

# Chapter 9

## Network Management

### A note on the use of these ppt slides:

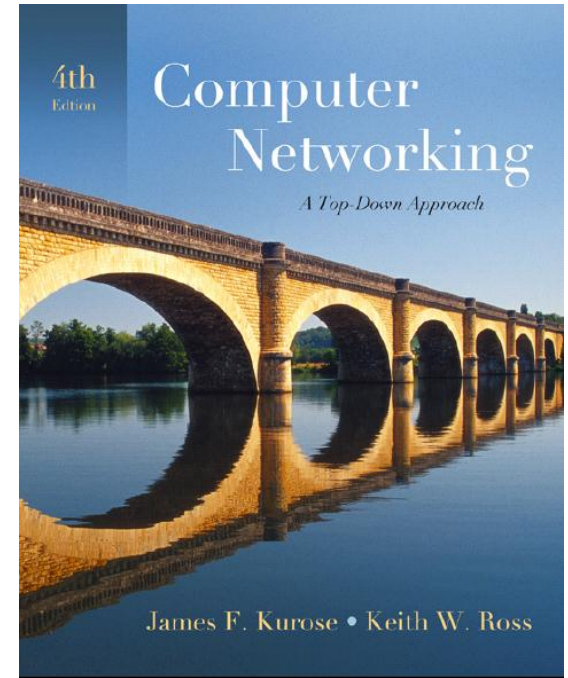
We're making these slides freely available to all (faculty, students, readers). They're in PowerPoint form so you can add, modify, and delete slides (including this one) and slide content to suit your needs. They obviously represent a *lot* of work on our part. In return for use, we only ask the following:

- ❑ If you use these slides (e.g., in a class) in substantially unaltered form, that you mention their source (after all, we'd like people to use our book!)
- ❑ If you post any slides in substantially unaltered form on a www site, that you note that they are adapted from (or perhaps identical to) our slides, and note our copyright of this material.

Thanks and enjoy! JFK/KWR

All material copyright 1996-2007

J.F Kurose and K.W. Ross, All Rights Reserved



*Computer Networking:  
A Top Down Approach ,  
4<sup>th</sup> edition.*

*Jim Kurose, Keith Ross  
Addison-Wesley, July  
2007.*

# Chapter 9: Network Management

## Chapter goals:

- ❑ introduction to network management
  - motivation
  - major components
- ❑ Internet network management framework
  - MIB: management information base
  - SMI: data definition language
  - SNMP: protocol for network management
  - security and administration
- ❑ presentation services: ASN.1

# Chapter 9 outline

- ❑ What is network management?
- ❑ Internet-standard management framework
  - Structure of Management Information: SMI
  - Management Information Base: MIB
  - SNMP Protocol Operations and Transport Mappings
  - Security and Administration
- ❑ ASN.1

# What is network management?

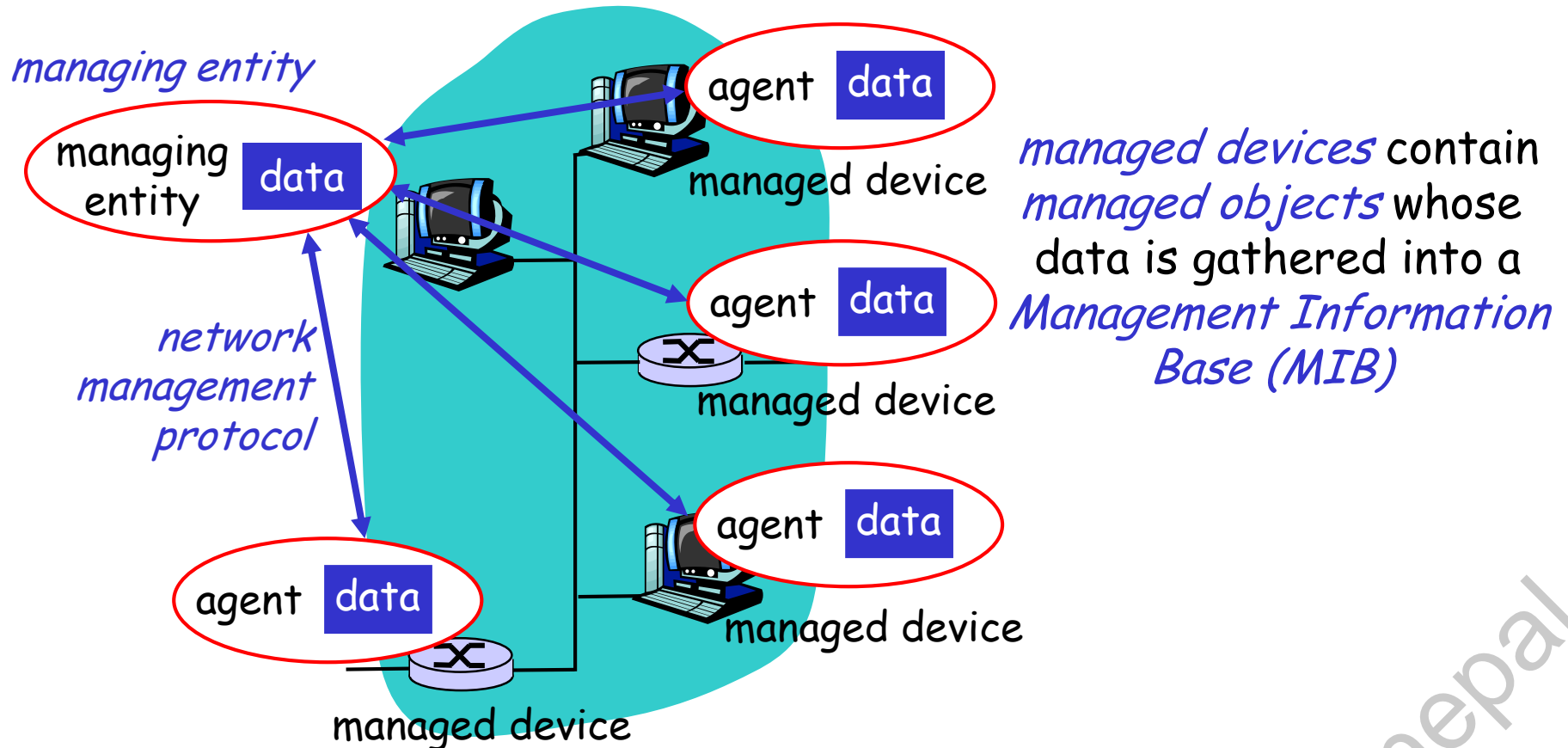
- ❑ **autonomous systems (aka "network")**: 100s or 1000s of interacting hardware/software components
- ❑ other complex systems requiring monitoring, control:
  - jet airplane
  - nuclear power plant
  - others?



