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Gestão/Management

Management of Local and Global Networks

Concepts and Protocols

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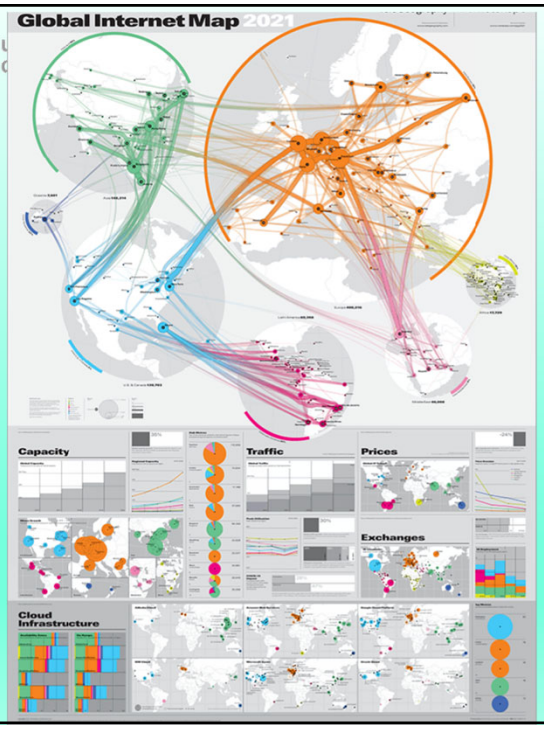

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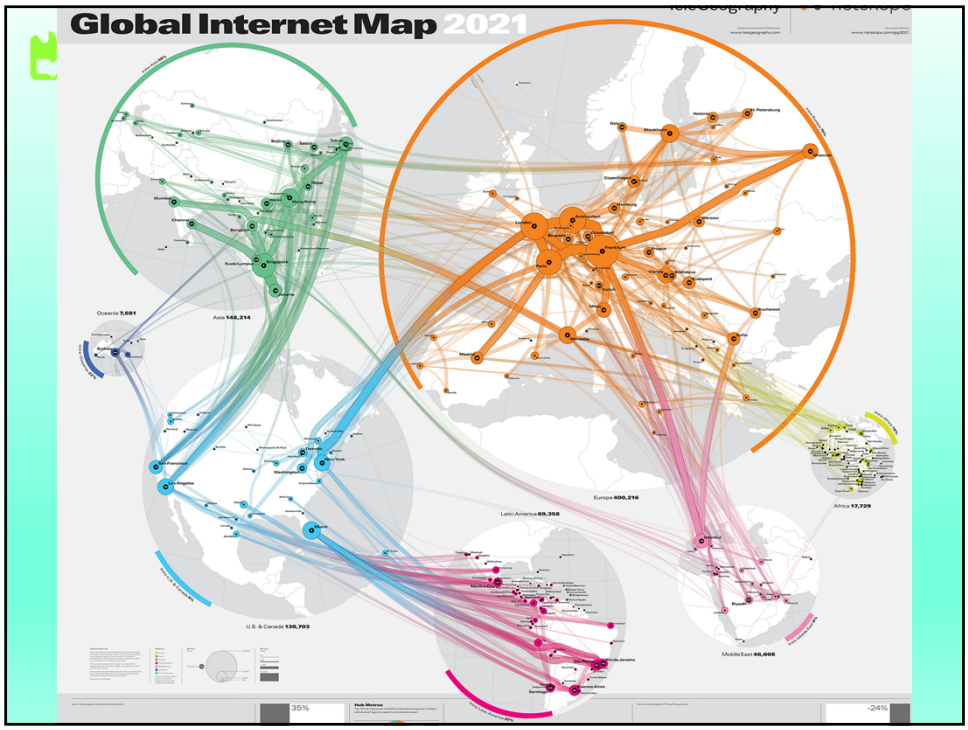
Global Internet Map 2021
Asia 140,214
Europe 400,216
U.S. & Canada 130,703
Latin America 69,358
Middle East 46,008
Africa 17,729
Oceania 7,681

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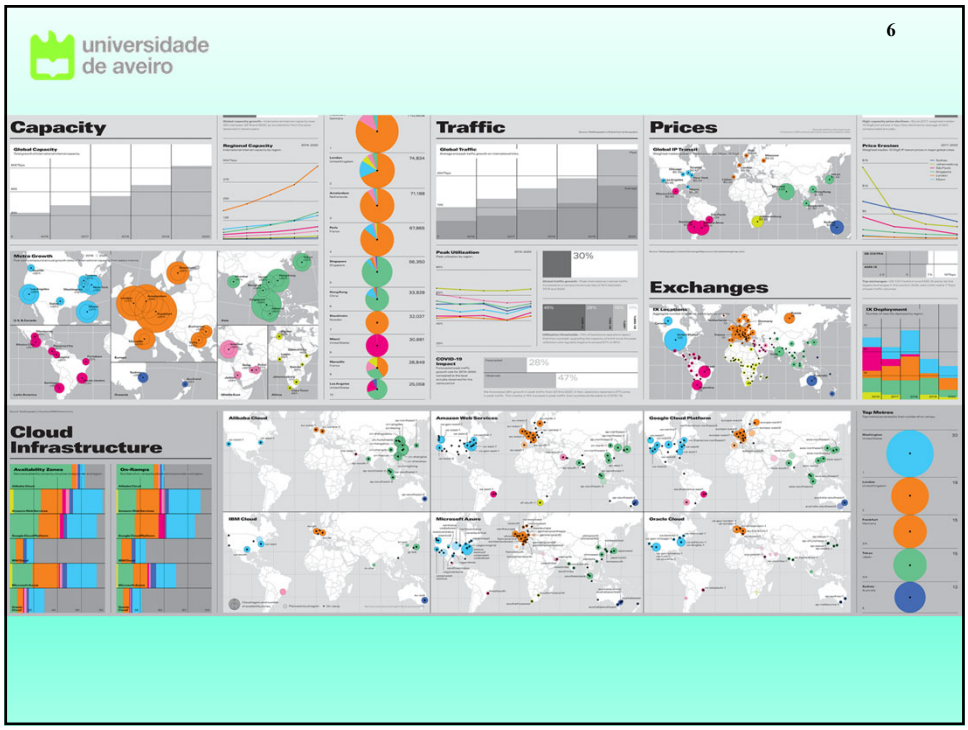
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Capacity
Traffic
Prices
Exchanges
Cloud Infrastructure

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Why Networks and Systems Management?

