

Network Management

Lecture 3

Basic Foundations:
Standards, Models, and
Language

Objectives

- Standards, Models, and Language needed for network management
- Network Models
 - OSI
 - Internet
 - TMN
 - IEEE 802
 - Web-based
- Management communication protocols
 - SNMP
 - CMIP
 - XML
 - CORBA
- ASN.1 language
 - Syntax
 - Macro
- Basic encoding rule
- Management application functions

Introduction

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

Notes

Table 3.1 Network Management Standards

| Standard | Salient Points |
|----------------------|---|
| OSI/CMIP | <ol style="list-style-type: none">1. International standard (ISO/OSI)2. Management of data communications network - LAN and WAN3. Deals with all 7 layers4. Most complete5. Object oriented6. Well structured and layered7. Consumes large resource in implementation |
| SNMP/Internet | <ol style="list-style-type: none">1. Industry standard (IETF)2. Originally intended for management of Internet components, currently adopted for WAN and telecommunication systems3. Easy to implement4. Most widely implemented |
| TMN | <ol style="list-style-type: none">1. International standard (ITU-T)2. Management of telecommunications network3. Based on OSI network management framework4. Addresses both network and administrative aspects of management5. eTOM industry standard for business processes for implementing TMN using NGOSS framework |
| IEEE | <ol style="list-style-type: none">1. IEEE standards adopted internationally2. Addresses LAN and MAN management3. Adopts OSI standards significantly4. Deals with first two layers of OSI RM |
| Web-based Management | <ol style="list-style-type: none">1. Web-Based Enterprise Management (WBEM)2. Java Management Extension (JMX)3. XML-Based Network Management4. CORBA-based Network Management |

OSI Architecture and Model

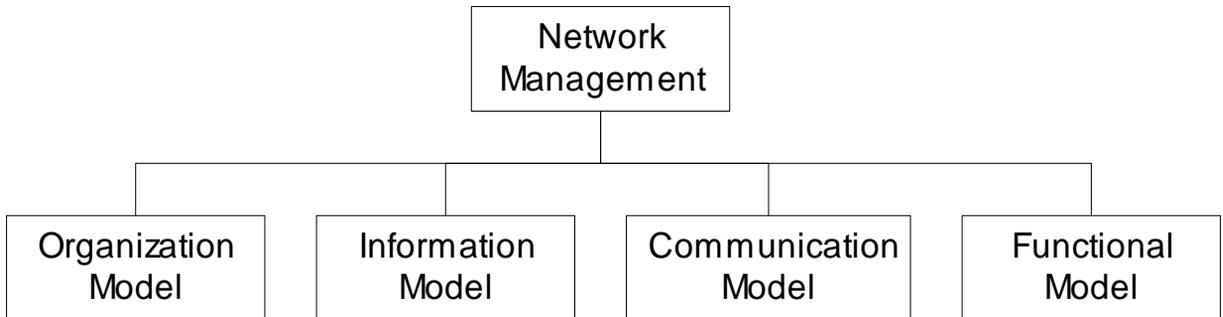


Figure 3.1 OSI Network Management Model

Notes

- 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 (cont.)

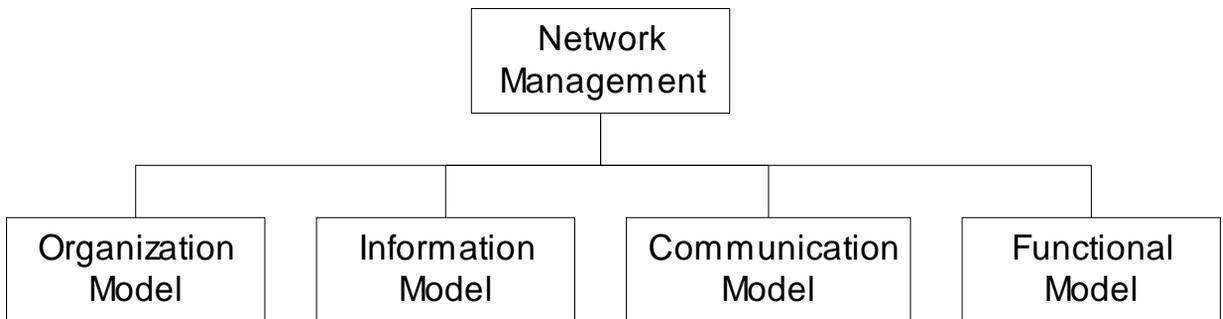
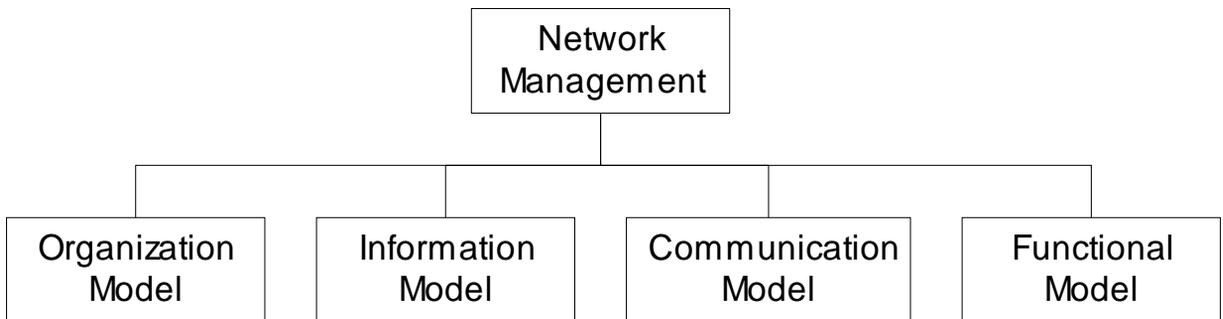


