NET311
Computer Networks Management
Standards, Models and Language

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  - Network Management: Principles and Practice, 2E, Mani Subramanian.
  - Computer Networking, a Top-Down Approach, 6E, J. Kurose and K. Ross.

Overview

- Standards
- Network Models
- Management communication protocols
- ASN.1 language
- Basic encoding rule
- Management application functions

Standards

- Standards organizations
- Protocol standards of transport layers
- Protocol standards of management (application) layer

Table 3.1 Network Management Standards

Standard	Salient Points
OSI/CMIP	1. International standard (ISO/OSI) 2. Management of data communications network - LAN and WAN 3. Deals with all 7 layers 4. Most complete 5. Object oriented 6. Well structured and layered 7. Consumes large resource in implementation
SNMP/Internet	1. Industry standard (IETF) 2. Originally intended for management of Internet components, currently adopted for WAN and telecommunication systems 3. Easy to implement 4. Most widely implemented

Table 3.1 Network Management Standards

Standard	Salient Points
TMN	1. International standard (ITU-T) 2. Management of telecommunications network 3. Based on OSI network management framework 4. Addresses both network and administrative aspects of management
IEEE	1. IEEE standards adopted internationally 2. Addresses LAN and MAN management 3. Adopts OSI standards significantly 4. Deals with first two layers of OSI RM

OSI Architecture and Model

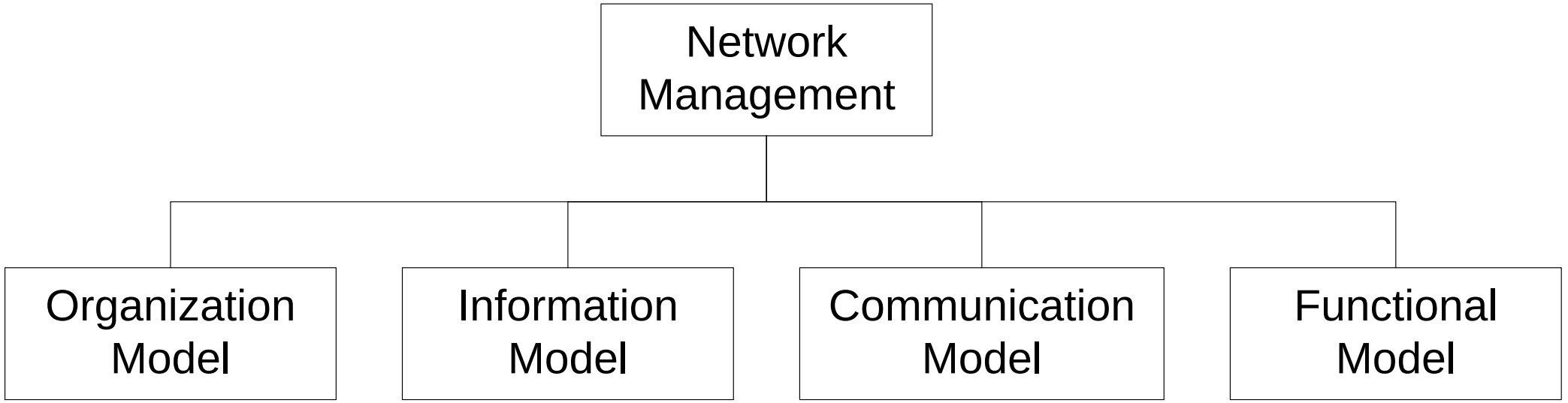


Figure 3.1 OSl Network Management Model

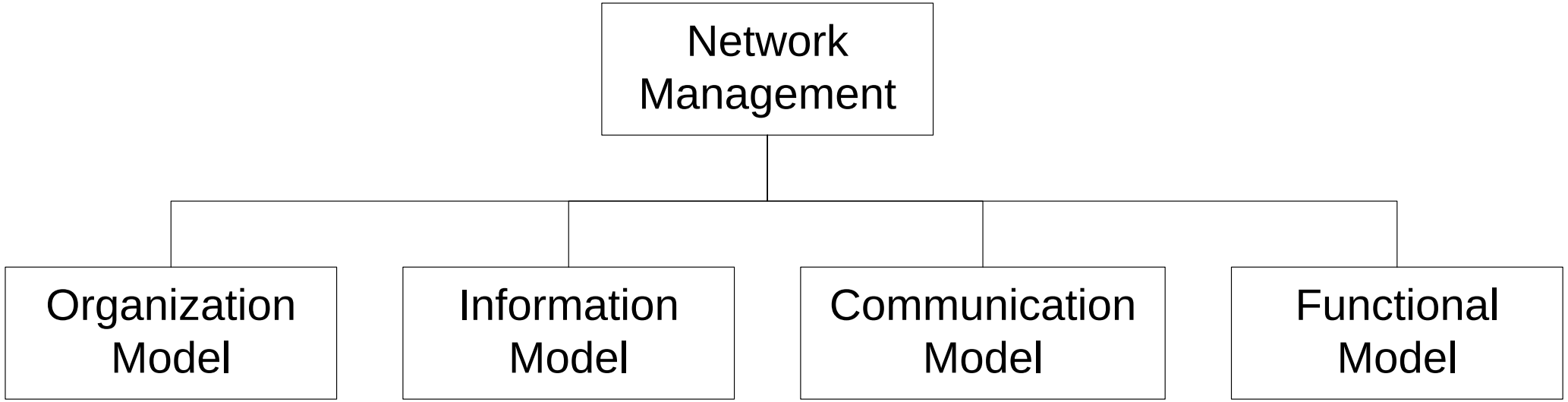
OSI Architecture and Model

- Organization
  - Network management components
  - Functions of components
  - Relationships
- Information
  - Structure of management information (SMI)
    - Syntax and semantics
  - Management information base (MIB)
    - Organization of management information
  - Object-oriented

OSI Architecture and Model

- Communication
  - Transfer syntax with bidirectional messages
  - Transfer structure (PDU)
- Functions
  - Application functions
    - Configure components
    - Monitor components
    - Measure performance
    - Secure information
    - Usage accounting

SNMP Architecture and Model



SNMP Architecture and Model

- Organization
  - Same as OSI model
- Information
  - Same as OSI, but scalar
- Communication
  - Messages less complex than OSI and unidirectional
  - Transfer structure (PDU)

