Network Management

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The Problem

- Need for Network Management
- Historical reasons
- Disparate environments of Telecommunications and Computer Networks
- Standardization
- Complexity of today networks
- More features to manage in equipment

Why Network Management?

- After the deployment and setup of the network and services, why do we need network management?
  - Things tend to break
  - Configuration changes are needed
  - Problems with performance
  - Security or bad usage problems
  - Network usage is not free of charge! Who pays the costs?

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OSI Management functional areas – FCAPS model

1. Fault Management
2. Configuration Management
3. Accounting Management
4. Performance Management
5. Security Management

ISO/IEC 7498-4 and ITU-T X.700

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Fault Management

- Detection and location of fault / malfunction
- Isolate the fault from the rest of the network
- Reconfigure or change the network to minimize the impact of the problem
- Repair or replace faulty equipment or components

Accounting Management

- Also known as Asset or Inventory Management
- Traffic accounting at network borders (in/out packets, in/out octets, ...)
- Detection of excessive traffic by a user or groups of users, limiting the use of the network
- Inefficient use of network resources (modification of procedures to optimize network utilization)
- Accounting management enables charges to be established for the use of resources
- It is the source of data for Billing operations

Configuration Management

- Maintenance of software versions of network systems (Operating Systems, Drivers)
- Maintaining system configurations
- Changing the system configurations
- Updates the software and eventually update hardware as consequence
- Scheduling updates / changes

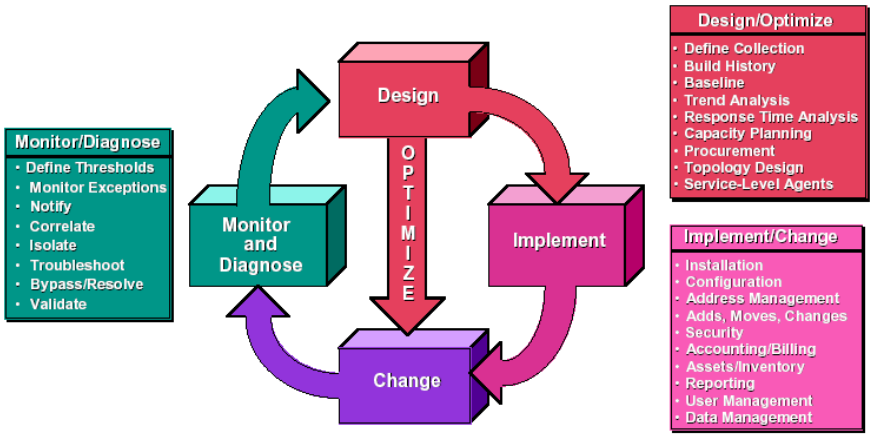
Performance Management

- Monitoring (monitor and track activities on the network)
- Gather statistical information
- Control to improve network performance (do adjustments to improve network performance)
  - What is the utilization rate?
  - Excessive traffic volume?
  - Response time is increasing?
  - There are bottlenecks?
- SLA verification

Security Management

- Protection of Information
- Access control to resources
- Centralized or distributed management
- Hierarchical access levels
- Event logging
- Log analysis! An IDS (*Intrusion Detection System*) helps...

Management Tasks



Typical Problems

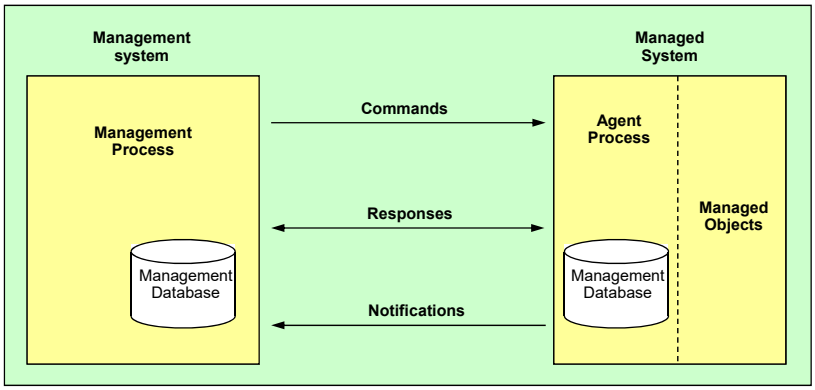
	Home User; WAN Connect	Small Office; Interconnected LANs; WAN/ Backbone Connect	Workgroup; Bridged/ Switched LANs	Campus; Multiple LANs; Campus Backbone; WAN Connect	WAN Backbone	Enterprise; Combination of All Environments
Tariffs, SLA					X	X
Many Geographic Sites/Operators					X	X
Accounting, Chargeback					X	X
Performance Tuning				X LAN only	X WAN only	X
Network Configuration				X	X	X
Status Monitoring		X	X	X	X	X
Problem Solving	X	X	X	X	X	X
Device Install and Configure	X	X	X	X LAN only	X WAN only	X