Figure 3.1 OSI Network Management Model

Notes

- 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



Notes

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

Notes

Organizational Model

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

Notes

Two-Tier Model

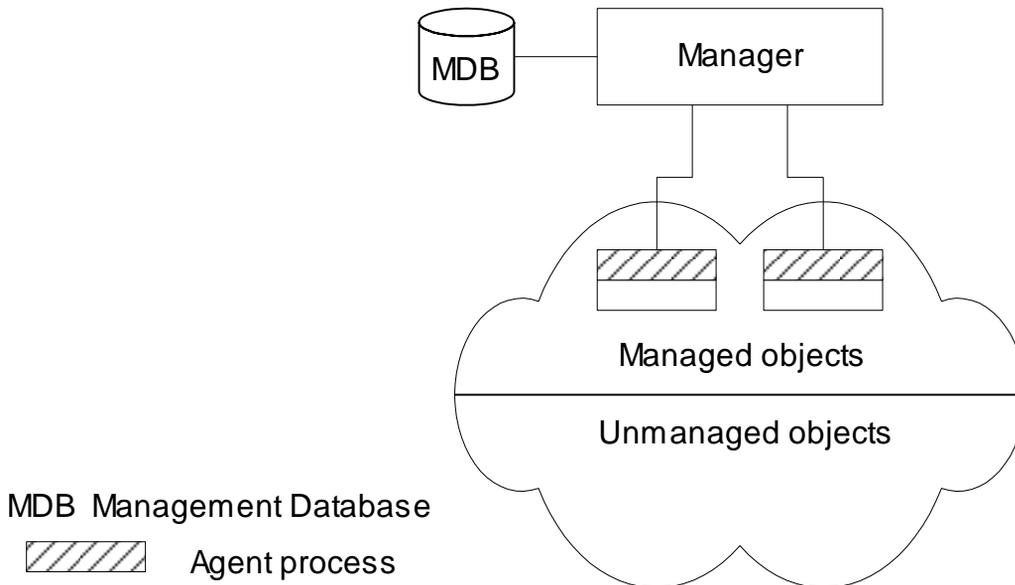


Figure 3.2 Two-Tier Network Management Organization Model

Notes

- 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

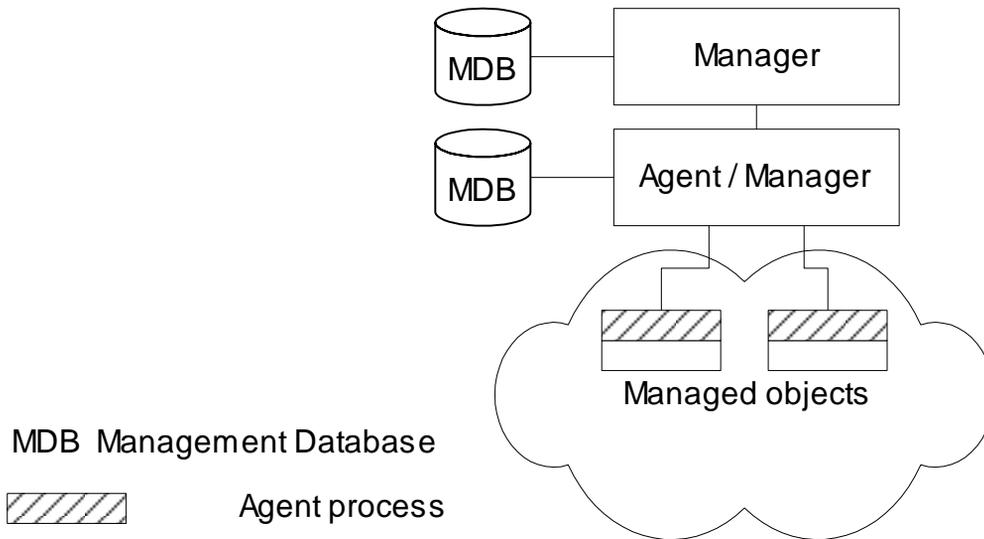


Figure 3.3 Three-Tier Network Management Organization Model

Notes

- 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

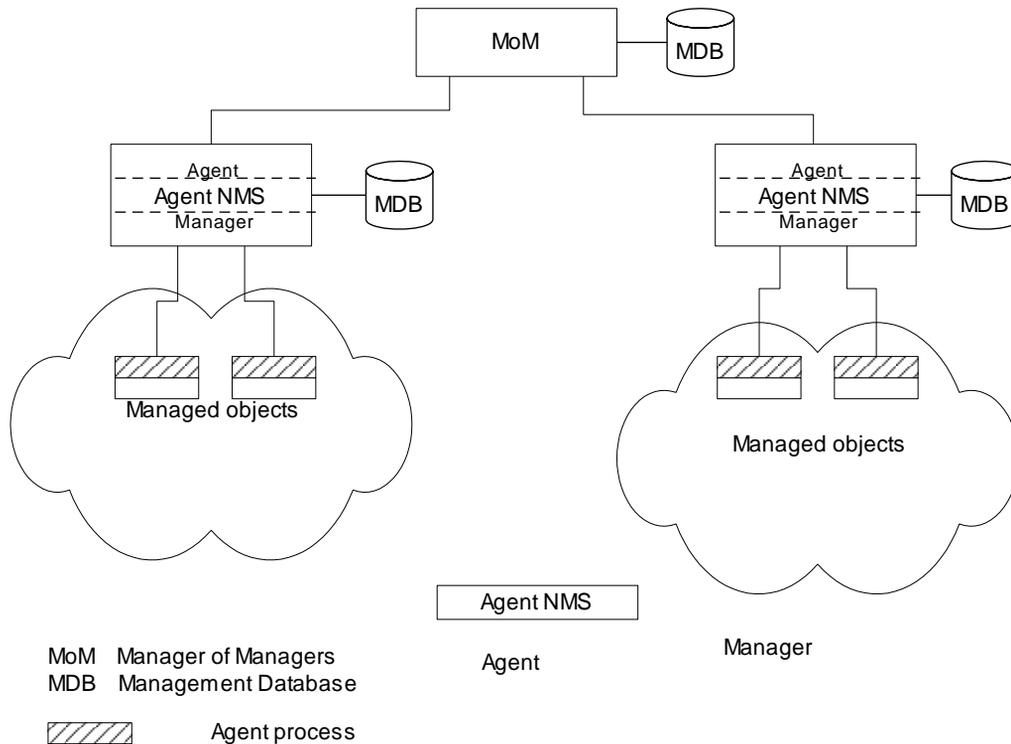


Figure 3.4 Network Management Organization Model with MoM

Notes

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

Peer NMSs

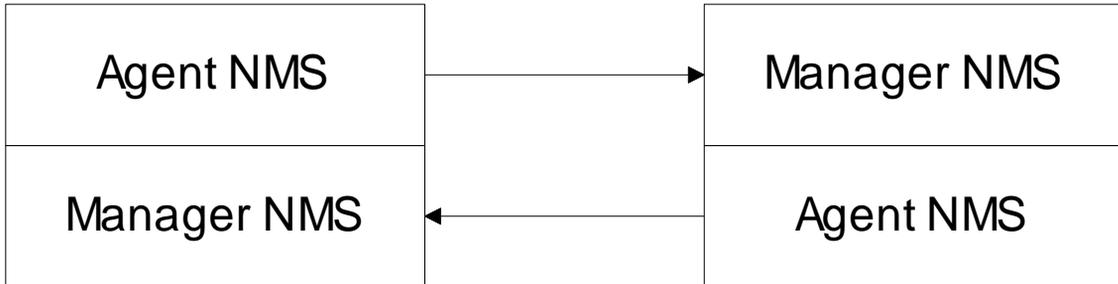


Figure 3.5 Dual Role of Management Process

Notes

- Dual role of both NMSs
- Network management system acts as peers
- Dumbbell architecture discussed in Chapter 1
- Notice that the manager and agent functions are processes and not systems

