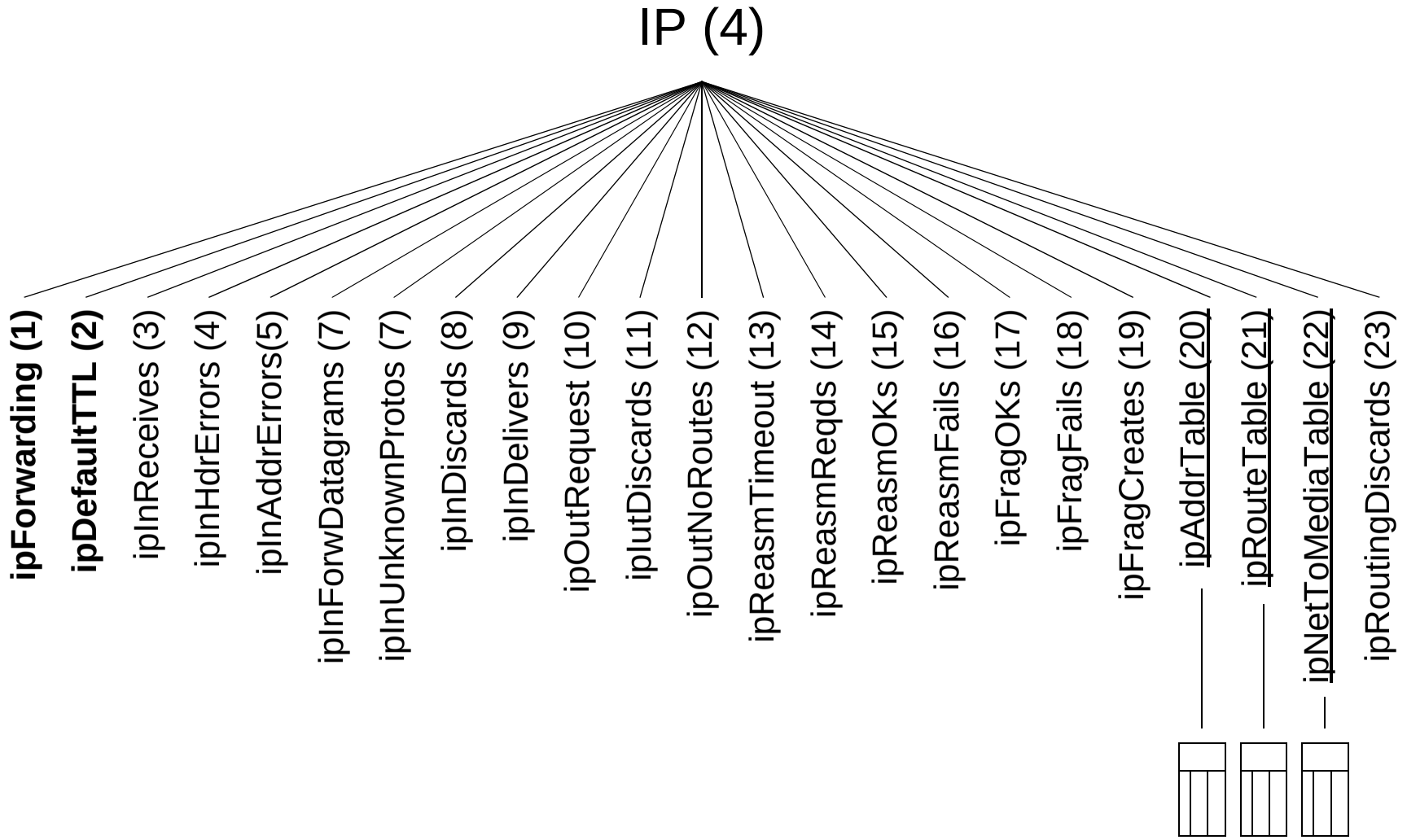


- DEPRECATED STATUS

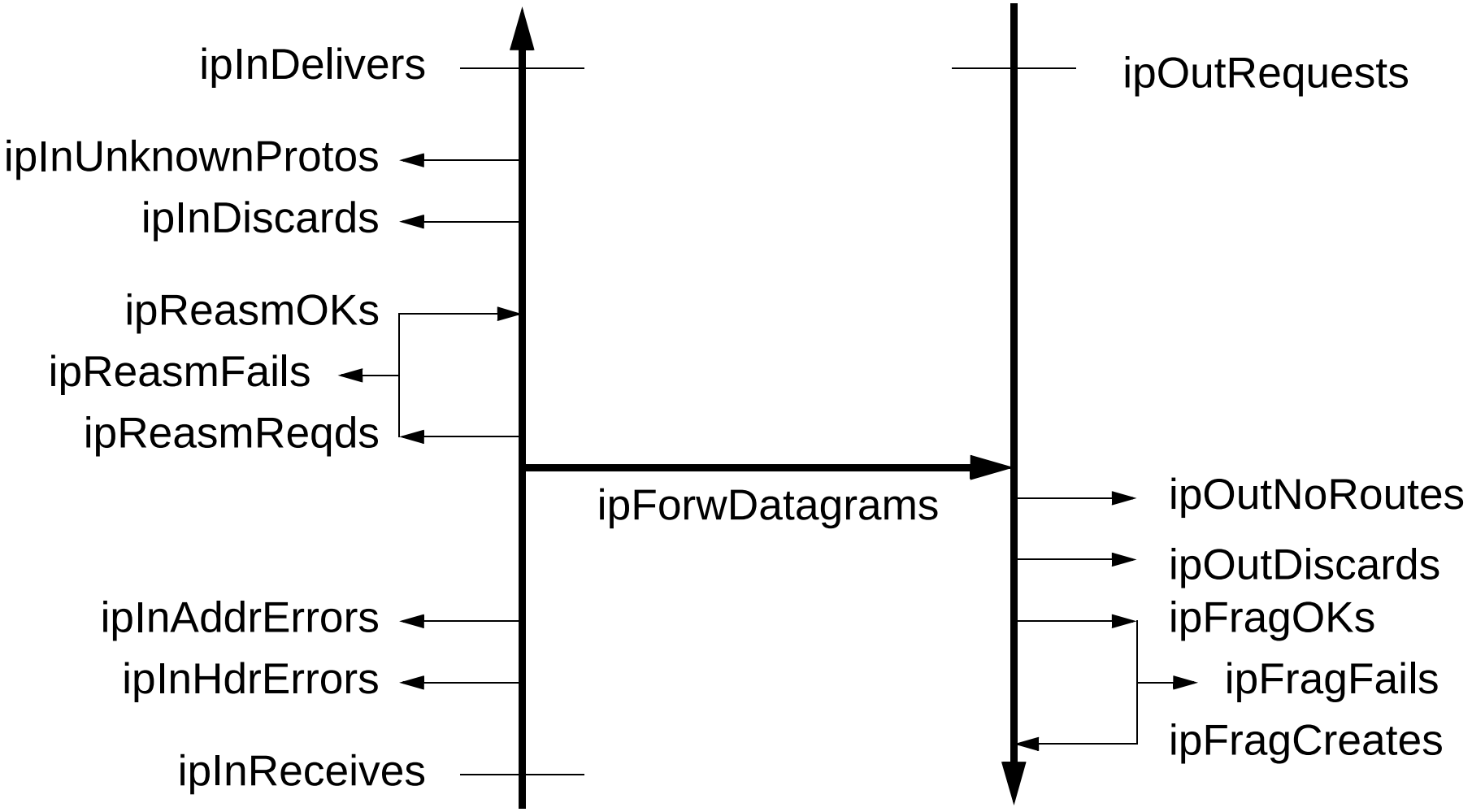
atTable

atIfIndex	atPhysAddress	atNetAddress
1		aa.bb.cc.dd
2		ee.ff.gg.hh
n		ww.xx.yy.zz

IP GROUP


IP (4)
ipForwarding (1)
ipDefaultTTL (2)
ipInReceives (3)
ipInHdrErrors (4)
ipInAddrErrors(5)
ipInForwDatagrams (7)
ipInUnknownProtos (7)
ipInDiscards (8)
ipInDelivers (9)
ipOutRequest (10)
ipIutDiscards (11)
ipOutNoRoutes (12)
ipReasmTimeout (13)
ipReasmReqds (14)
ipReasmOKs (15)
ipReasmFails (16)
ipFragOKs (17)
ipFragFails (18)
ipFragCreates (19)
ipAddrTable (20)
ipRouteTable (21)
ipNetToMediaTable (22)
ipRoutingDiscards (23)

IP PACKET COUNT



ipAddrTable

ipAdEntAddr	ipAdEntIfIndex	ipAdEntNetMask	ipAdEntBcastAddr	ipAdEntReasmMaxSize
192.89.16.4	1	255.255.255.0	1	65535
192.89.16.8				

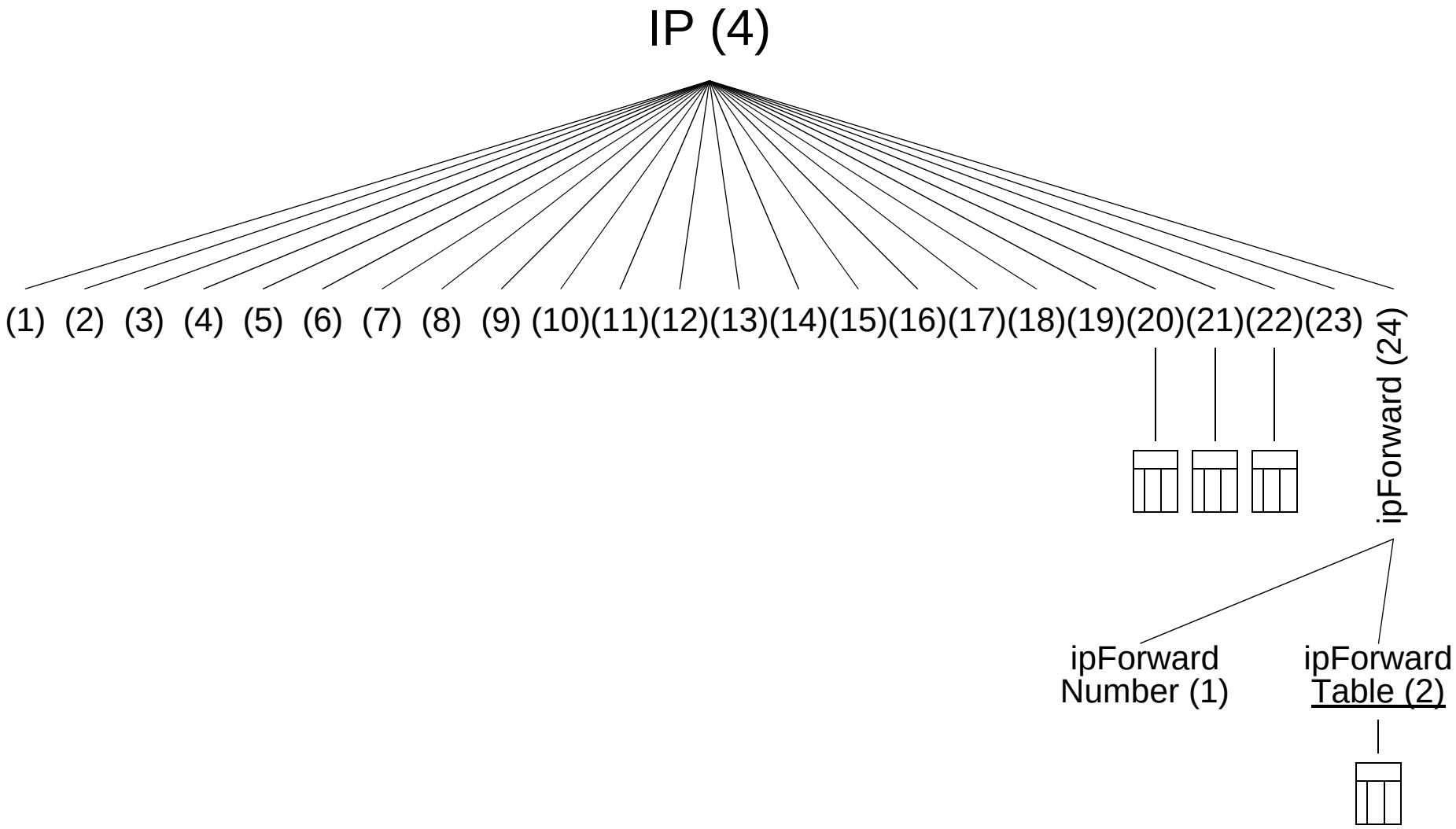
ipNetToMediaTable

ipNetToMedia IfIndex	ipNetToMedia PhysAddress	ipNetToMedia NetAddress	ipNetToMedia Type
1	08:00:20:00:25:66	129.14.16.4	3 (dynamic)
2			

ipRouteTable

ipRouteDest	ipRouteNextHop	ipRouteIfIndex	ipRouteMask	ipRouteType	ipRouteMetric1	ipRouteMetric2	ipRouteMetric3	ipRouteMetric4	ipRouteMetric5	ipRouteAge	ipRouteProto	ipRouteInfo
129.14.16.4	129.16.1.7	1	255.255.0.0	3							ospf	●
												●
192.89.16.8												●