The Internet Management Model

The model of a network management system has four components:

- One or more nodes to manage, each containing an agent;
- At least one Network Management Station (NMS) with one or more network management applications installed;
- A network management protocol that is used by the NMS and the agents to exchange management information;
- The Management Information.

Elements of Management Architecture



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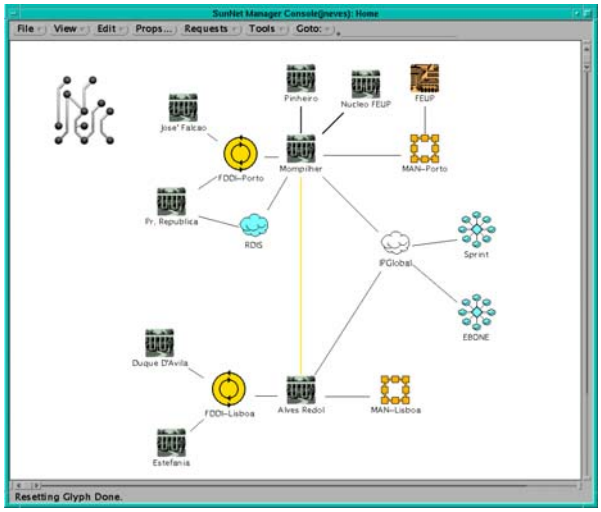
The Network



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Manageable Nodes

- A system: workstation, mainframe, desktop, printer…
- A router
- A bridge, a repeater, a hub, a network analyzer
- New IoT devices

The impact of adding the management functionality on the nodes should be minimized.

Network Management Station

- Network Management Protocols;
- One or more Management applications;
- Graphical and hierarchical representation;
- Different levels of management: privileges of administrators, operators;
- DBMS - storage of the information of each station of the network, recording of events/alarms and accounting data;
- *Trouble tickets...*

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Management Tools

- HP OpenView *(obsolete),* HP Operations Manager
- IBM Tivoli NetView
- Additional layers, eg. *CiscoWorks*
- SNMP Agents
- Public Domain tools: ping, mrtg, traceroute, tcpdump, etc.
- Specific developments

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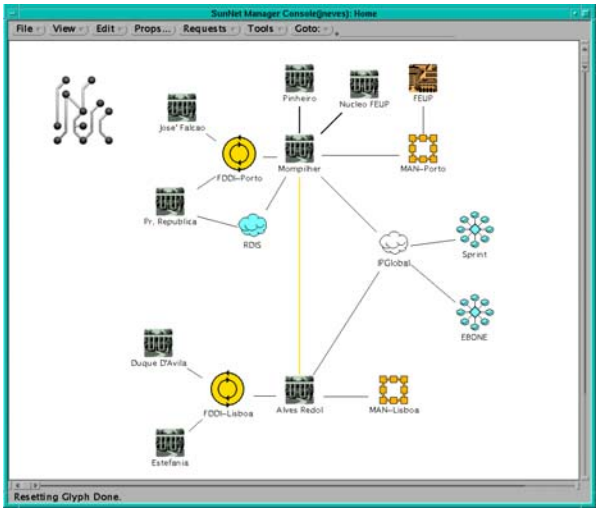
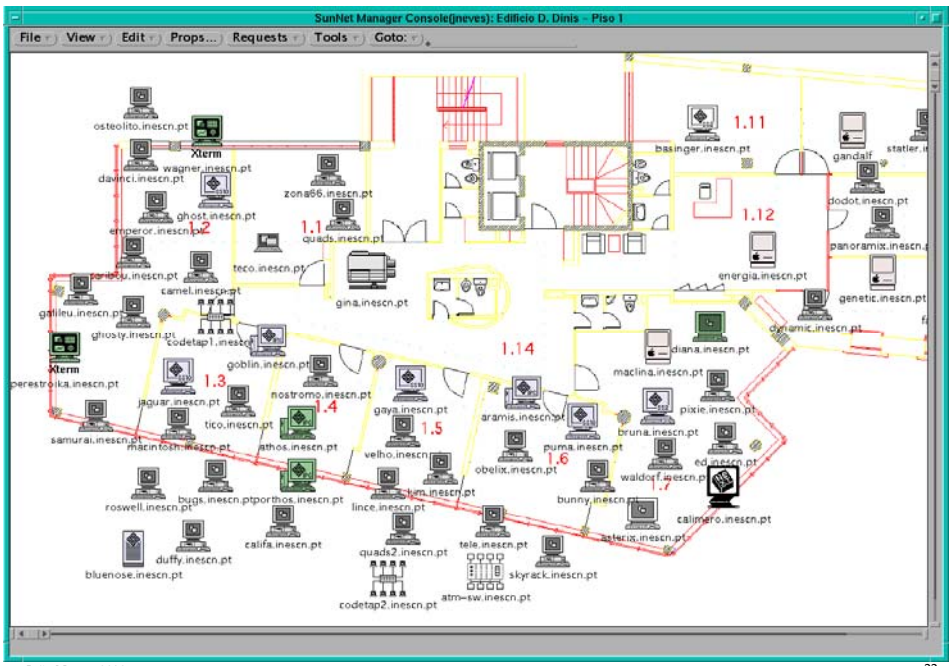
Graphical Representation