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

Notes

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

Notes

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

Notes

Information Base View: An Analogy

- Fulton County library system has many branches
- Each branch has a set of books
- The books in each branch is a different set
- The information base of the county has the view (catalog) of all books
- The information base of each branch has the catalog of books that belong to that branch. That is, each branch has its view (catalog) of the information base
- Let us apply this to MIB view

Notes

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 the object attributes that the agent perceives is the MIB view
- The operation that a user can perform is the MIB access

Notes

Management Data Base / Information Base

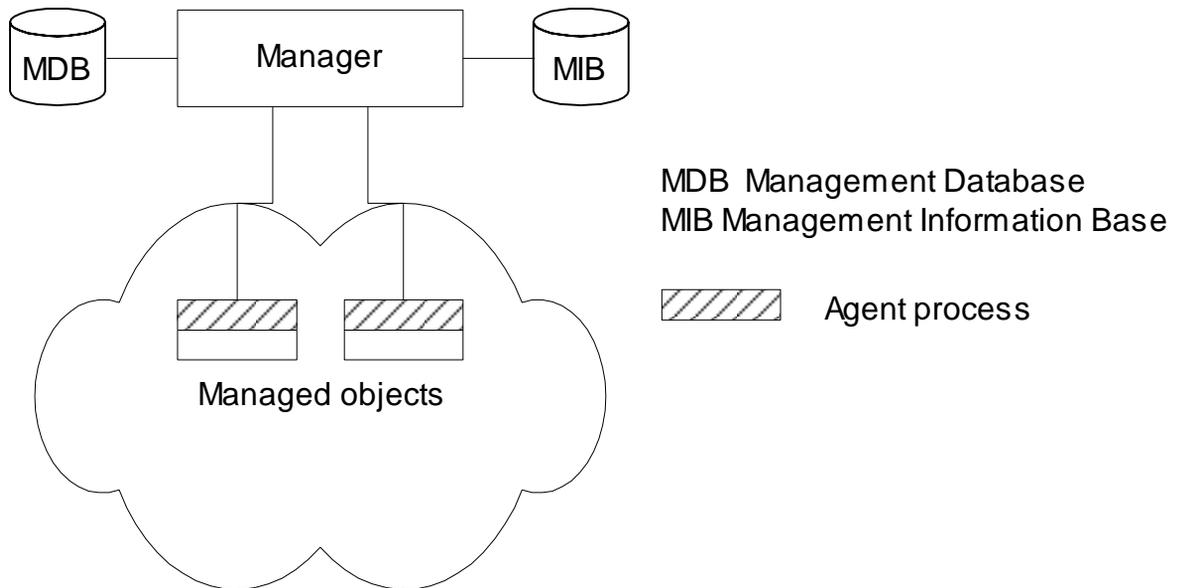


Figure 3.6 Network Configuration with Data and Information Base

Notes

- 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)

