Network Management & Monitoring
Introduction to SNMP

Network Startup Resource Center
www.nsrc.org

Overview

- What is SNMP?
- Polling and querying
- OIDs and MIBs
- Notifications
- SNMPv3

What is SNMP?

SNMP – Simple Network Management Protocol

- Structured protocol, structured information
- For querying network device state and receiving notifications
- Also can be used to change state
- Industry standard, hundreds of tools exist that use it
- Supported on any decent network equipment
- Transport : UDP ports 161 and 162 (notifications)

Uses for SNMP

Typical queries

- Bytes In/Out on an interface, errors
- CPU load
- Uptime
- Temperature or other vendor specific OIDs

For hosts (servers or workstations)

- Disk space
- Installed software
- Running processes
- ...

Windows and UNIX have SNMP agents

SNMP Versions

v1 (1988) Original specification
- Historic

v2 (1996) Failed Standard
- Security+new data types+new operators
- 64-bit counters, get-bulk, v2 notifications
- View-based access control model (VACM) introduced
- Historic, no current implementations left

v2c (1996) De facto standard
- v2 data types and operators
- v1 security (community string) (simple security model)
- Historic

v3 (1998) Robust security
- User/view based security (USM/VACM)
- Full Internet Standard

We will use SNMP v2c and v3 in this class

SNMP roles

Terminology—We will be using Manager and Agent

Manager (the monitoring station)

- Sometimes known as the SNMP client
- SNMPv3 calls it the Command Generator and Notification Receiver

Agent (running on the equipment/server)

- Sometimes known as the SNMP server
- SNMPv3 calls it the Command Responder and Notification Originator

How does SNMP work?

Basic operators

- **get** (manager -> agent)
  - Query for a value
- **getnext** (manager -> agent)
  - Get next value (e.g. list of values for a table)
- **getresponse** (agent -> manager)
  - Response to **get**, **getnext**, or **set**, includes error returns
- **set** (manager -> agent)
  - Set a value, or perform an action
- **trap** (agent -> manager)
  - Spontaneous notification from equipment (line down, temperature above threshold, ...)

How does SNMP work?

Query/response based

- Monitoring generally uses **get, getnext, getbulk**
- Changing state uses **set**
- Response is always a **getresponse**
- **getbulk** requires v2c or v3

Notifications are delivered as **traps** or **informs**

- **traps** are unacknowledged
- **informs** are acknowledged (v2c, v3)
- Use v2c format **traps**
- No one uses **informs**

The SNMP database

The information offered by a device is available in its Management Information Base (MIB)

- SNMP uses Object Identifiers (OIDs) to organize this information
- OIDs are keys to identifying each piece of data
- OIDs are organized into a tree structure that is the MIB
- MIB files document parts of the MIB on a device

OIDs

OID: Object Identifier

- A unique key to select a particular item of data in the device
- The same piece of information is always found at the same OID. That's simple!
- An OID is a variable-length string of numbers, e.g.

  `.1.3.6.1.2.1.1.3`

- Allocated hierarchically in a tree to ensure uniqueness (*similar to DNS*)

If Email Addresses were OIDs

user@nsrc.org

would have been something like:

user@nsrc.enterprises.private.internet.dod.org.iso

user@99999.1.4.1.6.3.1

except that we reverse the ordering, putting iso(1) first:

.1.3.6.1.4.1.99999.117.115.101.114

Note the portion after 99999—it spells “user” in ascii dotted decimal!

Don't worry about the deeply branched tree. What matters is that OIDs are unique.

- Ensures vendors don't have conflicting OIDs
- The numeric OID is what gets sent on the wire