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- Lower Cost – Manual management is costly
- More efficient – Automatic systems allow an efficient planning, and mechanisms to predict the utilization trends: lower errors and faster actuation
- Better service – The manager is informed at the same time the (client) is, and can make an automatic check of the situation
- Greater knowledge – more information exists about the network, allowing better decisions and planning
- Why not human intervention?
  - **Difficult to describe responsabilities**
  - **Technology rapidly evolves**
  - **Mangement systems rapidly evolve**
  - **Lack of technical resources**

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Commercial perspective

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- **Problems need to be quickly solved**
- **Management systems simplify the work of multi-functional networks (e.g. VoIP in multiple networks)**
- **Persons better used – they do not need to perform repetitive tasks**
- **Companies need to optimze their structures, and network management allow resources optimization**

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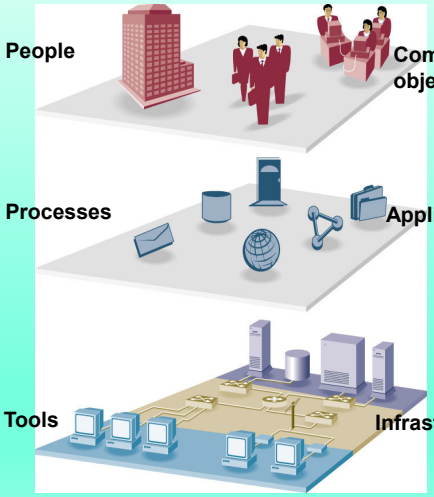
Network management is:

Implement, integrate and coordinate resources (HW, SW and people) to plan, operate, manage, analize, test, evaluate, design and expand the system to guarantee the service objectives (temporal, performance), with a reasonable cost and capacity.



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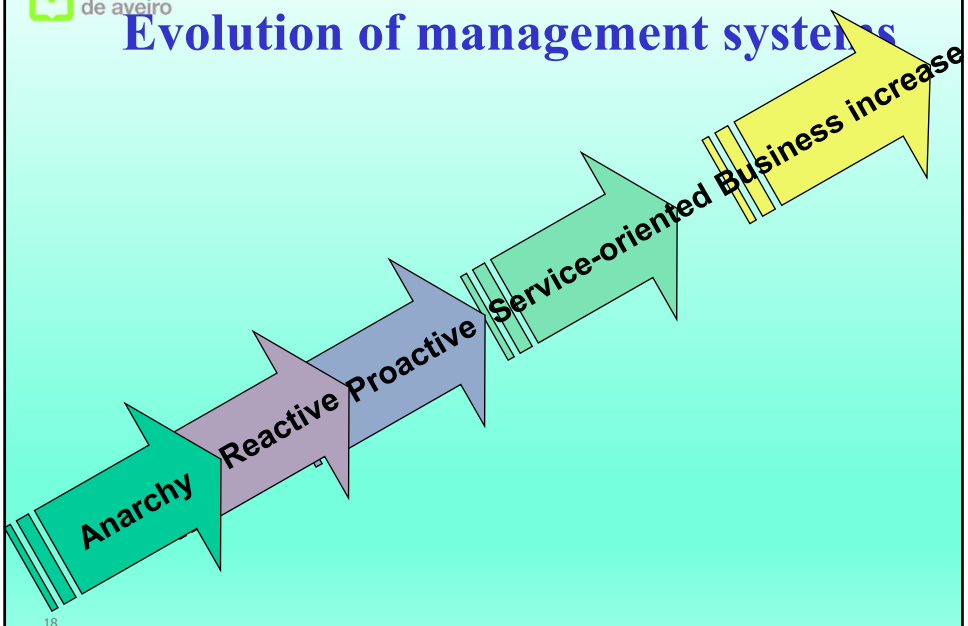
Evolution of management systems



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Management alternatives

scope

- **Systems management** – Covers all company aspects
- **Networks management** – Covers mainly network aspects and communications systems and equipment

comunication protocol

- **Dedicated protocols** – dedicated for networks
- **Web based systems** – resort to HTTP models, recently common

Decision model

- **Centralized models** – Agent-manager model
- **Distributed models** – Share of the management responsibilities
- **Hierarchical models** – Hierarchic structure with centralized information in the root

Current real management structures very complex, with several operational models simultaneously

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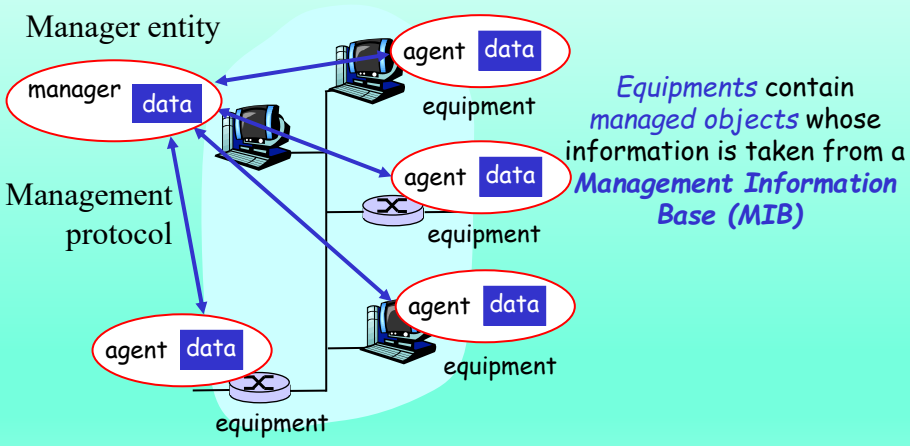
Basic Model for Network Management



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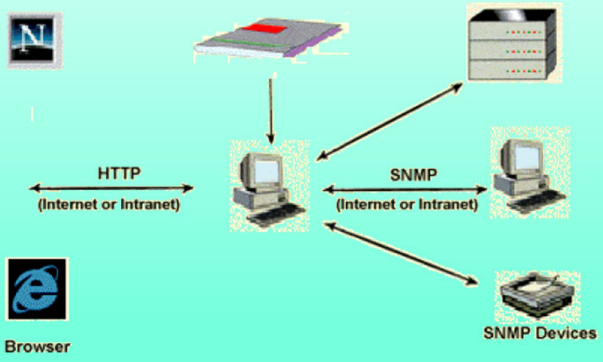
WEB-based management



Very common:
Network and device management via web interfaces

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Web-based management concept

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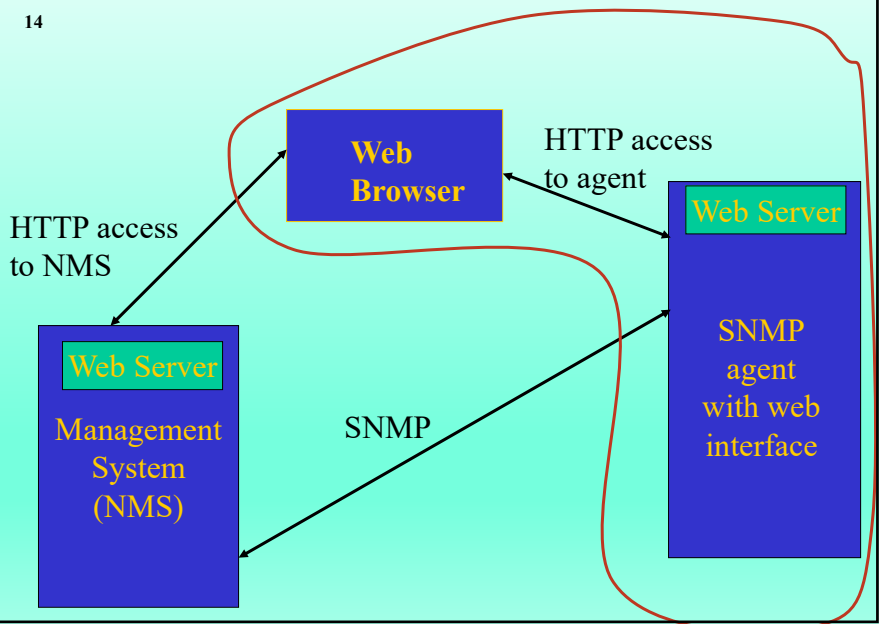