Notes

Management Information Tree

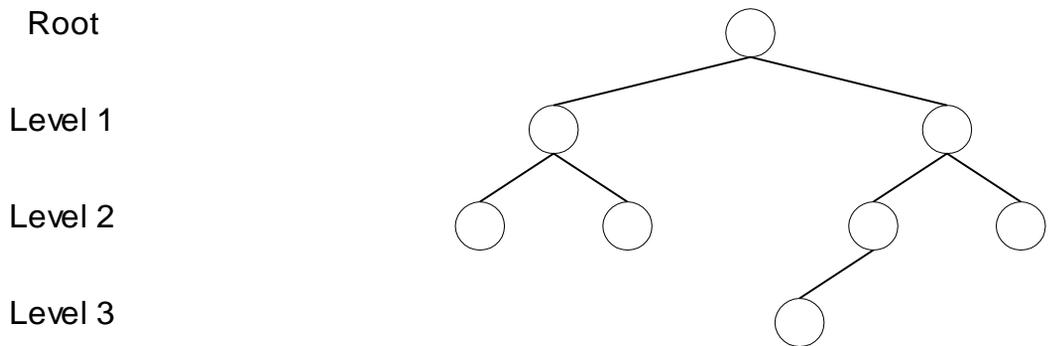


Figure 3.7 Generic Representation of Management Information Tree

Notes

OSI Management Information Tree

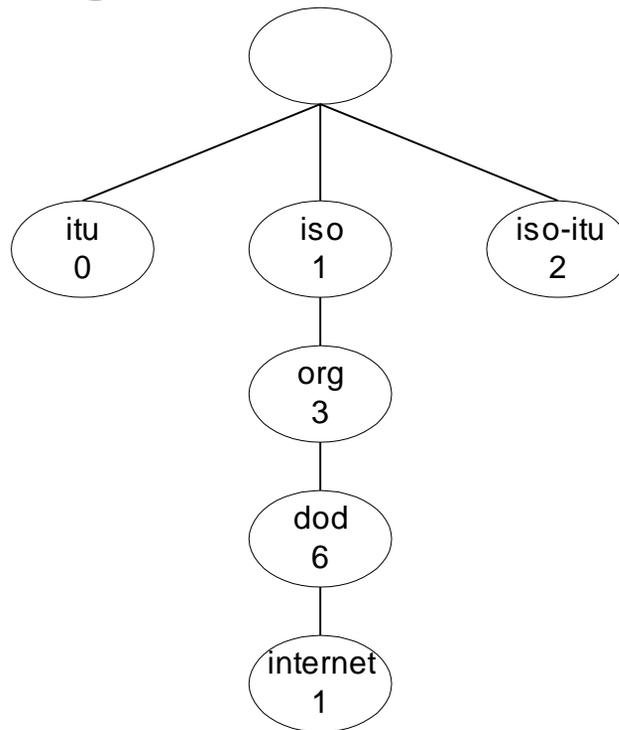


Figure 3.8 OSI Management Information Tree

Notes

- 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

Object Type and Instance

- Type
 - Name
 - Syntax
 - Definition
 - Status
 - Access
- Instance

Notes

- Example of a circle
 - “circle” is syntax
 - Semantics is definition from dictionary
“A plane figure bounded by a single curved line, every point of which is of equal distance from the center of the figure.”
- Analogy of nursery school

Managed Object: Internet Perspective

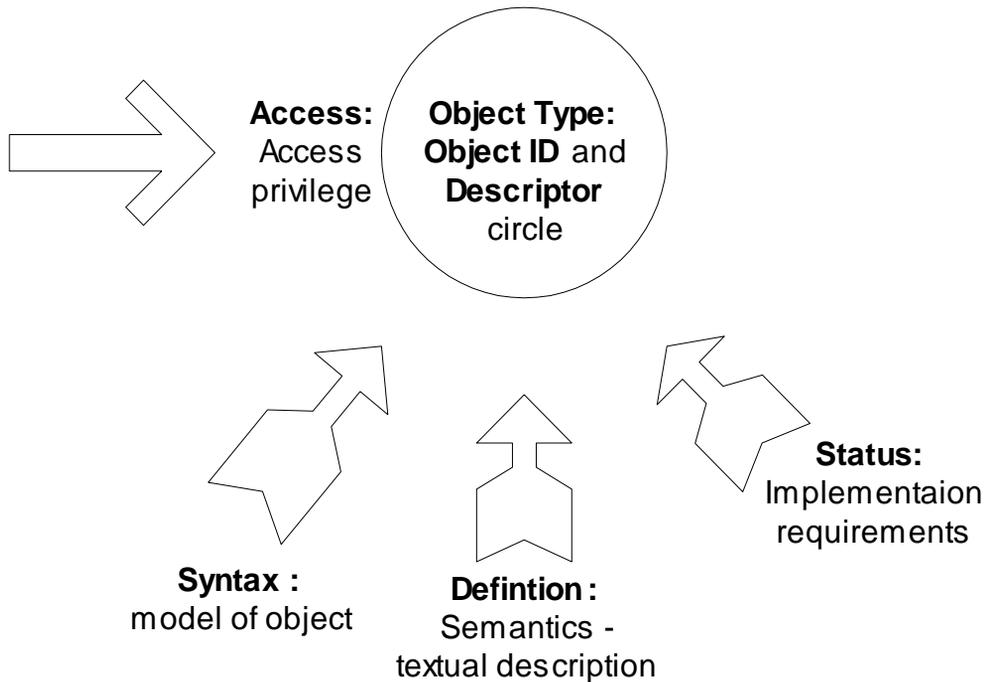


Figure 3.9(a) Internet Perspective

Notes

- *object ID* unique ID
- *and descriptor* and name for the object
- *syntax* used to model the object
- *access* access privilege to a managed object
- *status* implementation requirements
- *definition* textual description of the semantics of object type