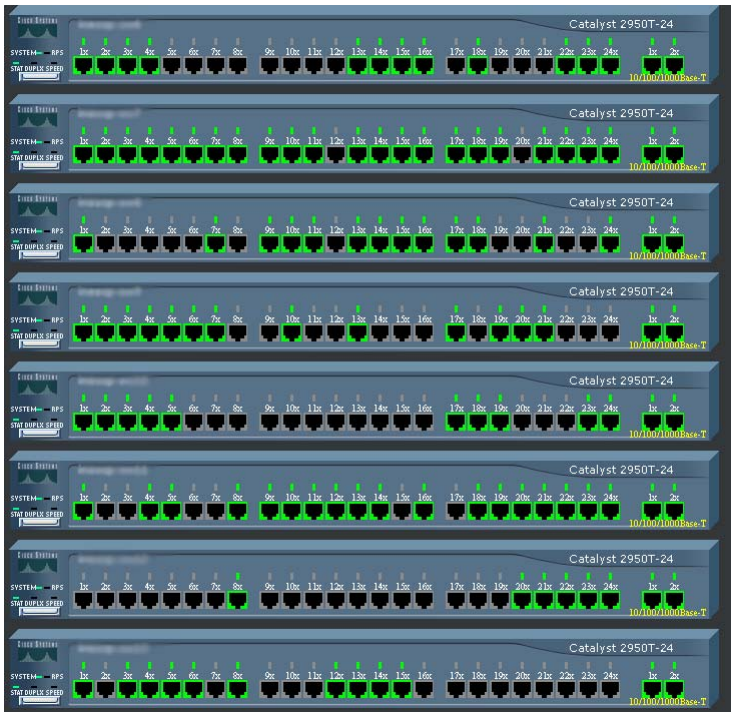
- Graphical interface
- Topological Representation
- Presentation and hierarchical structure
- Synoptic alarms

Graphical and Hierarchical Interface





Access to detail...