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Network management

- ISO defined five areas for network management
  - Fault management – detection, isolation, and correction of anomaly behaviors

FAULT

  - Configuration management – control data for the network elements / colect data from network elements

CONFIGURATION

  - Accounting management – measure network utilization and determine network costs and user accountings

ACCOUNTING

  - Performance management – evaluate/report network equipment behavior/efficiency

PERFORMANCE

  - Security management– support communications network secure management

SECURITY

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SECURITY

Isolating the management problems in distinct areas, ISO model allows conceptual solutions optimized to specific problems in each functional area

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Fault management

- Location of problems (or faults) in the communications network:
  - Fault detection
  - Fault isolation
  - Fault correction
- Faults can be:
  - Transients
  - Persistents
- Fault management includes functions to:
  - Mantain and examine error logs
  - Create and act in error notifications
  - Search, identify and correct faults
  - Perform diagnosis test sequences

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Accounting management

- Detect resource usage and its administration to assure its availability for the users
- Access control per user
- Allow costs per resource usage and association to tariffs
- It includes functions to
  - Inform users about costs and used resources
  - Establish utilization limits
  - Combine costs from multiple resources used to create the communication system

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Configuration management

- The configuration of critical elements controls the network behavior
  - The configuration management resides through these critical elements
- Configuration management identifies, acts, merges data and provides commands to systems to initialize, start, maintain in continuous operation, and terminate connections
- It includes functions to
  - Define parameters that control the system operation
  - Merge information about the actual system conditions
  - Modify the system configuration

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Performance management

- Measure the network performance (HW, SW). E.g.
  - Usage percentage, error rates, answer time, throughput
- Performance management supports the evaluation of system actions
- It includes functions to
  - Obtain statistical information
  - Maintain and examine logs of system state
  - Determine the system performance in normal and artificial conditions
  - Change working modes to perform management and performance functions

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Security management

1. Access control mechanism to network information
2. Security of the service provided

- Monitors access points, periodically stores information and creates *logs* and alarms for security reasons
- Supports the appliance of security policies through functions to:
  - Create, remove and control of services and security mechanisms
  - Distribute information related to security
  - Report events associated to security

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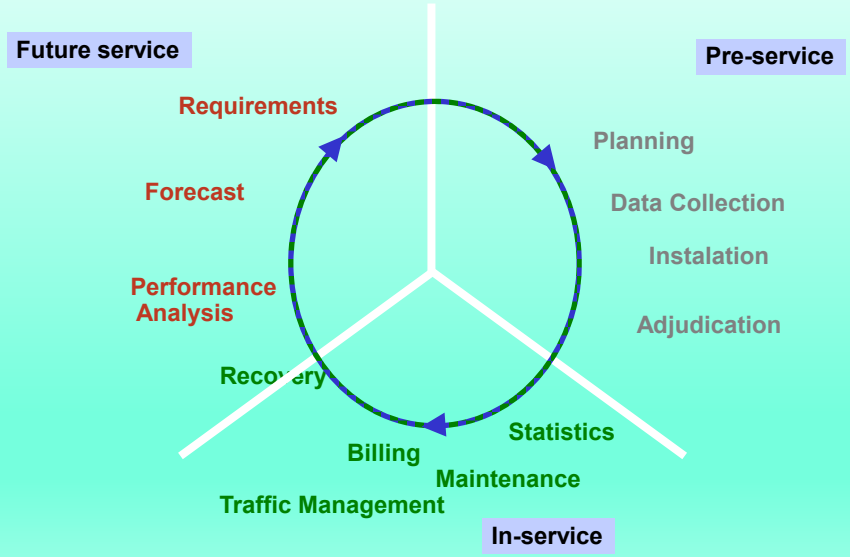
Management Life Cycle



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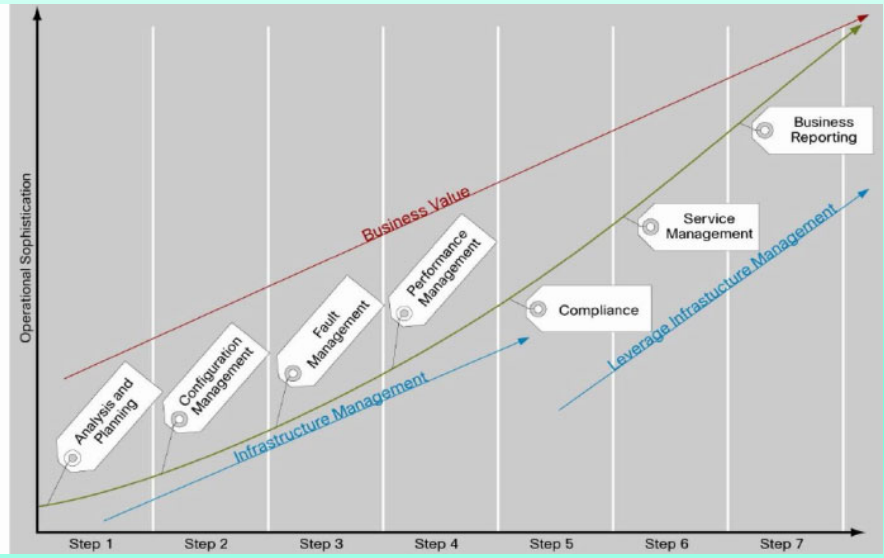
Implementation plans



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Aspects of Network Management

- What to manage?
  - Network, equipment, systems, users, services, applications
- How to manage?
  - Interfaces, actions, abstractions
- What protocol(s) format(s)?
  - Protocol abstraction, formats, messages
- What information format(s)?
  - Information type

Standards for all this – including global frameworks

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Management protocols

- Methods to monitor and configure network equipments
- Do not describe how to achieve management objectives

Simple protocols ² common data and parameters formats allowing easy information transfer

Complex protocols ² add flexibility and security capacity

Advanced protocols ² remotely execute network management tasks, without depending on specific protocol layers

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Tools for network management

- WAN/LAN monitoring and analyzers
- Software monitors
- Security managers
- Documents, presentations and administrative instruments
- Tools for cross-analysis
- Databases, tools for information management
- Console emulator
- Tools for systems modelling
- Toolkits for development

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Network management standardization global models

- Internet Engineering Task Force (IETF)
  - Simple Network Management Protocol
    - SNMP, disman
    - *Operations and Management Area*
- International Telecommunications Union (ITU-T)
  - Telecommunications Management Network
    - *SG IV*
- International Standard Organization (ISO)
  - OSI, CMIP-CSIS
    - *ISO-IEC/JTC 1/WG 4*
- Others
  - DMTF, TM FORUM, OMG, IEEE, …

Early discussions across bodies. Now cooperation is the normal across bodies.