Managed Object: OSI Perspective

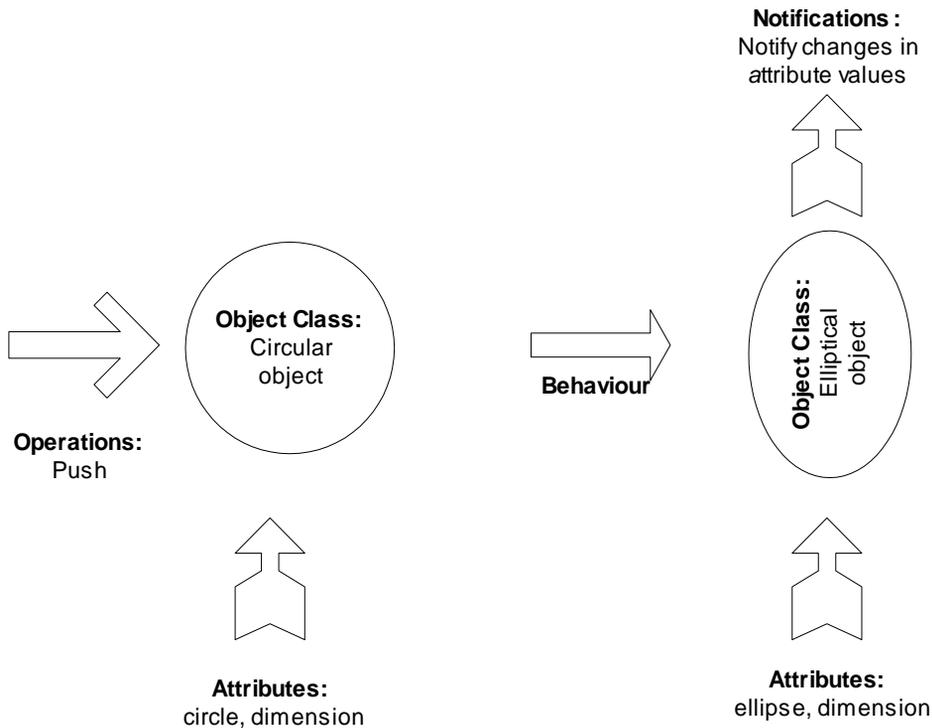


Figure 3.9(b) OSI Perspective

Notes

- *object class* managed object
- *attributes* attributes visible at its boundary
- *operations* operations which may be applied to it
- *behaviour* behavior exhibited by it in response to operation
- *notifications* notifications emitted by the object

Packet Counter Example

| Characteristics | Example |
|--------------------|--------------------------|
| <i>Object type</i> | PktCounter |
| <i>Syntax</i> | Counter |
| <i>Access</i> | Read-only |
| <i>Status</i> | Mandatory |
| <i>Description</i> | Counts number of packets |

Figure 3.10(a) Internet Perspective

| Characteristics | Example |
|----------------------|--------------------------------------|
| <i>Object class</i> | Packet Counter |
| <i>Attributes</i> | Single-valued |
| <i>Operations</i> | get, set |
| <i>Behavior</i> | Retrieves or resets values |
| <i>Notifications</i> | Generates notifications on new value |

Figure 3.10 (b) OSI Perspective

Figure 3.10 Packet Counter As Example of Managed Object

Notes

Internet vs. OSI Managed Object

- Scalar object in Internet vs. Object-oriented approach in OSI
- OSI characteristics of operations, behavior, and notification are part of communication model in Internet: get/set and response/alarm
- Internet syntax is absorbed as part of OSI attributes
- Internet access is part of OSI security model
- Internet status is part of OSI conformance application
- OSI permits creation and deletion of objects; Internet does not: Enhancement in SNMPv2

Notes

Mgmt. Communication Model

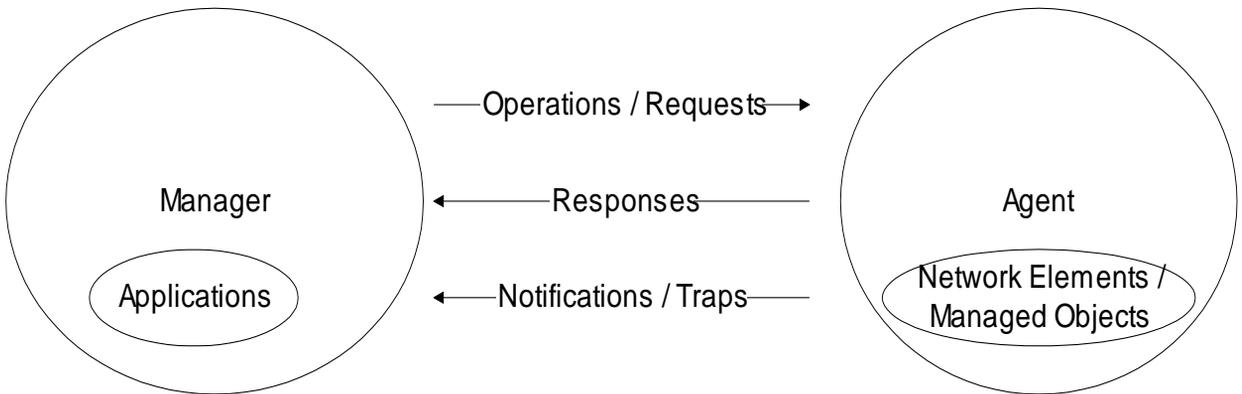


Figure 3.11 Management Message Communication Model

Notes

- In Internet requests/responses, in OSI operations
- In Internet traps and notifications (SNMPv2), in OSI notifications