OIDs and MIB files

Read from left to right

OID components separated by '.'

```
.1.3.6.1.4.1.9. ...
```

Each OID corresponds to a label

```
.1.3.6.1.2.1.1.5 => sysName
```

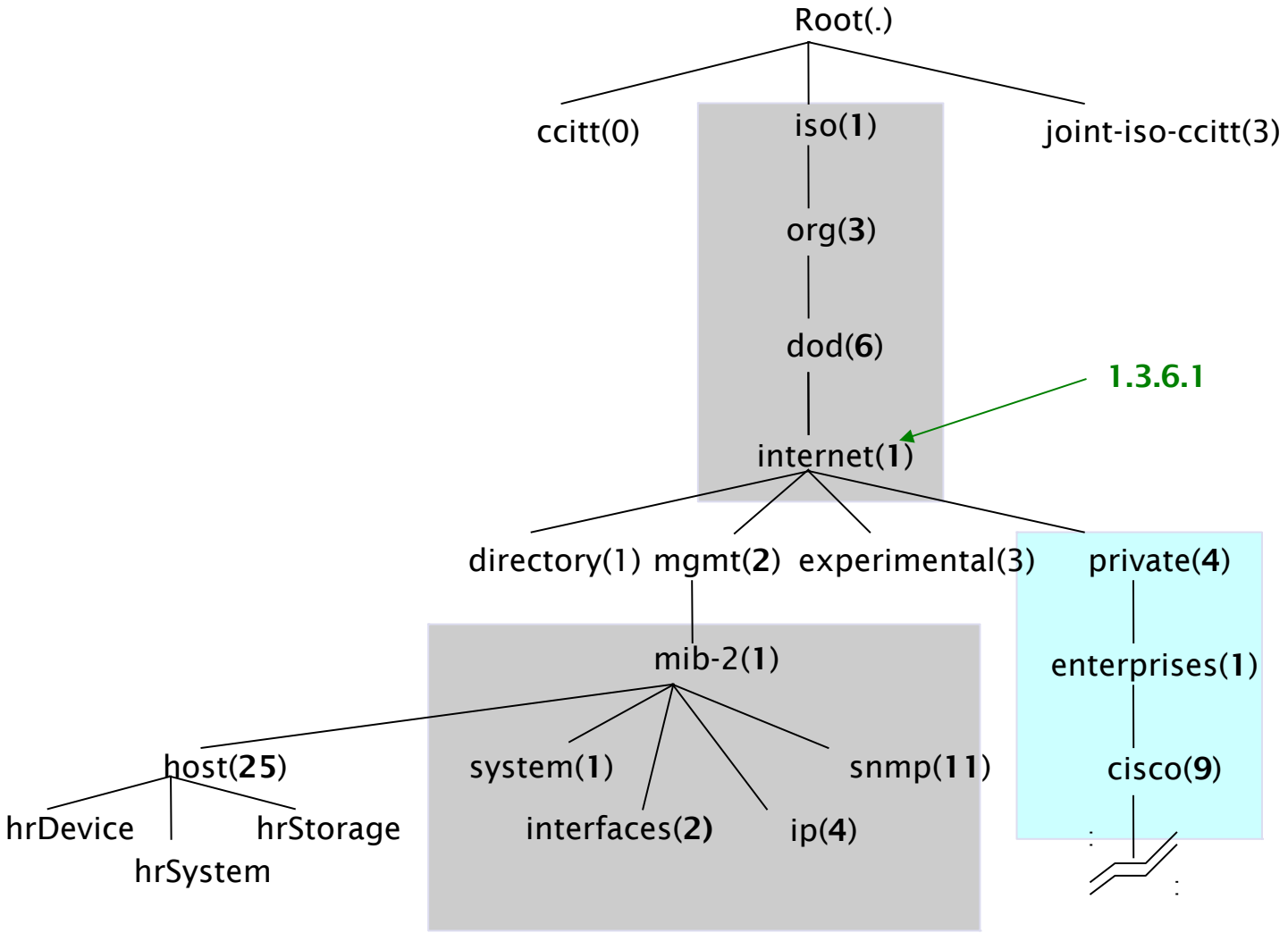
The complete path:

```
.iso.org.dod.internet.mgmt.mib-2.system.sysName
```