"**Network management** includes the deployment, integration and coordination of the hardware, software, and human elements to monitor, test, poll, configure, analyze, evaluate, and control the network and element resources to meet the real-time, operational performance, and Quality of Service requirements at a reasonable cost."

# Infrastructure for network management

definitions:



# Network Management standards

## OSI CMIP

- ❑ Common Management Information Protocol
- ❑ designed 1980's: *the* unifying net management standard
- ❑ too slowly standardized

## SNMP: Simple Network Management Protocol

- ❑ Internet roots (SGMP)
- ❑ started simple
- ❑ deployed, adopted rapidly
- ❑ growth: size, complexity
- ❑ currently: SNMP V3
- ❑ *de facto* network management standard

# Chapter 9 outline

- ❑ What is network management?
- ❑ Internet-standard management framework
  - Structure of Management Information: SMI
  - Management Information Base: MIB
  - SNMP Protocol Operations and Transport Mappings
  - Security and Administration
- ❑ ASN.1

# SNMP overview: 4 key parts

- ❑ **Management information base (MIB):**
  - distributed information store of network management data
- ❑ **Structure of Management Information (SMI):**
  - data definition language for MIB objects
- ❑ **SNMP protocol**
  - convey manager<->managed object info, commands
- ❑ **security, administration capabilities**
  - major addition in SNMPv3



# SMI: data definition language

Purpose: syntax, semantics of management data well-defined, unambiguous

- ❑ base data types:
  - straightforward, boring
- ❑ OBJECT-TYPE
  - data type, status, semantics of managed object
- ❑ MODULE-IDENTITY
  - groups related objects into MIB module

## Basic Data Types

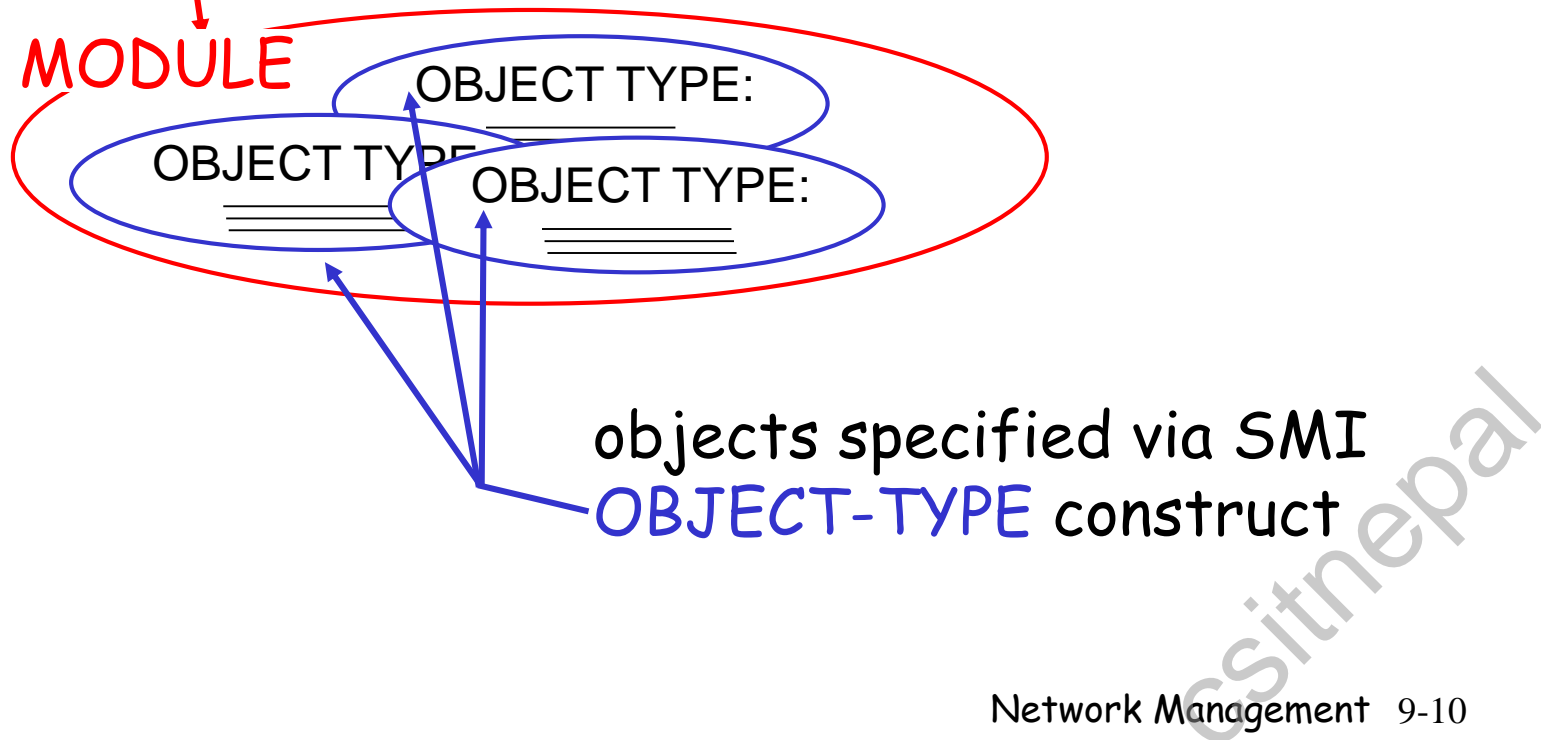
INTEGER  
Integer32  
Unsigned32  
OCTET STRING  
OBJECT IDENTIFIED  
IPAddress  
Counter32  
Counter64  
Gauge32  
Time Ticks  
Opaque