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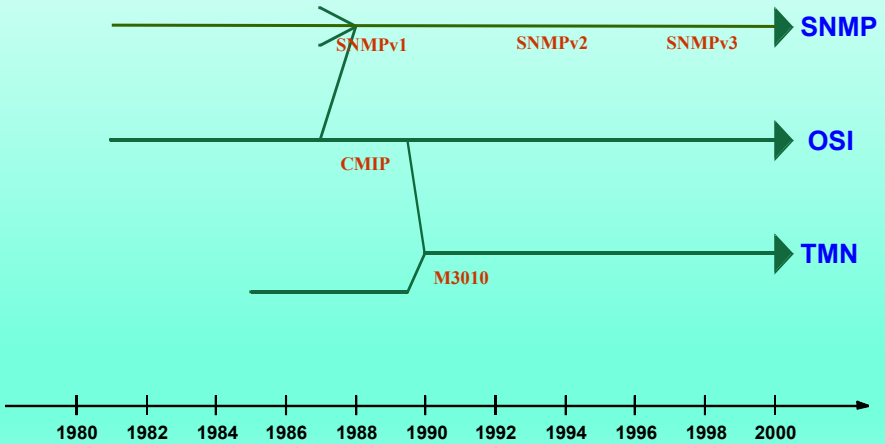
Early Cronology

(why we reached here)



Note that concepts are different: SNMP copes with part of the OSI management framework, and the TMN expands the OSI framework into a focused environment (telecomunication operators)

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SNMP

(short review)

Simple Network Management Protocol

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Manager/Agent Paradigm

- **Manager/agent: common in all NMS (especially in SNMP/CMIP)**
- **Idea of a client/server, but many clients and only some servers**
  - **(manager ° client; agent ° server)**
- **The agent operates with the equipment**
  - **Reports problems to the manager, to control all the equipment information**
- **The manager contains the intelligence to decide what the agents should do, and gives instructions to them**
  - **It controls the agents and manages their interworking**

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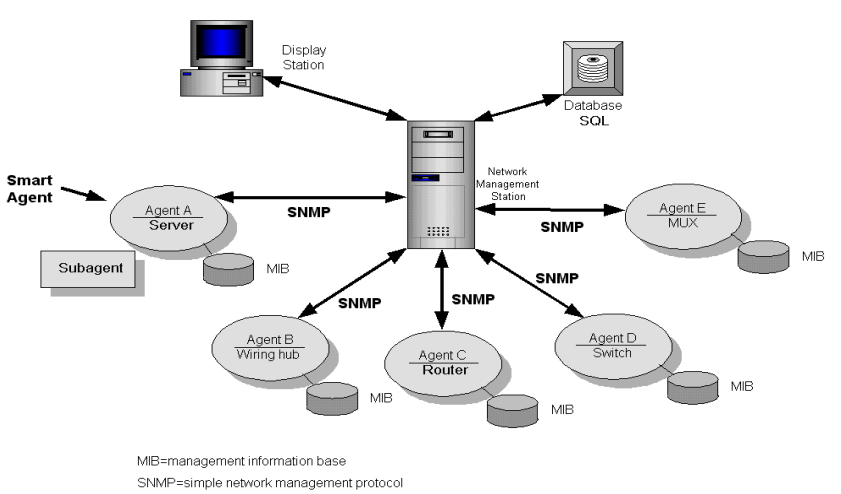
Structure of SNMP management



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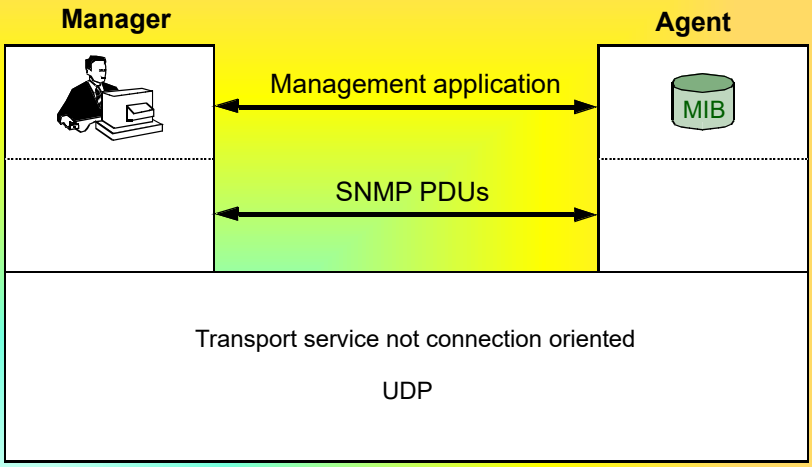
SNMP Structure



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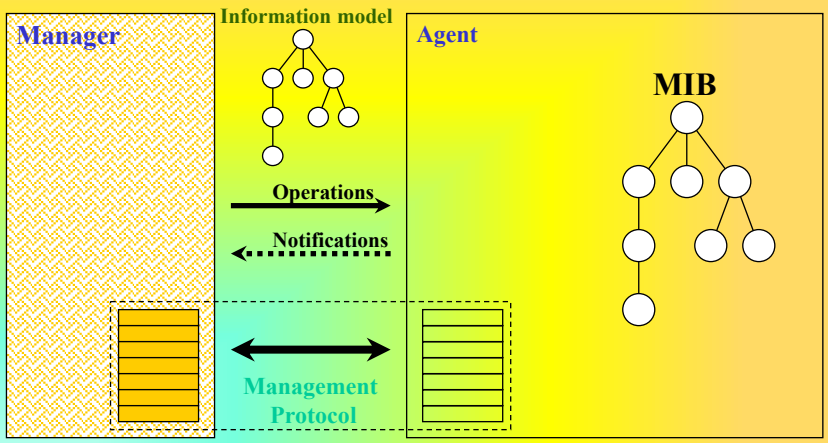
Manager/Agent model



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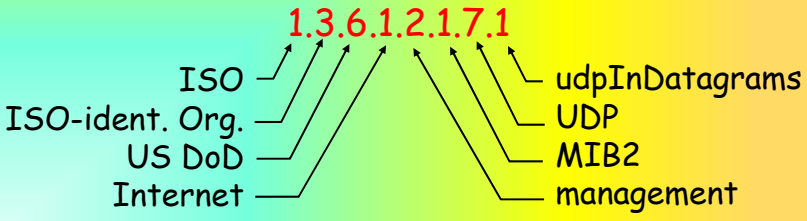
Names (numbers) SNMP

Problem: **How to name all possible objects (protocols, data, etc..) in all possible protocols??**