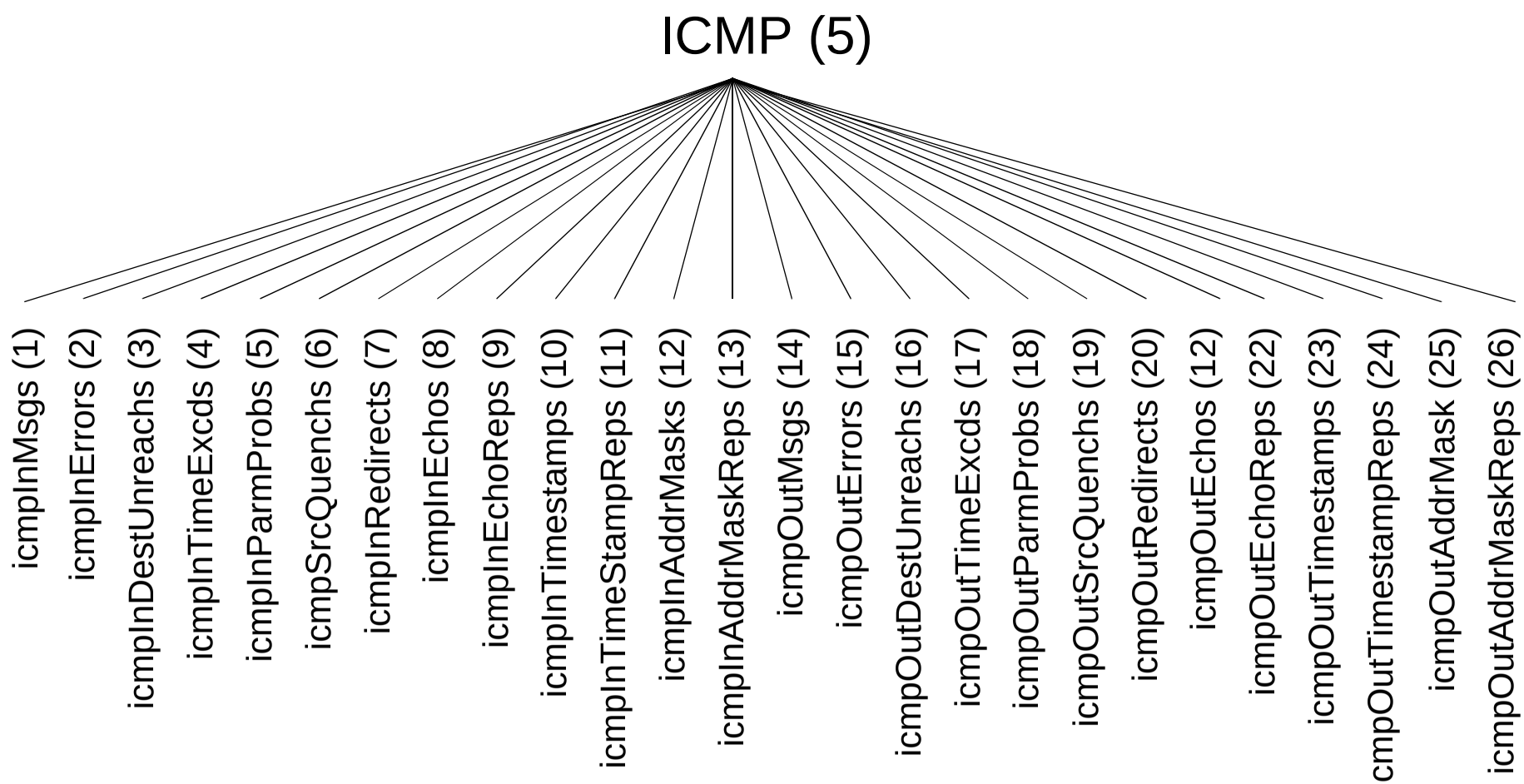
IP Forwarding Table



ipForwardTable

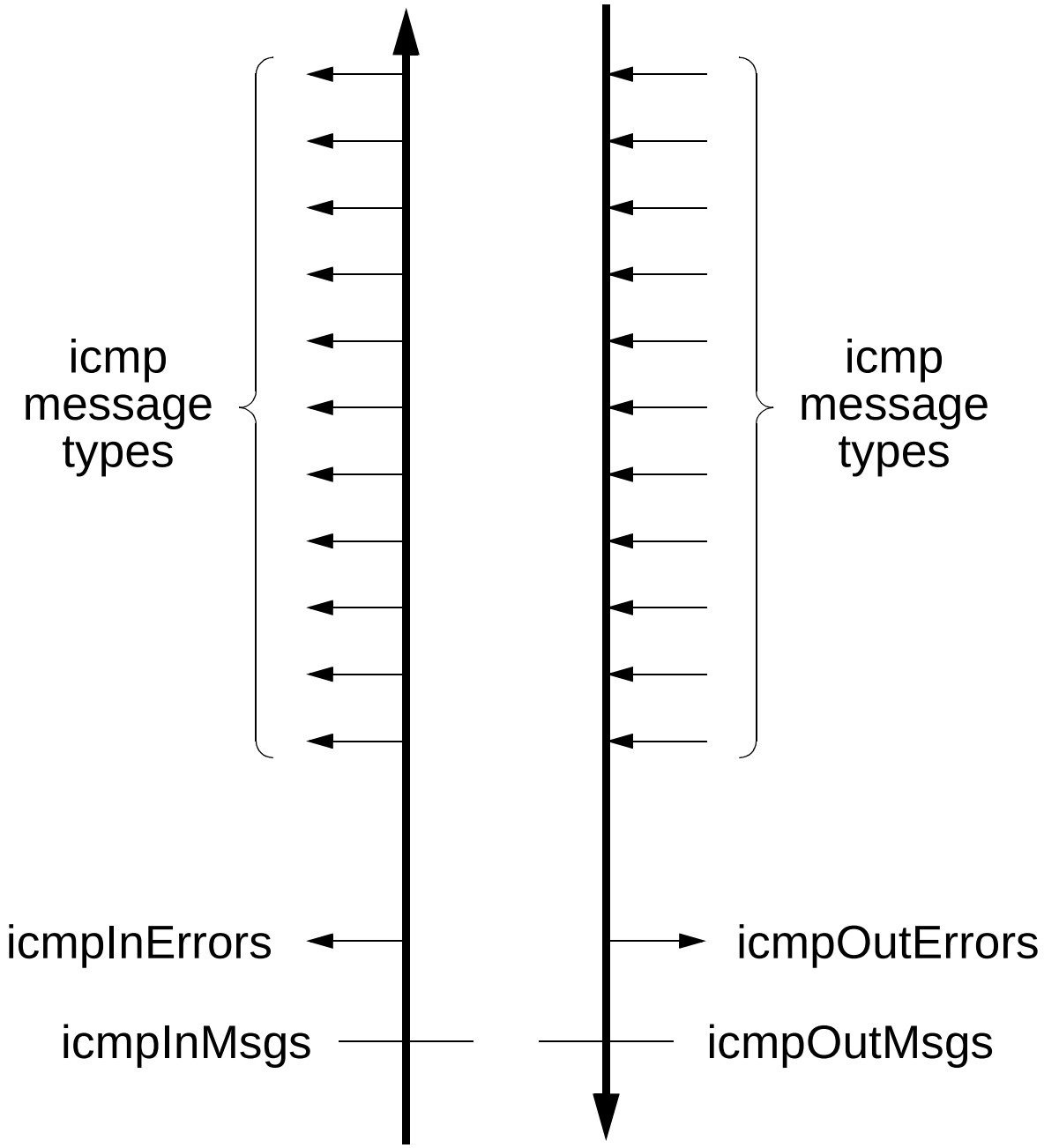
ipForwardDest	ipForwardNextHop	ipForwardNextHopAS	ipForwardIfIndex	ipForwardMask	ipForwardType	ipForwardPolicy	ipForwardMetric1	ipForwardMetric2	ipForwardMetric3	ipForwardMetric4	ipForwardMetric5	ipForwardAge	ipForwardProto	ipForwardInfo
33.14.16.4	33.1.1.7	16.1.1.1	1	255.0.0.0	3								ospf	●
														●
193.11.1.8														●

ICMP GROUP

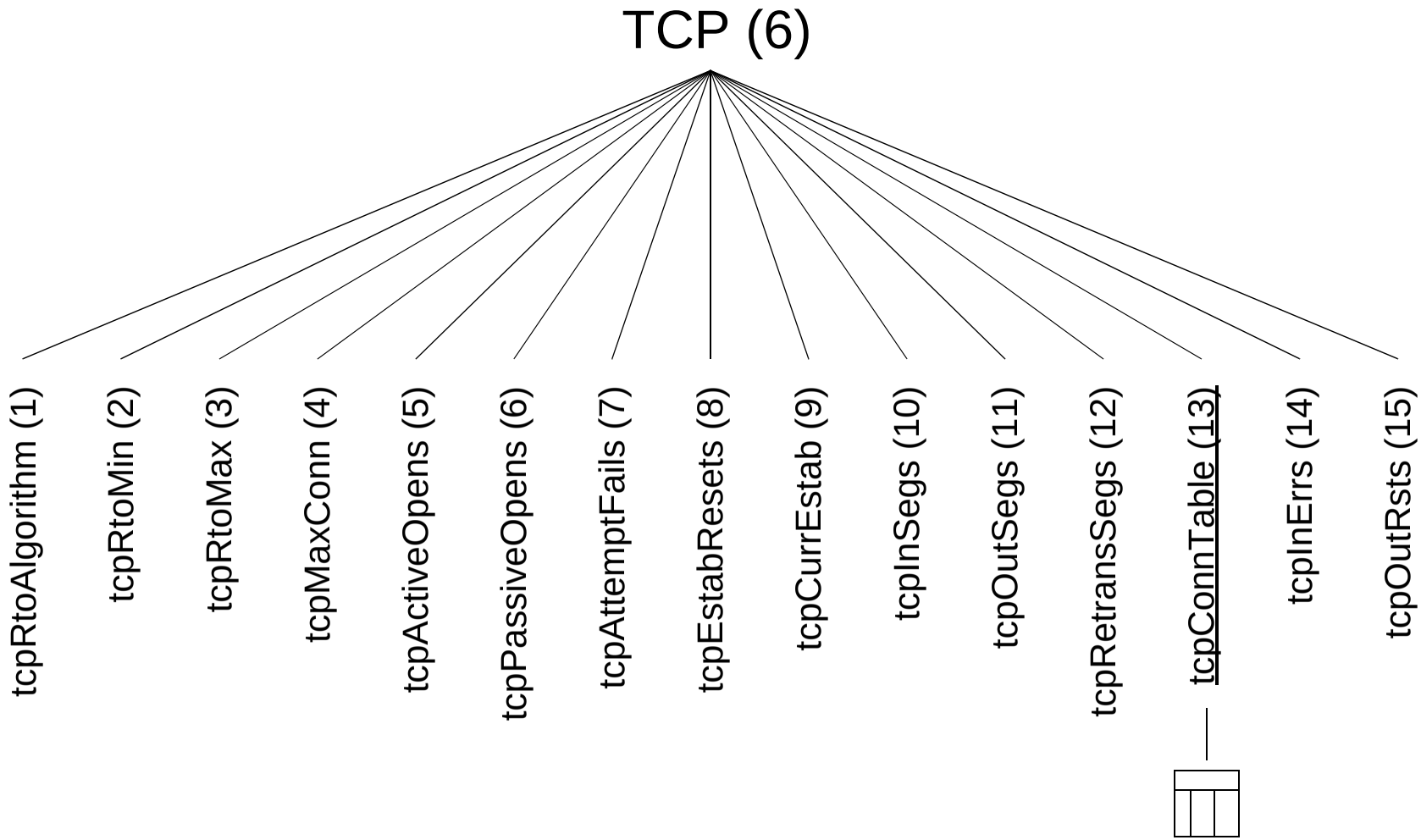

ICMP (5)
icmpInMsgs (1)
icmpInErrors (2)
icmpInDestUnreachs (3)
icmpInTimeExcds (4)
icmpInParmProbs (5)
icmpSrcQuenchs (6)
icmpInRedirects (7)
icmpInEchos (8)
icmpInEchoReps (9)
icmpInTimestamps (10)
icmpInTimeStampReps (11)
icmpInAddrMasks (12)
icmpInAddrMaskReps (13)
icmpOutMsgs (14)
icmpOutErrors (15)
icmpOutDestUnreachs (16)
icmpOutTimeExcds (17)
icmpOutParmProbs (18)
icmpOutSrcQuenchs (19)
icmpOutRedirects (20)
icmpOutEchos (12)
icmpOutEchoReps (22)
icmpOutTimestamps (23)
icmpOutTimestampReps (24)
icmpOutAddrMask (25)
icmpOutAddrMaskReps (26)

ICMP PACKET COUNT

COUNTS FOR EACH ICMP MESSAGE TYPE
HOW OFTEN IT HAS BEEN:
- TRANSMITTED
- RECEIVED



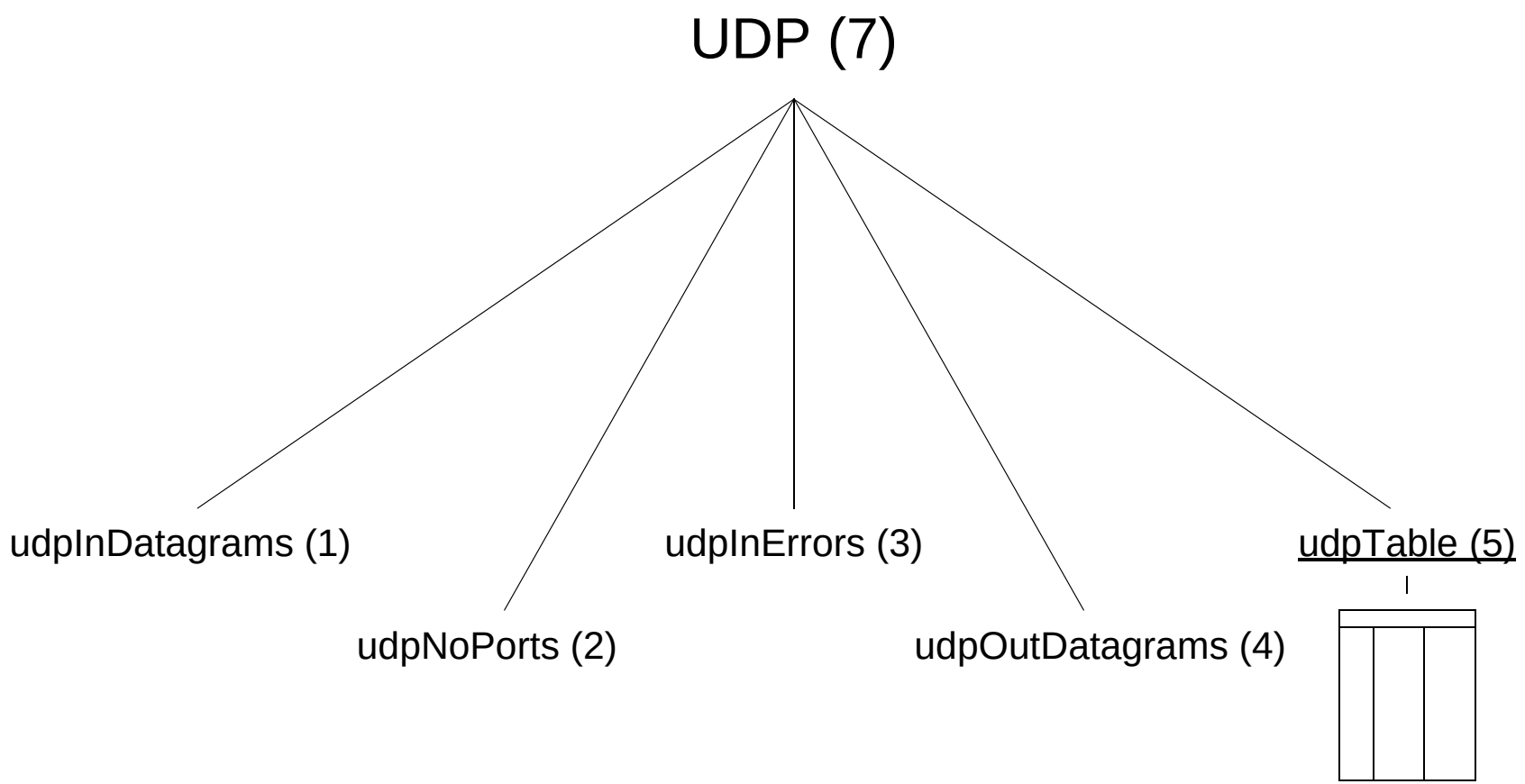
TCP GROUP


TCP (6)
tcpRtoAlgorithm (1)
tcpRtoMin (2)
tcpRtoMax (3)
tcpMaxConn (4)
tcpActiveOpens (5)
tcpPassiveOpens (6)
tcpAttemptFails (7)
tcpEstabResets (8)
tcpCurrEstab (9)
tcpInSegs (10)
tcpOutSegs (11)
tcpRetransSegs (12)
tcpConnTable (13)
tcpInErrs (14)
tcpOutRsts (15)

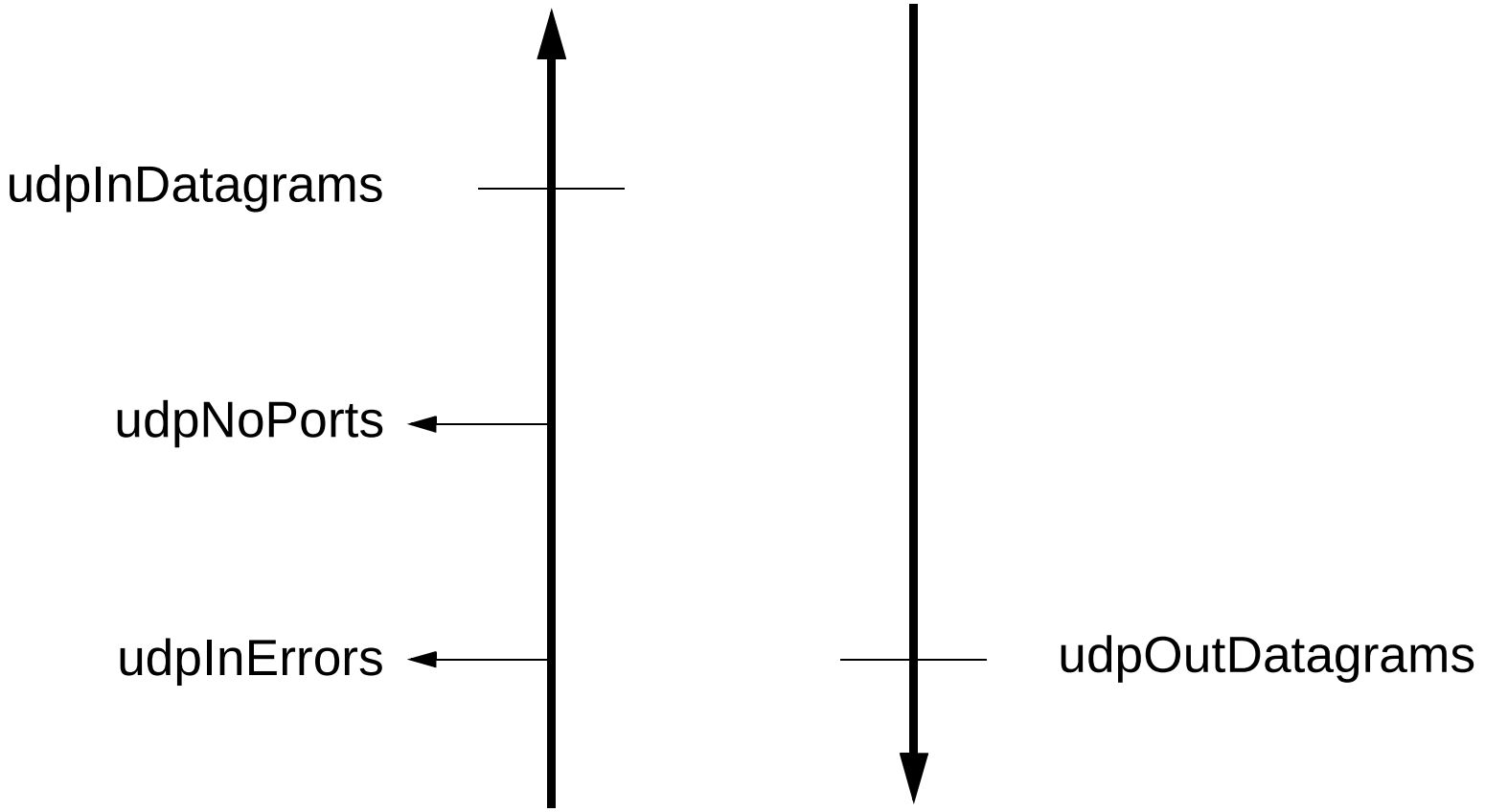
tcpConnTable

tcpConn State	tcpConn LocalAddress	tcpConn LocalPort	tcpConn RemoteAddress	tcpConn RemotePort
listen	0.0.0.0	23	0.0.0.0	0

UDP GROUP


UDP (7)
udpInDatagrams (1)
udpNoPorts (2)
udpInErrors (3)
udpOutDatagrams (4)
udpTable (5)