# SNMP MIB

MIB module specified via SMI

**MODULE-IDENTITY**

(100 standardized MIBs, more vendor-specific)



# SMI: Object, module examples

## OBJECT-TYPE: ipInDelivers

ipInDelivers OBJECT TYPE  
SYNTAX Counter32  
MAX-ACCESS read-only  
STATUS current  
DESCRIPTION  
    "The total number of input  
    datagrams successfully  
    delivered to IP user-  
    protocols (including ICMP)"  
 ::= { ip 9}

## MODULE-IDENTITY: ipMIB

ipMIB MODULE-IDENTITY  
    LAST-UPDATED "941101000Z"  
    ORGANIZATION "IETF SNMPv2  
        Working Group"  
    CONTACT-INFO  
        " Keith McCloghrie  
        ....."  
    DESCRIPTION  
        "The MIB module for managing IP  
        and ICMP implementations, but  
        excluding their management of  
        IP routes."  
    REVISION "019331000Z"  
    .....  
 ::= { mib-2 48}

# MIB example: UDP module

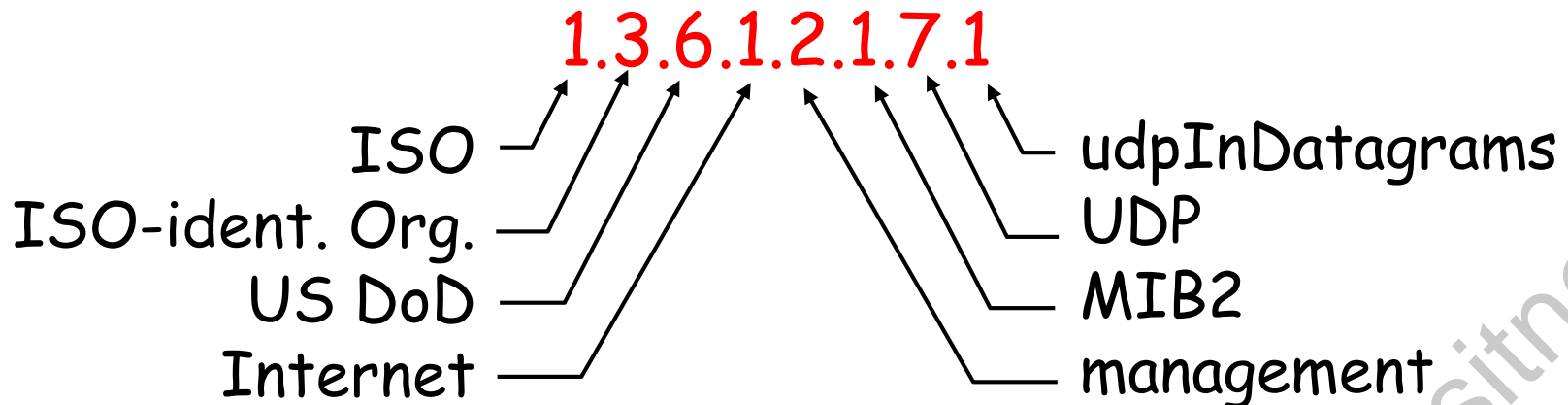
<u>Object ID</u>	<u>Name</u>	<u>Type</u>	<u>Comments</u>
1.3.6.1.2.1.7.1	UDPInDatagrams	Counter32	total # datagrams delivered at this node
1.3.6.1.2.1.7.2	UDPNoPorts	Counter32	# undeliverable datagrams no app at port
1.3.6.1.2.1.7.3	UDInErrors	Counter32	# undeliverable datagrams all other reasons
1.3.6.1.2.1.7.4	UDPOutDatagrams	Counter32	# datagrams sent
1.3.6.1.2.1.7.5	udpTable	SEQUENCE	one entry for each port in use by app, gives port # and IP address