Transfer Protocols

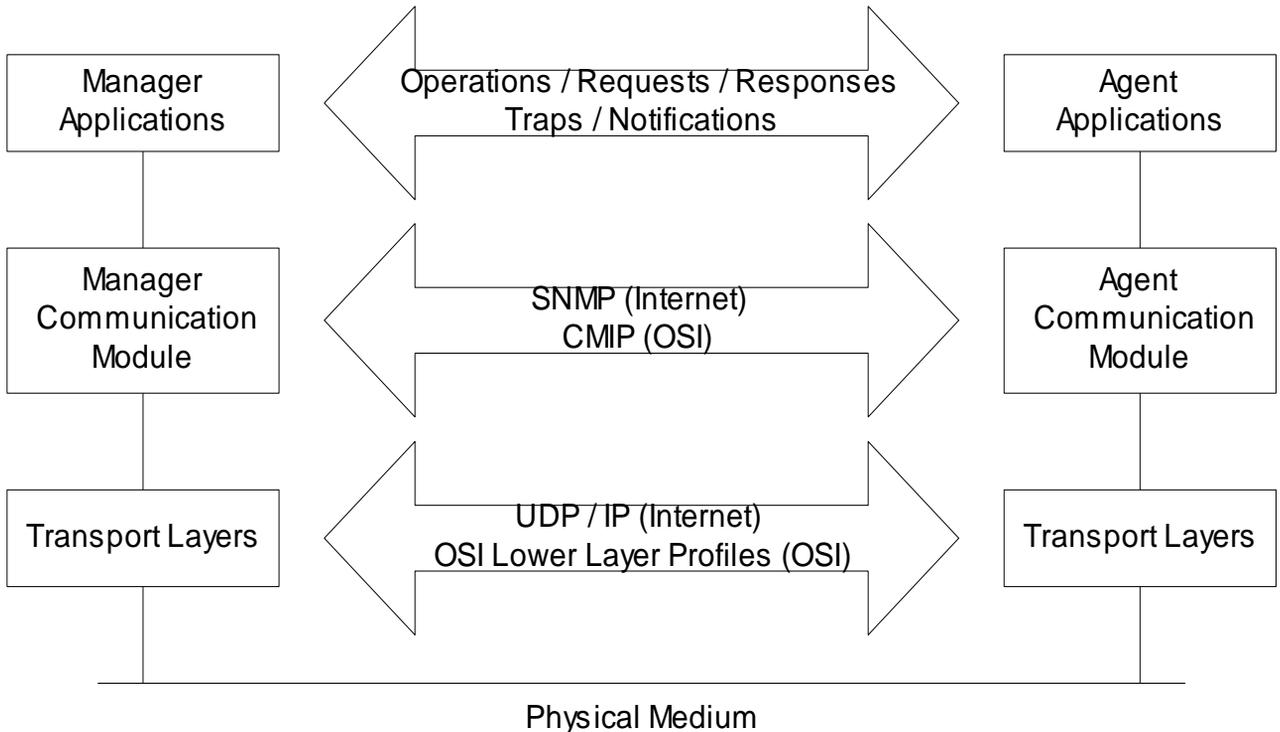


Figure 3.12 Management Communication Transfer Protocols

Notes

- Internet is based on SNMP; OSI is based on CMIP
- OSI uses CMISE (Common Management Information Service Element) application with CMIP
- OSI specifies both c-o and connectionless transport protocol; SNMPv2 extended to c-o, but rarely used

Abstract Syntax Notation One

- 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

Notes

Backus-Naur Form (BNF)

Definition:

$\langle \text{name} \rangle ::= \langle \text{definition} \rangle$

Rules:

$\langle \text{digit} \rangle ::= 0|1|2|3|4|5|6|7|8|9$

$\langle \text{number} \rangle ::= \langle \text{number} \rangle | \langle \text{digit} \rangle \langle \text{number} \rangle$

$\langle \text{op} \rangle ::= +|-|*|/$

$\langle \text{SAE} \rangle ::= \langle \text{number} \rangle | \langle \text{SAE} \rangle | \langle \text{SAE} \rangle \langle \text{op} \rangle \langle \text{SAE} \rangle$

Example:

- 9 is *primitive* 9
- 19 is *construct* of 1 and 9
- 619 is *construct* of 6 and 19

Notes

- BNF is used for ASN.1 constructs
- Constructs developed from primitives
- The above example illustrates how numbers are constructed from the primitive $\langle \text{digit} \rangle$
- Simple Arithmetic Expression entity ($\langle \text{SAE} \rangle$) is constructed from the primitives $\langle \text{digit} \rangle$ and $\langle \text{op} \rangle$

Simple Arithmetic Expression

$\langle \text{SAE} \rangle ::= \langle \text{number} \rangle \mid \langle \text{SAE} \rangle \langle \text{op} \rangle \langle \text{number} \rangle$

Example: $26 = 13 \times 2$

Constructs and primitives

Notes

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"
 - }

Notes

Data Type: Example 1

```
PersonnelRecord ::= SET
{
    Name,
    title    GraphicString,
    division CHOICE
        marketing    [0] SEQUENCE
            {Sector,
             Country},
        research     [1] CHOICE
            {product-based [0] NULL,
             basic         [1] NULL},
        production   [2] SEQUENCE
            {Product-line,
             Country }
}
```

etc.