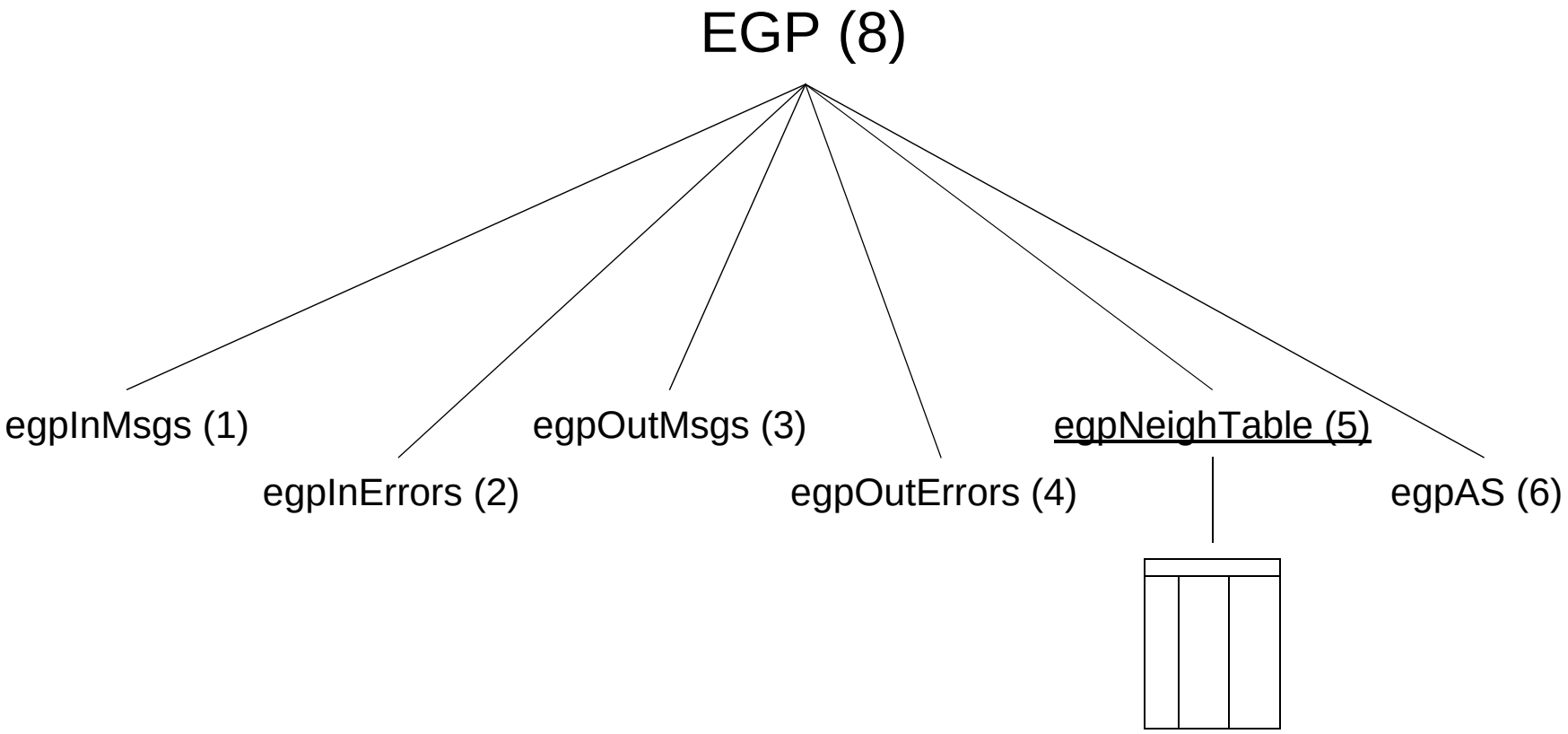
UDP PACKET COUNT



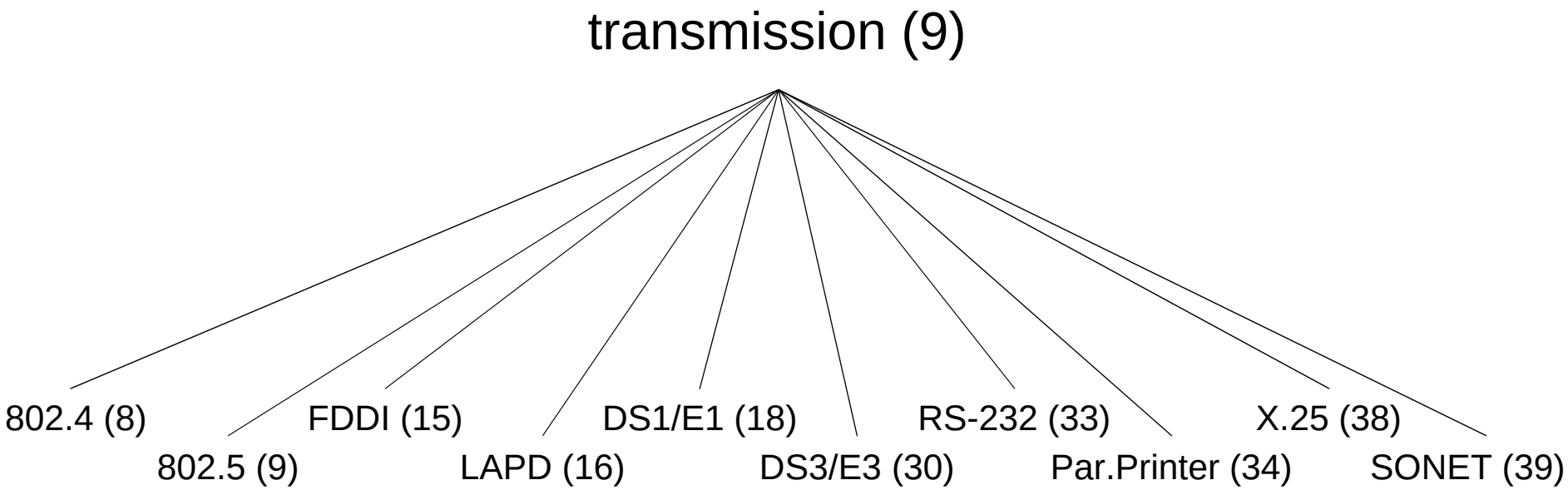
udpTable

udpLocalAddress	udpLocalPort
129.16.4.12	161

EGP GROUP


EGP (8)
egpInMsgs (1)
egpInErrors (2)
egpOutMsgs (3)
egpOutErrors (4)
egpNeighTable (5)
egpAS (6)

TRANSMISSION GROUP



SNMP GROUP

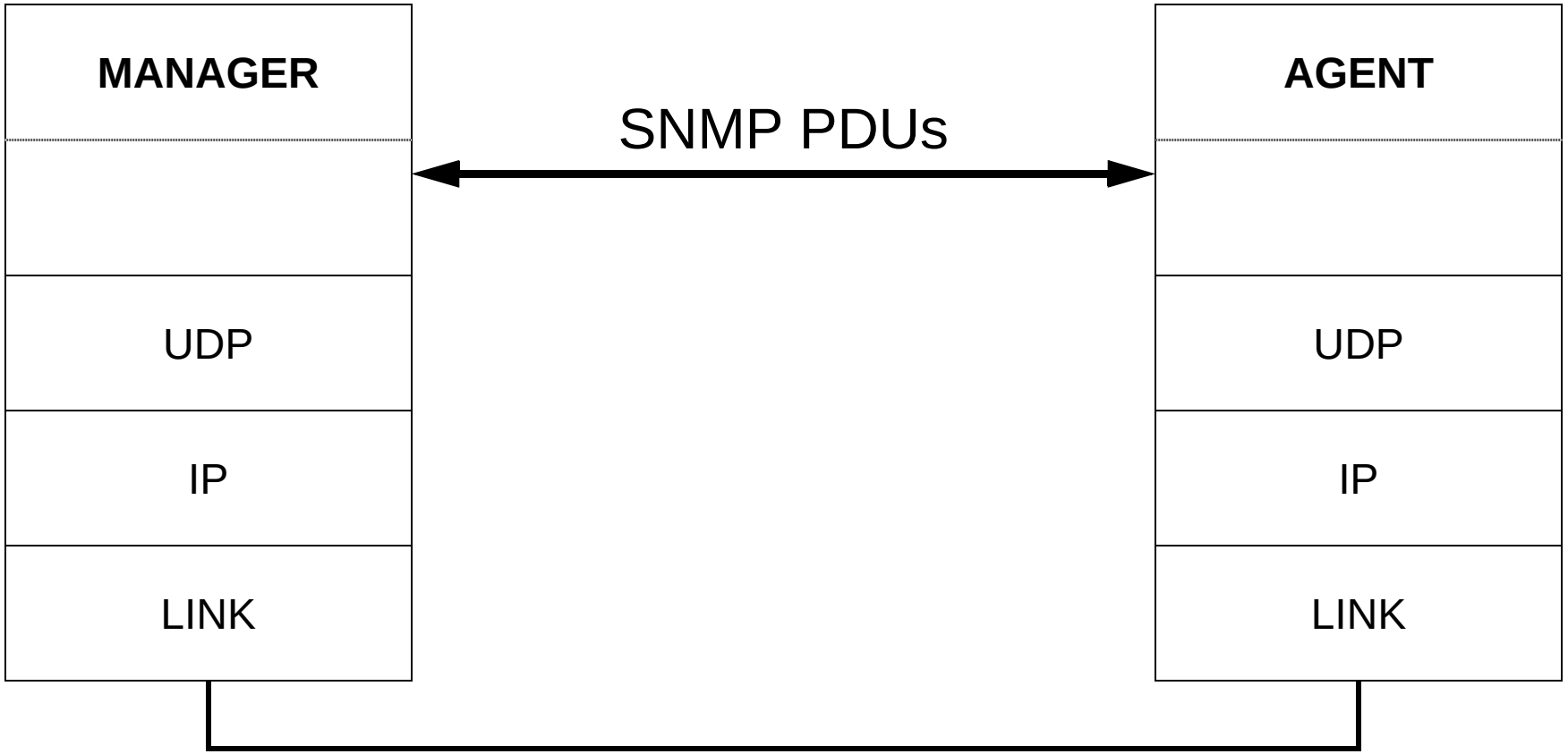
29 READ-ONLY COUNTERS

- THE NUMBER OF TRANSMITTED PDUs
- THE NUMBER OF RECEIVED PDUs
- FOR THE VARIOUS KINDS OF PDUs
- FOR THE VARIOUS KINDS OF ERRORS

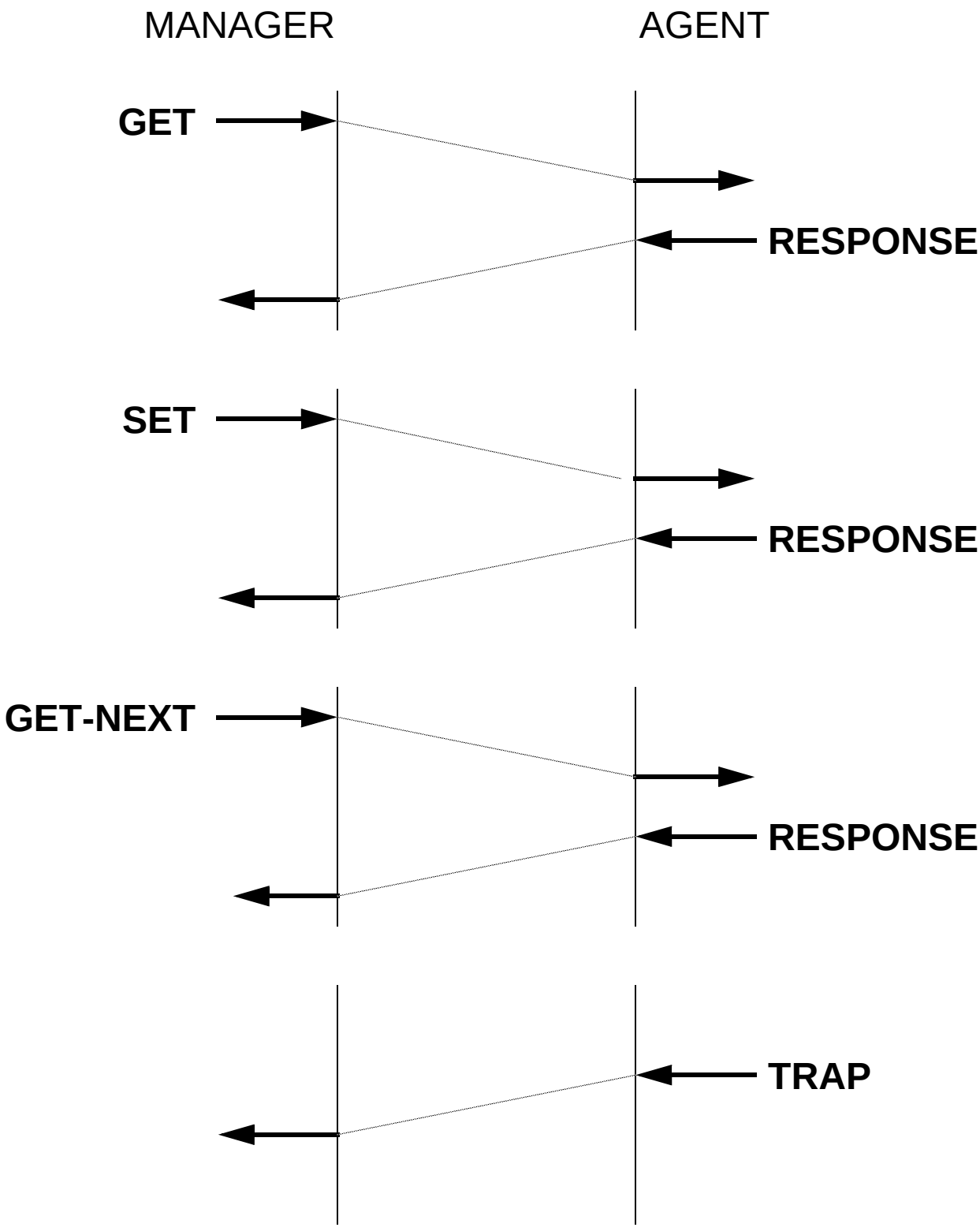
1 READ-WRITE VARIABLE

- TO ENABLE / DISABLE AUTHENTICATION TRAPS

SNMP PROTOCOL



OVERVIEW OF PDUs



MESSAGE & PDU STRUCTURE

variable bindings:

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

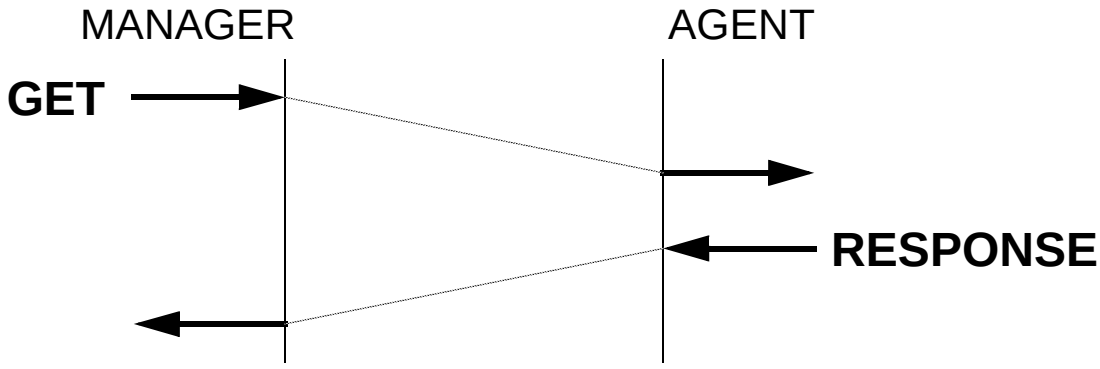
SNMP PDU:

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

⇩

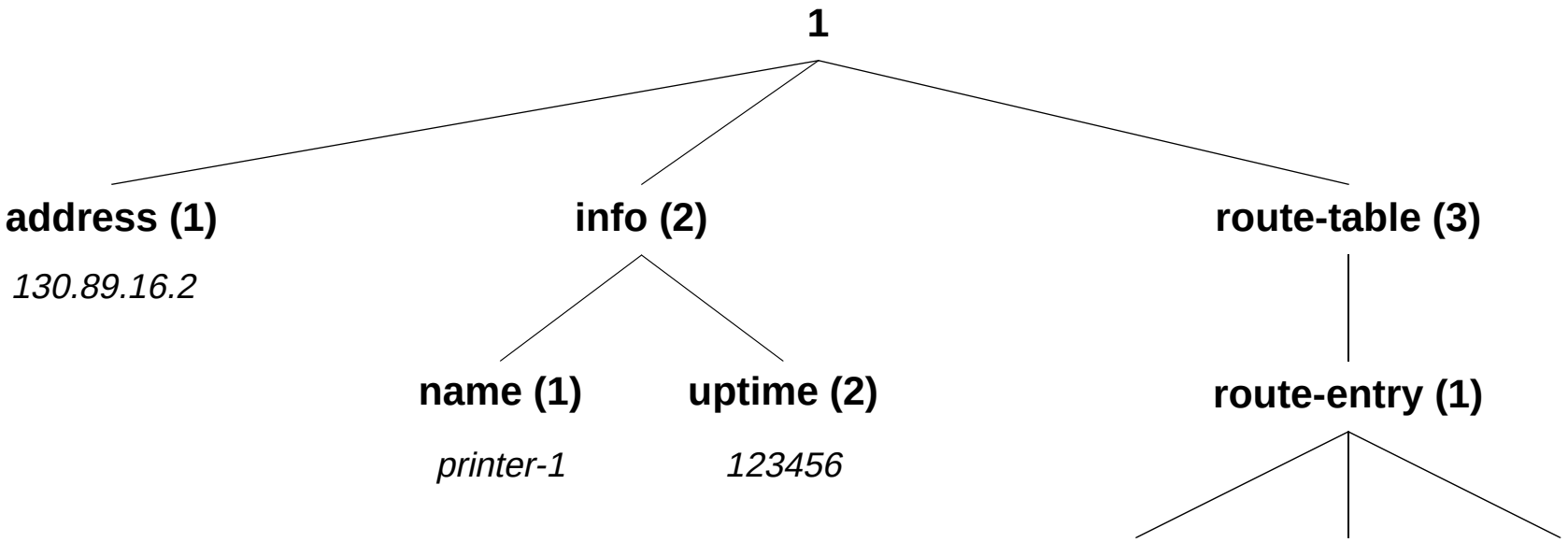
Result does not fit in Response PDU

• genErr

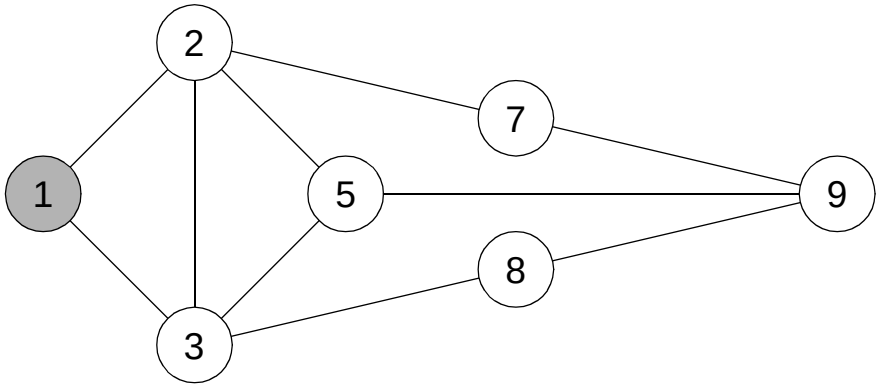
⇩

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)