SNMP Architecture and Model

- Functions
  - Application functions
    - Fault management
    - Configuration management
    - Account management
    - Performance management
    - Security management

TMN Architecture

- Addresses management of telecommunication networks
- Based on OSI model
- Superstructure on OSI network
- Addresses network, service, and business management

Organizational Model

- Manager
  - Sends requests to agents
  - Monitors alarms
  - Houses applications
  - Provides user interface

Organizational Model

- Agent
  - Gathers information from objects
  - Configures parameters of objects
  - Responds to managers' requests
  - Generates alarms and sends them to managers
- Managed object
  - Network element that is managed
  - Houses management agent
  - All objects are not managed / manageable

Two-Tier Model

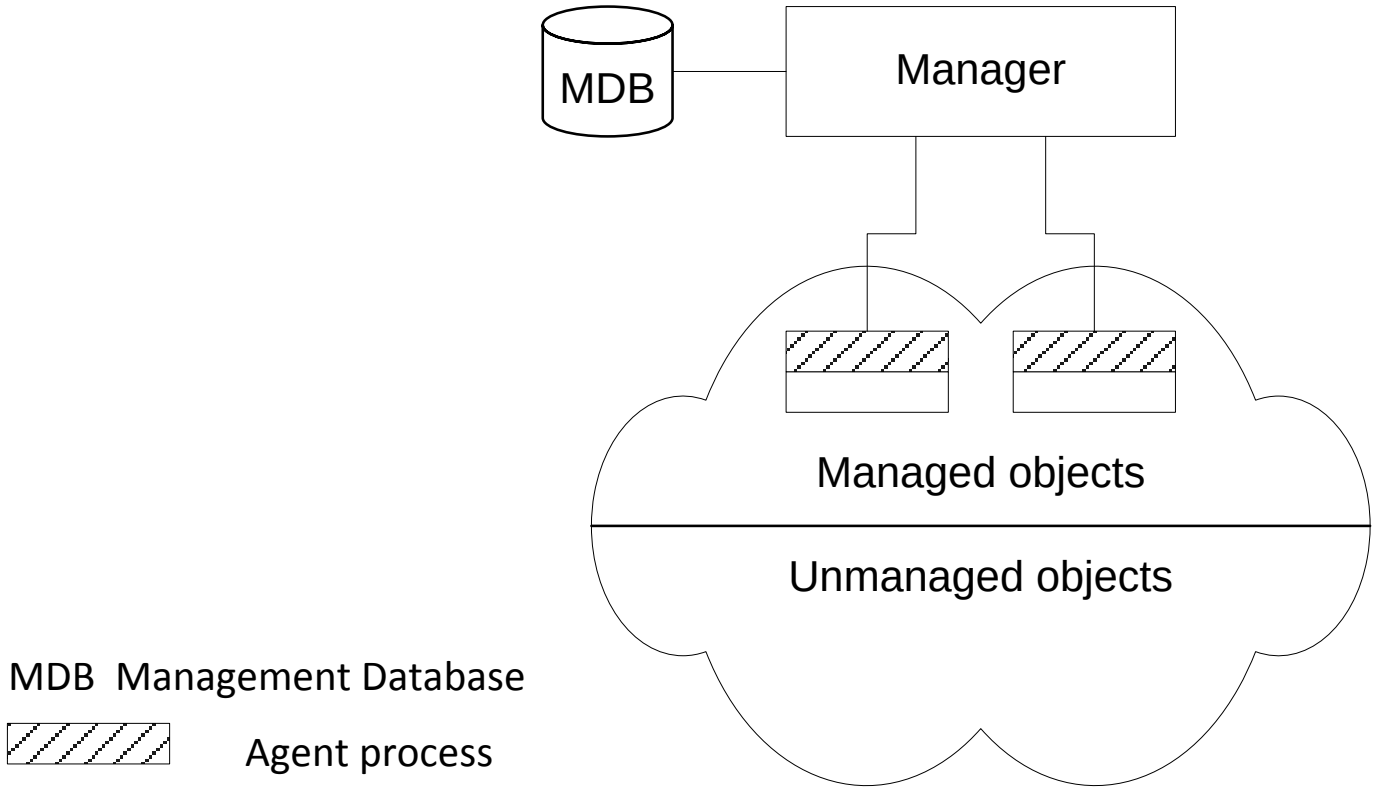


Figure 3.2 Two-Tier Network Management Organization Model

Two-Tier Model

- Agent built into network element
  - Example: Managed hub, managed router
- An agent can manage multiple elements
  - Example: Switched hub, ATM switch
- MDB is a physical database
- Unmanaged objects are network elements that are not managed - both physical (unmanaged hub) and logical (passive elements)