# SNMP Naming

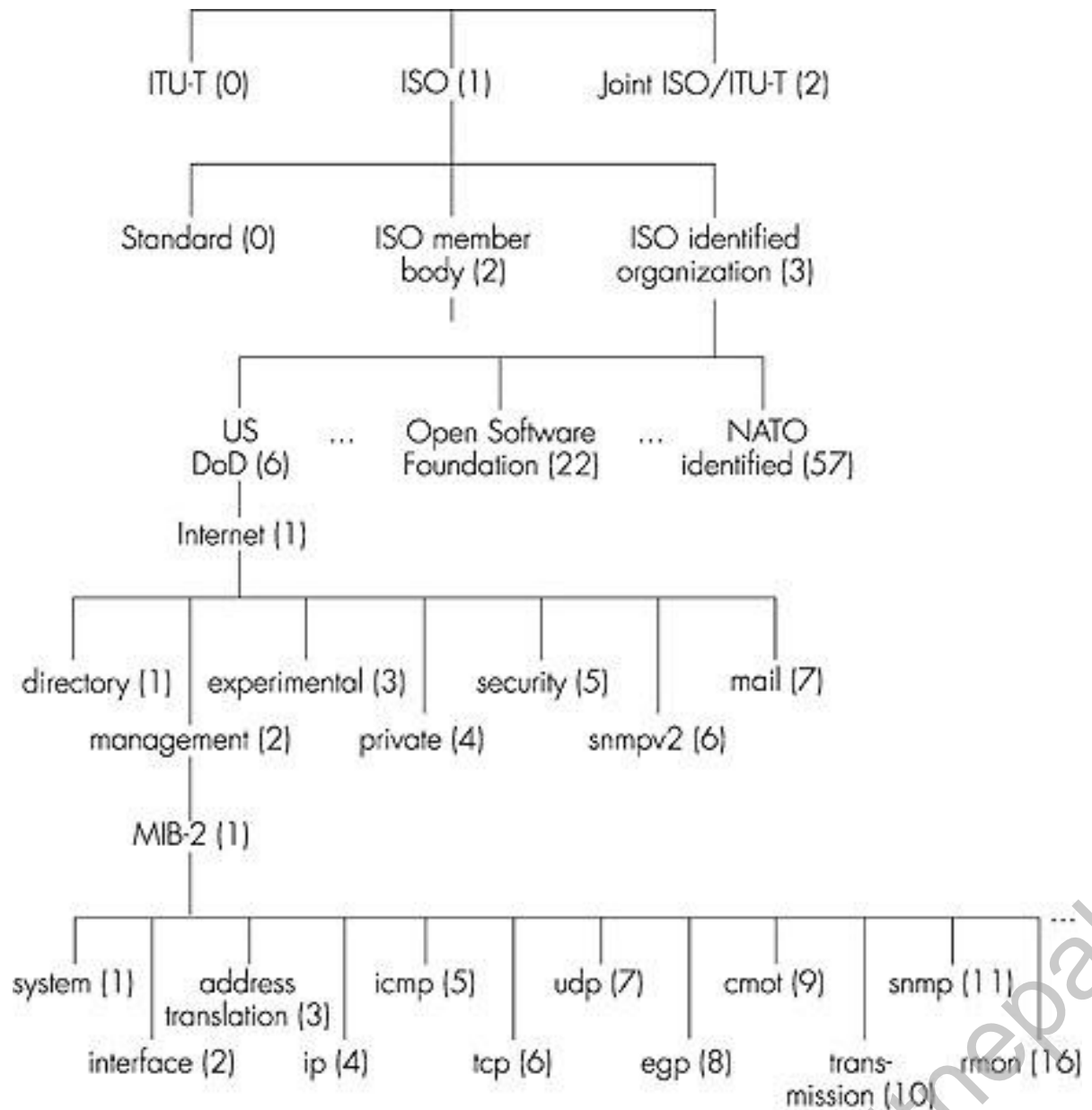
question: how to name every possible standard object (protocol, data, more..) in every possible network standard??