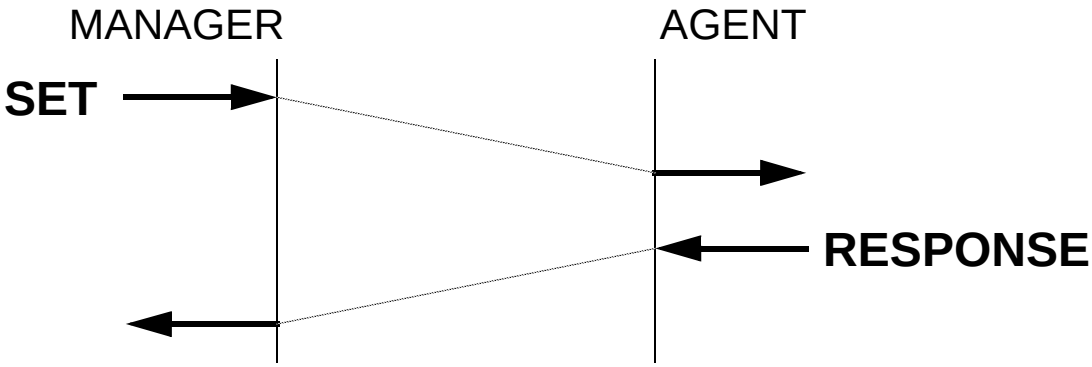
GET(1.1.0; 1.2.2.0)
RESPONSE(1.1.0 => *130.89.16.2*; 1.2.2.0 => *123456*)

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:

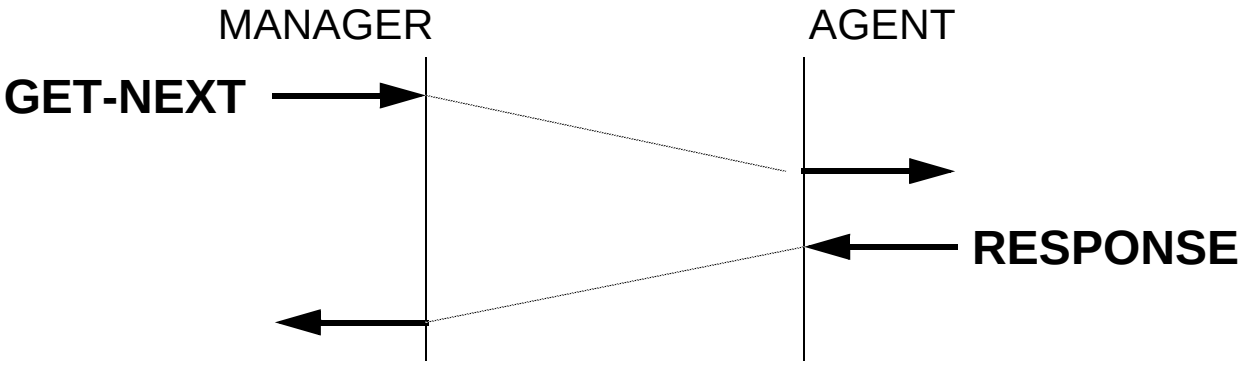
- noSuchName
- badValue
- genErr
- tooBig

SET

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*)

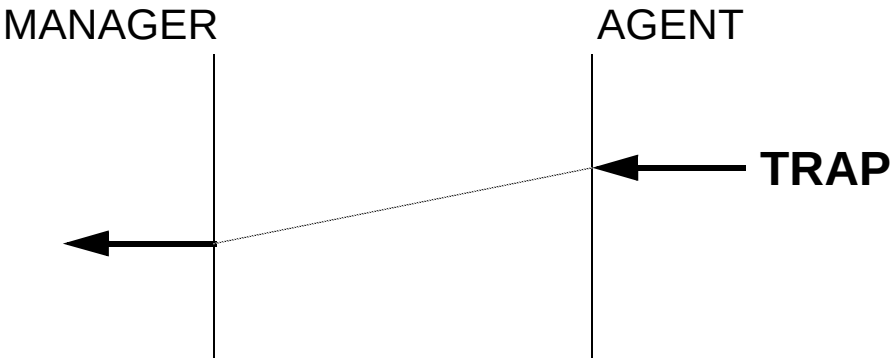
GET-NEXT(1.3.1.1.1; 1.3.1.2.1; 1.3.1.3.1)
RESPONSE(1.3.1.1.2 => *2*; 1.3.1.2.2 => *3*; 1.3.1.3.2 => *3*)

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

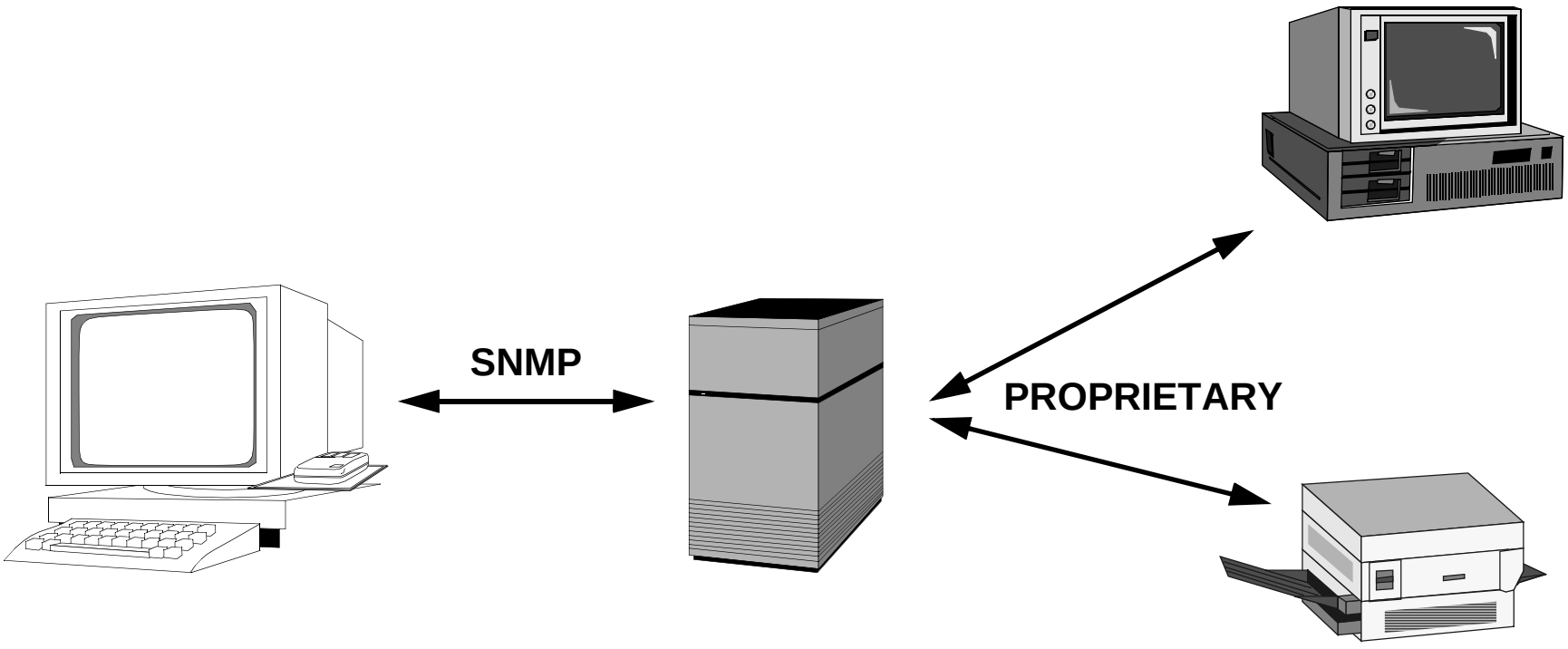
DEFINED TRAPS

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

TRAP - PDU FORMAT

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

PROXY MANAGEMENT



SNMPv2

IMPROVED INFORMATION MODEL (SMIv2)

- ADDITIONAL DATA TYPES
- TEXTUAL CONVENTIONS

E.G. ROW STATUS

- NOTIFICATIONS

IMPROVED COMMUNICATION MODEL

- TRAPS HAVE SAME FORMAT AS OTHER PDUS
- GET-BULK PDU
- ADDITIONAL ERROR CODES FOR SETS

TWO SECURITY MODELS

- SNMPv2C: COMMUNITY BASED
- SNMPv2U: USER BASED

MIB-II

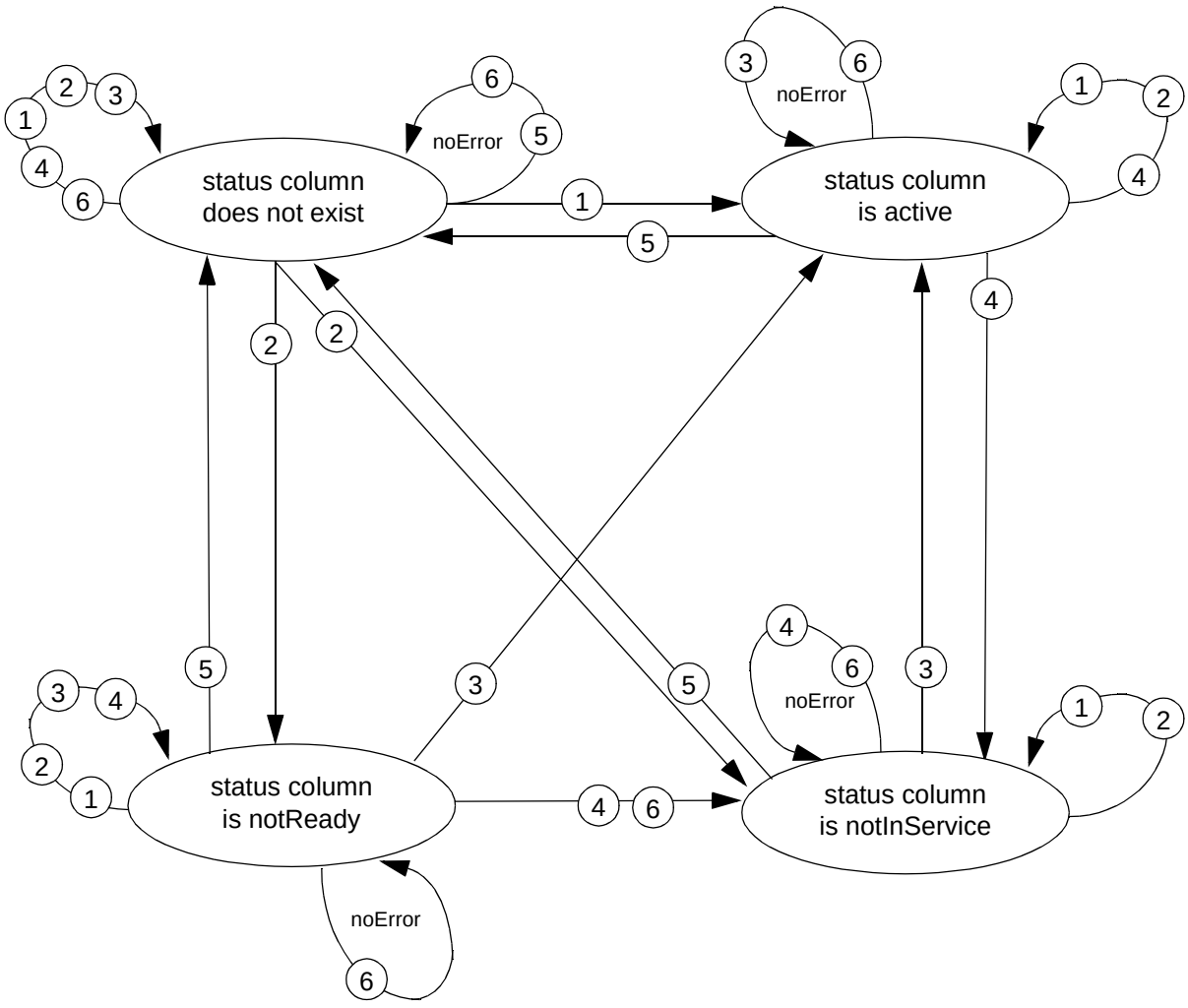
- SPLIT INTO MODULES:

INDEPENDENCE OF TCP/IP

ADDITIONAL DATA TYPES

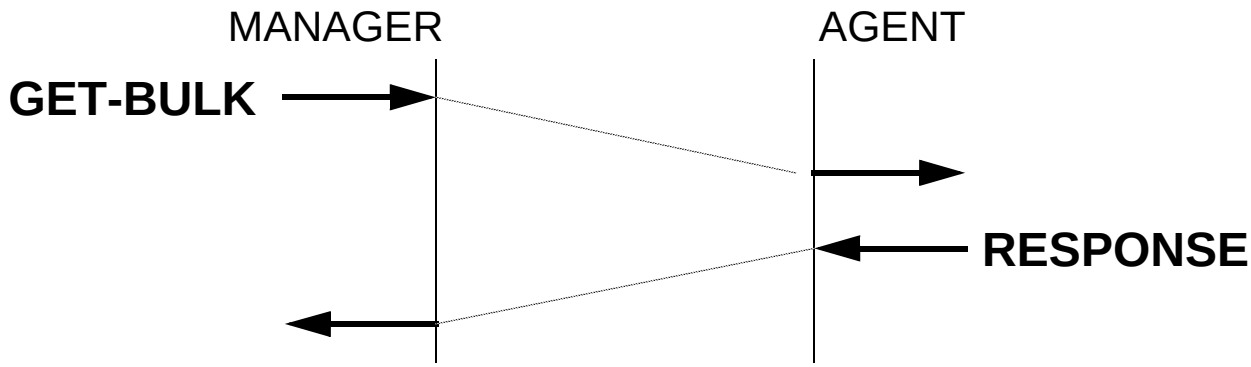
SMIv1	SMIv2
INTEGER	INTEGER
OCTET STRING	OCTET STRING
OBJECT IDENTIFIER	OBJECT IDENTIFIER
INTEGER	INTEGER32
-	UNSIGNED32
GAUGE	GAUGE32
COUNTER	COUNTER32
-	COUNTER64
TIMETICKS	TIMETICKS
IPADDRESS	IPADDRESS
OPAQUE	OPAQUE
-	BITS
NETWORKADDRESS	-

ROW STATUS



1	set status column to createAndGo	4 6	4 or 6
2	set status column to createAndWait		
3	set status column to active		
4	set status column to notInService		
5	set status column to destroy		
6	set any other column to some value		

GET-BULK



GET-BULK(max-repetitions = 4; 1.1)

RESPONSE(
1.1.0 => *130.89.16.2*
1.2.1.0 => *printer-1*
1.2.2.0 => *123456*
1.3.1.1.1 => *1*
)

GET-BULK(max-repetitions = 3;
1.3.1.1; 1.3.1.2; 1.3.1.3)

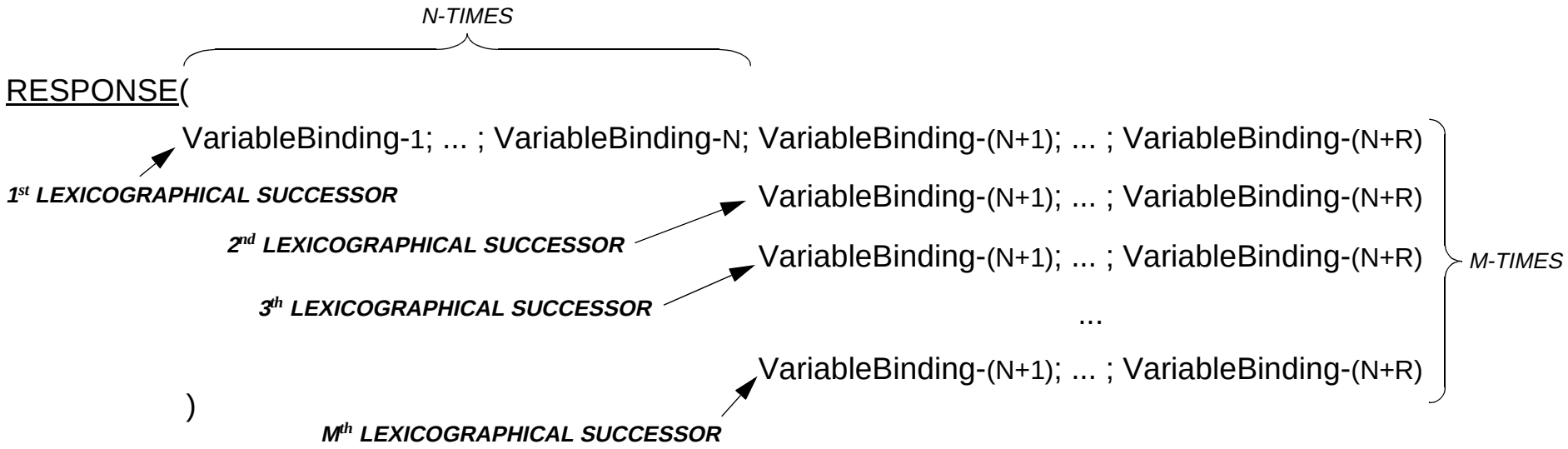
RESPONSE(

1.3.1.1.1 => *1*;	1.3.1.2.1 => *2*;	1.3.1.3.1 => *2*
1.3.1.1.2 => *2*;	1.3.1.2.2 => *3*;	1.3.1.3.2 => *3*
1.3.1.1.3 => *3*;	1.3.1.2.3 => *5*;	1.3.1.3.3 => *2*

)

GET-BULK

REQUEST(non-repeaters = N; max-repetitions = M;
VariableBinding-1; ... ; VariableBinding-N; VariableBinding-(N+1); ... ; VariableBinding-(N+R)
)



ADDITIONAL ERROR CODES FOR SETS

SNMPv1	SNMPv2
badValue	wrongValue
badValue	wrongEncoding
badValue	wrongType
badValue	wrongLength
badValue	inconsistentValue
noSuchName	noAccess
noSuchName	notWritable
noSuchName	noCreation
noSuchName	inconsistentName
genErr	resourceUnavailable
genErr	CommitFailed
genErr	undoFailed
...	...