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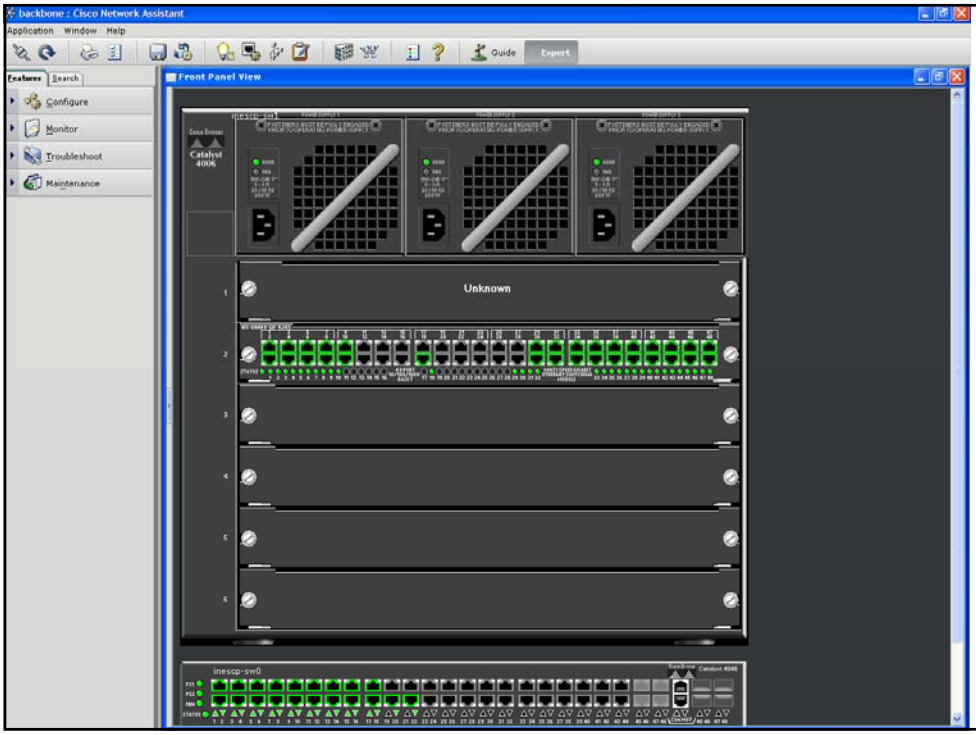

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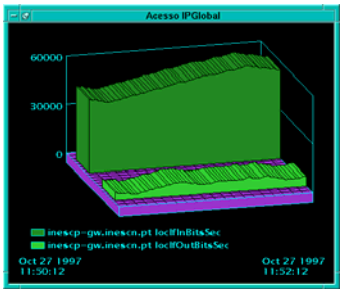
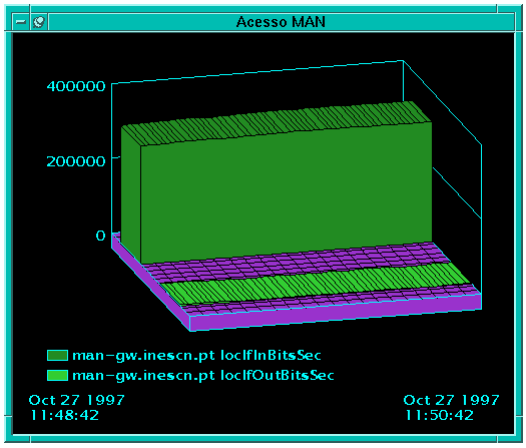
Real Time Monitoring





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Network Management Station

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- *Trouble tickets...*

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Network Management Station

- Distinct levels of management: administrator privileges, operators, common user
  - Conditional / full access to the network representation
  - Conditional / full access to network information or network stations
  - Permission to change the state of operation of the stations / interfaces
  - Write permissions / change settings

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Network Management Station

- Storage in DBMS
  - Information of each network station: hardware, software, contacts, physical and network location, etc.
  - Event / alarm recording
  - Billing records.
  - Router configurations, switches, hubs ...
  - Routers operating system upgrades, switches ...
- Centralized access to management information

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Network Management Station

- *Trouble tickets...*
  - Nowadays we identify in CRM equal functionalities;
  - Linked to the help-desk service;
  - Fundamentals for Fault Management;
  - Feedback to the Performance Management function.
- Examples:
  - BMC Helix ITSM (former Remedy Service Management)
    `http://www.bmc.com/it-solutions/helix-itsm.html`
  - Broadcom Inc. (former CA Technologies)
    CA Service Management
    `http://www.ca.com/`

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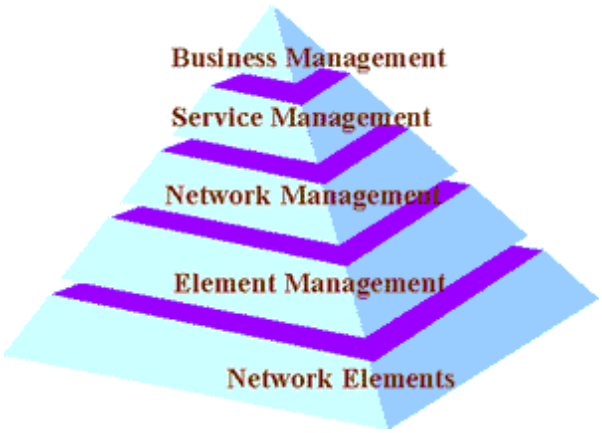
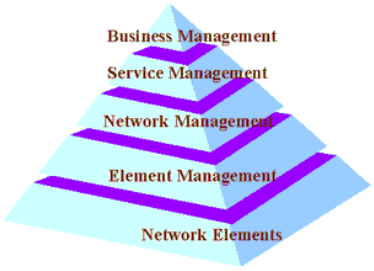
Network Management Protocols

