Simple Network Management Protocol

Slide Set 8

Network Management Framework

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

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

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

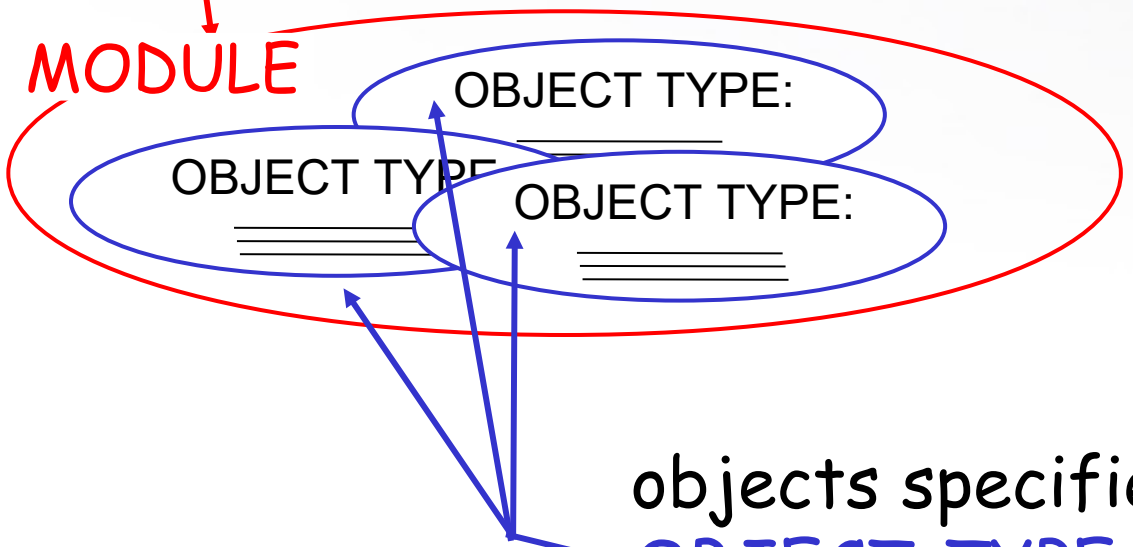
- BASIC DATA TYPES:
  - straightforward
- OBJECT-TYPE
  - data type, status, semantics of managed object
- MODULE-IDENTITY
  - groups related objects into MIB module

BASIC DATA TYPES

Integer
Integer32
Unsigned32
Octet String
Object Identifier
IPaddress
Counter32
Counter64
Gauge32
Time Ticks
Opaque

SNMP MIB

MIB module specified via SMI
MODULE-IDENTITY
(100 standardized MIBs, more vendor-specific)



objects specified via SMI
OBJECT-TYPE construct

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"
  ORGANZATION "IETF SNPv2
           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

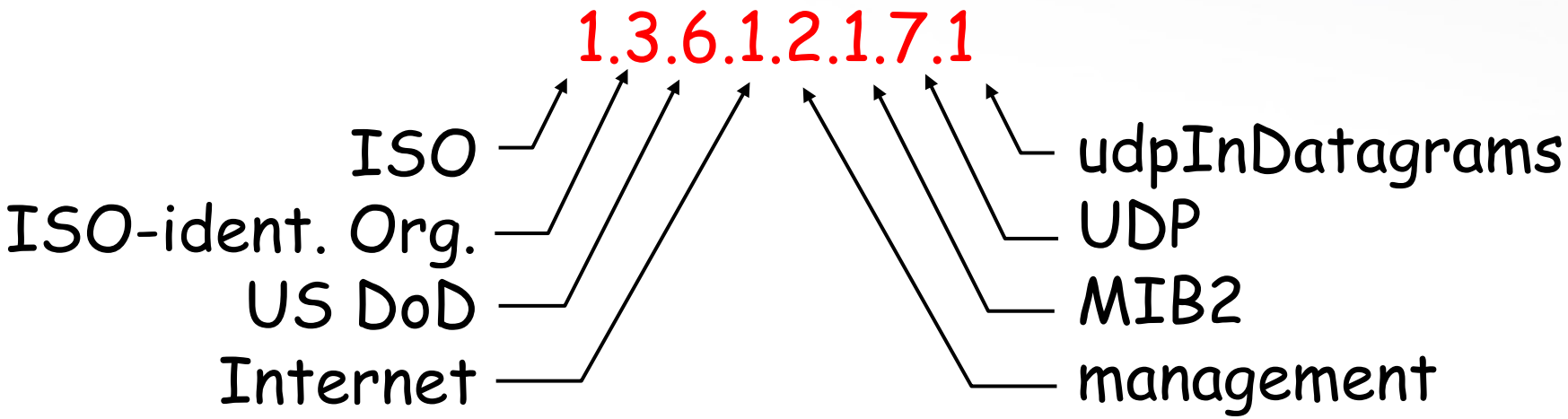
Object ID	Name	Type	Comments
1.3.6.1.2.1.7.1	UDPInDatagrams	Counter32	total # datagrams delivered at this node
1.3.6.1.2.1.7.2	UDPNoPorts	Counter32	# underliverable datagrams no app at port
1.3.6.1.2.1.7.3	UDInErrors	Counter32	# undeliverable datagrams all other reasons
1.3.6.1.2.1.7.4	UDPOutDatagrams	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