Answer: ***ISO Object Identifier tree:***

- **Hierarchical naming for objects**
- **Each node has a name and a number**



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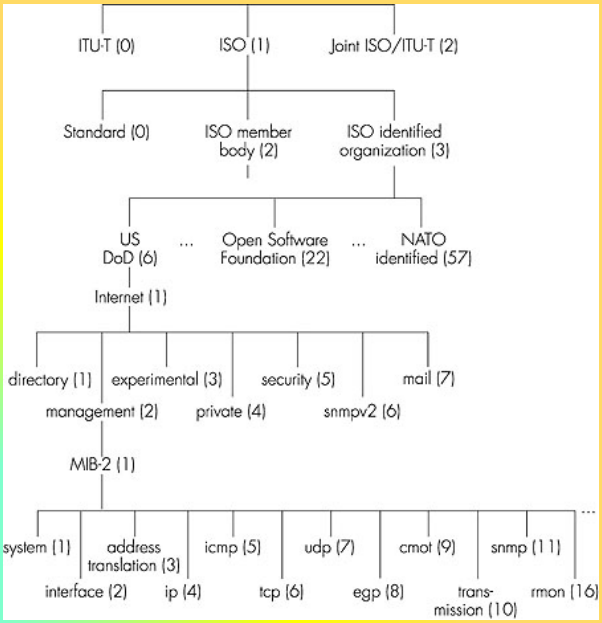
OSI Object Identifier Tree



www.alvestrand.no/harald/objectid/top.html

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SNMP: Polling

- **Manager periodically asks the agent for new information**

☺ **Advantage: Manager completely controls the equipment, and knows all network details**

☹ **Disadvantage: delay between event and its entry in the system, and unnecessary communication overhead:**
  - **Slow polling, slow answer to the events**
  - **Quick polling, quick reaction, but large bandwidth wastage**

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SNMP: Traps

- There is an event ² trap is sent
- Trap contains appropriate information
  equipment name, time instant of event, type of event

☺ Advantage: information only generated when required

☹ Disadvantage:

☹ More resources required in the managed equipment

☹ Traps can be useless

- If many events occur, bandwitdh can be wasted with all traps (thresholds can solve)
- Since the agent has only a limited scope of the network, NMS may already know about the events.

- Traps&Polling
  - Event occurs ² trap is sent
  - Manager performs polling to obtain the rest of information
  - Manager also performs periodic polling, as backup

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SNMP Protocol: types of messages

Types of messages	Function
GetRequest GetNextRequest GetBulkRequest	Mgr ↥ agent: "get me data" (instantiates, next on the list, block of information)
InformRequest	Agent ↥ Mgr: informs the Manager of exception in a reliable way
SetRequest	Mgr ↥ agent: defines MIB value
Response	Agent ↥ mgr: answer value to Request
Trap	Agent ↥ mgr: informs the manager of an exception event

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SNMP: security and authentication

- In its initial version, the authorization and authentication were based in the notion of "SNMP community string"
- The "community words" identifying the permissions of the machine that access the agente: read-only ou read-write
- By default, all systems come configured with the strings:
  - public (read-only)
  - private (read-write)
- These strings are case sensitive.

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REMOTE MONITORING

- RMON1 (RFC 1757)
- Token Ring extensions to RMON (RFC 1513)
- RMON2 (RFC 2021)
- SMON (RFC 2613)

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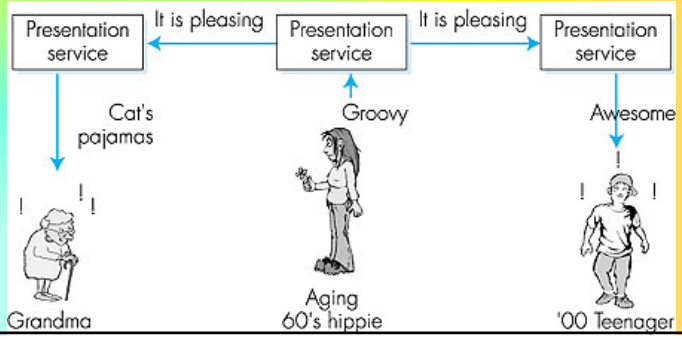
RMON

- Remote monitoring MIB – measure network traffic
  - Agents – management interface
  - Probes – equipment for network analysis (promiscuous); usually configured to specific data types.
- Off-line operation (separated from the network)
- Preemptive monitoring, providing multiple information in the network.
- Support multiple managers and probes
- Detection and report of problems
- RMON has 9 groups:

  Statistics, History, Alarm, Host, HostTopN, Matrix, Filter, Packet Capture, and Event

The presentation problem?

1. Translate the local format to a host-independente format.
2. Transmit the data in a host independente format
3. Translate the host-independente format in a format adequate to the new machine adequado à nova máquina.



ASN.1

- ISO X.680 standard
  - Formal language to describe SMI
  - Frequent in Internet
  - "Heavy", but essential for heterogenous environments.
- Data types, object constructors
  - As in SMI
- BER: Basic Encoding Rules
  - Specified the format as ASN.1 data should be transmitted.
  - Each transmitted object has a coding Type, Length, Value (TLV) encoding

TLV Coding

Idea: Data must be auto-identified
- T: data type, (ASN.1-defined)
- L: data lenght in bytes
- V: data, coded according with ASN.1 syntax.

Valor Tag	Tipo
1	Boolean
2	Integer
3	Bitstring
4	Octet string
5	Null
6	Object Identifier
9	Real

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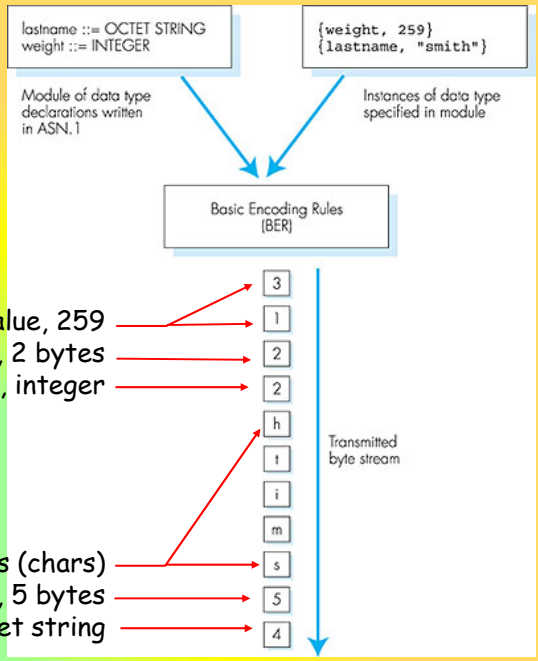
TLV coding example



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SNMP: Pros and Cons

- Agents widely used/known
- Simple to implement
- Robust e extensible
- Polling approach adequate to LAN objects

Critical requirement satisfied: available to be developed in the right time

- Very simple: does not scale
- Specifc semantics make its integration with other approaches difficult
- Large communication overhead due to polling
- Many specific implementations (private MIBs)
- In several management systems, small agents may be inadequate

Note that SNMP became a misnomer, referring both to the management protocol and the management framework. These are different things.

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PBM and COPS

Concept: Policy Based Management

Protocol: Common Open Policy Service

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Policies - Example

- **Network with multiple services support**
  - **Differentiated QoS**
  - **Additional requirements in AAA functions**
    - Different levels
      - User
      - Service
      - QoS
- **Service authorized**
  - **only to some users**
  - **between authorized network points**
  - **with specific QoS requirements**
  - **between specific time intervals**
- **User also needs to be charged according to the service characteristics being received**

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Management based on Policies

- **Objective: globally manage the network and not its elements.**
- **Mechanism:**
  - **Define policies (rules) to inform the network of what to do – e.g:**
    - Operation center should have access to all routers
    - Charging department has priority in the last 3 months of each year
    - In the maximum, only 10% of each link can transport video.
  - **The policy rules are translated in equipment configuration changes**

Elements of systems based on policies

Conceptual parts:

- **Management policy tools:**
  - Used to create the policy rules
- **Policies repository**
  - Store the policy rules
- **Policy consumers – *policy decision points*, PDP**
  - Make decisions and transfer the policy rules (eventually translated) to the policy targets.
- **Policy targets, *policy enforcement points*, PEP**
  - Functional elements affected by the policy rules.