SNMPv2 SECURITY: WHAT HAPPENED?

APRIL 1993:
PROPOSED STANDARD
SECURITY BASED ON *PARTIES*
FOUR EDITORS

SOON AFTERWARDS:
FIRST PROTOTYPES

SPRING 1995:
MANAGEMENT HIERARCHIES REMOVED
SPECIAL WORKING GROUP FORMED
(DISMAN)

JUNE 1995:
PROPOSED STANDARD REJECTED
BY TWO OF THE ORIGINAL EDITORS!

AUGUST 1995:
GENERAL AGREEMENT THAT
PARTY BASED SECURITY MODEL WAS
TOO COMPLEX!
MANY NEW PROPOSALS APPEARED

SNMPv2 STATUS

INFORMATION MODEL:

- DRAFT STANDARD
- RFC1902, RFC1903, RFC1904

COMMUNICATION MODEL

- DRAFT STANDARD
- RFC 1905, RFC1906

SECURITY MODEL - SNMPv2C:

- COMMUNITY BASED SNMP
- SAME ‘SECURITY MECHANISMS’ AS SNMPv1
- EXPERIMENTAL STATUS
- RFC 1901

SECURITY MODEL - SNMPv2U:

- USER BASED SECURITY
- AUTHENTICATION
- ENCRYPTION
- ACCESS CONTROL
- EXPERIMENTAL STATUS
- RFC 1909, RFC1910

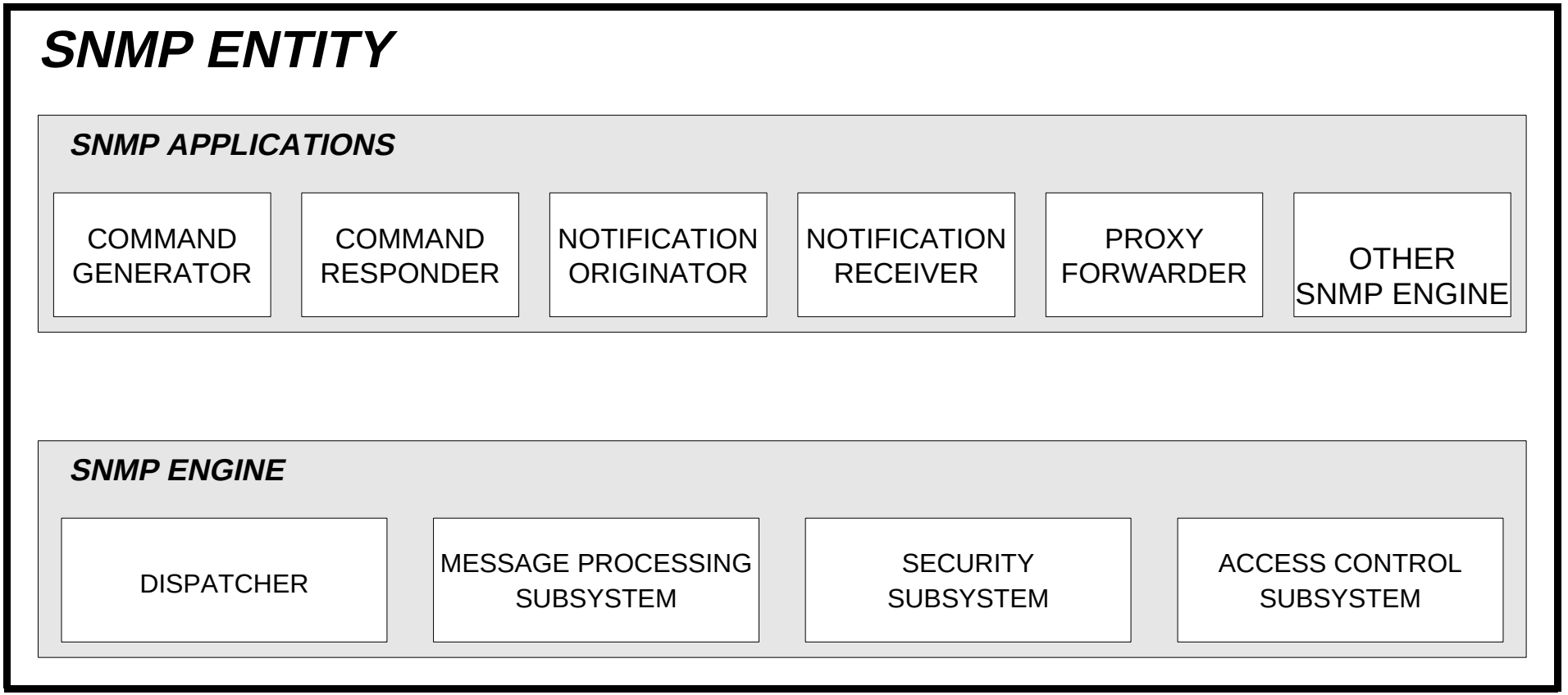
SNMPv3

ALLOWS SECURE COMMUNICATION

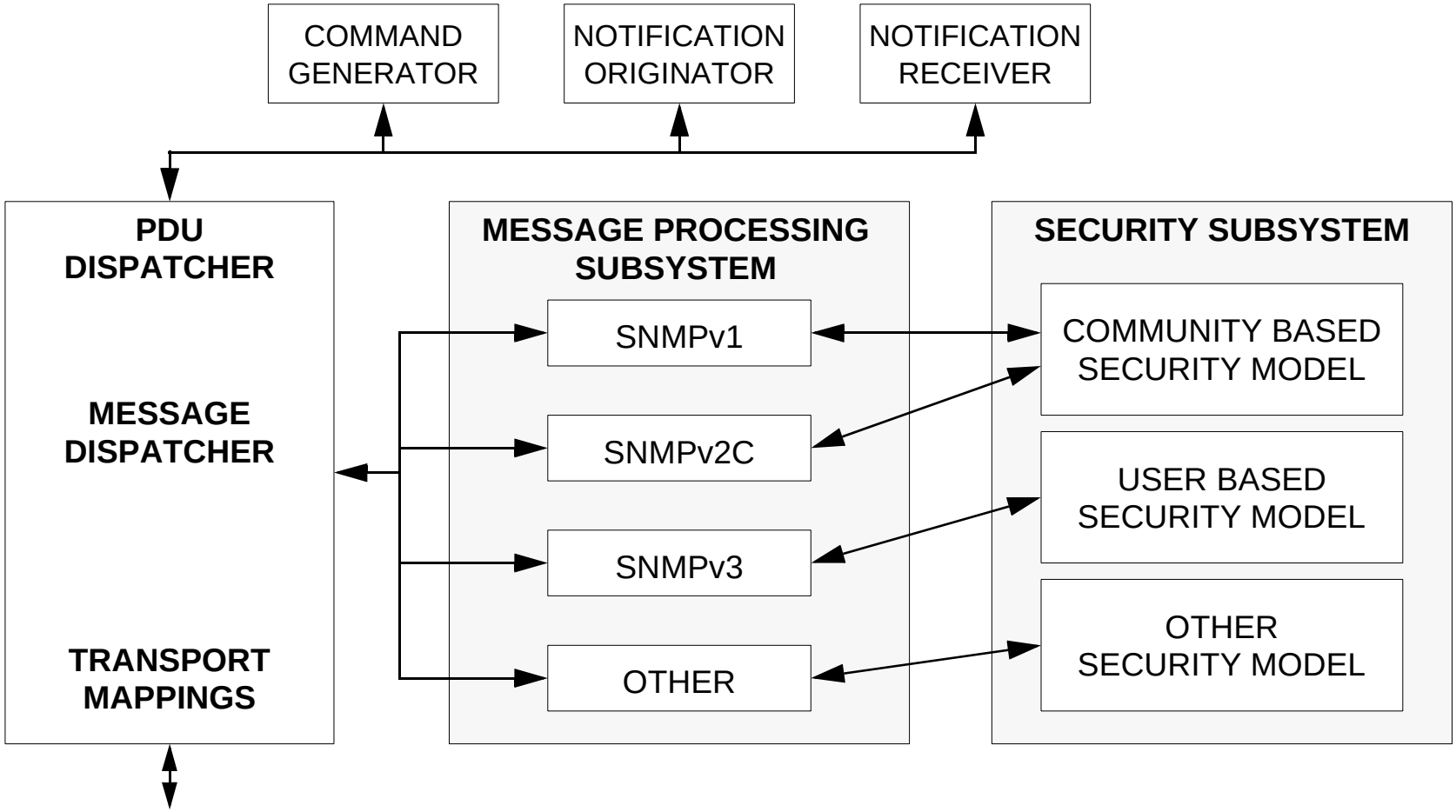
ALLOWS ACCESS CONTROL

HAS A MODULAR ARCHITECTURE

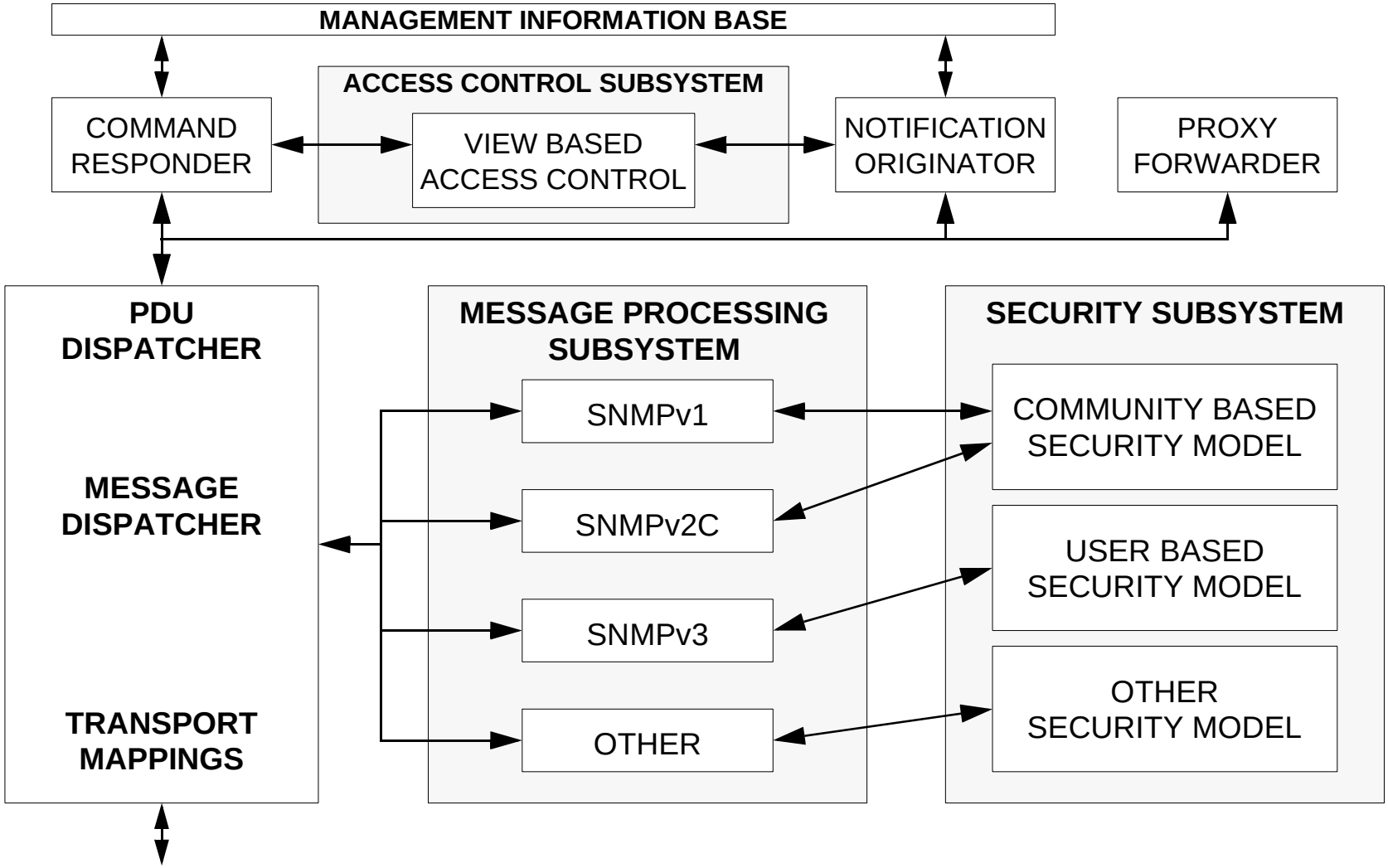
MODULAR SNMPv3 ARCHITECTURE



MODULAR SNMPv3 ARCHITECTURE: MANAGER



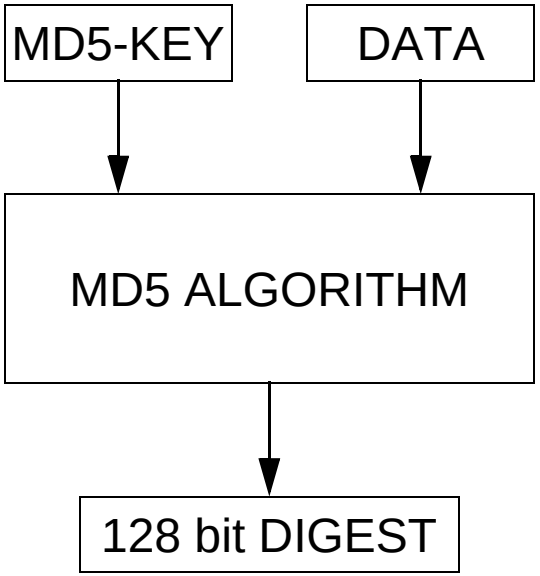
MODULAR SNMPv3 ARCHITECTURE: AGENT



SECURITY THREATS

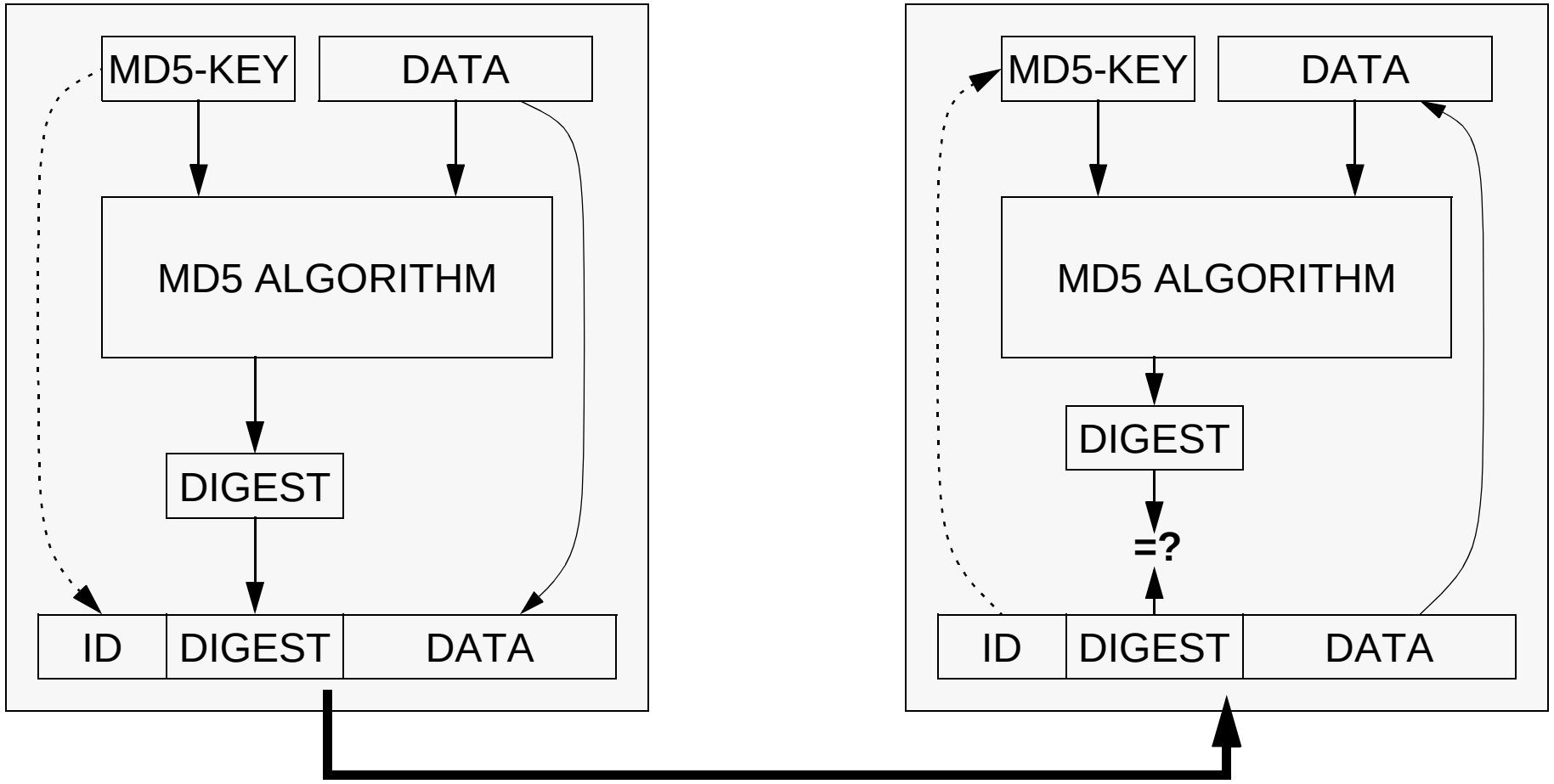
THREAT	ADDRESSED?	MECHANISM
MASQUERADE	YES	MD5 / SHA-1
REPLAY	YES	TIME STAMP
DISCLOSURE	YES	DES
INTEGRITY	YES	(MD5)
DENIAL OF SERVICE	NO	
TRAFFIC ANALYSIS	NO	