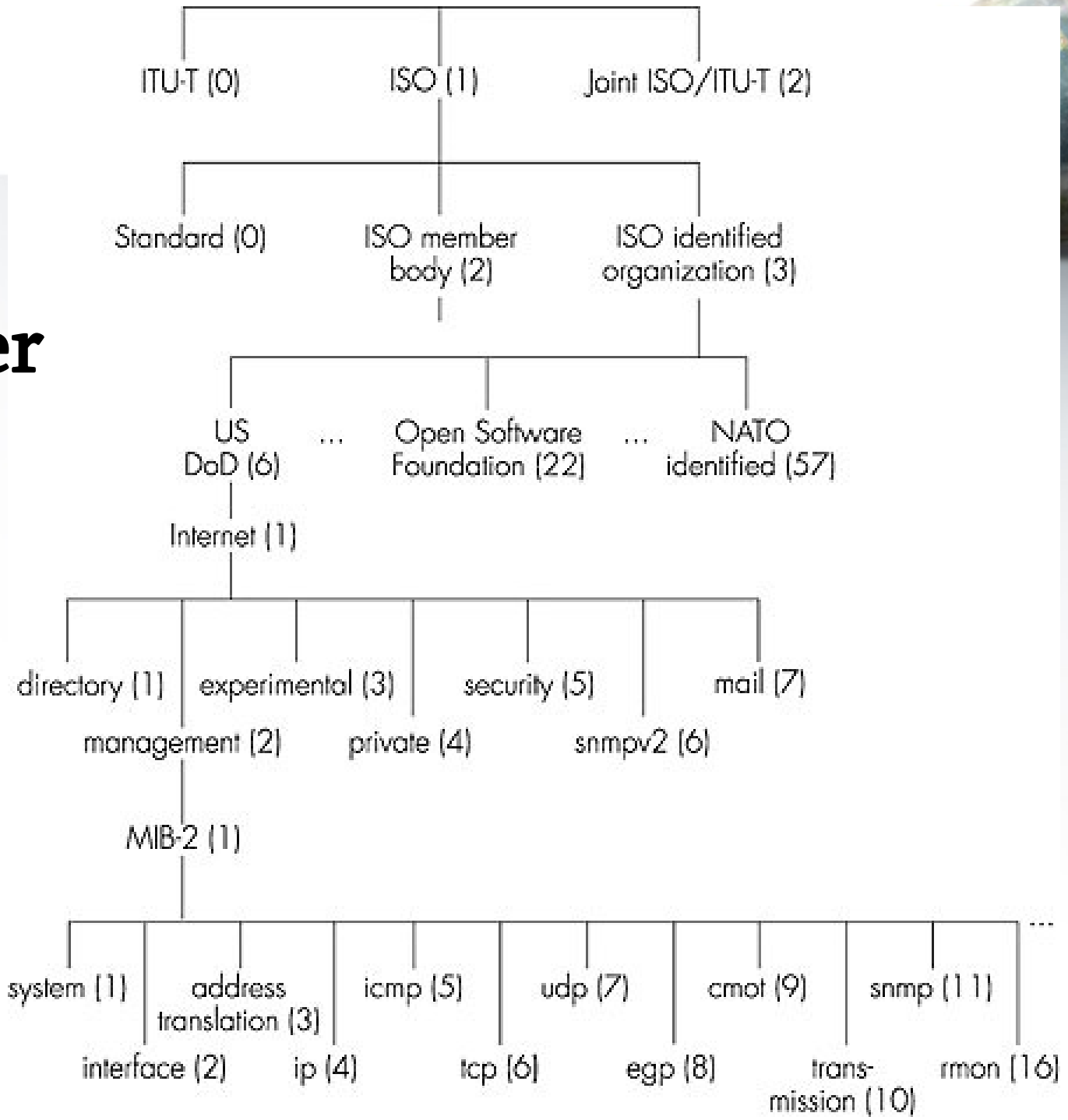
question: how to name every possible standard object (protocol, data, more..) in every possible network standard.