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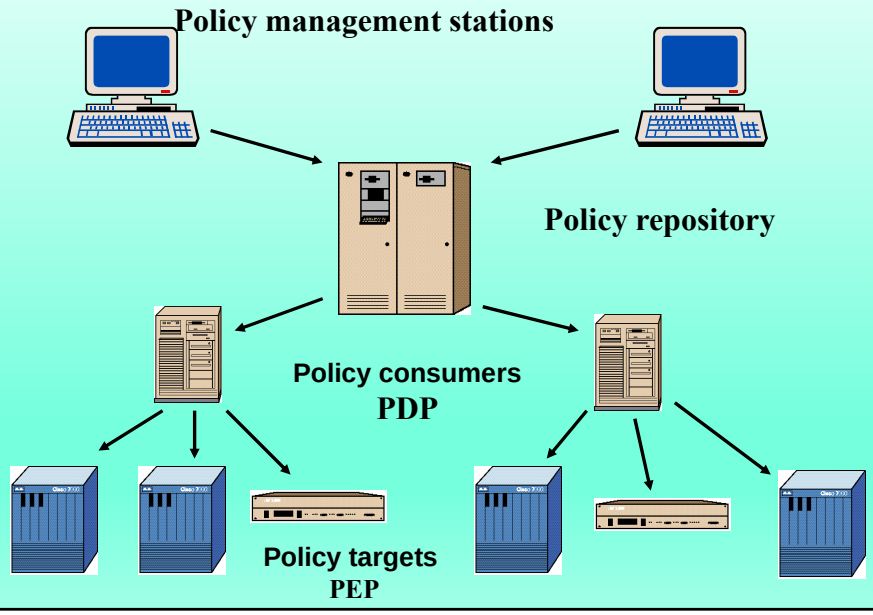
Policy management system - example



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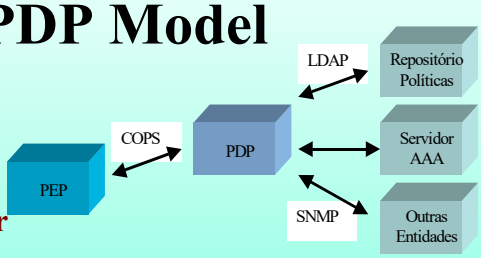
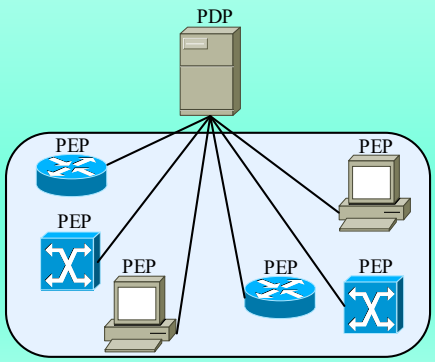
PEP-PDP Model

- Model uses (may use) different protocols
  - Abstraction levels differ
- Increasing trend
  - Software defined netwoking (SDN) can be seen as a variation of this concept

  (OpenFlow is a protocol for SDN)





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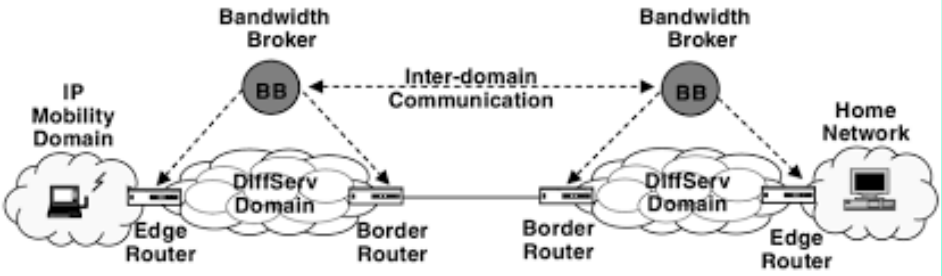
Diffserv: Bandwidth/QoS Broker



This model is incerasingly common with centralized control architectures (e.g. celular)

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Processing rules - sequence

- Rules definition
  - Verify internal conflicts
  - Include in a repository (e.g. with LDAP)
- Get policies from policy consumers
  - Take decisions based on policies
  - Processed to create configurations in policy targets
  - May use temporal restrictions
- Send policies to policy targets
  - Can be “pushed” or “pulled” (e.g. by COPS or SNMP)
- Policy targets
  - Instal configurations

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COPS – Common Open Policy Service

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- Question/answer protocol to PDP-PEP interaction
- Based on TCP
- Maintains state synchronization
  - Recovers from fault
  - State maintenance with keep-alive
- PDP can send notifications to PEP
  - Default concept was for QoS support/control
- PDP can receive policies through LDAP and SNMP
- Supports two types of clients
  - RSVP, outsourcing model
  - Diff-serv, configuration model

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PDP-PEP Interactions

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- Outsourcing (RSVP)
  - PEP contacts PDP when a decision is needed
  - Request contains relevant elements for the policy, and admission control information (e.g. flowspec)
  - Best match for RSVP-based QoS systems
- Configuration requests (Diffserv)
  - PDP configures PEP with specific equipment information
  - Considers a PIB (policy information base) that maintains provisioning information
  - Best match for DiffServ-based QoS systems

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COPS Session

- PEP opens a COPS session
  (specifying a client type: RSVP, DiffServ)
- PEP sends requests and receives answers
- PEP can also send non-solicited commands
- PDP can change commands previously sent
- PEP sends messages related to resources utilization (charging)
- *KeepAlives* are sent if there is no activity

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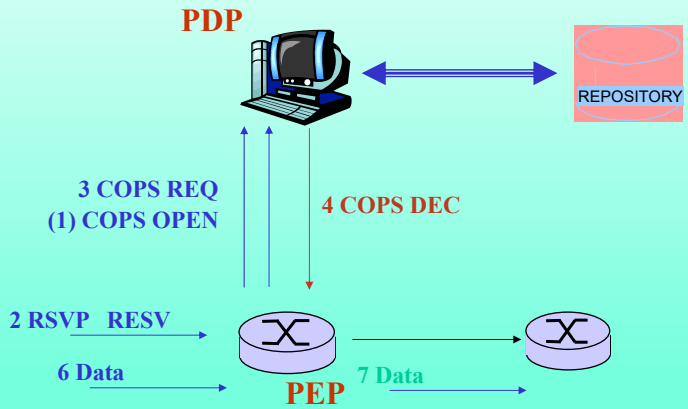
COPS with RSVP