IDEA BEHIND MESSAGE DIGEST ALGORITHM (MD5)

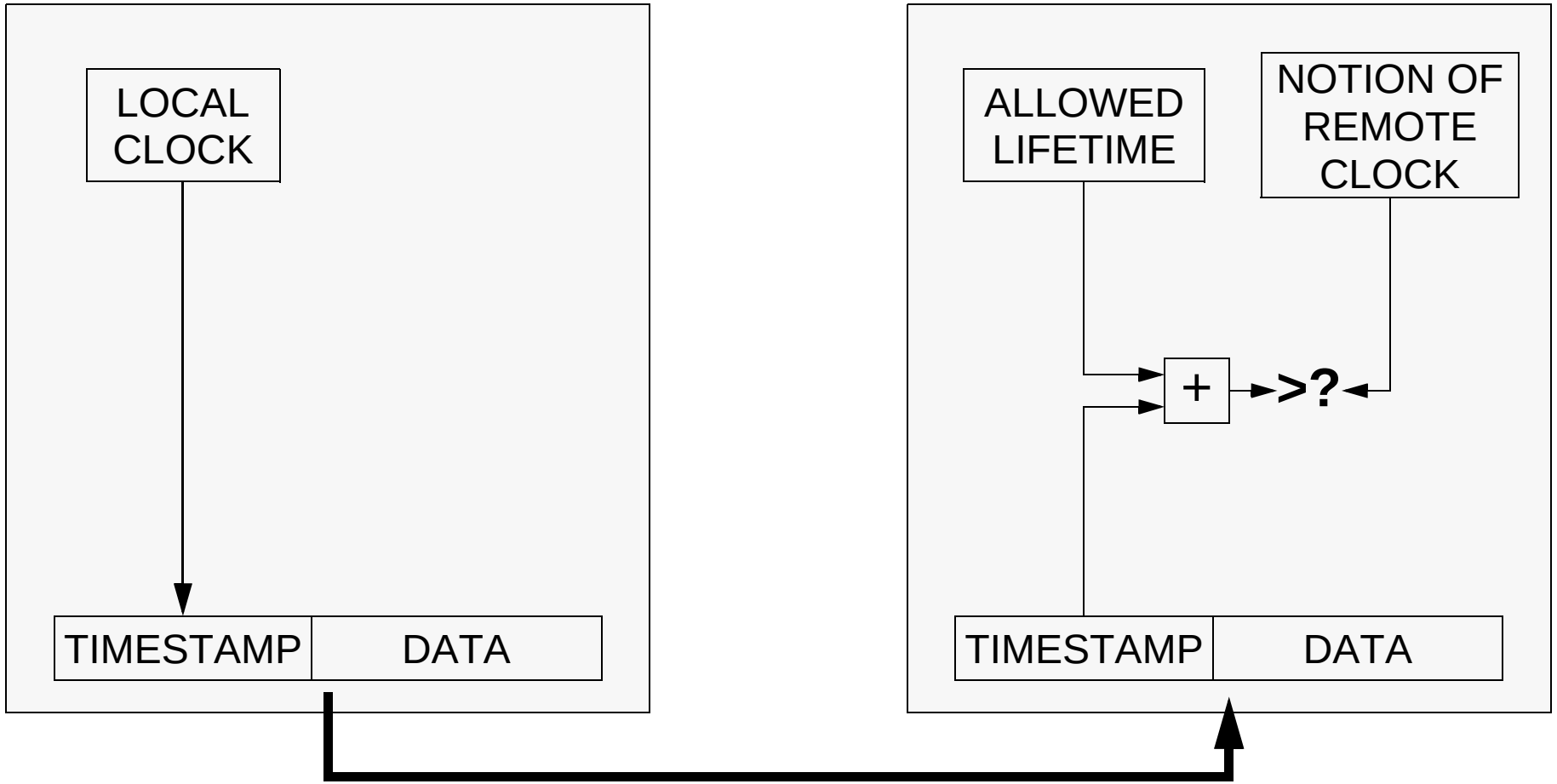


ADD THE DIGEST TO THE DATA
AND SEND THE RESULT

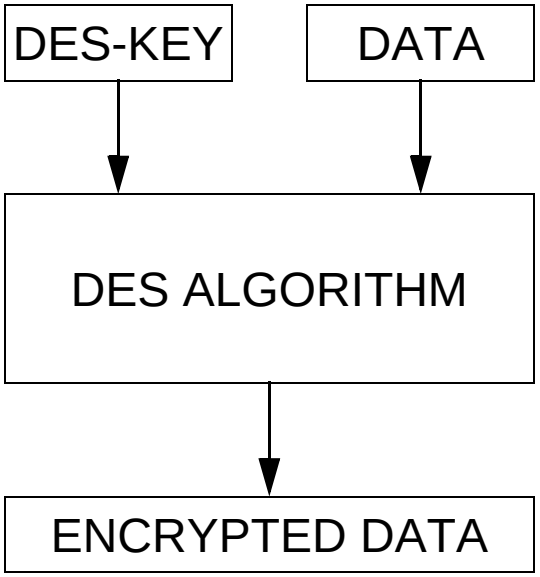
IDEA BEHIND AUTHENTICATION



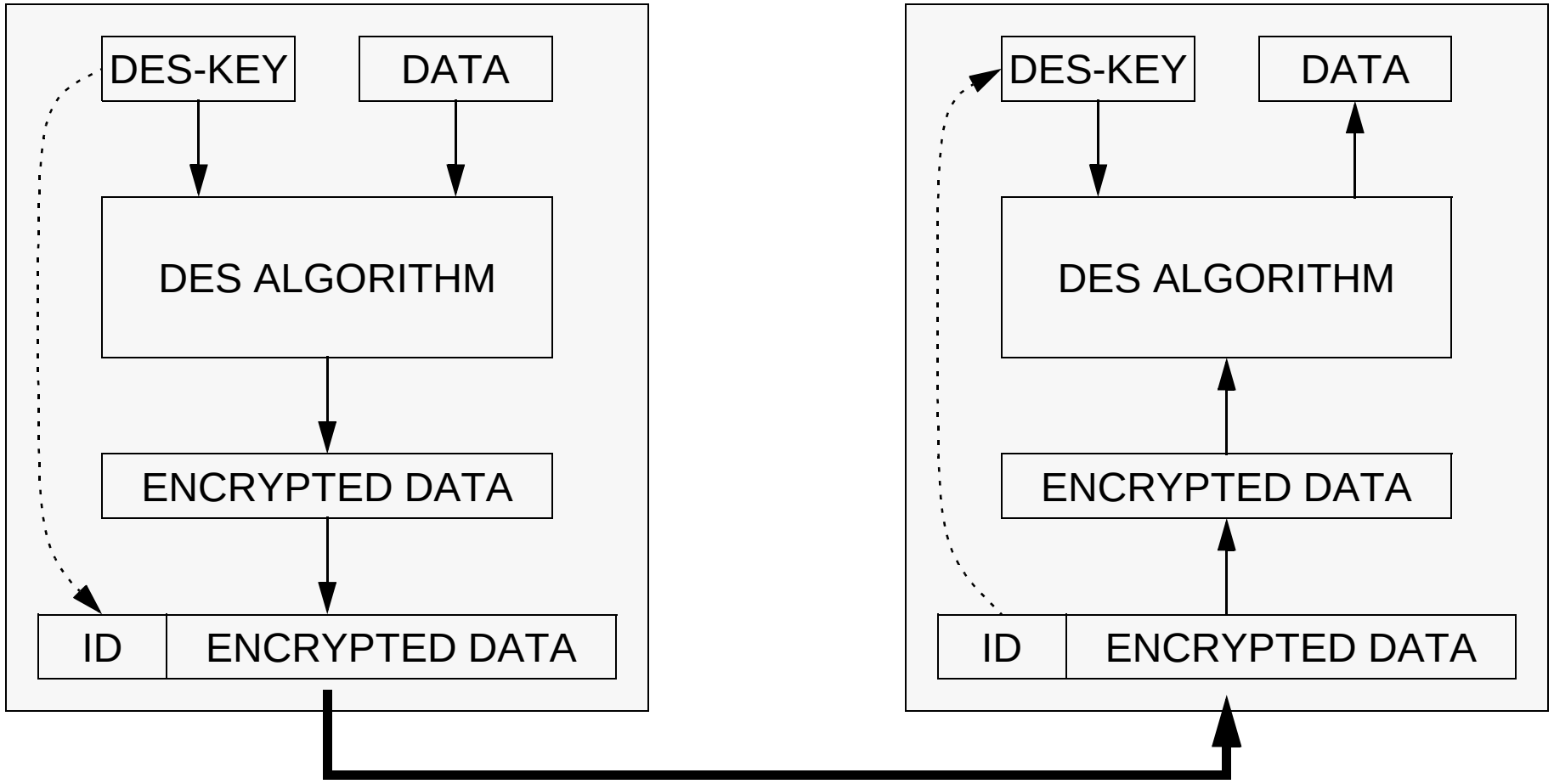
IDEA BEHIND REPLAY PROTECTION



IDEA BEHIND THE DATA ENCRYPTION STANDARD (DES)



IDEA BEHIND ENCRYPTION



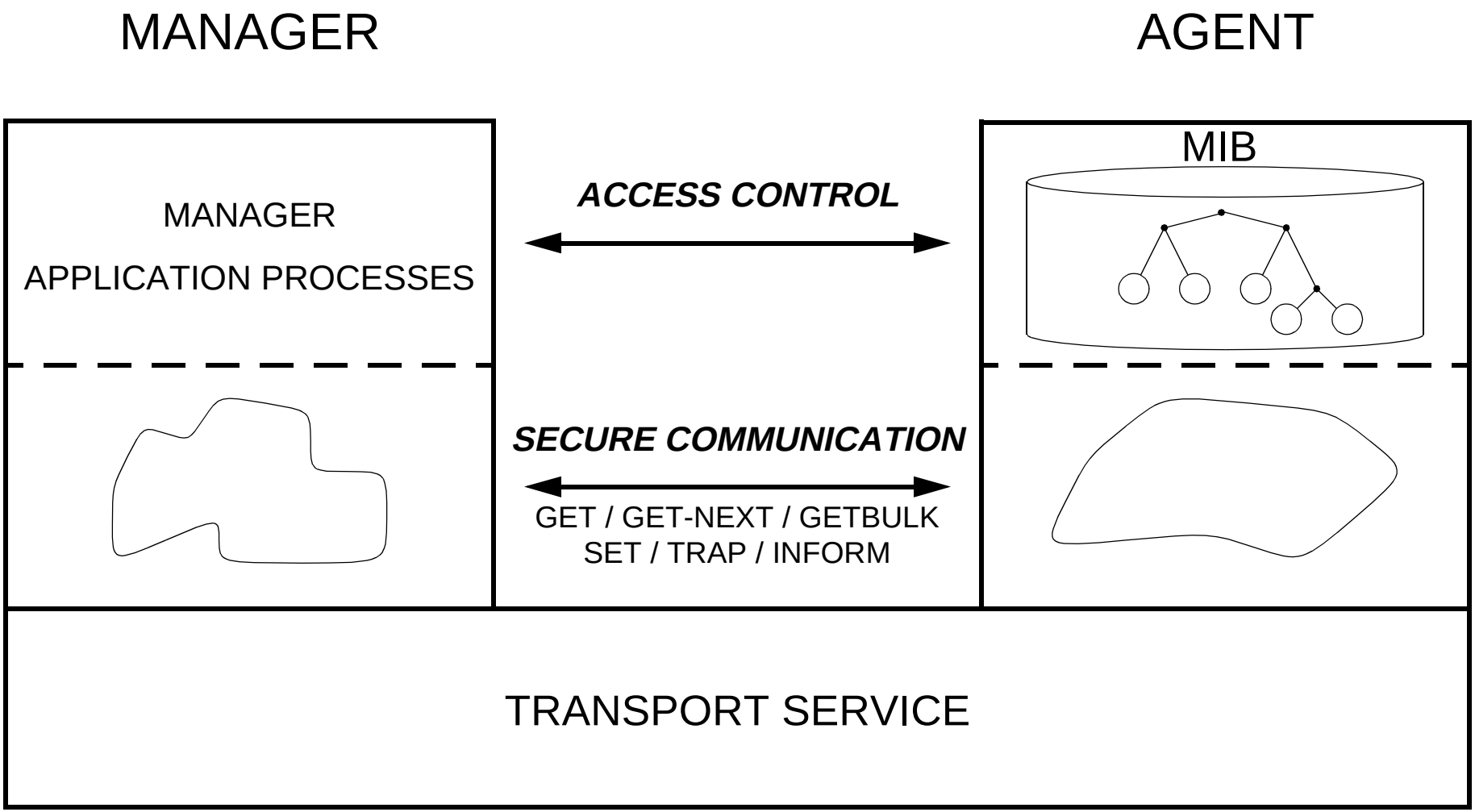
OTHER SECURITY ASPECTS

ACCESS CONTROL

MIB VIEWS

CONTEXTS

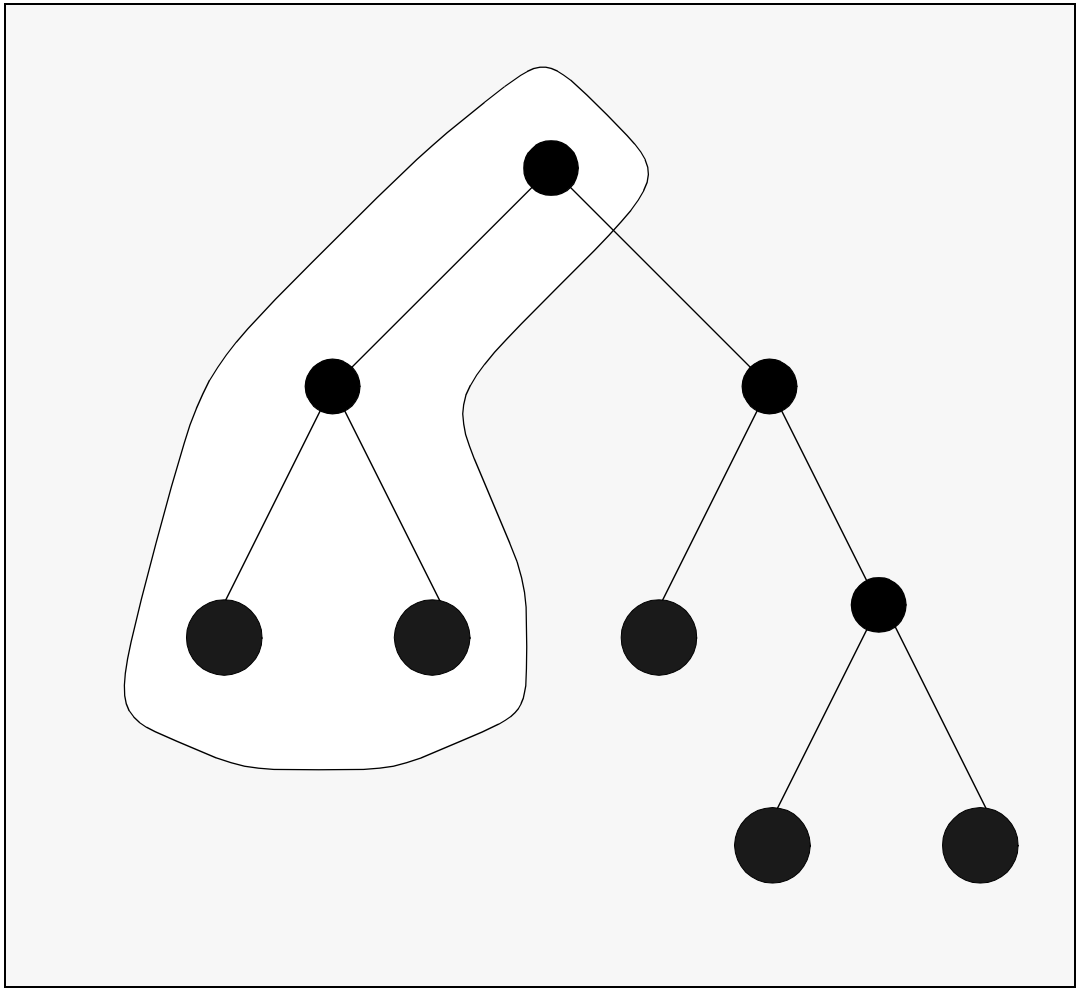
SECURE COMMUNICATION VERSUS ACCESS CONTROL



ACCESS CONTROL TABLES

MIB VIEW	ALLOWED OPERATIONS	ALLOWED MANAGERS	REQUIRED LEVEL OF SECURITY
•••	•••	•••	•••

MIB VIEWS



TRANSMISSION MIBs

Title	RFC	STATUS
Classical IP and ARP over ATM (IPOA)	2320	P
IEEE 802.12 Repeater Devices	2266	P
IEEE 802.3 Medium Attachment Units	2239	P
Interfaces Group MIB	2233	P
Dial Control	2128	P
ISDN	2127	P
Frame Relay DTEs	2115	D
IEEE 802.3 Repeater Devices	2108	P
Data Link Switching	2024	P
IEEE 802.12 Interfaces	2020	P
IEEE 802.5 Station Source Routing	1749	P
IEEE 802.5	1748	D
ATM	1695	P
SMDS	1694	D
Ethernet	1650	P
Frame Relay	1604	P
SONET / SDH	1595	P
Source Routing Bridges	1525	P
FDDI	1512	P
Bridges	1493	D
Bridge Network Control Protocol of PPP	1474	P
IP Network Control Protocol of PPP	1473	P
Security Protocols of PPP	1472	P
Link Control Protocol of PPP	1471	P
Multiprotocol Interconnect over X.25	1461	P
DS3 / E3	1407	P
DS1 / E1	1406	P
X.25 Packet Layer	1382	P
X.25 LAPB	1381	P