Three-Tier Model

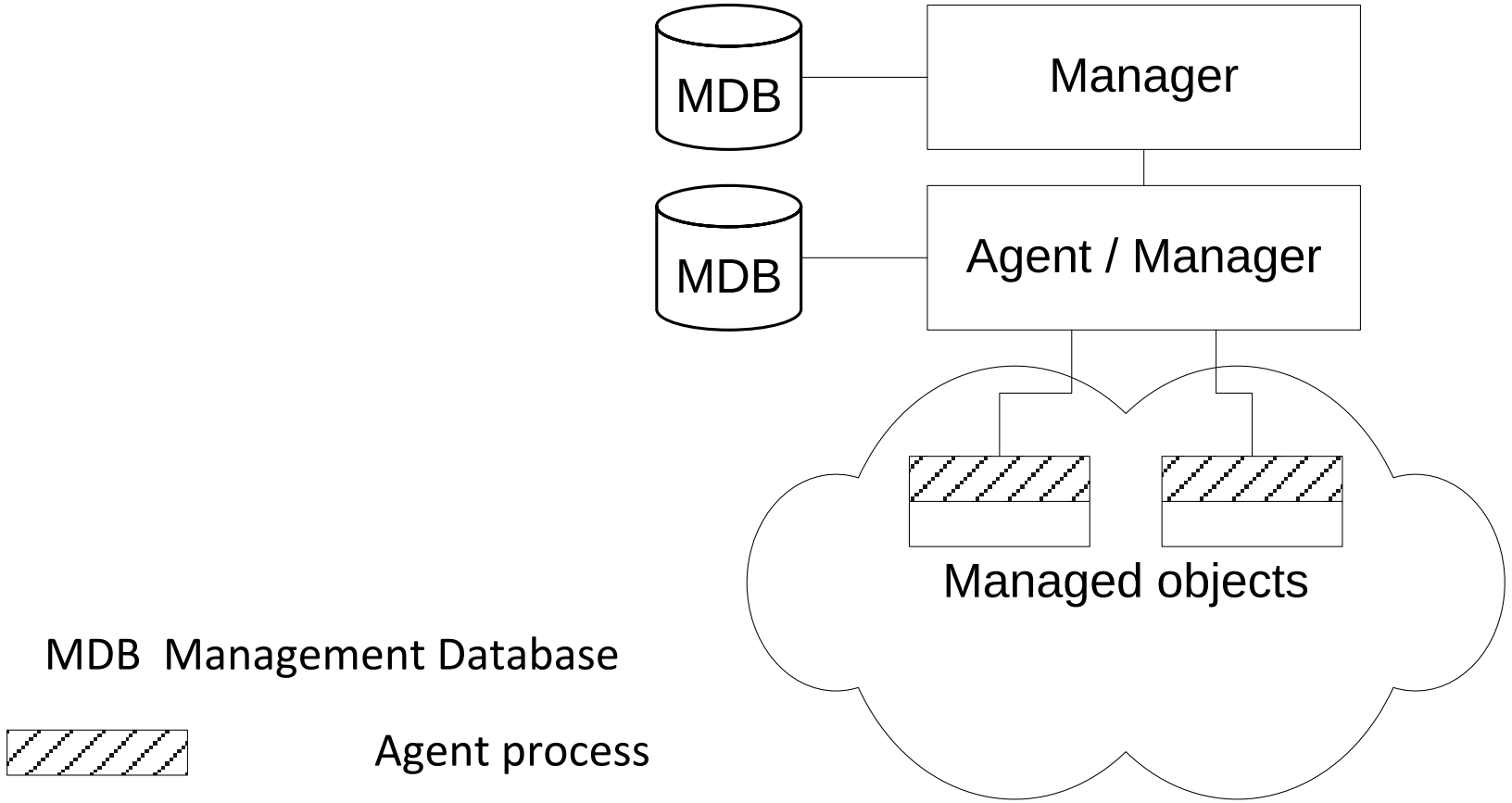


Figure 3.3 Three-Tier Network Management Organization Model

Three-Tier Model

- Middle layer plays the dual role
  - Agent to the top-level manager
  - Manager to the managed objects
- Example of middle level: Remote monitoring agent (RMON)

Manager of Managers

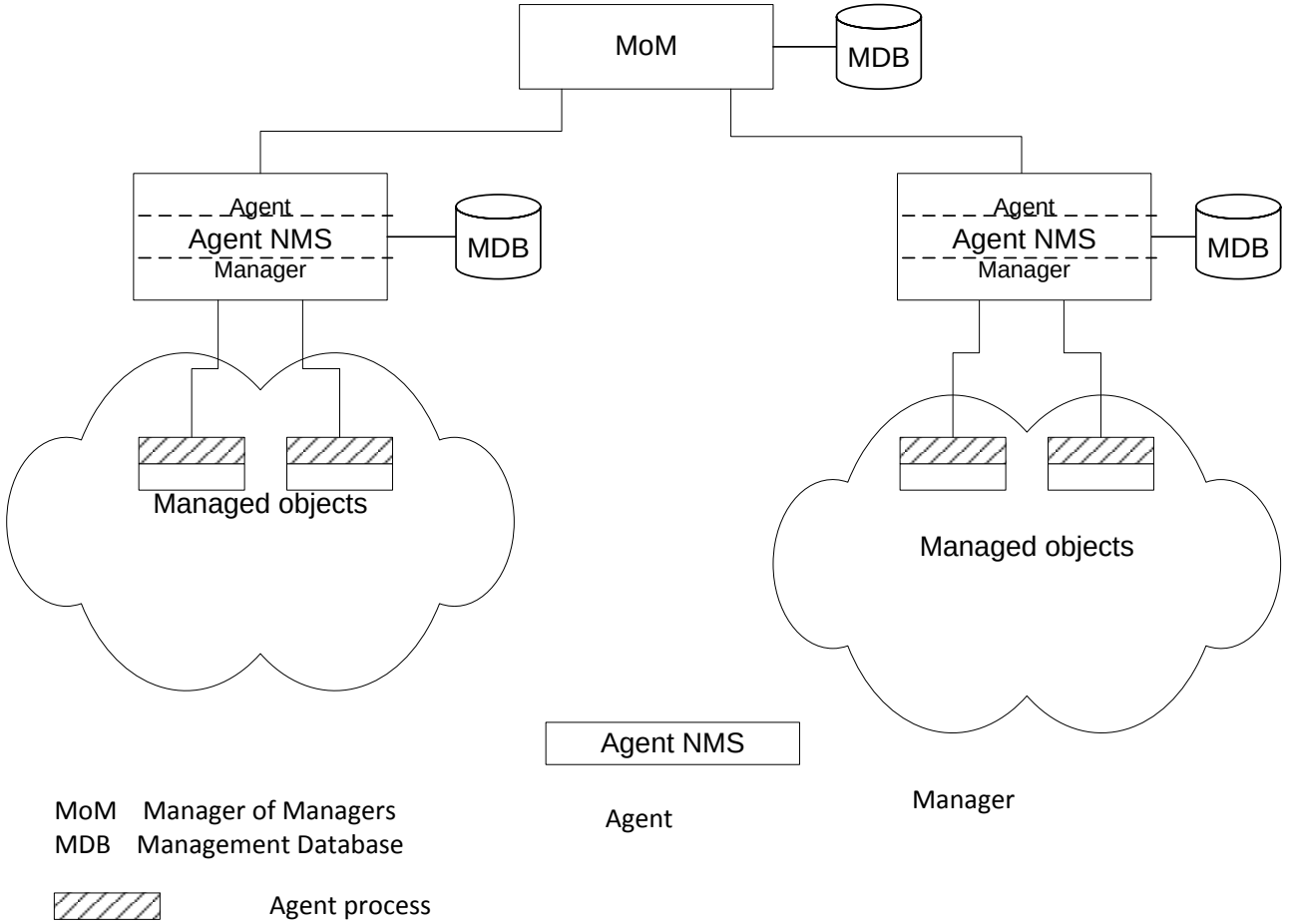


Figure 3.4 Network Management Organization Model with MoM

Manager of Managers

- Agent NMS manages the domain
- MoM presents integrated view of domains
- Domain may be geographical, administrative, vendor-specific products, etc.