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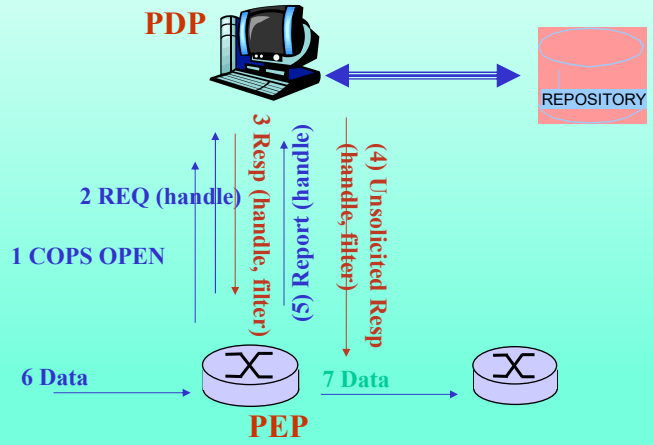
COPS with DiffServ



It is not required end-to-end signalling
It configures routers with packets lists and actions

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CMIS/CMIP

Common Management Information Services/Protocol

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Management protocolos (LAN-oriented)

OSI CMIP

- Common Management Information Protocol
- Designed in 1980's: *the* unifying protocol ("advanced") to network management
- Implemented very slowly

SNMP: Simple Network Management Protocol

- Internet based (SGMP)
- Very simple in the beginning
- Rapidly spreaded
- It grew in largeness and complexity
- actual: SNMPv3
- Management protocol *de facto*

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OSI Management architecture

ITU-T	Acronym	Title
X.701		*System Management Overview*
X.710	CMIS	*Common Management Information Service*
X.711	CMIP	*Common Management Information Protocol*
X.712	CMIP-PICS	*CMIP Protocol Implementation Conformance State Proforma*
X.720	MIM	*Management Information Model (defines fundamental concepts of the objects)*
X.721	DMI	*Definition of Management Information*
X.722	GDMO	*Guideline for Definition of Management Objects (techniques for specification of objects)*

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CMIS/CMIP

- Approach object-oriented - objects
  - Have attributes
  - Generate events/notifications (reliably)
  - Execute operations
- Objects with same attributes, notifications and operations belong to the same class
- Objects inserted in multiples hierarchies, with different inherits and containers
- Intelligent agents
  - Can use rules or policies defined by the manager
  - Can be changed on-line
- Actions (verbs)

  GET, SET, CREATE, DELETE, ACTION, NOTIFICATION, CANCEL_GET
- Capacity of CMIP actions is related to scoping and filtering capacities - through GDMOs

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CMIP - GDMOs

- Guideline for the Definition of Managed Objects
  - The equipment through which the agent operates
- Model objects inside the equipment
  - Instantiation of GDMOs is called MIB
- Do not have well-defined behaviors, with large implementation freedom
  - Flexibility
  - Problem (complexity)
- CMIP is not polling oriented
  - Better scalability is achieved
- There are not so many defined GDMOs as MIBs

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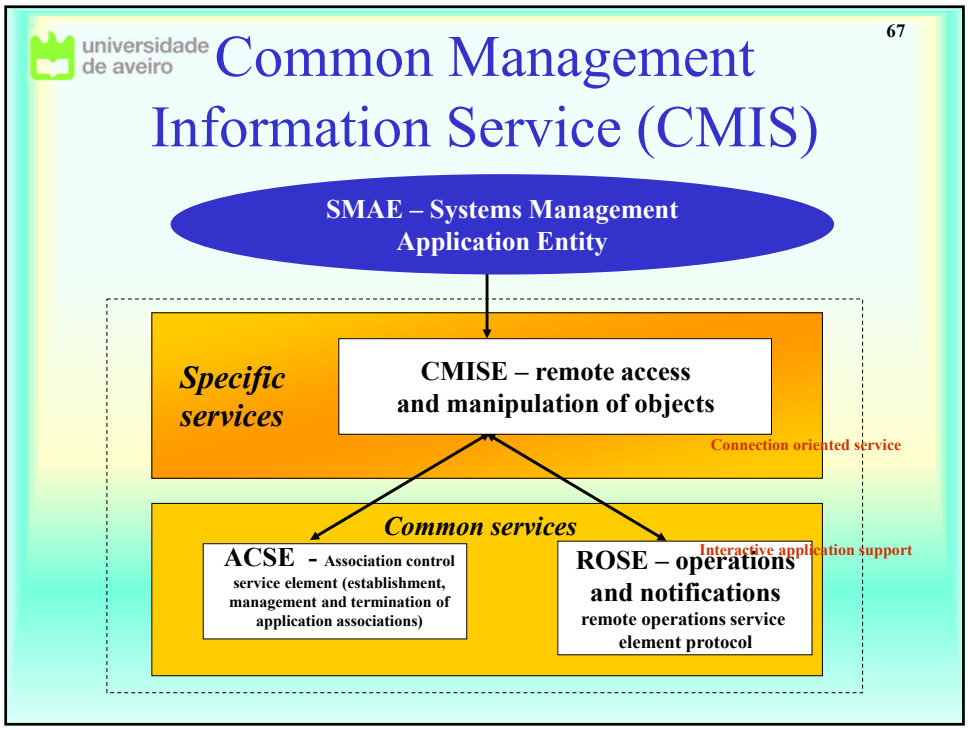
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Common Management Information Service (CMIS)
SMAE – Systems Management Application Entity
Specific services
CMISE – remote access and manipulation of objects
Connection oriented service
Common services
ACSE - Association control service element (establishment, management and termination of application associations)
ROSE – operations and notifications remote operations service element protocol
Interactive application support

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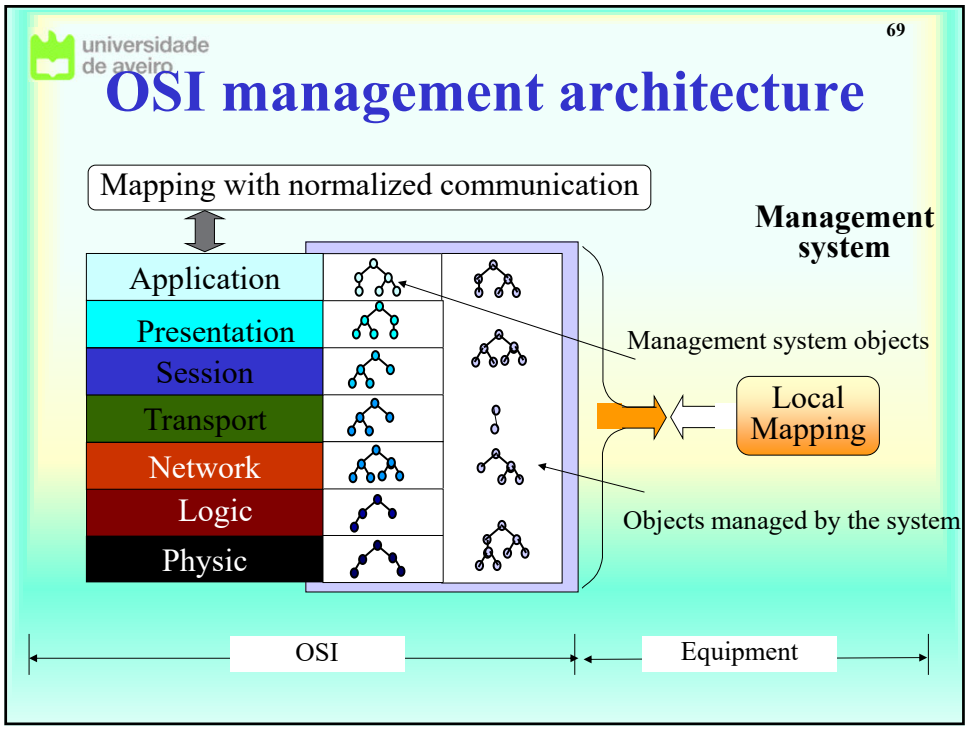
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OSI management architecture
Mapping with normalized communication
Application
Presentation
Session
Transport
Network
Logic
Physic
Management system
Management system objects
Local Mapping
Objects managed by the system
OSI
Equipment