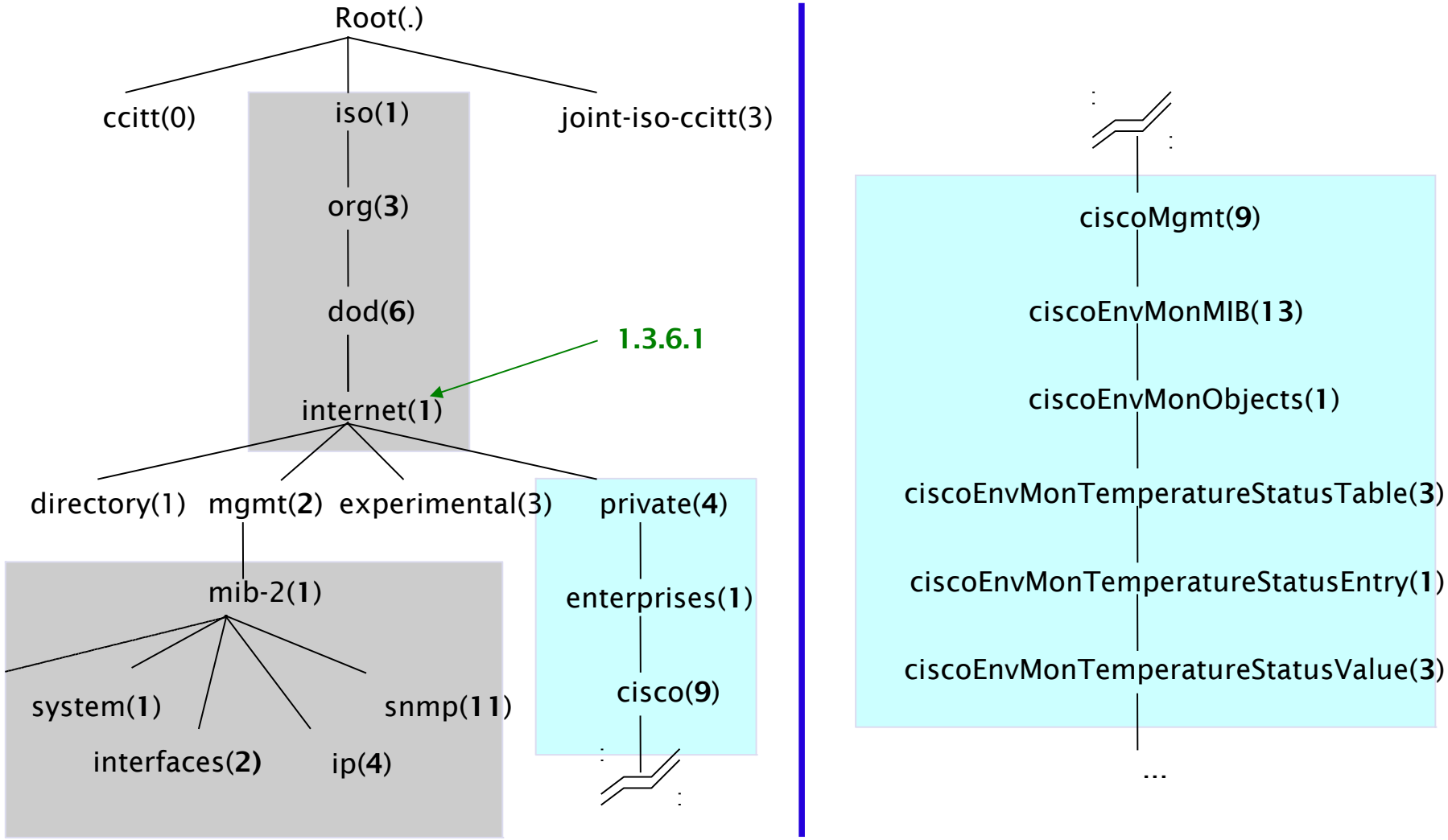
How do we convert from OIDs to Labels (and vice versa)?

- Use the MIBs files!

The MIB Tree


Root(.)
ccitt(0)
iso(1)
joint-iso-ccitt(3)
org(3)
dod(6)
1.3.6.1
internet(1)
directory(1)
mgmt(2)
experimental(3)
private(4)
mib-2(1)
enterprises(1)
host(25)
system(1)
snmp(11)
cisco(9)
hrDevice
hrStorage
interfaces(2)
ip(4)
hrSystem

The MIB Tree


Root(.)
ccitt(0)
iso(1)
joint-iso-ccitt(3)
org(3)
dod(6)
1.3.6.1
internet(1)
directory(1)
mgmt(2)
experimental(3)
private(4)
mib-2(1)
enterprises(1)
system(1)
snmp(11)
cisco(9)
interfaces(2)
ip(4)
ciscoMgmt(9)
ciscoEnvMonMIB(13)
ciscoEnvMonObjects(1)
ciscoEnvMonTemperatureStatusTable(3)
ciscoEnvMonTemperatureStatusEntry(1)
ciscoEnvMonTemperatureStatusValue(3)
...

Interesting parts of the MIB tree

The Internet MIB, `.1.3.6.1`, really only two branches of interest:

- Standard MIBs

  `.1.3.6.1.2.1` = `.iso.org.dod.internet.mgmt.mib-2`

- Vendor-specific (proprietary) MIBs

  `.1.3.6.1.4.1` = `.iso.org.dod.internet.private.enterprises`

The IEEE has MIBs of interest in three parts of the tree:

- IEEE 802 MIBs, including LLDP

  `.1.0.8802` = `.iso.standard.iso8802`

- IEEE 802.3 MIBs, including LAG

  `.1.2.840.10006` = `.iso.member-body.us.ieee802dot3`

- IEEE 802.11 wireless MIBs

  `.1.2.840.10036` = `.iso.member-body.us.ieee802dot11`

MIB Files

MIB files define the objects that can be queried, including:

- Object name
- Object description
- Data type (integer, text, list)

MIB files are structured text

- using an ASN.1 subset called the Structure of Management Information (SMI)

Standard MIB files include:

- MIB-II – (RFC1213) – a sub-group of MIBs
- HOST-RESOURCES-MIB (RFC2790)

MIB Sample

```
sysUpTime OBJECT-TYPE
              SYNTAX TimeTicks
              ACCESS read-only
              STATUS mandatory
              DESCRIPTION
                      "The time (in hundredths of a second) since the
                      network management portion of the system was last
                      re-initialized."
              ::= { system 3 }
```

`sysUpTime OBJECT-TYPE`

This defines the object called `sysUpTime`.

`SYNTAX TimeTicks`

This object is of the type `TimeTicks`. Object types are specified in the SMI we mentioned a moment ago.

`ACCESS read-only`

This object can only be read via SNMP (i.e., **get**, **getnext**); it cannot be changed (i.e., **set**).

`STATUS mandatory`

This object must be implemented in any SNMP agent.

`DESCRIPTION`

A description of the object

`::= { system 3 }`

The `sysUpTime` object is the third branch off of the `system` object group tree.

MIB Files

MIB files also make it possible to interpret a returned value from an agent

- For example, the status for a fan could be:
  - `1, 2, 3, 4, 5, or 6`
  - What does it mean?
- Look for the Textual Convention (tc) in the MIB

MIB Sample

```
CiscoEnvMonState ::= TEXTUAL-CONVENTION
        STATUS current
        DESCRIPTION
                "Represents the state of a device being monitored.
                 Valid values are:

                 normal(1):          the environment is good, such as low
                                     temperature.

                 warning(2):         the environment is bad, such as temperature
                                     above normal operation range but not too
                                     high.

                 critical(3):        the environment is very bad, such as
                                     temperature much higher than normal
                                     operation limit.

                 shutdown(4):        the environment is the worst, the system
                                     should be shutdown immediately.

                 notPresent(5):      the environmental monitor is not present,
                                     such as temperature sensors do not exist.

                 notFunctioning(6): the environmental monitor does not
                                     function properly, such as a temperature
                                     sensor generates a abnormal data like
                                     1000 C.
```

SNMP and Security

SNMP versions 1 and 2c are insecure

SNMP version 3 was created to fix this

SNMPv3 authentication is based on a user

- "User-based Security Model" (USM)
  - Authenticity and integrity
  - Keys are used for users and messages have digital signatures generated with a hash function (MD5 or SHA)
  - Privacy
  - Messages can be encrypted with secret-key (private) algorithms (DES or AES)
  - Temporary validity
  - Utilizes a synchronized clock with a 150 second window with sequence checking

SNMPv3 Security Levels

noAuthNoPriv

- No authentication, no privacy

authNoPriv

- Authentication with no privacy

authPriv

- Authentication with privacy

Cisco SNMP Configuration

Read-only

```
snmp-server community NetManage RO
```

- Enables SNMPv1 and v2c

```
snmp-server group ReadGroup v3 auth
snmp-server user admin ReadGroup v3 auth sha NetManage
```

- SNMPv3 authentication, no encryption

Read-write

```
snmp-server group WriteGroup v3 auth write v1default
snmp-server user admin-rw WriteGroup v3 auth sha NetManage priv aes 128 NetWrite
```

- Cisco allows authNoPriv and authPriv queries with this user
- You could also define a read-write user without encryption (priv)
- Note that we recommend using SNMP version 3 if you want write access using the **set** operator

Net-SNMP Configuration

Add a community string by editing `/etc/snmp/snmpd.conf` and adding:

```
rocommunity NetManage  10.10.0.0/16
```

Add the SNMPv3 user

```
# service snmpd stop
# net-snmp-create-v3-user -a SHA -A NetManage admin
# service snmpd start
```

Modify your user configuration file `~/.snmp/snmp.conf`, adding:

```
defVersion 3
defCommunity NetManage
defSecurityName admin
defSecurityLevel authNoPriv
defAuthPassphrase NetManage
defAuthType SHA
```

Querying an SNMP agent

Using Net-SNMP command line tools...