answer: *ISO Object Identifier tree:*

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

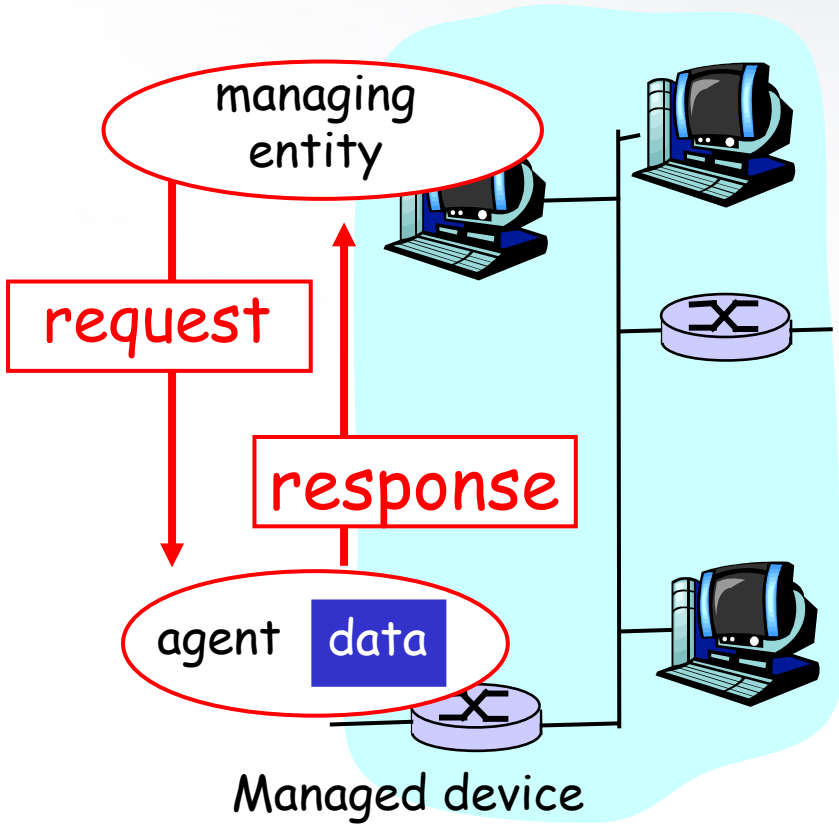


OSI Object Identifier Tree

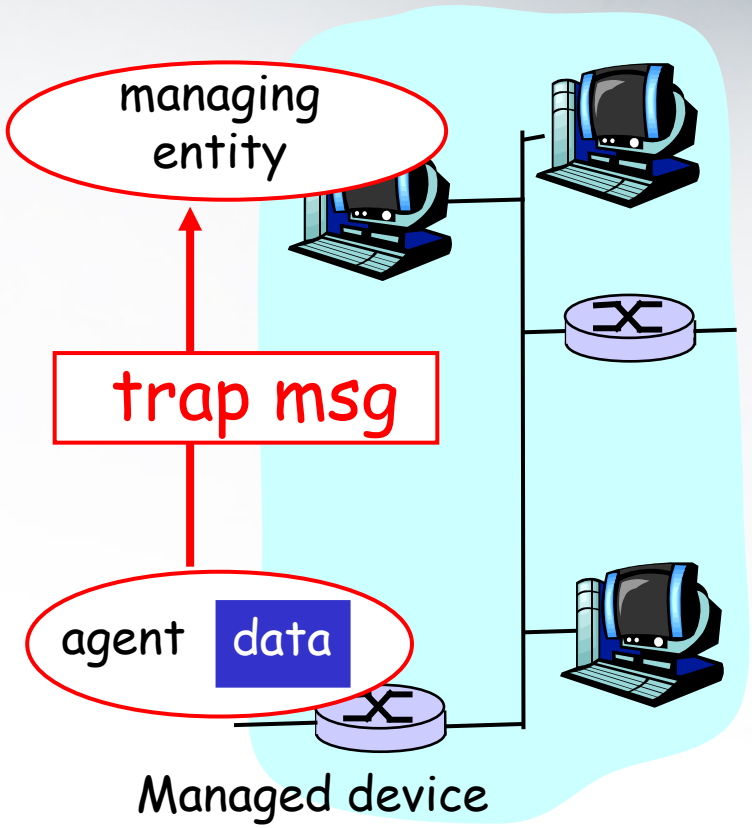


SNMP protocol

Two ways to convey MIB info, commands:



request/response mode

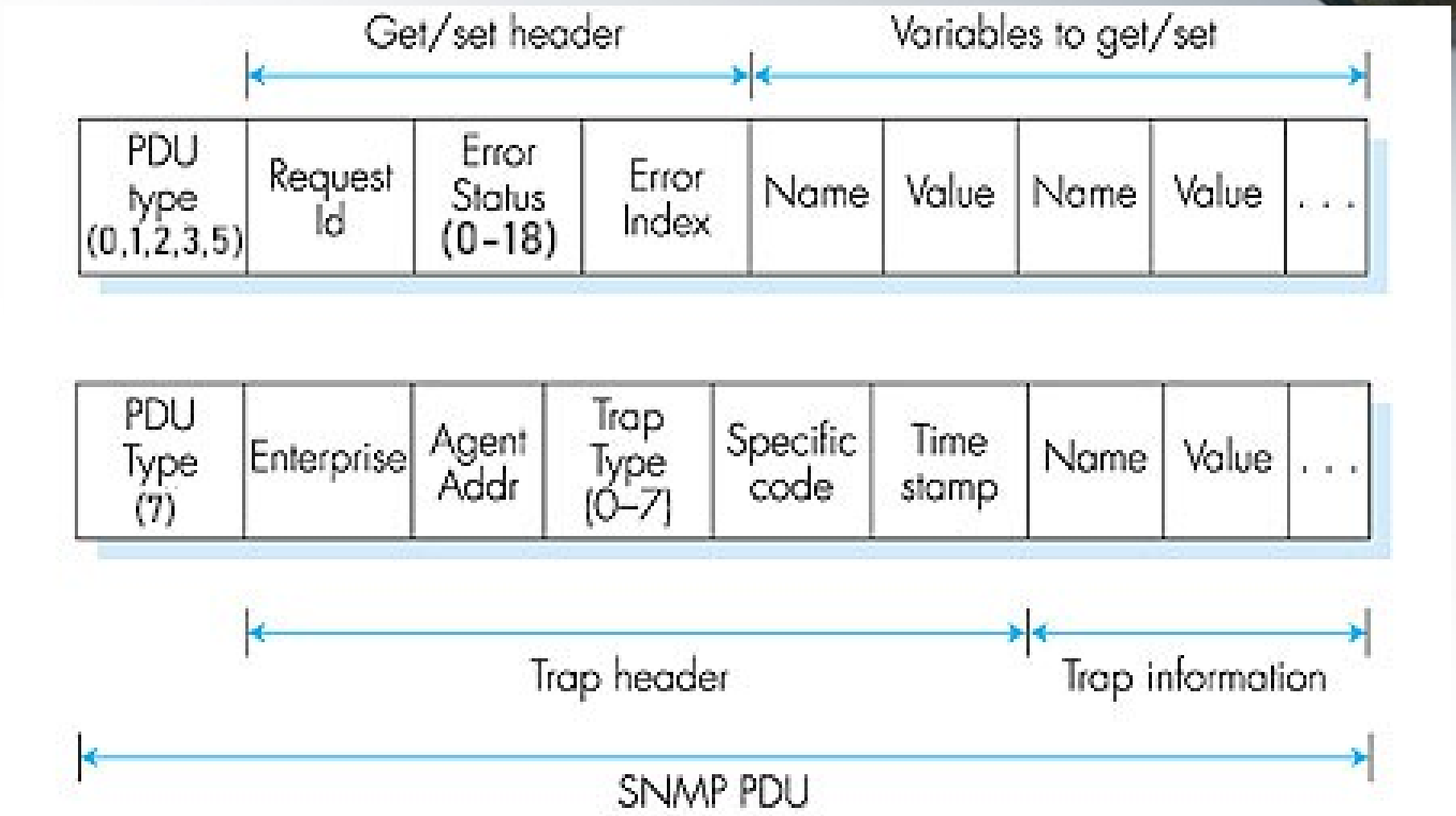


trap mode

SNMP protocol: message types

Message type	Function
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 v2/3 protocol messages format



SNMP v2/3 PDU Type Values

PDU Type: An integer value that indicates the PDU type:

PDU Type Value	PDU Type
0	*GetRequest-PDU*
1	*GetNextRequest-PDU*
2	*Response-PDU*
3	*SetRequest-PDU*
4	Obsolete, not used (this was the old *Trap-PDU* in SNMPv1)
5	*GetBulkRequest-PDU* (has its own format, see below)
6	*InformRequest-PDU*
7	*Trapv2-PDU*
8	*Report-PDU*

SNMP v2/3 Error Status field Values

Error Status Value	Error Code	Description
0	noError	No error occurred. This code is also used in all request PDUs, since they have no error status to report.
1	tooBig	The size of the *Response-PDU* would be too large to transport.
2	noSuchName	The name of a requested object was not found.
3	badValue	A value in the request didn't match the structure that the recipient of the request had for the object. For example, an object in the request was specified with an incorrect length or type.
4	readOnly	An attempt was made to set a variable that has an *Access* value indicating that it is read-only.
5	genErr	An error occurred other than one indicated by a more specific error code in this table.
6	noAccess	Access was denied to the object for security reasons.
7	wrongType	The object type in a variable binding is incorrect for the object.