answer: *ISO Object Identifier tree:*

- hierarchical naming of all objects
- each branchpoint has name, number



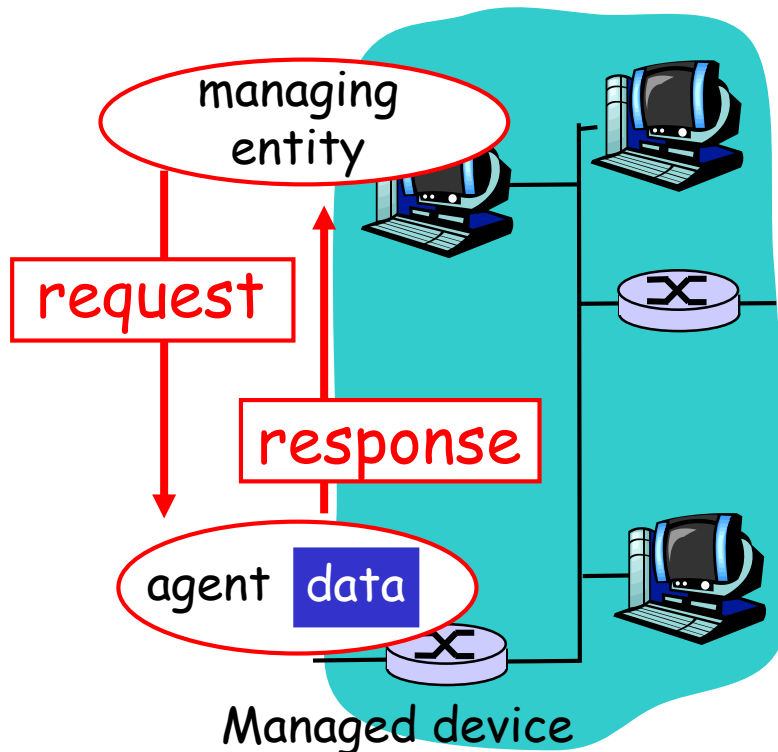
# OSI Object Identifier Tree



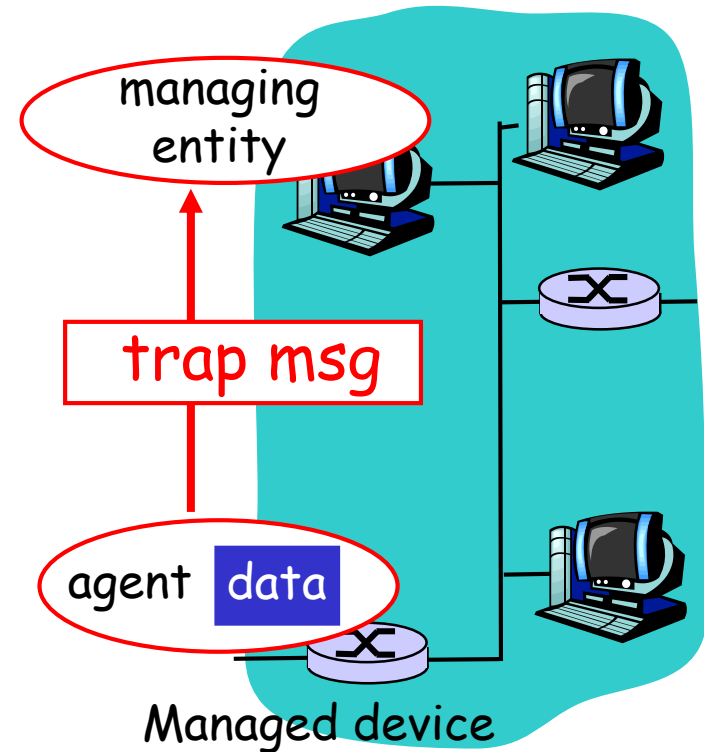
Check out [www.alvestrand.no/harald/objectid/top.html](http://www.alvestrand.no/harald/objectid/top.html)

# SNMP protocol

Two ways to convey MIB info, commands:



request/response mode



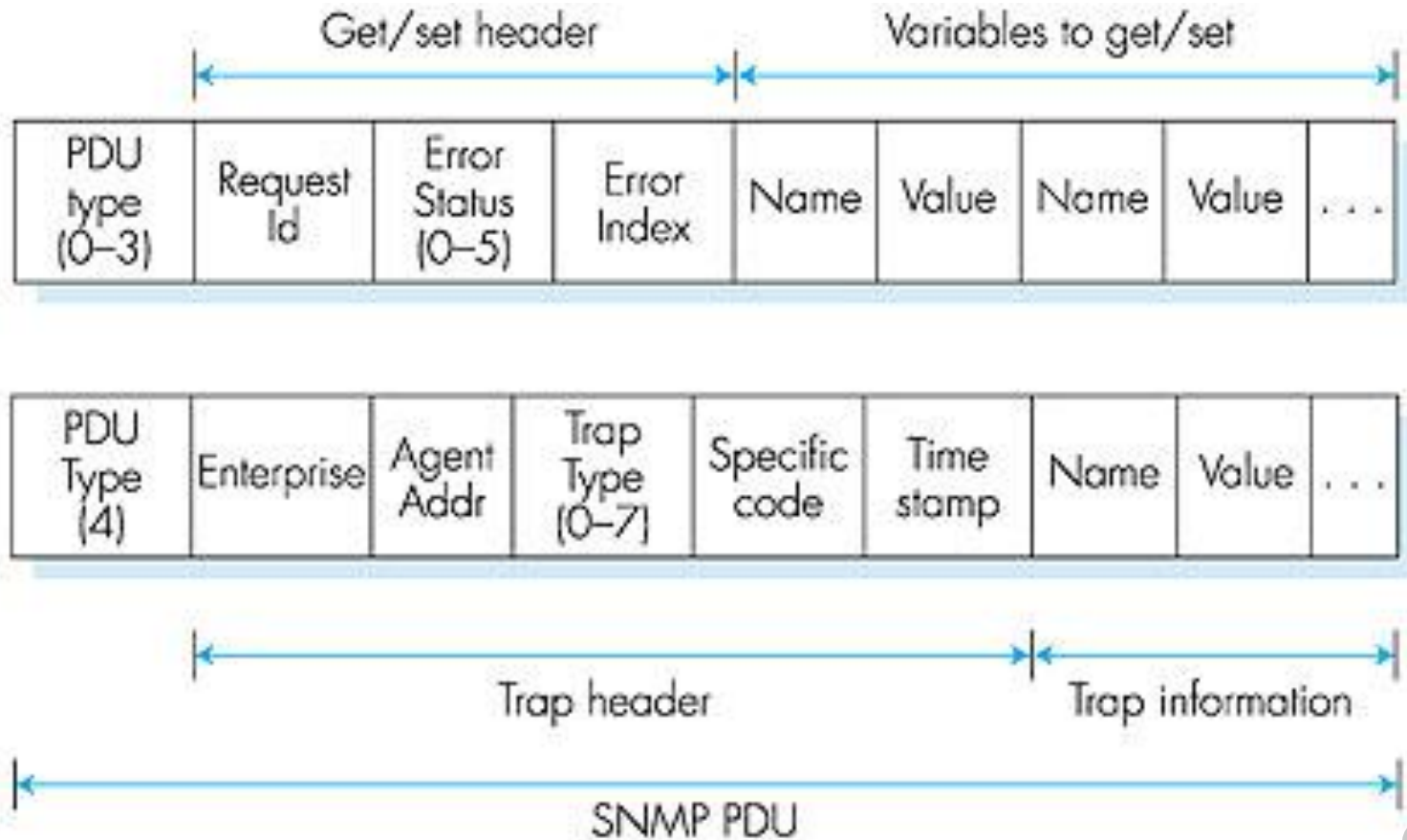
trap mode

# SNMP protocol: message types

<u>Message type</u>	<u>Function</u>
GetRequest GetNextRequest GetBulkRequest	Mgr-to-agent: "get me data" (instance,next in list, block)
InformRequest	Mgr-to-Mgr: here's MIB value
SetRequest	Mgr-to-agent: set MIB value
Response	Agent-to-mgr: value, response to Request
Trap	Agent-to-mgr: inform manager of exceptional event



# SNMP protocol: message formats



# SNMP security and administration

- ❑ **encryption:** DES-encrypt SNMP message
- ❑ **authentication:** compute, send  $\text{MIC}(m,k)$ :  
compute hash (MIC) over message (m),  
secret shared key (k)
- ❑ **protection against playback:** use nonce
- ❑ **view-based access control**
  - SNMP entity maintains database of access rights, policies for various users
  - database itself accessible as managed object!

# Chapter 9 outline

- ❑ What is network management?
- ❑ Internet-standard management framework
  - Structure of Management Information: SMI
  - Management Information Base: MIB
  - SNMP Protocol Operations and Transport Mappings
  - Security and Administration
- ❑ The presentation problem: ASN.1

# The presentation problem

Q: does perfect memory-to-memory copy solve "the communication problem"?

A: not always!

```
struct {  
    char code;  
    int x;  
} test;  
test.x = 256;  
test.code='a'
```