NETWORK LAYER MIBs

Title	RFC	STATUS
Integrated Services - Guaranteed Service Ext.	2214	P
Integrated Services	2213	P
RSVP	2206	P
IP Forwarding Table	2096	P
RMON Version 2	2021	P
SNMPv2	2011	P
IP Mobility Support	2006	P
OSPF Version 2	1850	D
RMON	1757	D
RIP	1724	D
BGP Version 4	1657	D
Token Ring extensions to RMON	1513	P
Identification MIB	1414	P
BGP Version 3	1269	P
MIB-II	1213	S

TRANSPORT LAYER MIBs

Title	RFC	STATUS
User Datagram Protocol (UDP)	2013	P
Transmission Control Protocol (TCP)	2012	P

APPLICATION LAYER MIBs

Title	RFC	STATUS
System-Level M.O. for Applications	2287	P
Mail Monitoring	2249	P
Network Service Monitoring	2248	P
RDBMS	1697	P
DNS Resolver	1612	P
DNS Server	1611	P
X.500 Directory	1567	P
Host Resources	1514	P

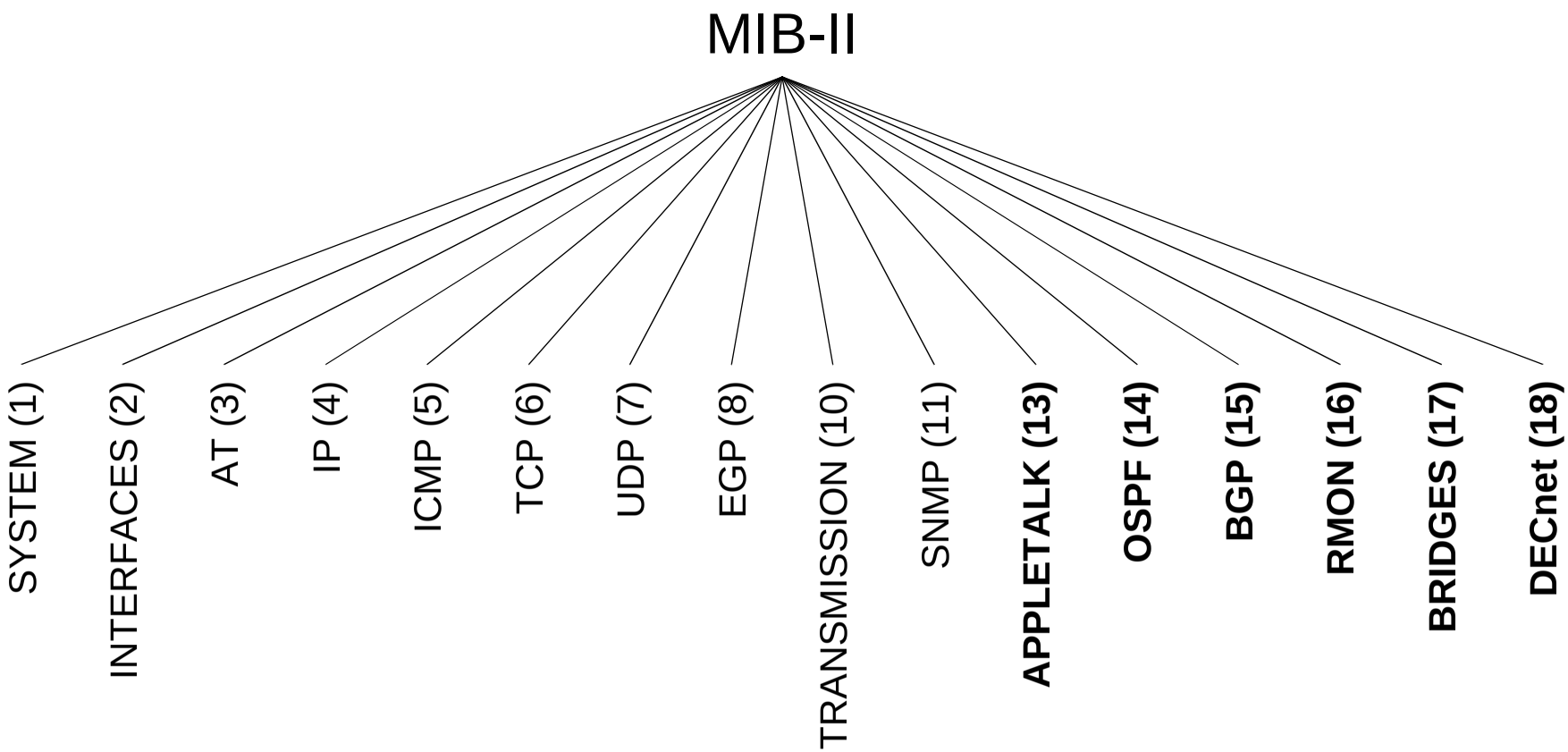
HARDWARE SPECIFIC MIBs

Title	RFC	STATUS
Entity	2037	P
Printer	1759	P
Modem	1696	P
Parallel printer-like Hardware	1660	D
RS-232-like Hardware	1659	D
Character Stream Devices	1658	D
UPS	1628	P

VENDOR SPECIFIC MIBs

Title	RFC	STATUS
HPN	2238	P
DLUR	2232	P
APPN	2155	P
APPC	2051	P
TCP/IPX Connection	1792	E
SNA Data Link Control (SDLC)	1747	P
Appletalk	1742	P
SNA NAUs	1666	P
DECNET Phase IV	1559	D
SNMP over IPX	1420	P
SNMP over Appletalk	1419	P

OTHER MIBs


MIB-II
SYSTEM (1)
INTERFACES (2)
AT (3)
IP (4)
ICMP (5)
TCP (6)
UDP (7)
EGP (8)
TRANSMISSION (10)
SNMP (11)
APPLETALK (13)
OSPF (14)
BGP (15)
RMON (16)
BRIDGES (17)
DECnet (18)

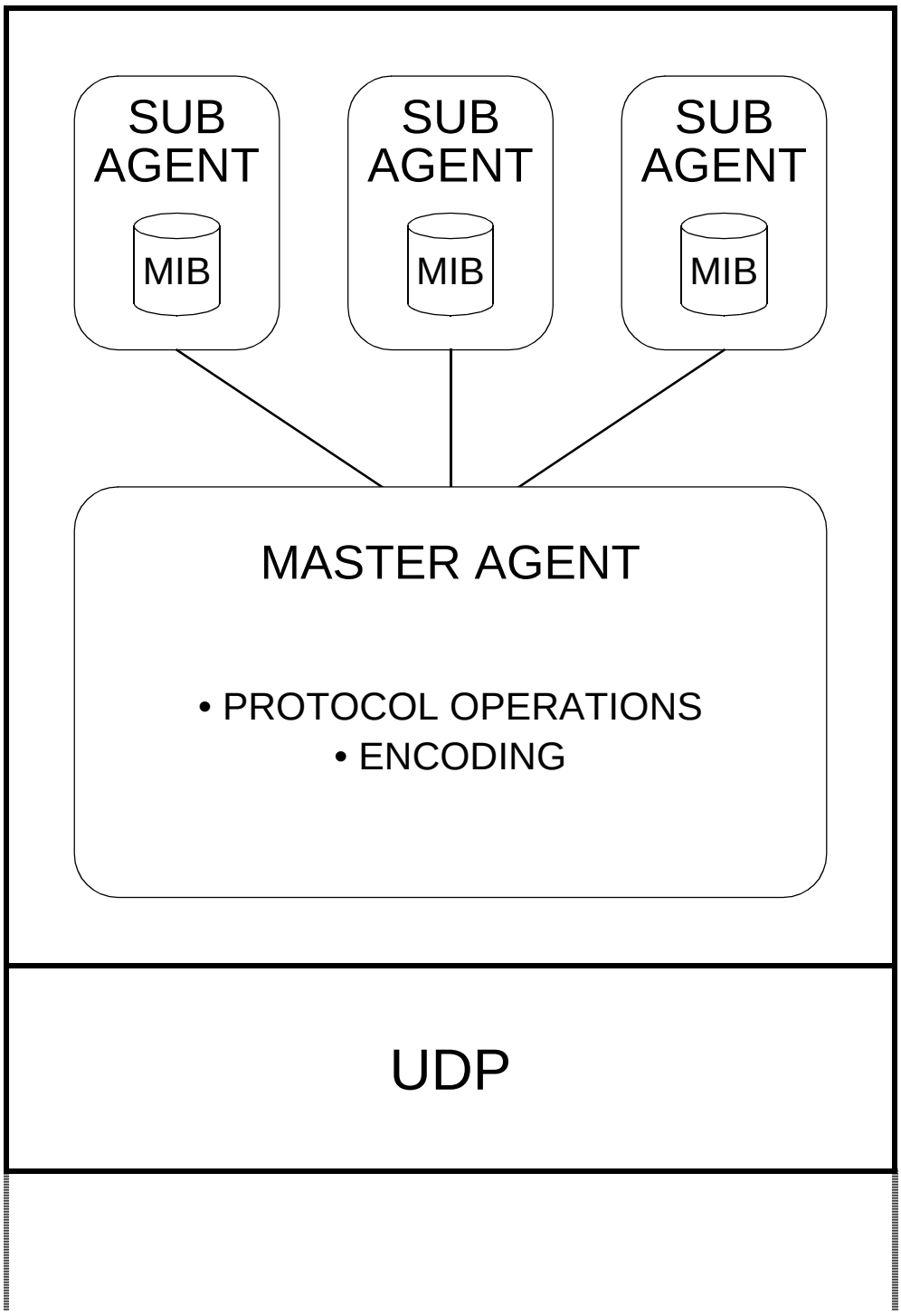
RELATION BETWEEN MIBs - 1

	MIB-II	HOST	REPEATER	BRIDGE	RMON
INTERFACE STATISTICS	✓				
IP, TCP & UDP STATISTICS	✓				
SNMP STATISTICS	✓				
HOST JOB COUNTS		✓			
HOST FILE SYSTEM INFORMATION		✓			
LINK TESTING			✓	✓	
NETWORK TRAFFIC STATISTICS			✓	✓	✓
TABLE WITH ALL MAC ADDRESSES			✓		✓
STATISTICS PER HOST			✓		✓

RELATION BETWEEN MIBs - 2

	MIB-II	HOST	REPEATER	BRIDGE	RMON
HISTORICAL STATISTICS					✓
SPANNING TREE PERFORMANCE				✓	
WIDE AREA LINK PERFORMANCE				✓	
TRESHOLDS FOR ANY VARIABLE					✓
CONFIGURABLE STATISTICS					✓
TRAFFIC MATRIX WITH ALL NODES					✓
‘HOST TOP N’ INFORMATION					✓
PACKET / PROTOCOL ANALYSIS					✓
DISTRIBUTED LOGGING					✓

EXTENSIBLE AGENTS



EXTENSIBLE AGENTS

PROPOSALS

SMUX
SNMP MULTIPLEXING PROTOCOL
RFC 1227

DPI
DISTRIBUTED PROTOCOL INTERFACE
RFC 1228 & RFC 1592

OAA
OPEN AGENT ARCHITECTURE

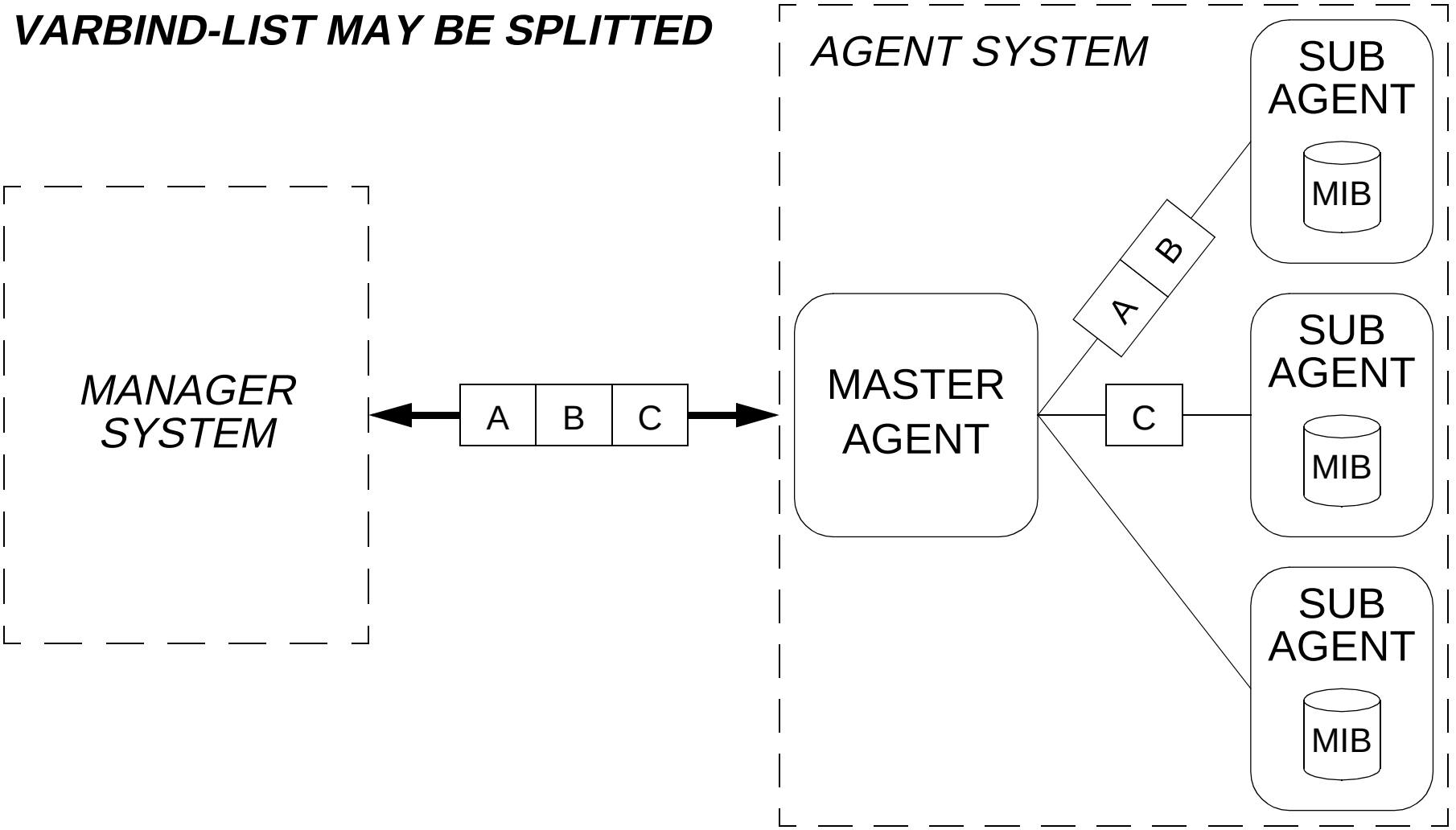
EMANATE
ENHANCED MANAGEMENT AGENT THROUGH EXTENSIONS

MCSA
MULTIPLE COMPONENT SNMP AGENT

UNIVERSITY OF TWENTE
UT-SNMPv2

EXTENSIBLE AGENTS

VARBIND-LIST MAY BE SPLITTED



EXTENSIBLE AGENTS

REQUIRES OID REGISTRATION:

- TOP REGISTRATION
- RANGE REGISTRATION

TABLE ENTRIES MAY BE
CREATED AND DELETED
AT RUN-TIME!