8	wrongLength	A variable binding specifies a length incorrect for the object.
9	wrongEncoding	A variable binding specifies an encoding incorrect for the object.
10	wrongValue	The value given in a variable binding is not possible for the object.
11	noCreation	A specified variable does not exist and cannot be created.
12	inconsistentValue	A variable binding specifies a value that could be held by the variable but cannot be assigned to it at this time.
13	resourceUnavailable	An attempt to set a variable required a resource that is not available.
14	commitFailed	An attempt to set a particular variable failed.
15	undoFailed	An attempt to set a particular variable as part of a group of variables failed, and the attempt to then undo the setting of other variables was not successful.
16	authorizationError	A problem occurred in authorization.
17	notWritable	The variable cannot be written or created.
18	inconsistentName	The name in a variable binding specifies a variable that does not exist.

SNMP security and Administration

- encryption: DES-encrypt SNMP message
- authentication: compute, send 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!

Outline

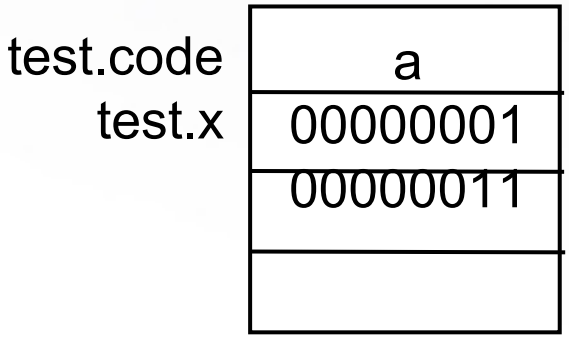
- What is network management?
- Internet-standard management framework
  - Structure of Management Information: SMI
  - Management Information Base: MIB
  - SNMP Protocol Operations and Transport Mappings
  - Security and Administration
- The presentation problem: ASN.1