test.code	a
test.x	00000001
	00000011

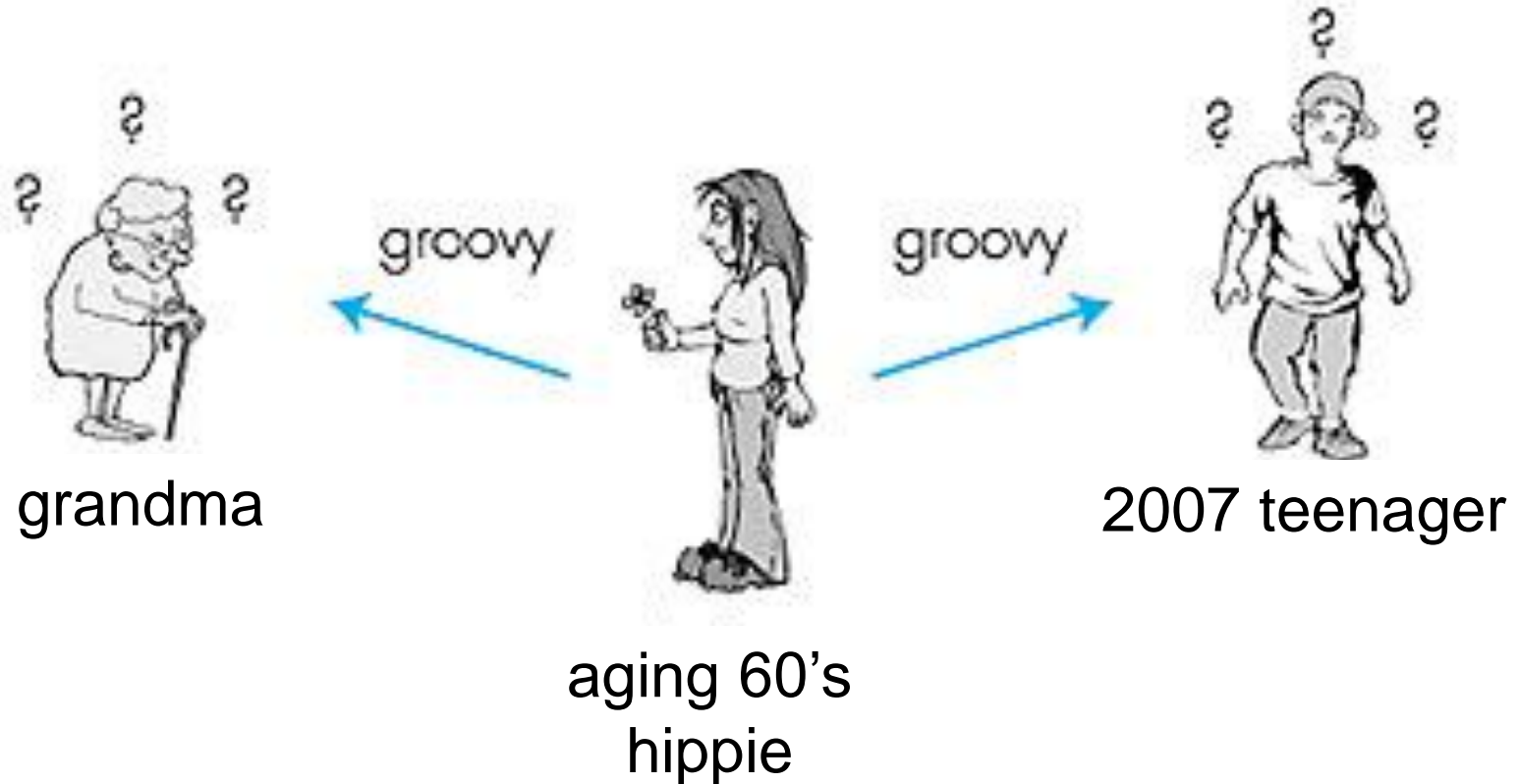
host 1 format

test.code	a
test.x	00000011
	00000001

host 2 format

problem: different data format, storage conventions

# A real-life presentation problem:

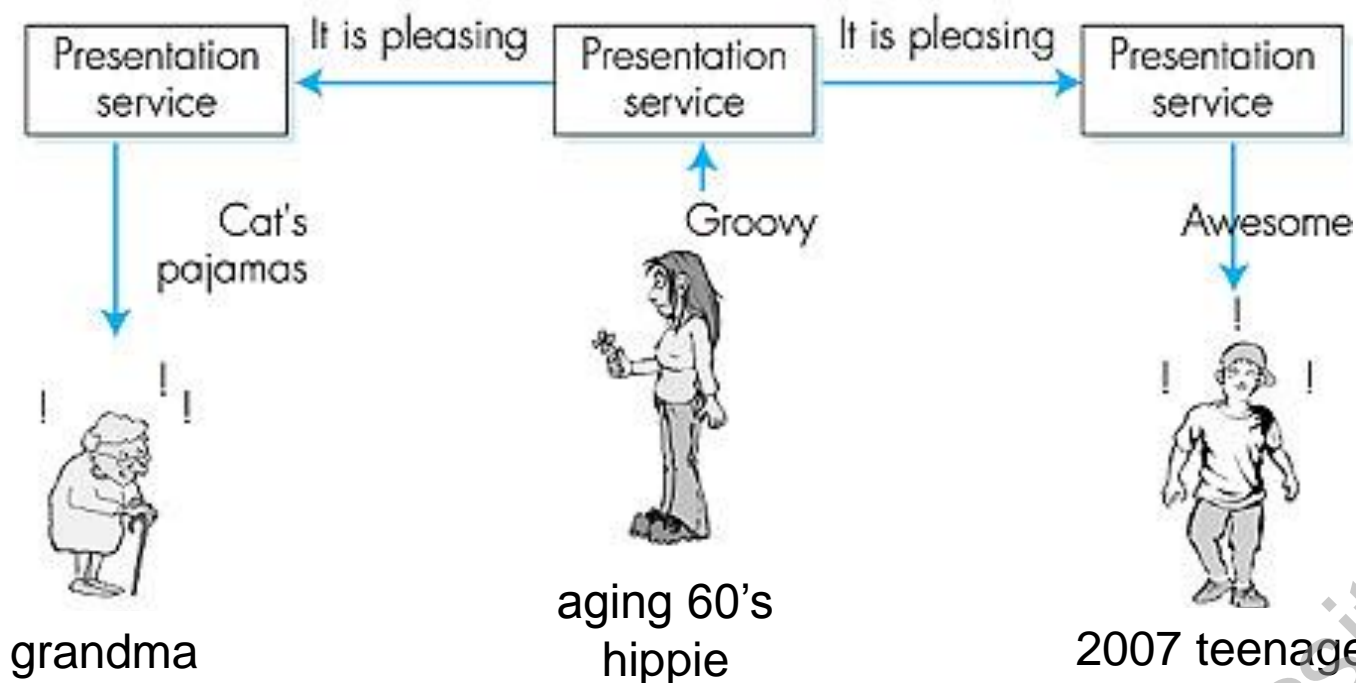


# Presentation problem: potential solutions

1. Sender learns receiver's format. Sender translates into receiver's format. Sender sends.
  - real-world analogy?
  - pros and cons?
2. Sender sends. Receiver learns sender's format. Receiver translate into receiver-local format
  - real-world-analogy
  - pros and cons?
3. Sender translates host-independent format. Sends. Receiver translates to receiver-local format.
  - real-world analogy?
  - pros and cons?