- ITU-T
  - Telecommunications Management Network (TMN)
- ISO
  - Common Management Information Protocol (CMIP)
- IETF Internet Management
  - Simple Network Management Protocol (SNMP)

TMN Management Structure



TMN Management Structure



TMN Layers

Business Management	Inventory, Sales & Finance
Service Management	Billing, Physical Provisioning, Trouble Ticket, Value Added Service
Network Management	Network Management Application, Open API
Element Management	Element Manager, Other Element Managers

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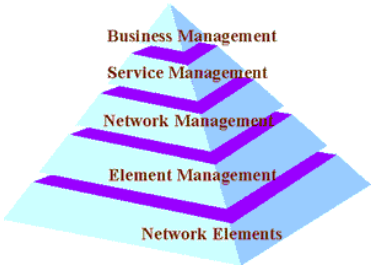
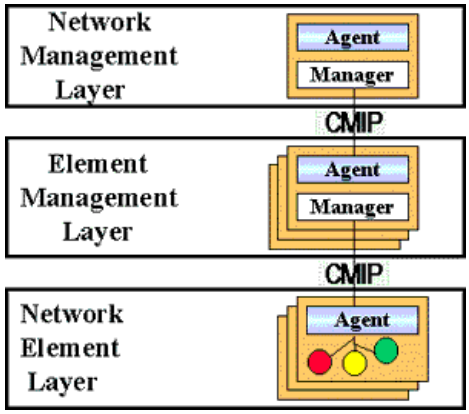
TMN Management Structure





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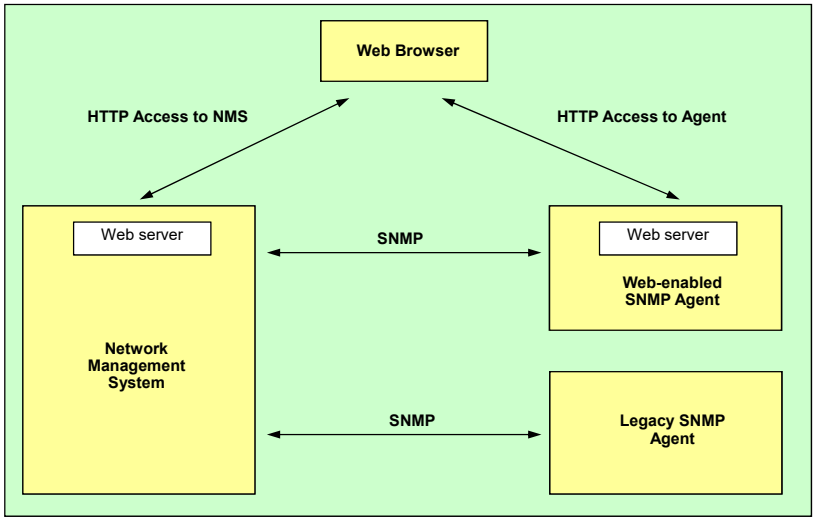
The CMIP

- Common Management Information Protocol (CMIP)
  - Telecommunications Management Network (TMN)
  - Open Systems Interconnection (OSI) model
  - Intended to replace the SNMP in the late 80
  - Works according to SNMP Get / Set model
  - Allows connection to the directory service X.500
  - Computing power requirements, either in the NMS or the NE agent
  - Complex implementation

IETF Internet Management

- Based on the Simple Network Management Protocol, but is more than a protocol, is a complete framework:
  - **A data definition language** - The Structure and Identification of Management Information (SMI)
  - **Definitions of management information** - Instrumentation described in the Management Information Base (MIB)
  - **Protocol definition** - The Simple Network Management Protocol (SNMP)