The presentation problem

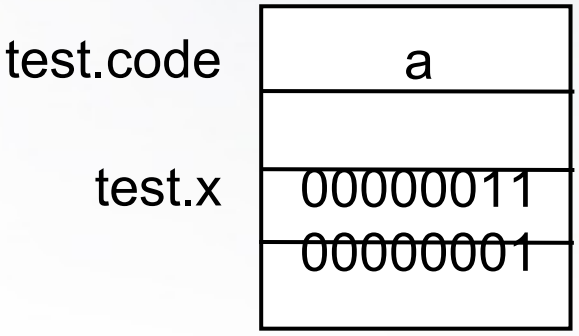
Q: does perfect memory-to-memory copy solve "the communication problem"?

A: not always!

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



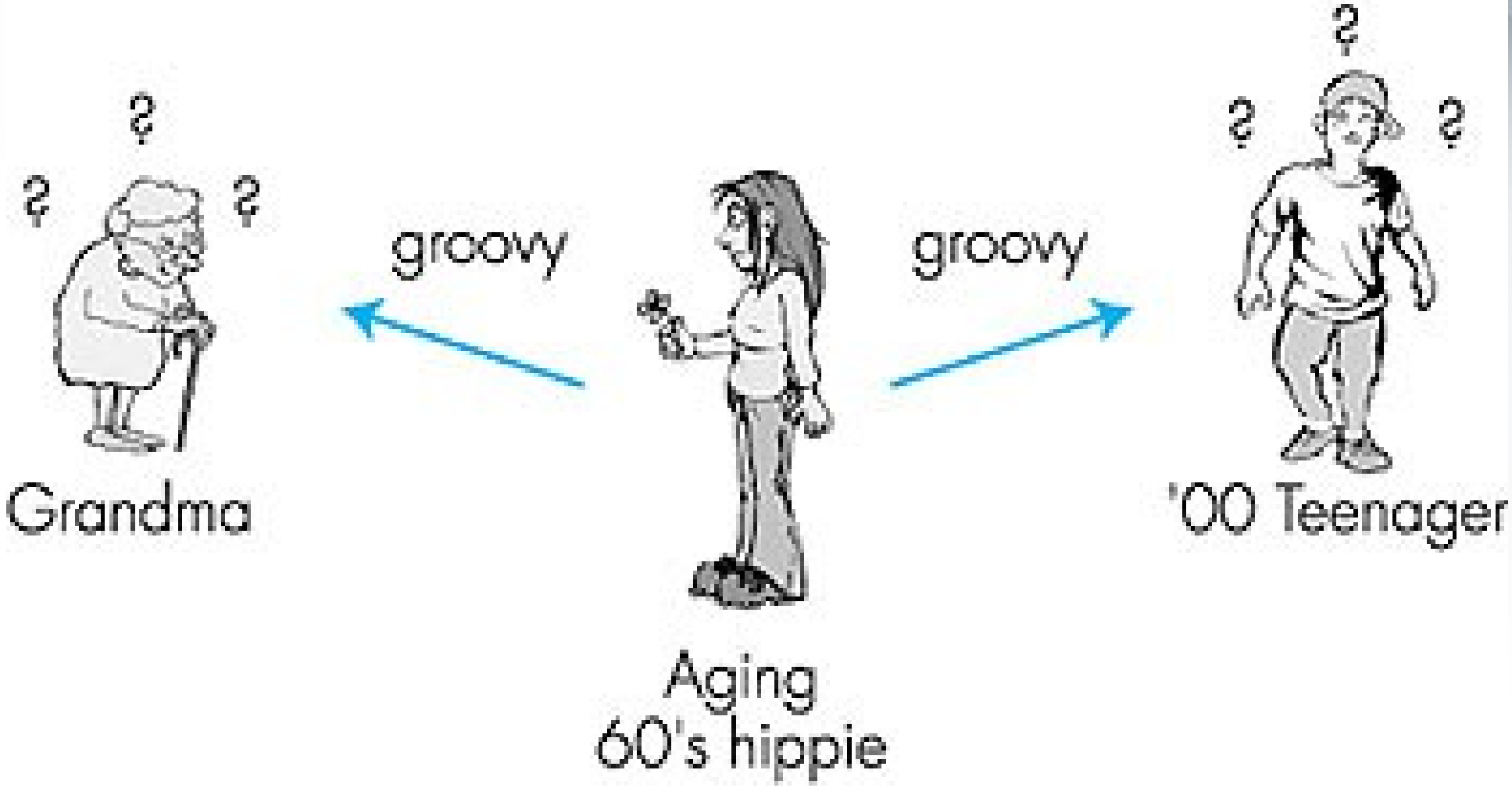
host 1 format



host 2 format

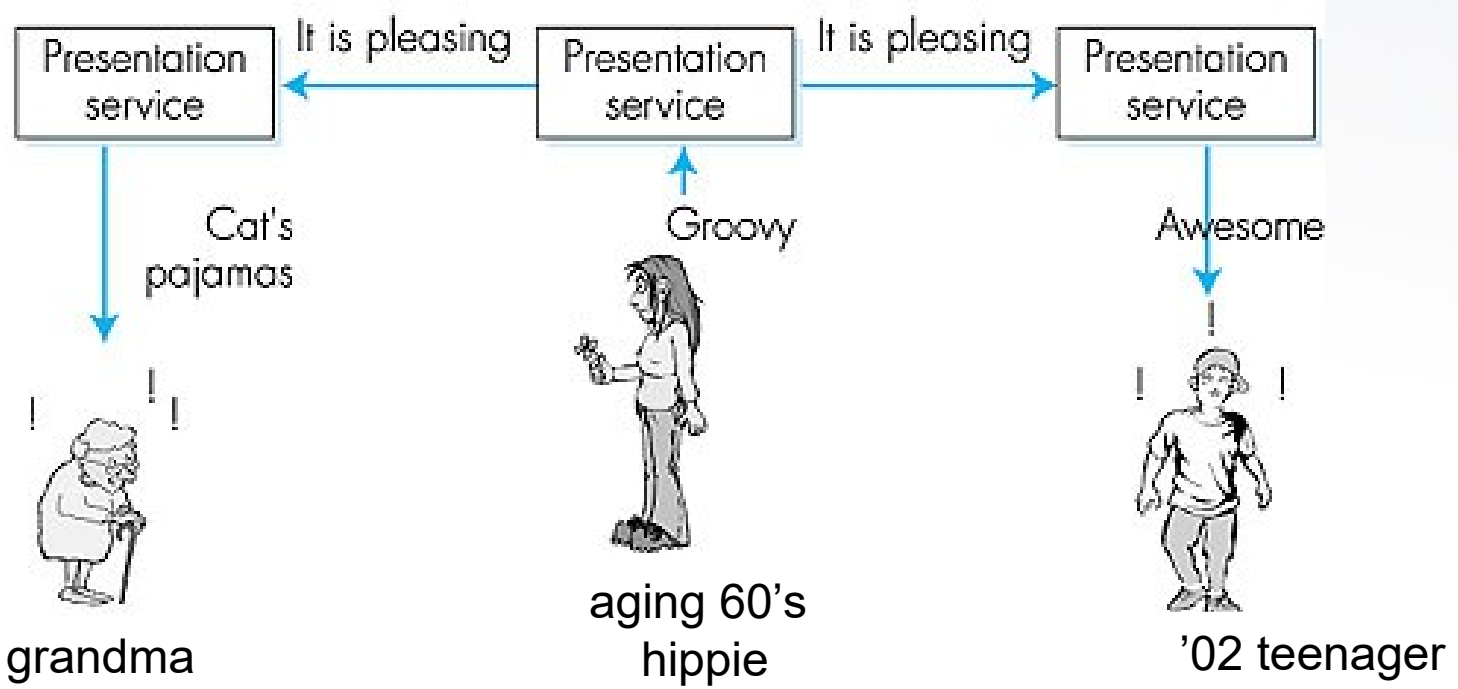
problem: different data format, storage conventions