Peer NMSs

- Dual role of both NMSs
- Network management system acts as peers
- Manager and agent functions are processes and not systems

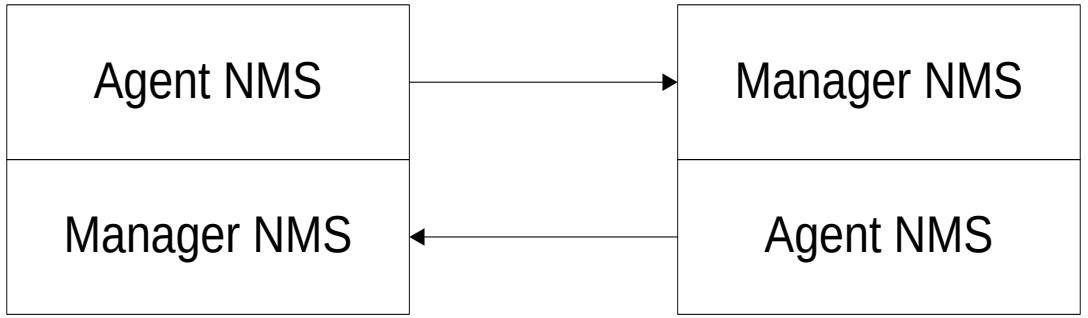


Figure 3.5 Dual Role of Management Process

Information Model: Analogy

- Figure in a book uniquely identified by
  - ISBN, Chapter, and Figure number in that hierarchical order
  - ID: {ISBN, chapter, figure}
- The three elements above define the syntax
- Semantics is the meaning of the three entities according to Webster's dictionary
- The information comprises syntax and semantics about an object

Structure of Management Information (SMI)

- SMI defines for a managed object
  - Syntax
  - Semantics
  - Plus additional information such as status
- Example

  sysDescr: { system 1 }

  Syntax: OCTET STRING

  Definition: "A textual description of the entity. "

  Access: read-only

  Status: mandatory

Management Information Base (MIB)

- Information base contains information about objects
- Organized by grouping of related objects
- Defines relationship between objects
- It is NOT a physical database. It is a virtual database that is compiled into management module

MIB View and Access of an Object

- A managed object has many attributes – its information base
- There are several operations that can be performed on the objects
- A user (manager) can view and perform only certain operations on the object by invoking the management agent
- The view of object attributes that agent perceives is the **MIB view**
- The operation that a user can perform is the **MIB access**

Management Data Base / Information Base

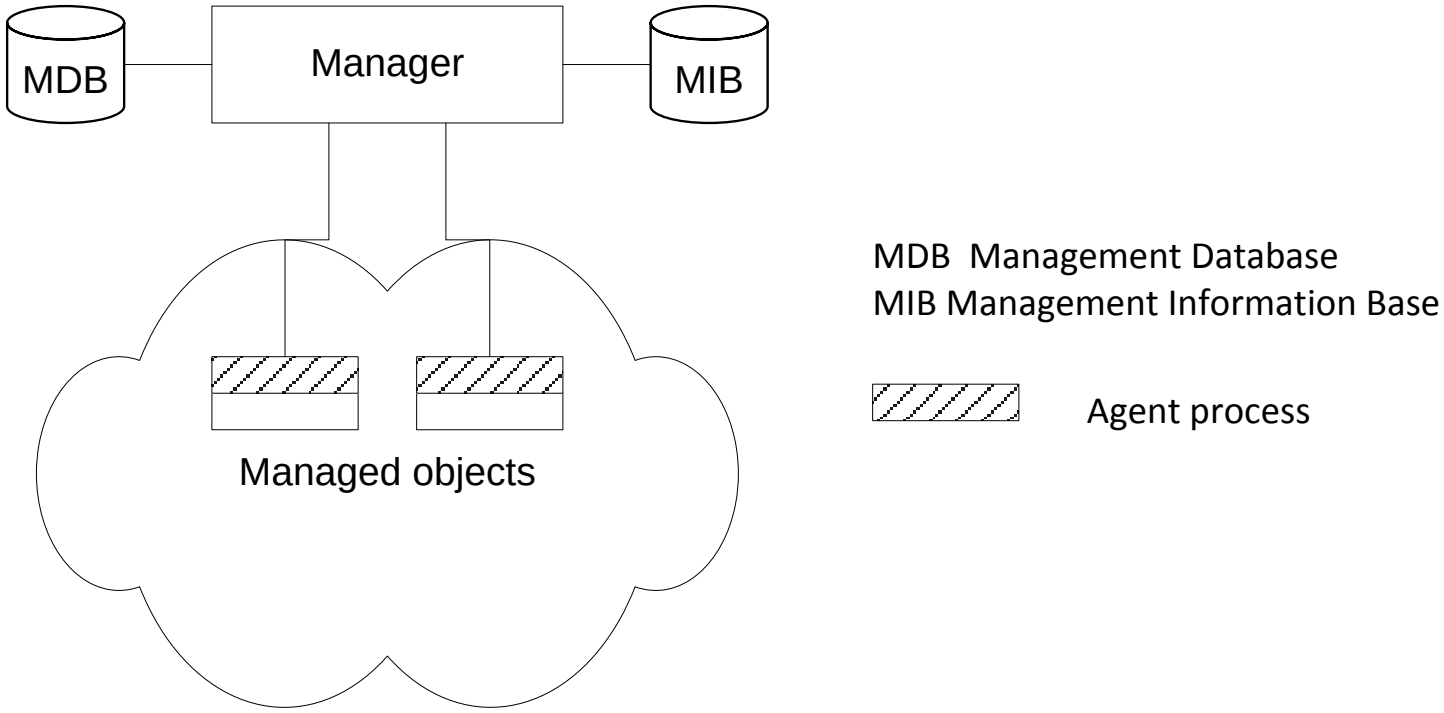


Figure 3.6 Network Configuration with Data and Information Base

Management Data Base / Information Base

- Distinction between MDB and MIB
  - MDB physical database; e.g., Oracle, Sybase
  - MIB virtual database; schema compiled into management software
- An NMS can automatically discover a managed object, such as a hub, when added to the network
- The NMS can identify the new object as hub only after the MIB schema of the hub is compiled into NMS software