Figure 3.13 ASN.1 Data Type Definition: Example 1

Notes

- 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
  {
    ...
    ...
    ... }
```

Figure 3.14 ASN.1 Data Type Definition: Example 2

Notes

- SEQUENCE OF SEQUENCE makes table of rows

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 |

Notes

Keyword Examples

- CHOICE
- SET
- SEQUENCE
- OF
- NULL

Notes

- 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 |

Notes

Data Type: Structure & Tag

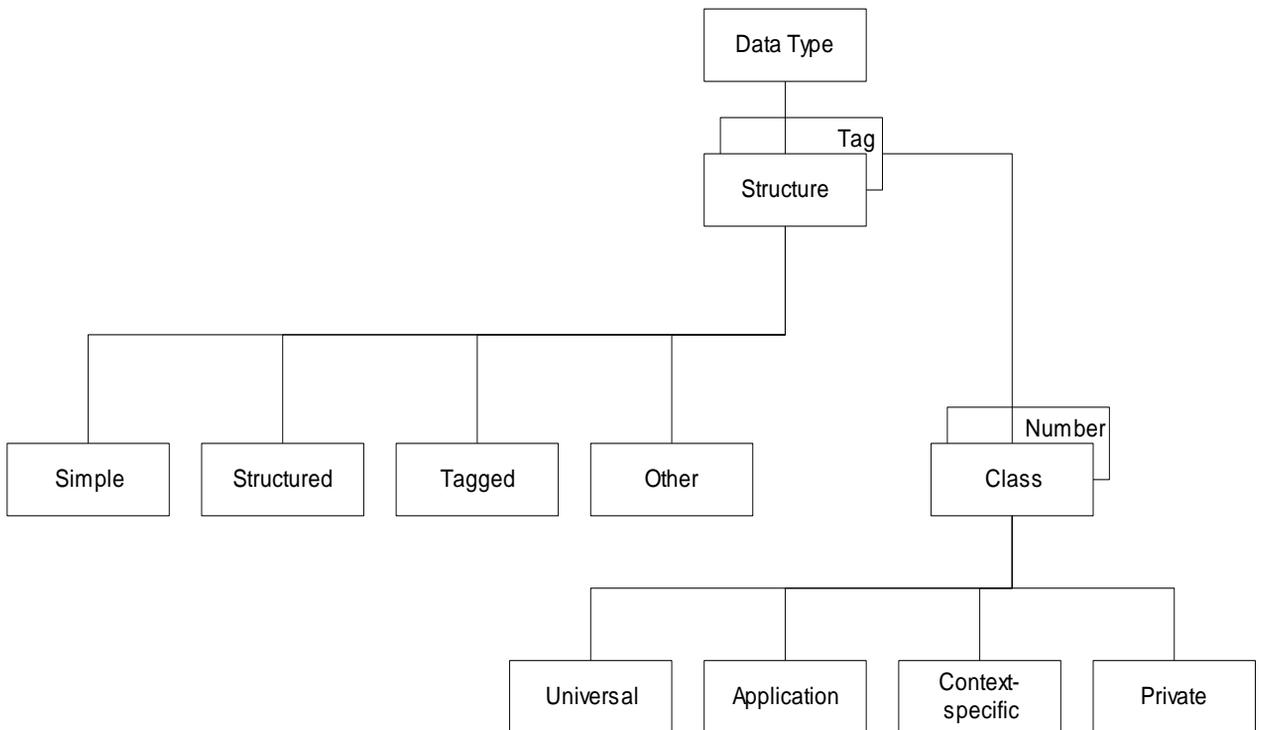


Figure 3.15 ASN.1 Data Type: Structure and Tag

Notes

- Structure defines how data type is built
- Tag uniquely identifies the data type

Tag

- Tag uniquely identifies a data type
- Comprises *class* and *tag number*
- Class:
 - Universal - always true
 - Application - only in the application used
 - Context-specific - specific context in application
 - Private - used extensively by commercial vendors

Notes

Example:

BOOLEAN Universal 1

INTEGER Universal 2

research Application [1] (Figure 3.13)

product-based Context-specific under *research* [0]

Enumerated Integer

```
RainbowColors ::= ENUMERATED
```

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

Notes

- 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}
```

Notes

Name: John T Smith
Title: Director
Employee Number 51
Date of Hire: 17 September 1971
Name of Spouse; Mary T Smith
Number of Children 2

Child Information

Name Ralph T Smith
Date of Birth 11 November 1957

Child Information

Name Susan B Jones
Date of Birth 17 July 1959

(a) Informal description of personnel record

```
PersonnelRecord ::= [APPLICATION 0] IMPLICIT SET {  
    Name,  
    title [0] VisibleString,  
    number EmployeeNumber,  
    dateOfHire [1] Date,  
    nameOfSpouse [2] Name,  
    children [3] IMPLICIT SEQUENCE OF ChildInformation DEFAULT { } }
```

```
ChildInformation ::= SET {
```

```
    Name,  
    dateOfBirth [0] Date }
```

```
Name ::= [APPLICATION 1] IMPLICIT SEQUENCE {
```

```
    givenName VisibleString,  
    initial VisibleString,  
    familyName VisibleString }
```

```
EmployeeNumber ::= [APPLICATION 2] IMPLICIT INTEGER
```