A real-life presentation problem



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

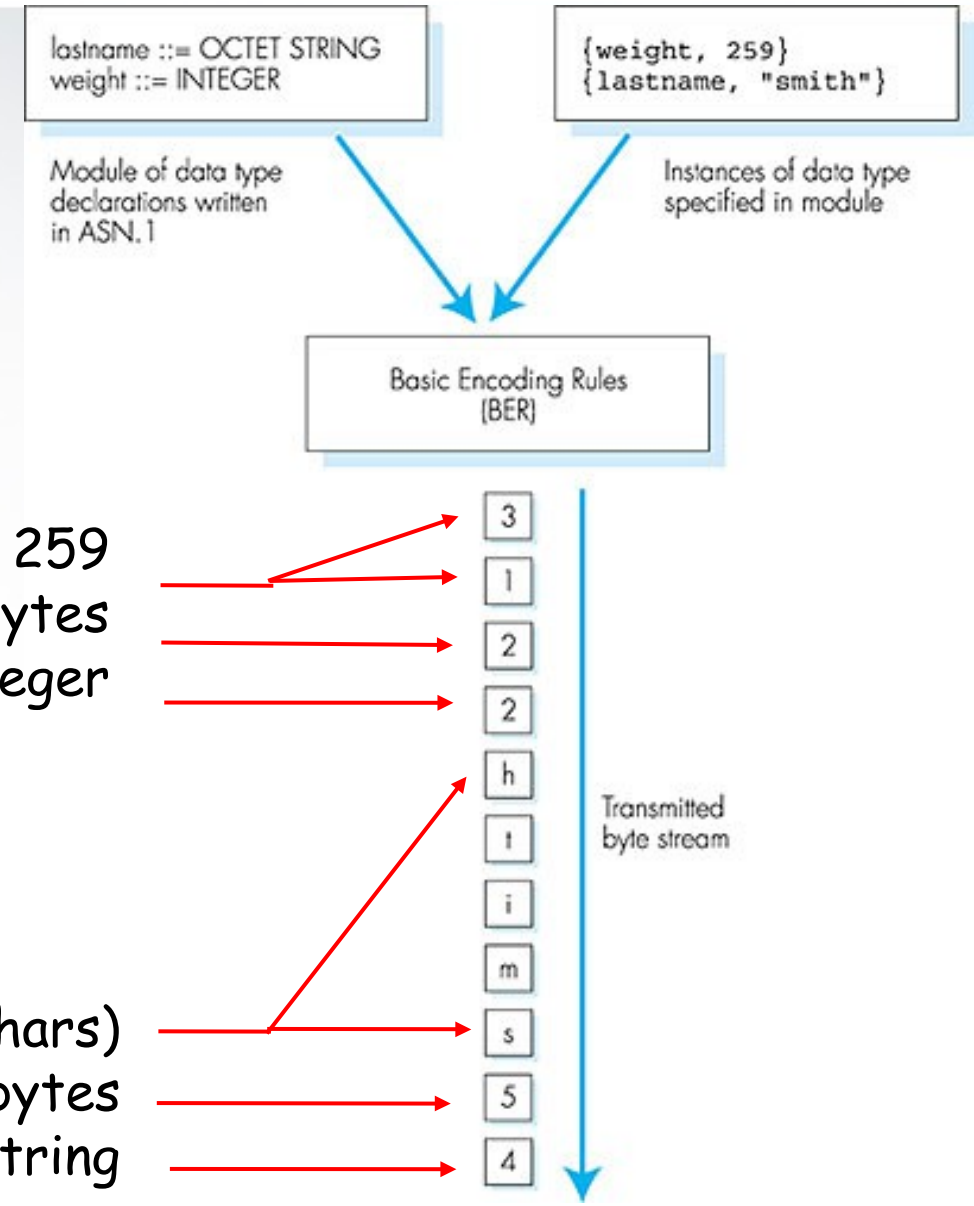
TLV Encoding

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

Tag Value	Type
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?