Managed Object

- Managed objects can be
  - Network elements (hardware, system)
    - Hubs, bridges, routers, transmission facilities
  - Software (non-physical)
    - Programs, algorithms
  - Administrative information
    - Contact person, name of group of objects (IP group)

Management Information Tree

Root

Level 1

Level 2

Level 3

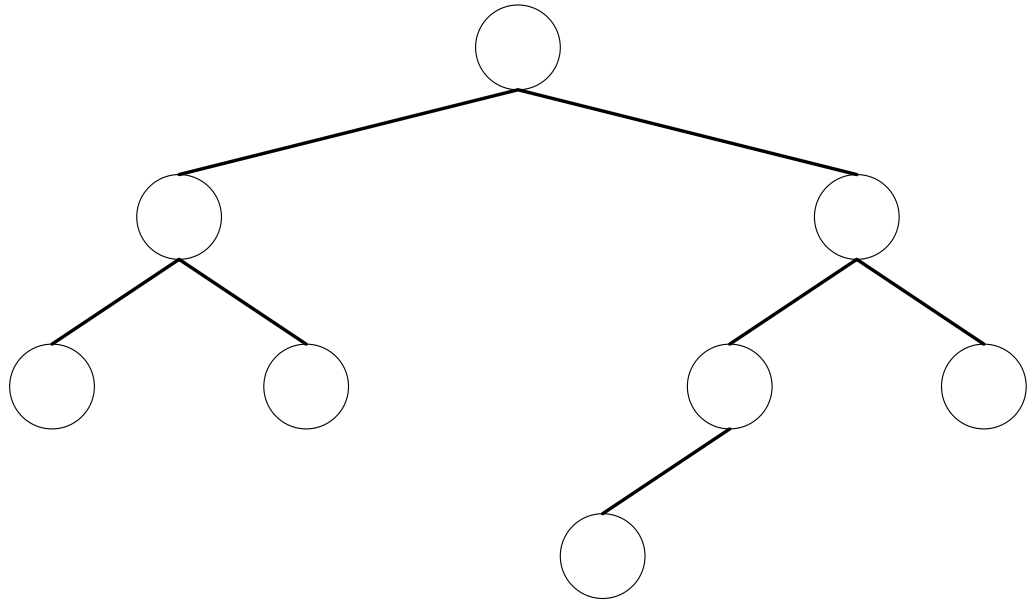


Figure 3.7 Generic Representation of Management Information Tree

OSI Management Information Tree

- iso International Standards Organization
  itu International Telecommunications Union
  dod Department of Defense
- Designation:
  - iso 1
  - org 1.3
  - dod 1.3.6
  - internet 1.3.6.1