# Solving the presentation problem

1. Translate local-host format to host-independent format
2. Transmit data in host-independent format
3. Translate host-independent format to remote-host format



# ASN.1: Abstract Syntax Notation 1

## ❑ ISO standard X.680

- used extensively in Internet
- like eating vegetables, knowing this “good for you”!

## ❑ defined data types, object constructors

- like SMI

## ❑ BER: Basic Encoding Rules

- specify how ASN.1-defined data objects to be transmitted
- each transmitted object has Type, Length, Value (TLV) encoding



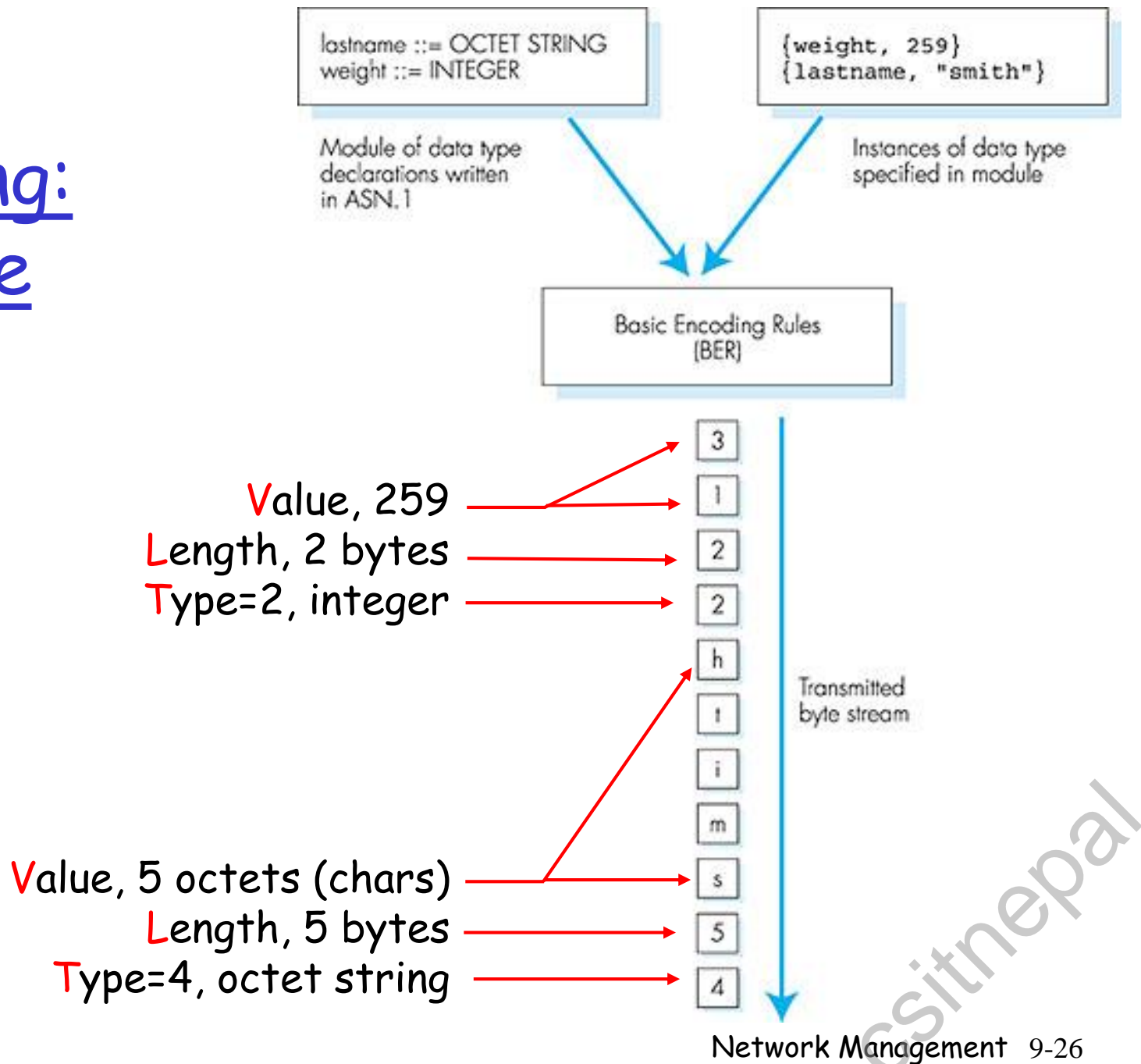
# TLV Encoding

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

<u>Tag Value</u>	<u>Type</u>
1	Boolean
2	Integer
3	Bitstring
4	Octet string
5	Null
6	Object Identifier
9	Real

# TLV encoding: example



# Network Management: summary

- ❑ network management
  - extremely important: 80% of network “cost”
  - ASN.1 for data description
  - SNMP protocol as a tool for conveying information
- ❑ Network management: more art than science
  - what to measure/monitor
  - how to respond to failures?
  - alarm correlation/filtering?