Some typical commands for querying:

- `snmpget`
- `snmpwalk`
- `snmpbulkwalk` (requires v2c or v3)
- `snmpstatus`
- `snmptable`

Syntax:

```
snmpXXX -v1 -c<community> host [OID]
snmpXXX -v2c -c<community> host [OID]
snmpXXX -v3 -lauthNoPriv -u<user> -aSHA -A<pass> host [OID}
```

However, because you've setup the snmp.conf file, it's much easier

```
snmpxxx host [OID]
```

- Or, if you want to force the version to v2c, for example:

```
snmpxxx -v2c host [OID]
```

Querying an SNMP agent

Let's look at some examples

```
snmpstatus 10.10.0.254
snmpget 10.10.0.254 ifNumber.0
snmpwalk -v2c 10.10.0.254 ifDescr
```

Querying an SNMP agent

Community:

- A ”security” string (password) to define whether the querying manager will have RO (read only) or RW (read write) access
- This is the simplest form of authentication in SNMP

OID

- A value, for example, `.1.3.6.1.2.1.1.5.0`
- or its name equivalent: `sysName.0`

Let's ask for the system's name (using the OID above)

- Why the `.0`? What do you notice?

Queries Using snmp.conf

Two walks:

```
# snmpwalk 10.10.0.252 sysUpTime
DISMAN-EVENT-MIB::sysUpTimeInstance =
Timeticks: (1946738) 5:24:27.38
# snmpwalk -v2c 3 10.10.0.252 sysUpTime
DISMAN-EVENT-MIB::sysUpTimeInstance =
Timeticks: (1953429) 5:25:34.29
```

First walk used SNMPv3 as it was the default in snmp.conf, second walk specified SNMPv2c, and used the community string from snmp.conf.

Failed Query...Why?

Two gets:

```
# snmpget -v1 10.10.0.252 ifHCInOctets.1
Error in packet
Reason: (noSuchName) There is no such variable name in this MIB.
Failed object: IF-MIB::ifHCInOctets.1

# snmpget 10.10.0.252 ifHCInOctets.1
IF-MIB::ifHCInOctets.1 = Counter64: 475028252
```

Why? Notice the data type: Counter64. 64-bit counters are only supported in SNMPv2c and v3.

64-bit counters are important because 32-bit interface counters (ifInOctets) can wrap in 34 seconds on Gig interfaces.

How fast can it wrap on 10G?

SNMP failure: no response?

The device might be offline or unreachable

The device might not be running an SNMP agent

The device might be configured with a different community string

The device might be configured to refuse SNMP queries from your IP address

In all of these cases you will get no response

SNMP Best Practices

- Secure your SNMP access and traffic:
  - Management VLAN
  - Access lists
  - Use SNMPv3 with authentication for queries and sets where possible
- Use SNMPv2c traps
  - Better formatted than v1 traps
  - Accurate timestamps
- Do no harm
  - Only poll as fast as you really need
  - Possible to drive CPU load on devices up and affect other protocol processing
  - It does no good to poll every 5 seconds if the device updates the counter every 10

Coming up in our exercises...

- Using `snmpwalk`, `snmpget`
- Config file: `/etc/snmp/snmp.conf`

- Running Linux SNMP agent (daemon)
- Config file: `/etc/snmp/snmpd.conf`

- Loading MIBs

References

Essential SNMP (O'Reilly Books) Douglas Mauro, Kevin Schmidt

- http://www.amazon.com/Essential-Second-Edition-Douglas-Mauro/dp/0596008406

Wikipedia

- http://en.wikipedia.org/wiki/Simple_Network_Management_Protocol

MIB/OID Browser

- http://oid-info.com/

Cisco SNMP on IOS, MIB tools, and MIB/OID browser

- http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/snmp/command/nm-snmp-cr-book.html
- http://tools.cisco.com/ITDIT/MIBS/servlet/index
- http://tools.cisco.com/Support/SNMP/do/BrowseOID.do?local=en&substep=2&translate=Translate&tree=NO

Open Source Java MIB Browser

- http://www.dwipal.com/mibbrowser.htm

SNMP Link – collection of SNMP resources

- http://www.snmplink.org/

Net-SNMP Open Source SNMP tools

- http://net-snmp.sourceforge.net/

Integration with Nagios

- https://web.archive.org/web/20100614010336/http://www.cisl.ucar.edu/nets/tools/nagios/SNMP-traps.html

SNMP Versions

v1 Original specification

RFCs 1155,1157,1213

v2 Security+new data types+new operators

RFCs 1901,1909-1910,2011,2576,2578-2580,3416-3418

v2c De facto standard

Documented in RFC 3584

v3 Robust security: USM/VACM

RFCs 3411-3415,3417-3418,3826,5343,5345,5590

RFC 3584 specifies coexistence between versions