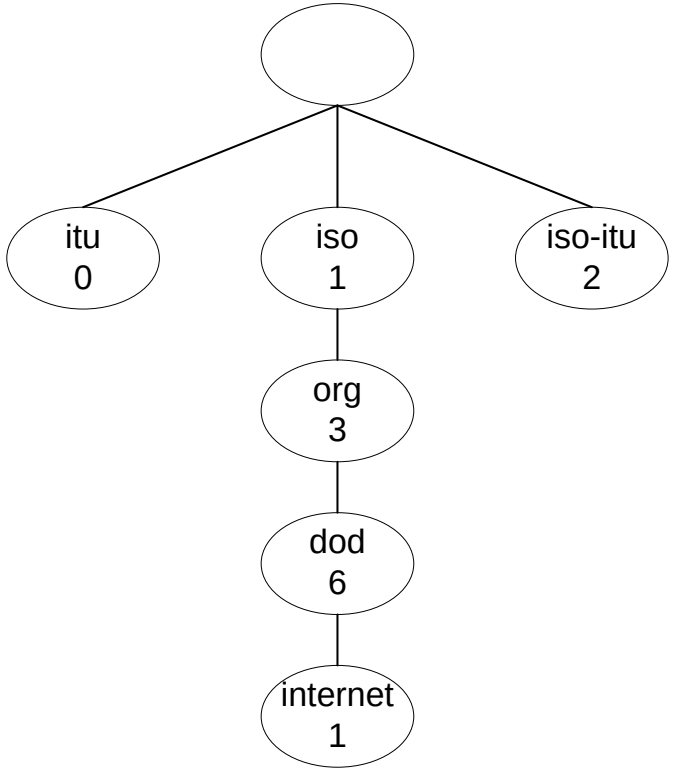


Figure 3.8 **OSI Management Information Tree**

Management and Communication Model

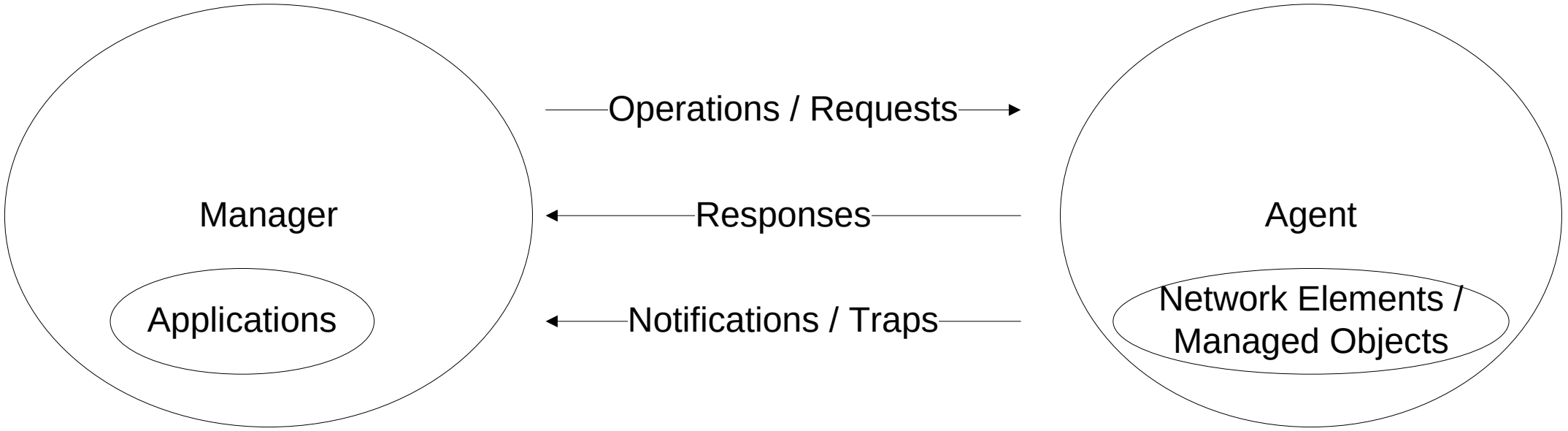


Figure 3.11 Management Message Communication Model

Transfer Protocols

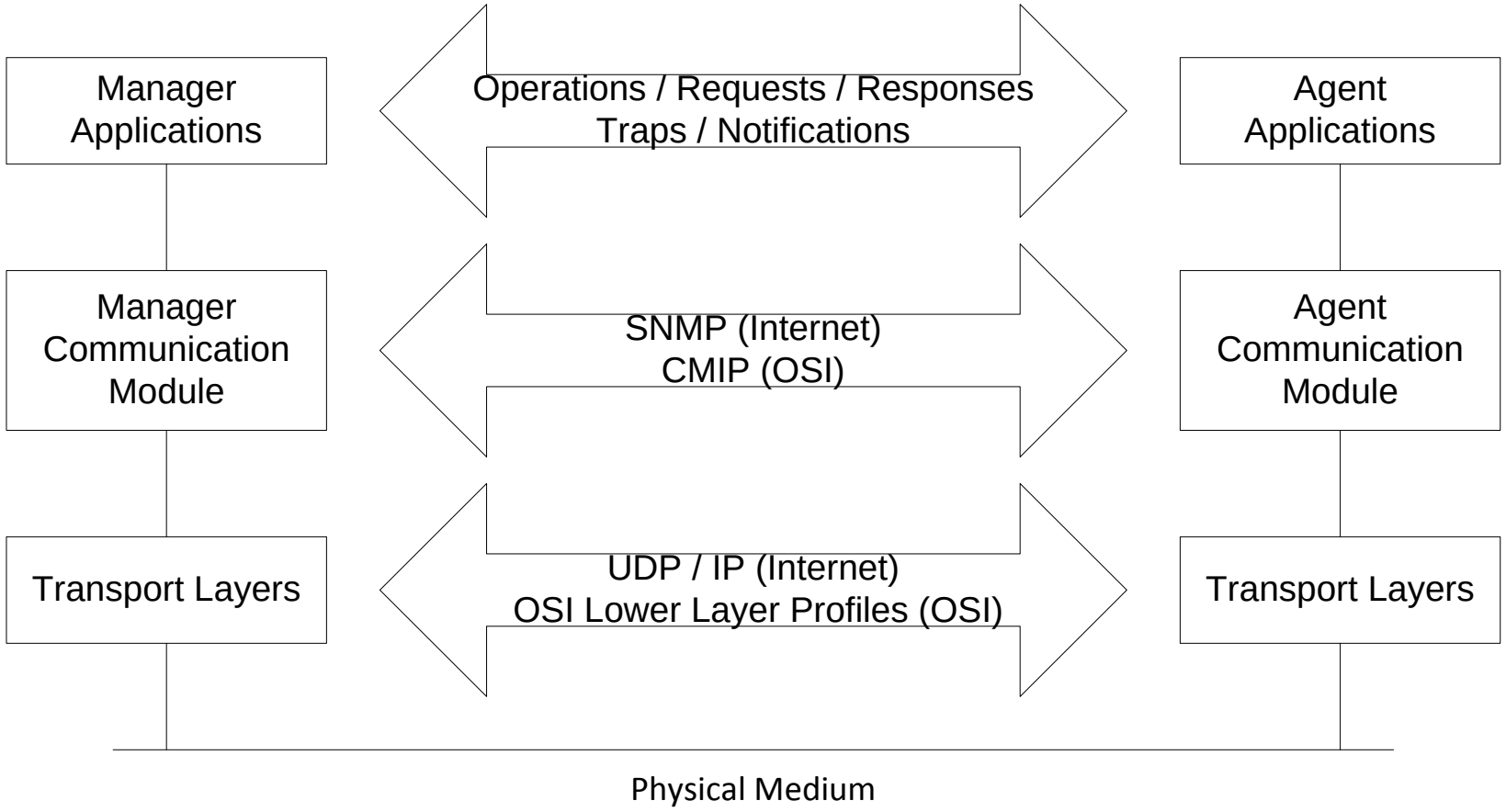


Figure 3.12 Management Communication Transfer Protocols

Abstract Syntax Notation One (ASN.1)

- ASN.1 is more than a syntax; it's a language
- Addresses both syntax and semantics
- Two types of syntax
  - Abstract syntax: set of rules that specify data type and structure for information storage
  - Transfer syntax: set of rules for communicating information between systems
- Makes application layer protocols independent of lower layer protocols
- Can generate machine-readable code
  - Basic Encoding Rules (BER) is used in management modules

Backus-Naur Form (BNF)

- Definition:
  - <name> ::= <definition>
- Rules:
  - <digit> ::= 0|1|2|3|4|5|6|7|8|9
  - <number> ::= <digit> | <number> <digit>
  - <op> ::= +|-|x|/
  - <SAE> ::= <number>|<SAE>|<SAE><op><SAE>
- Example:
  - 9 is primitive 9
  - 19 is construct of 1 and 9
  - 619 is construct of 6 and 19

Backus-Nauer Form (BNF)

- BNF is used for ASN.1 constructs
- Constructs developed from primitives
- The above example illustrates how numbers are constructed from the primitive <digit>
- Simple Arithmetic Expression entity (<SAE>) is constructed from the primitives <digit> and <op>

Simple Arithmetic Expression

- <SAE> ::= <number> | <SAE><op><number>
- Example: 26 = 13 x 2
- Constructs and primitives

Type and Value

- Assignments
  - <BooleanType> ::= BOOLEAN
  - <BooleanValue> ::= TRUE | FALSE
- ASN.1 module is a group of assignments

```
person-name      Person-Name::=
      {
            first      "John",
            middle   “T",
            last     "Smith“
      }
```

Data Type: Example 1

```
PersonnelRecord ::= SET {
    name,
    title        GraphicString,
    division     CHOICE {
        marketing   SEQUENCE {Sector, Country},
        research    CHOICE {
                        product-based NULL,
                        basic NULL
                    }
    }
}
```