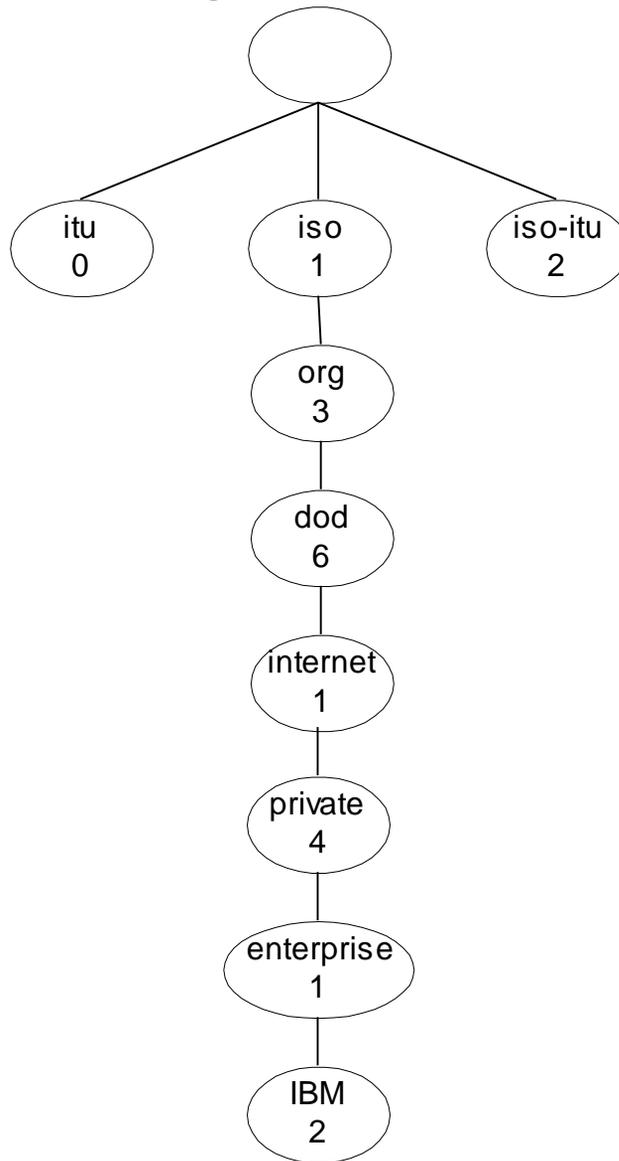
```
Date ::= [APPLICATION 3] IMPLICIT VisibleString -- YYYYMMDD
```

(b) ASN.1 description of the record structure

```
{  
    title {givenName "John", initial "T", familyName "Smith"},  
           "Director"  
    number 51  
    dateOfHire "19710917"  
    nameOfSpouse {givenName "Mary", initial "T", familyName "Smith"},  
    children { {  
        dateOfBirth {givenName "Ralph", initial "T", familyName "Smith"},  
                    "19571111"},  
        {  
            dateOfBirth {givenName "Susan", initial "B", familyName "Jones"},  
                        "19590717"} } }
```

(c) ASN.1 description of a record value

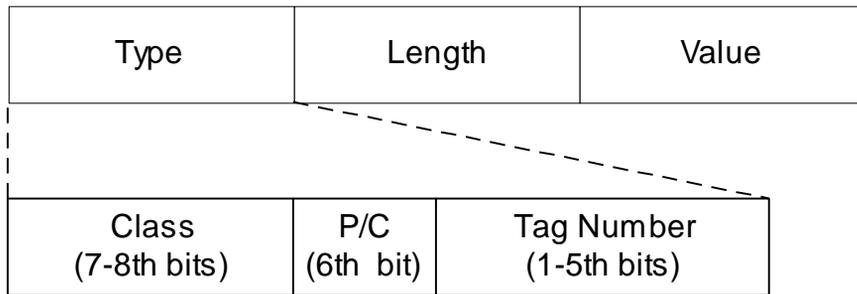
Object Name



Notes

- internet OBJECT IDENTIFIER ::= {ISO(1) ORG(3) DOD(6) INTERNET(1)}

TLV Encoding



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

Notes

- TLV Type, length, and value are components of the structure

Macro

```
<macroname> MACRO ::=
BEGIN
    TYPE NOTATION ::= <syntaxOfNewType>
    VALUE NOTATION ::= <syntaxOfNewValue>
    <auxiliaryAssignments>
END
```

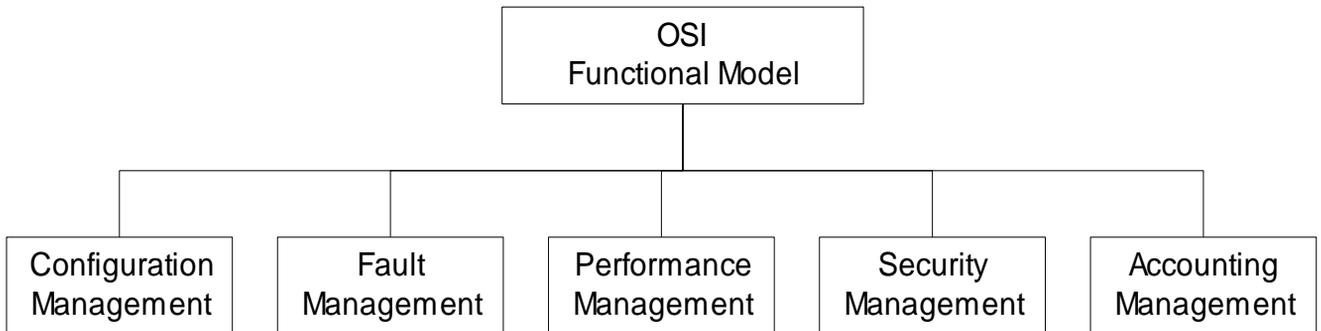
Example:

```
CS8803 OBJECT-IDENTITY
STATUS      current
DESCRIPTION "A graduate-level network
management course offered every fall by
College of Computing in Georgia Institute of
Technology."
           ::= {csclasses 50}
```

Notes

- Macro is used to create new data types

Functional Model



Notes

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