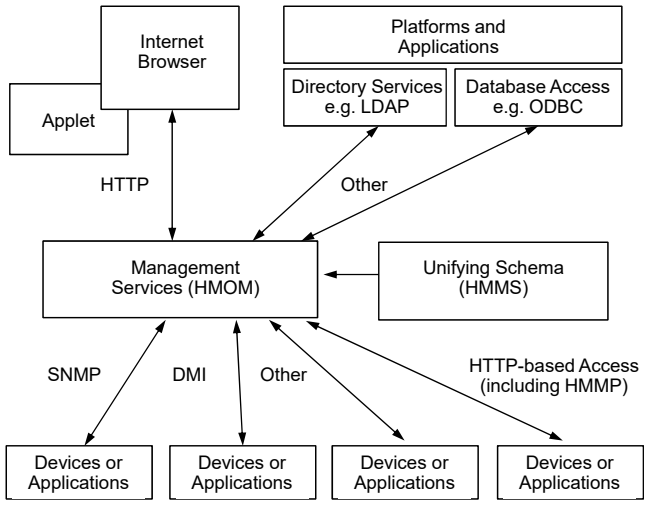
Web-Based Network Management



Web-Based Enterprise Management (WBEM)

- WBEM is an Industry initiative to provide a set of management and Internet standard technologies developed to unify the management of systems, networks, users and applications across multiple vendor environments.

WBEM Architecture



DMI: Distributed Management Interface
HMOM: HyperMedia Object Manager
HMMS: HyperMedia Management Schema
HMMP: HyperMedia Management Protocol
ODBC: Open Database Connectivity

The SNMP

Each managed node is viewed as having a set of "variables“:

- Reading Operation: The monitoring of a node is done by reading the variables
- Writing Operation: Changing the value of these variables makes node control
- Traversal Operation: the management station can find out which variables are supported on the node to be managed
- Trap Operation: allows the node to report extraordinary events to the management station

Information Representation

Structure of Management Information (SMI)

- Uses Abstract Syntax Notation One (ASN.1) to:
  - Describe the information;
  - Define the formats of the information and control packets (Protocol Data Unit) exchanged by the management protocol;
  - Define managed objects, eg: `{ 1.3.6.1.2.1.1.3 }`

```
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 }
```

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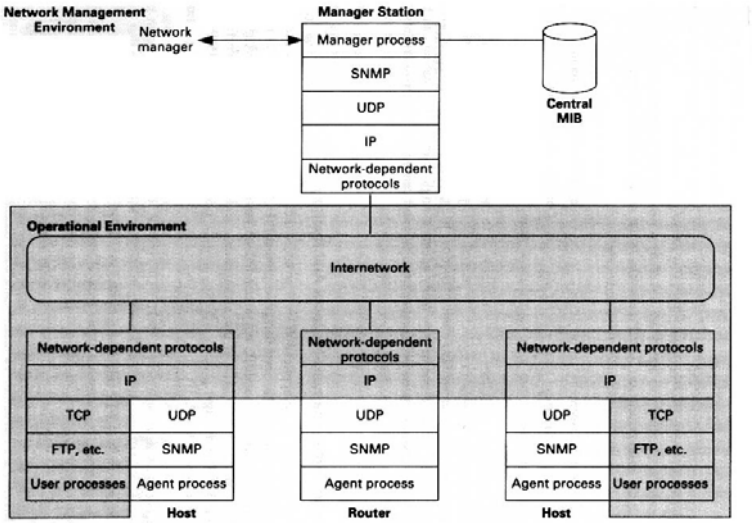
SNMP Configuration