Figure 3.13 ASN.1 Data Type Definition: Example 1

Data Type: Example 1

- Module name starts with capital letters
- Data types:
  - Primitives: NULL, GraphicString
  - Constructs
    - Alternatives : CHOICE
    - List maker: SET, SEQUENCE
    - Repetition: SET OF, SEQUENCE OF:
- Difference between SET and SEQUENCE

Data Type: Example 2

```
Trade-message ::= SEQUENCE {
    invoice-no  INTEGER
    name        GraphicString,
    details     SEQUENCE OF
                    SEQUENCE {
                        part-no INTEGER
                        quantity INTEGER
                    },
    charge REAL,
    authenticator Security-Type
}

Security-Type ::= SET {
  …
}
```

--SEQUENCE OF SEQUENCE makes table of rows

Figure 3.14 ASN.1 Data Type Definition: Example 2

ASN.1 Symbols

Symbol	Meaning
::=	Defined as
|	or, alternative, options of a list
-	Signed number
--	Following the symbol are comments
{}	Start and end of a list
[]	Start and end of a tag
()	Start and end of subtype
..	Range

Keyword Examples

- CHOICE
- SET
- SEQUENCE
- OF
- NULL

- Keywords are in all UPPERCASE letters

ASN.1 Data Type Conventions

Data Types	Convention	Example
Object name	Initial lowercase letter	sysDescr, etherStatsPkts
Application data type	Initial uppercase letter	Counter, IpAddress
Module	Initial uppercase letter	PersonnelRecord
Macro, MIB module	All uppercase letters	RMON-MIB
Keywords	All uppercase letters	INTEGER, BEGIN

Structure

- Simple
  - PageNumber ::= INTEGER
  - ChapterNumber ::= INTEGER
- Structure / Construct
  - BookPageNumber ::= SEQUENCE {ChapterNumber, Separator, PageNumber}
- Tagged
  - Derived from another type; given a new ID
- Other types:
  - CHOICE, ANY

Structure

- BookPages ::= SEQUENCE OF {BookPageNumber}

or

- BookPages ::=
  SEQUENCE OF {
  SEQUENCE {ChapterNumber, Separator, PageNumber}
  }

- Example: {1-1, 2-3, 3-39}

Enumerated Integer

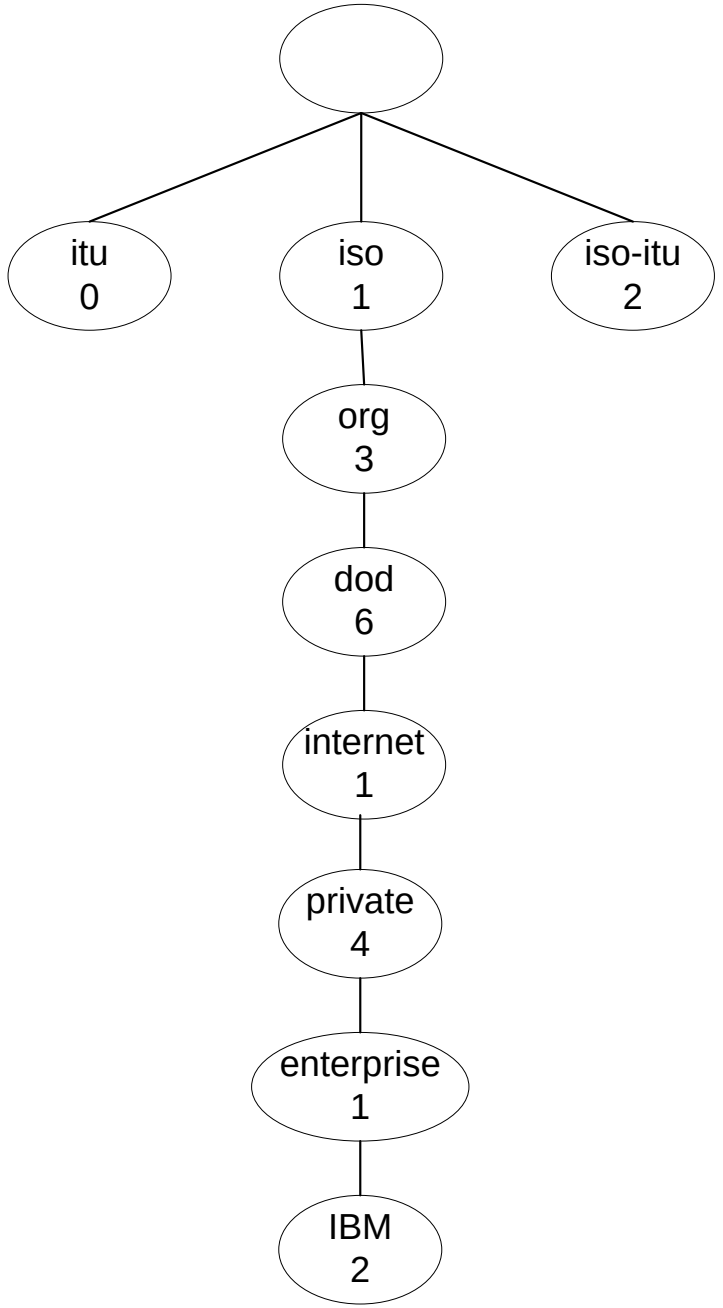
```
RainbowColors ::= ENUMERATED {
    violet   (0)
    indigo   (1)
    blue     (2)
    green    (3)
    yellow   (4)
    orange   (5)
    red      (6)
}
```

- ENUMERATED is a special case of INTEGER
- Example: RainbowColors(5) is orange

ASN.1 Module Example

```
IpNetMediaEntry ::=SEQUENCE{
     ipNetToMediaIfIndex          INTEGER
     ipNetToMediaPhysAddress      PhysAddress
     ipNetToMediaNetAddress       IpAddress
     ipNetToMediaType             INTEGER
}
```