EXTENSIBLE AGENTS

POTENTIAL PROBLEMS:

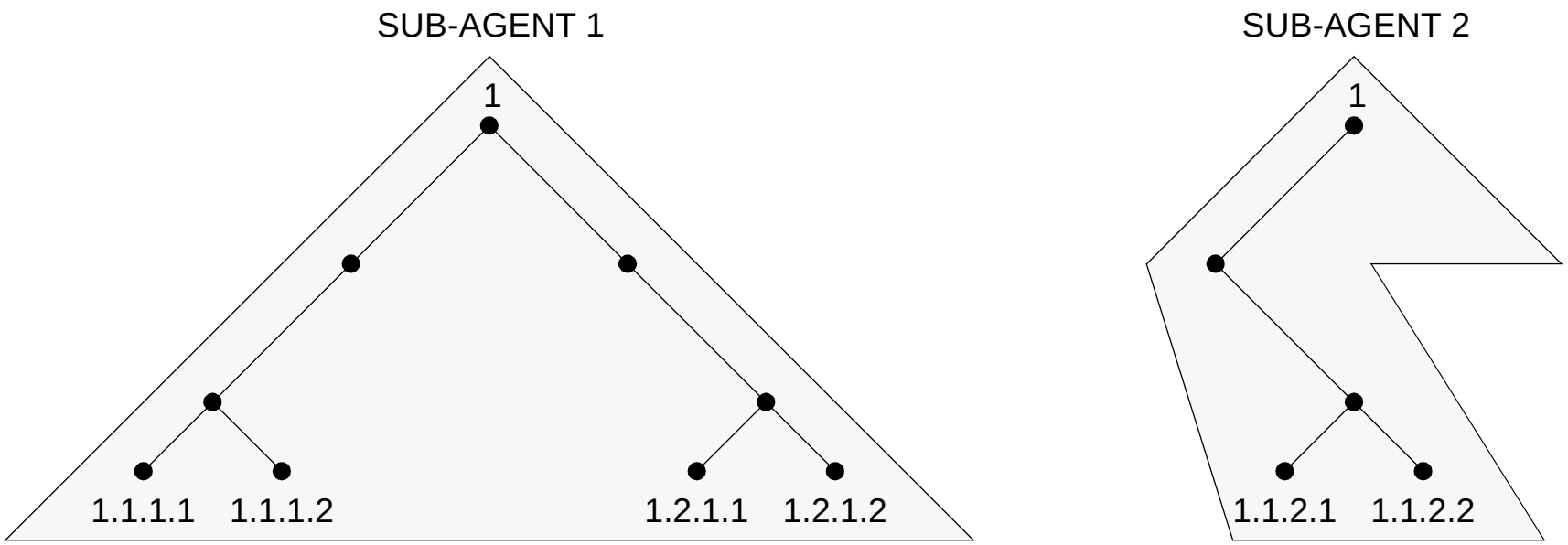
- ENTRIES OF A SINGLE TABLE MAY BE LOCATED IN DIFFERENT SUBAGENTS

- DUPLICATED OIDs

- GAPS

- SETS

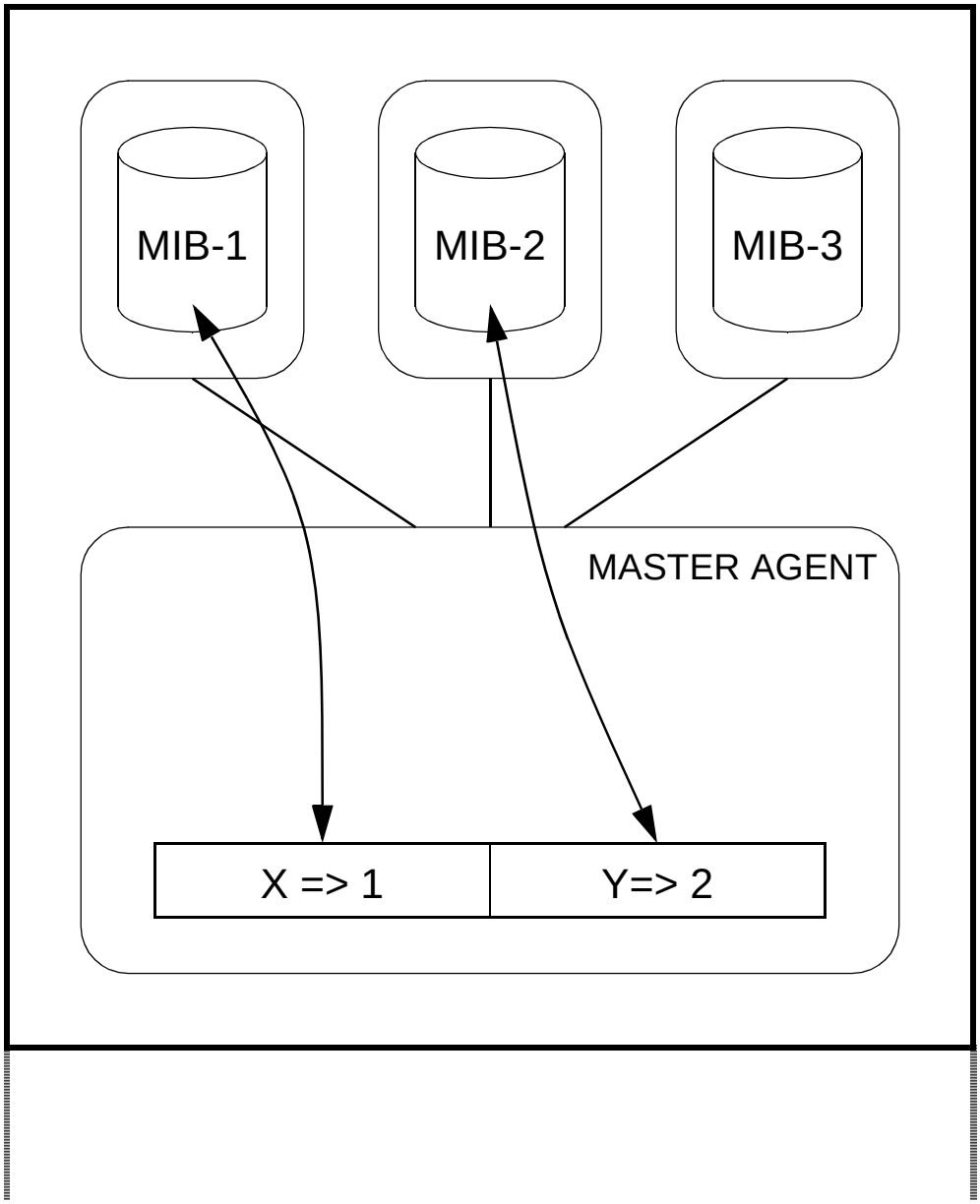
EXTENSIBLE AGENTS



GET-NEXT ...

EXTENSIBLE AGENTS

SETS AND ATOMICITY

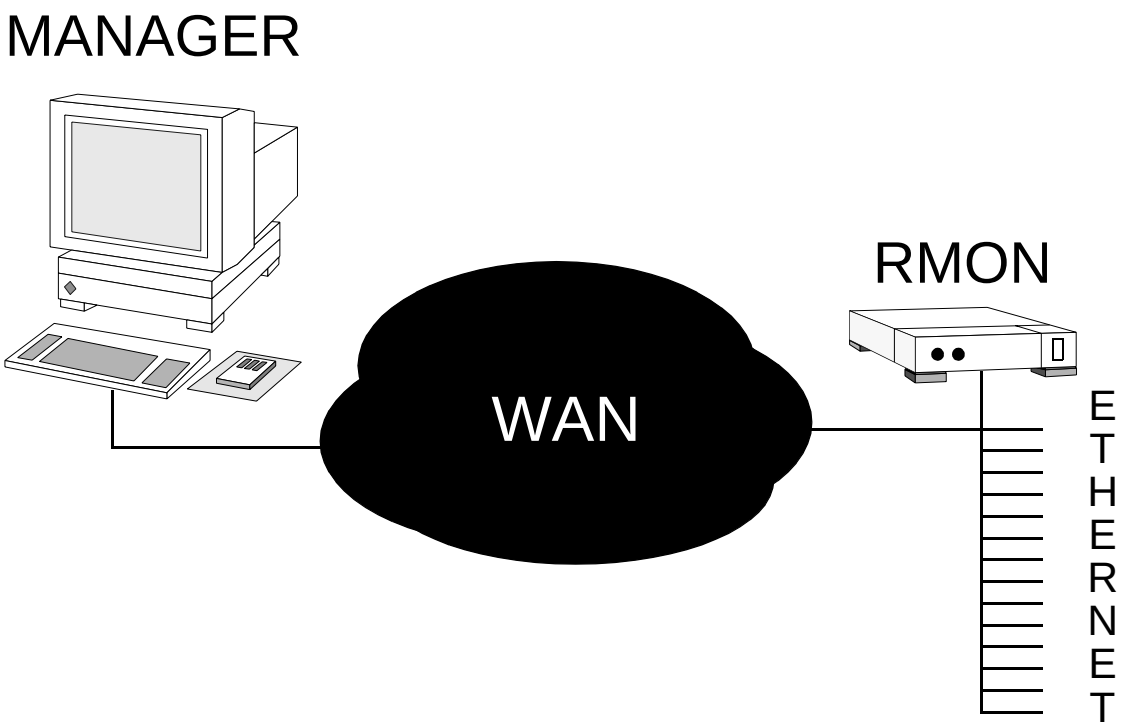


TRANSACTION-LIKE APPROACH

- PROBE
- COMMIT
- CLEAR / ROLL-BACK

REMOTE MONITORING

RMON



RFC 1757

RMON GROUPS

NINE GROUPS:

- STATISTICS
- HISTORY
- HOST TABLE
- HOST TOP N
- TRAFFIC MATRIX
- ALARMS
- FILTERS
- PACKET CAPTURE
- EVENTS

STATISTICS GROUP

KEEPS STATISTICS PER ETHERNET SEGMENT

SHOWS:

- PACKETS
- OCTETS
- BROADCASTS
- MULTICASTS
- COLLISIONS
- ERRORS

	< 64 Bytes	**64 to 1518**	**>1518 bytes**
WELL-FORMED PACKETS	undersize	GOOD!	oversize
BAD FCS ERRORS	fragments	CRC or alignment errors	jabber

KEEPS TRACK OF PACKET SIZE DISTRIBUTION:

- 65 - 127 OCTETS
- 128 - 255 OCTETS
- 256 - 511 OCTETS
- 512 - 1023 OCTETS
- 1024 - 1518 OCTETS

HISTORY GROUP

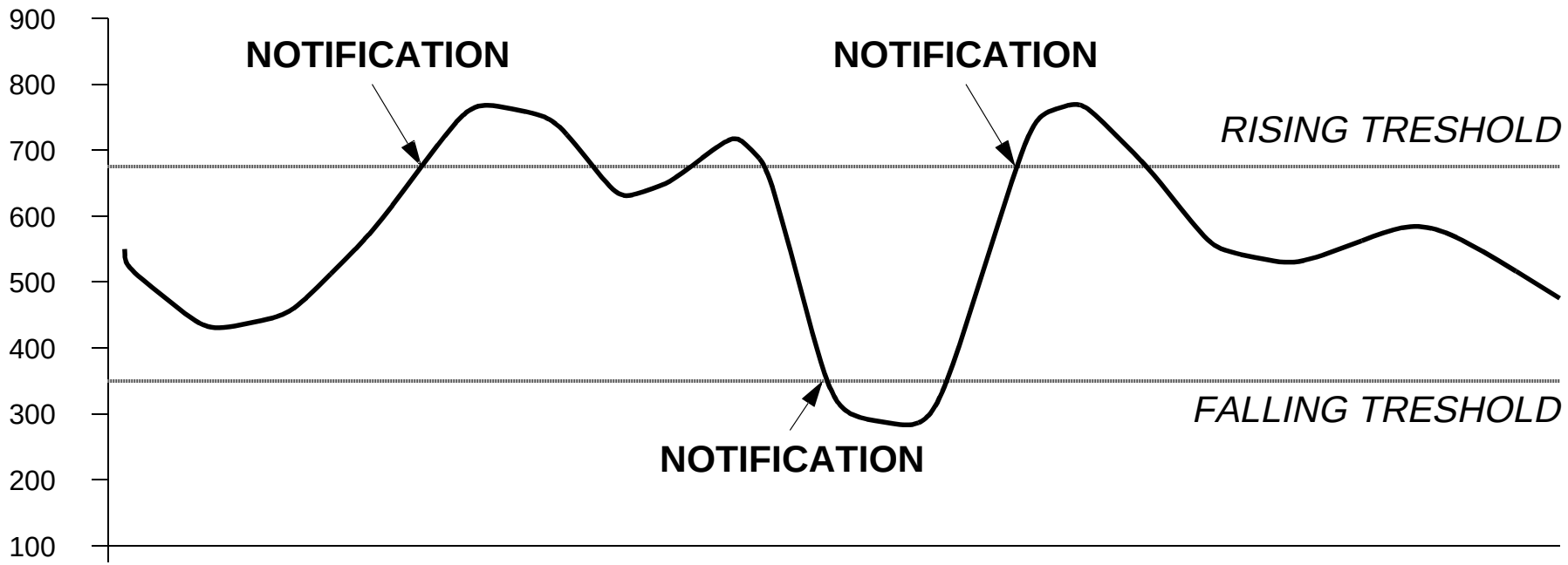
STORES INFORMATION OF STATISTICS GROUP
EXCEPT PACKET SIZE DISTRIBUTION

USES A CIRCULAR BUFFER

- BUCKETS
- SIZE MAY BE SET BY MANAGER

SAMPLING INTERVAL
MAY BE SET BY MANAGER

ALARM GROUP



ABSOLUTE OR DELTA VALUES

HOST INFORMATION

- HOST GROUP
- HOST TOP N

IN / OUT:
PACKETS / OCTETS

OUT:
BROADCASTS
MULTICASTS
ERRORS

INFORMATION INDEXED BY:

- INTERFACE AND MAC ADDRESS
hostTable

- CREATION TIME
hostTimetable

- SORTED ON SOME VARIABLE VALUE
hostTopN

OTHER GROUPS

- TRAFFIC MATRIX

FOR EACH SOURCE & DESTINATION

- PACKETS
- OCTETS
- ERRORS

- FILTER GROUP

TO COUNT PACKETS
THAT CARRY A SPECIFIC BIT-PATTERN

- PACKET CAPTURE GROUP

TO STORE SPECIFIC PACKETS

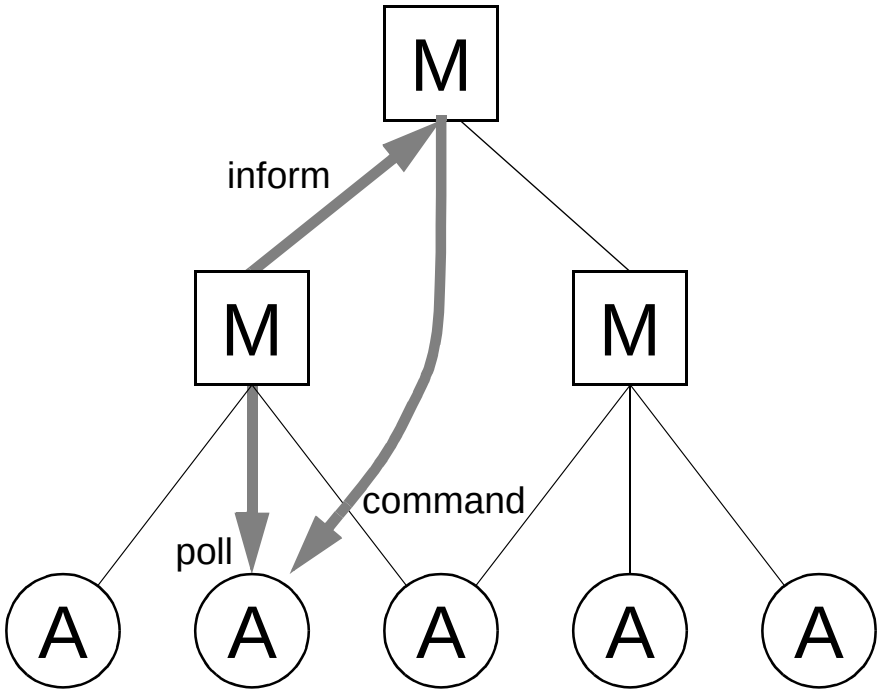
- EVENT GROUP

TO DEFINE THE VARIOUS EVENTS
DETERMINE TRANSMISSION OF TRAPS

DISTRIBUTED MANAGEMENT

TWO APPROACHES ARE BEING DEFINED:
- MIB BASED
- SCRIPT BASED

MIB-BASED:



- STANDARD MIB APPROACH
- LIMITED FUNCTIONALITY
- RUN-TIME BEHAVIOUR MUST BE DEFINED AT IMPLEMENTATION TIME

SCRIPT BASED

• FUNCTIONALITY CAN BE DEFINED
AT RUN-TIME

• POWERFUL
AUTONOMOUS ACTIONS

• MAY BE EASIER TO OPERATE
FOR THE TOP-LEVEL MANAGER

• PROTECTION MECHANISMS NECESSARRY

• DIFFERENT SCRIPT LANGUAGES

CMIP versus SNMP - 1

	CMIP	SNMP
model	event based	polling based
information approach	object oriented	variable oriented
complexity	agent is complex	agent is simple
state information	kept by agent	kept by manager
underlying service	CO - reliable	CL - unreliable
efficiency	good	acceptable
implementation	difficult	simple *(V2& V3 are more difficult)*

CMIP versus SNMP - 2

	CMIP	SNMP
retrieves	objects	scalars
many items	multiple replies	error: tooBIG
object selection	scoping & filtering	-
synchronization	atomic & best effort	atomic
events / traps	confirmed & unconfirmed	unconfirmed
actions	possible	via ‘trick’

CMIP versus SNMP - 3

	CMIP	SNMP
security	via underlying services	- *authentication / encryption / ACL-lists*
management functions	many	none
ASN.1	full support	subset
naming structure	flexible	simple

CMIP versus SNMP - CONCLUSION

	CMIP	SNMP
price	**high**	**low**
market acceptance	**no**	**yes**

CONCLUSIONS

NEW DEVELOPMENTS

BOOKS

WEBSITES

NEW DEVELOPMENTS

WEB BASED MANAGEMENT!

EMBEDDED MANAGEMENT APPLICATIONS:

• MANAGER IS A STANDARD WWW BROWSER

• DEVICE VENDORS CAN SELL MANAGEMENT CAPABILITIES

• AGENT BECOMES MORE COMPLEX

• USE OF JAVA

HTTP AS MANAGEMENT PROTOCOL:

• CONNECTION ORIENTED TRANSPORT

• USE OF HTTP SECURITY

APPLICATIONS:

• DEVICE MANAGEMENT

• CUSTOMER NETWORK MANAGEMENT

ADDITIONAL INFORMATION

BOOKS

• W. Stallings
SNMP, SNMPv2 and RMON
2nd edition, Addison-Wesley, 1996
ISBN: 0-201-63479-1

• M.T. Rose
The Simple Book
2nd edition, Prentice Hall, 1994
ISBN: 0-131-77254-6

• M.T. Rose, K. McCloghrie
How to manage your network using SNMP
Prentice Hall, 1995
ISBN: 0-13-141517-4

• D. Perkins, E. McGinnis
Understanding SNMP MIBs
Prentice Hall, 1997
ISBN: 0-13-437708-7

ADDITIONAL INFORMATION

WWW SERVERS

- The SimpleWeb
http://wwwsnmp.cs.utwente.nl

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

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

- IETF
http://www.ietf.org