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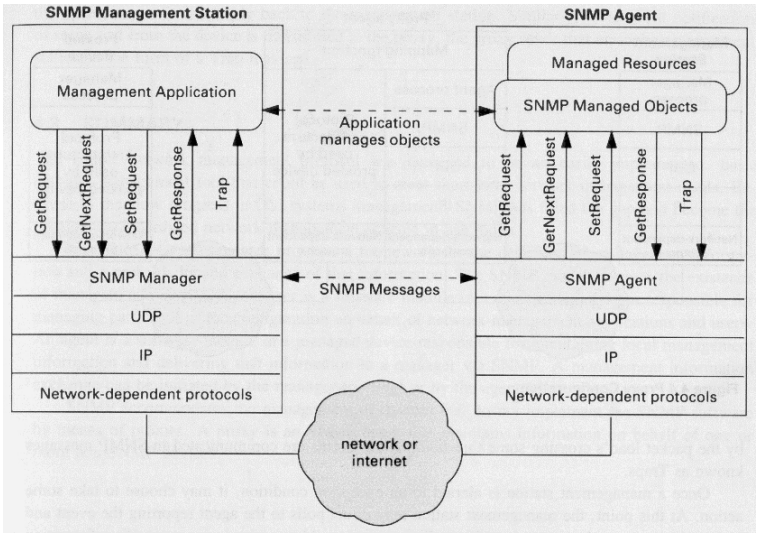
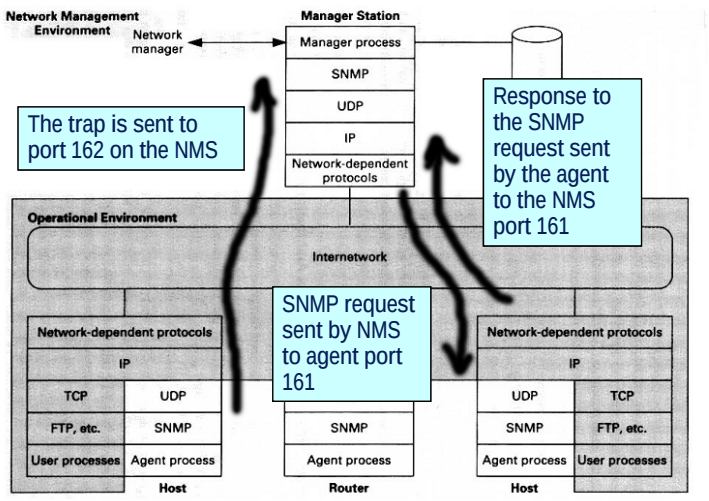
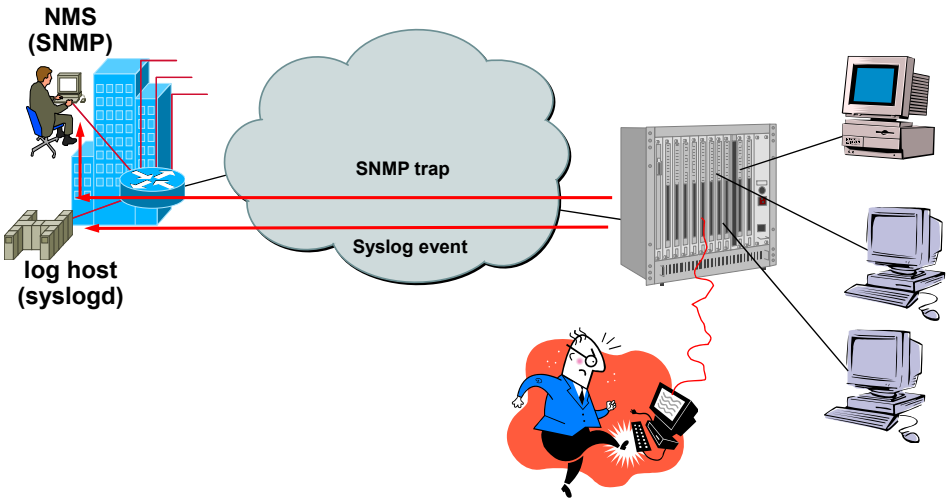
The SNMP intervention