Object Name



internet OBJECT IDENTIFIER ::=
{iso(1) org(3) dod(6) internet(1)}

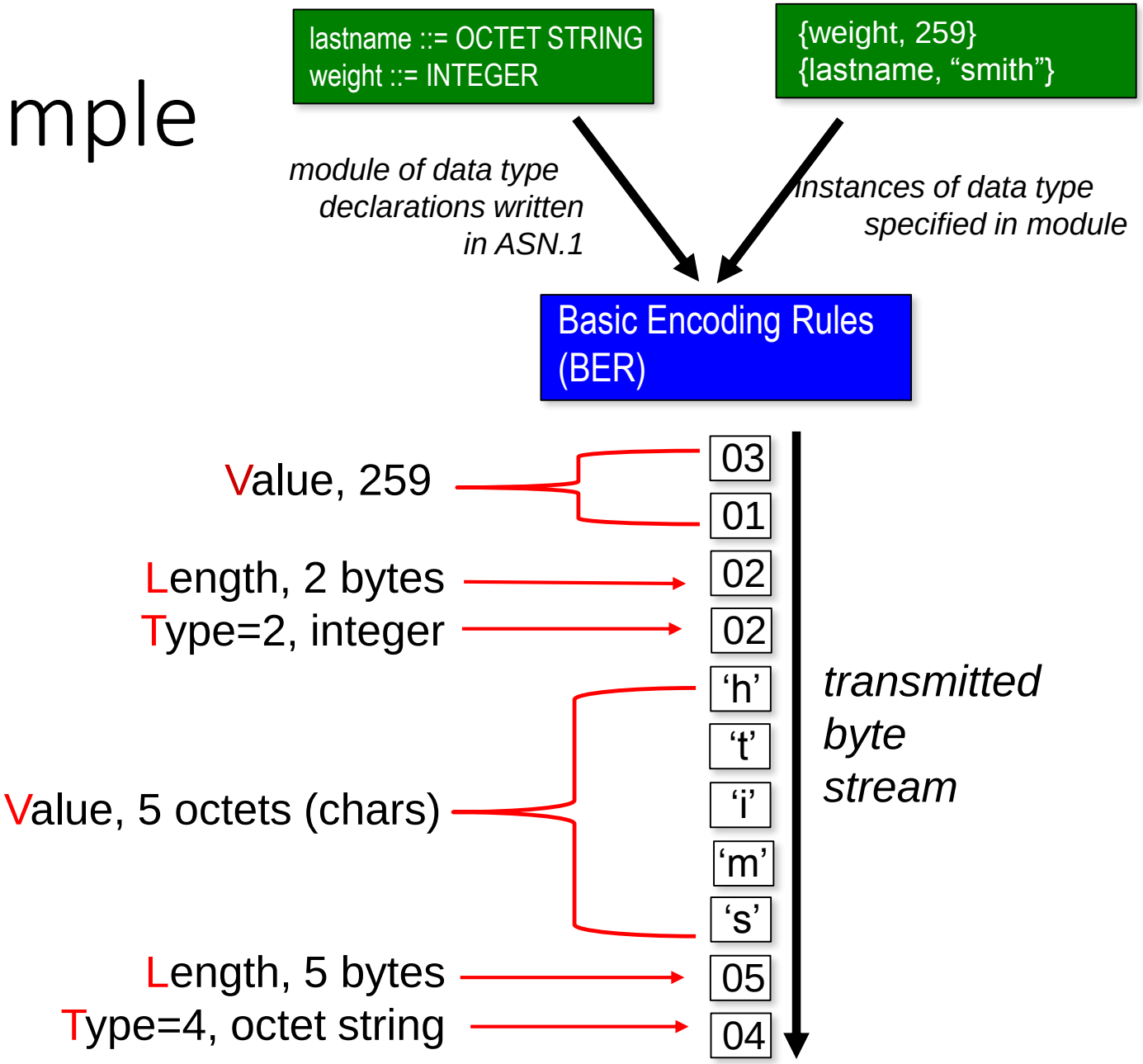
Basic Encoding Rules (BER)

- Specify how ASN.1-defined data objects to be transmitted
- Each transmitted object has Type, Length, Value (TLV) encoding
- Idea: transmitted data is self-identifying
  - T: data type, one of ASN.1-defined types
  - L: length of data in bytes
  - V: value of data, encoded according to ASN.1 standard

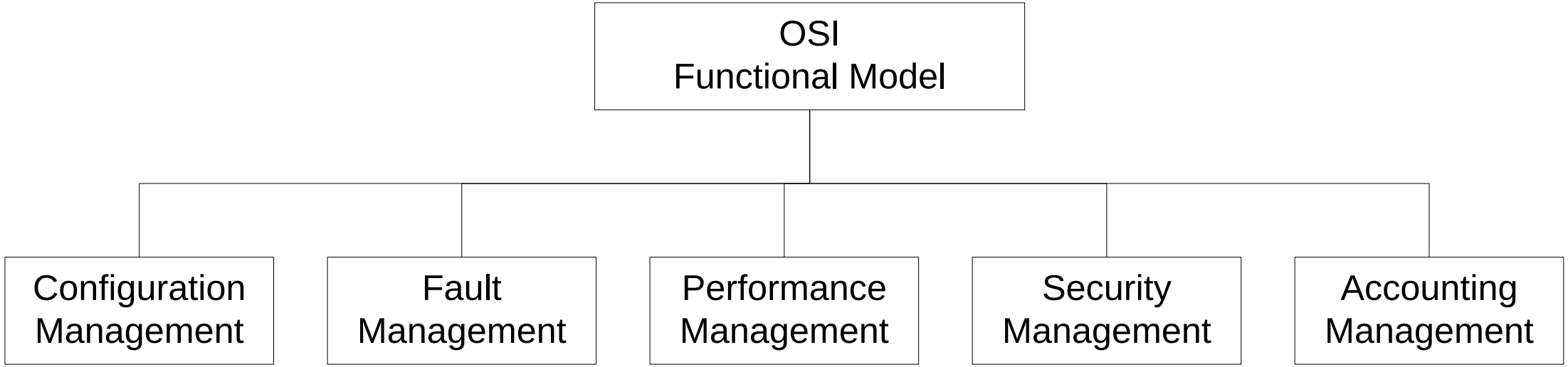
Basic Encoding Rules (BER)

Tag Value	Type
1	BOOLEAN
2	INTEGER
3	BIT STRING
4	OCTET STRING
5	NULL
6	OBJECT IDENTIFIER
9	REAL

TLV Encoding Example



Functional Model



Functional Model

- Configuration management
  - Set and change network configuration component parameters
  - Set up alarm thresholds
- Fault management
  - Detection and isolation of failures in network
  - Trouble ticket administration

Functional Model

- Performance management
  - Monitor performance of network
- Security management
  - Authentication
  - Authorization
  - Encryption
- Accounting management
  - Functional accounting of network usage

References

- Backus–Naur Form - Wikipedia https://en.wikipedia.org/wiki/Backus%E2%80%93Naur_Form