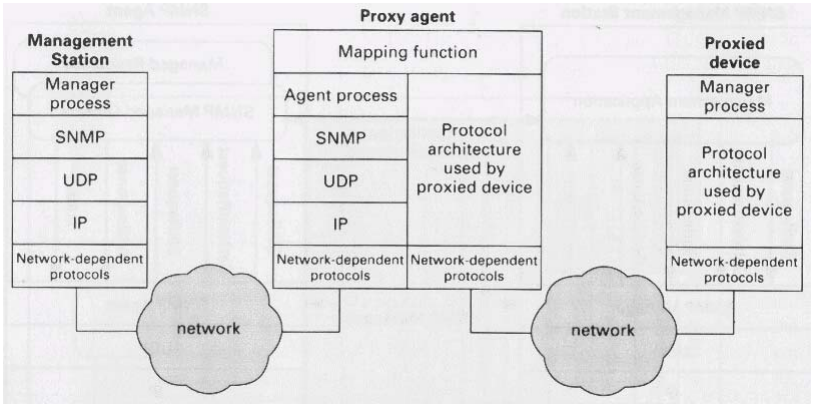
SNMP and TCP/IP



Traps and Events



The Proxy Service

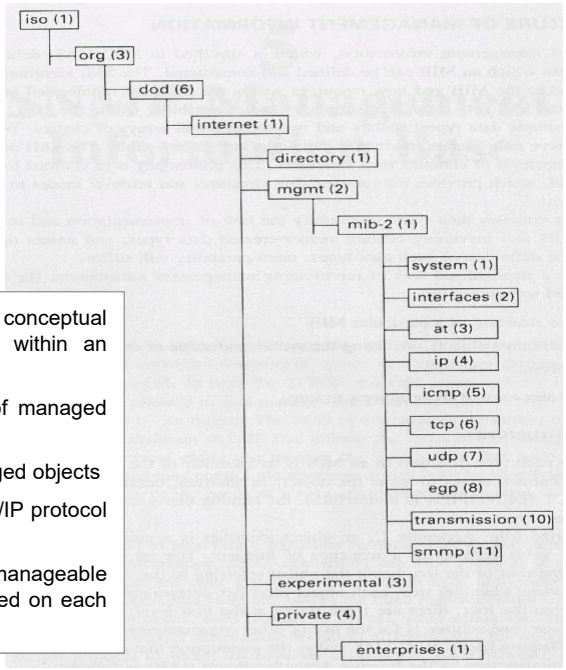


Proxy Interaction

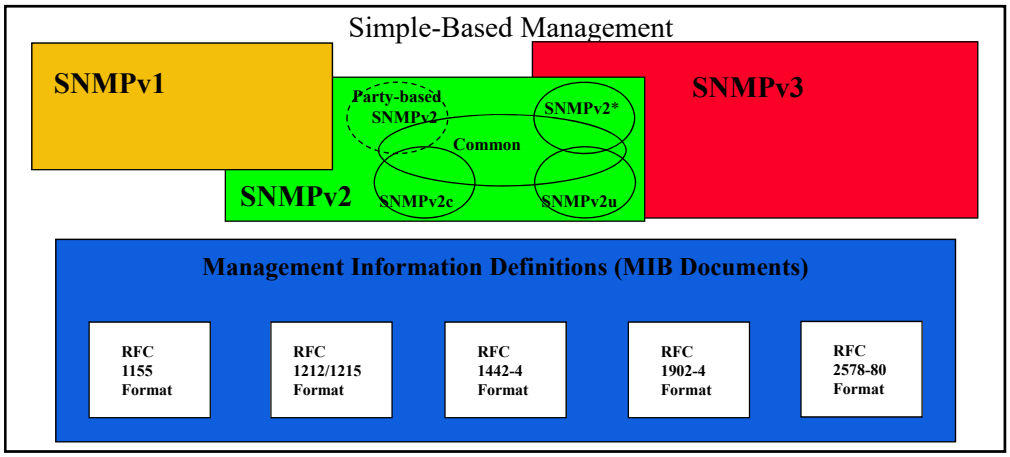
- ***Administrative firewall*** – makes authentication and authorization of requests
- ***Caching Firewall*** – does cache information
- ***Transport Bridging*** – makes the end-to-end connection between the remote system and the NMS
- ***Protocol Translation*** – translates the management protocol

Management Information Base

- **Management Information Base**: The conceptual repository of management information within an open system (cf. ISO/IEC 7498-4)
- The MIB specification is the core set of managed objects for the Internet suite of protocols
- Virtual information store to access managed objects
- Define the variables to manage the TCP/IP protocol suite
- Specifies the data elements that a manageable system must have, the operations allowed on each and what the meaning



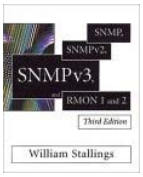
Protocol Versions



Evolution of the Protocol

Generation	Protocol Operations	Transport Mappings	Security & Administration
1st		RFC 1157 (1988–1993)	Community-based
2nd	RFC 1905 (1993-)	RFC 1906 (1993-)	Party-based RFC 1445-47 (1993-1995)
3rd	SNMP EOS (new work)		User-based RFC 2570-76 (1998-)

Bibliography



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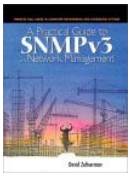

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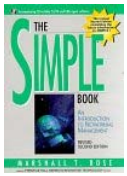

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