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CMIP: pros and cons

- CMIP advantages
  - Object-oriented approach is flexible and extensible
  - Support from telecommunications industry and international vendors
  - Support of manager-manager interaction
  - Support of automation environments
  - Imposed in some industrial areas
- CMIP disadvantages
  - Complex and multi-layer
  - Large management overhead
  - Few management systems based on CMIP
  - Few CMIP agents in use
  - Generally rejected in the Internet.

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Frameworks: SNMP and CMIS

SNMP

- Static MIBs
- Concepts of limited models
- Non-connection oriented protocol
- Polling model
- Implementation-oriented
- Ligth
- Limited functionalities

- Bulk capcacity only in new versions
- Completely dominating the market
- Many SNMP-based products

CMIS

- Dynamic MIBs
- Object-oriented models
- Connection-oriented protocol

- Event-oriented model
- Specification-oriented
- Heavy
- Functionalities until the system management level
- Bulk capacity with scope and filtering
- Some relevance in the telecommunications market
- Some CMIP-based products in the market

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TMN

Telecomunications Management Network

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What is TMN ?

- ***Objective***
  - **Support the management of the telecommunication networks and services**
- ***Concept***
  - **Create an organized structure to allow the interconnection of several operating systems and telecommunications equipments, using a well-defined architecture, with normalized protocols and interfaces**

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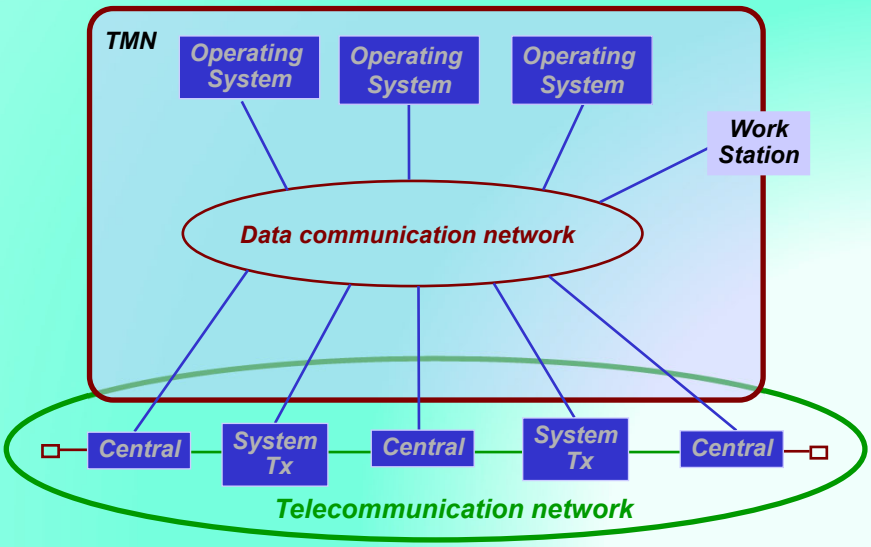
TMN and the communications network



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TMN

- **TMN is the telecommunications management network.**
  - **Relies on other management protocols and concepts.**
  - **Operations systems are where the main management functionality resides**
    - Now also known as OSS operational support systems
  - **The data communications network is where the management information flows**
  - **The TMN boundary intersects NEs (network elements) as they include some CM functionality.**
  - **Workstations provides user access to management functionality.**
    - The workstation glass interface is outside the bounds of standardisation.

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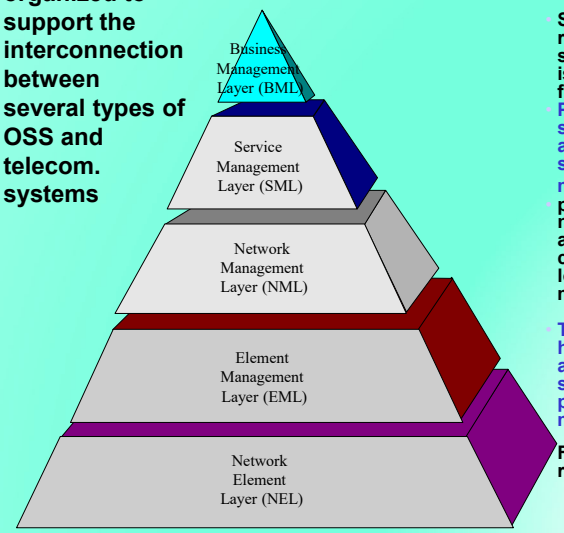
Multi-layer model

Architecture organized to support the interconnection between several types of OSS and telecom. systems



- Service levels, contact point for client reports, definition of policies for fault support, analyzes trends and quality issues, for example, or to provide a basis for billing and other financial reports
- Performs functions for the handling of services in the network: definition, administration and charging of services, scalability policies, service restore, monitoring and report of SLAs availability.
- performs functions for distribution of network resources: configuration, control and supervision of the network, correlation of events and filtering, fault location, problem isolation, syslog management and monitor.
- This includes alarm management, handling of information, backup, logging, and maintenance of hardware and software, automatic correction of faults, polling of network elements, event management.

Fault detection, trap generation, restoration/substitution procedures.

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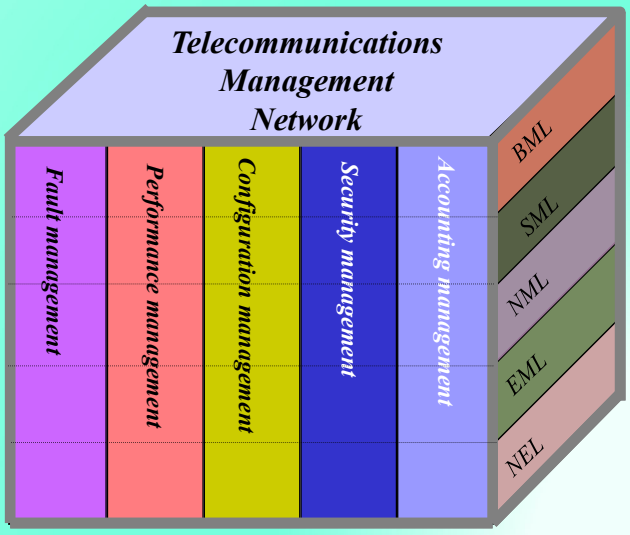
TMN Matrix



Depicts the FCAPS functionality along the TMN layers

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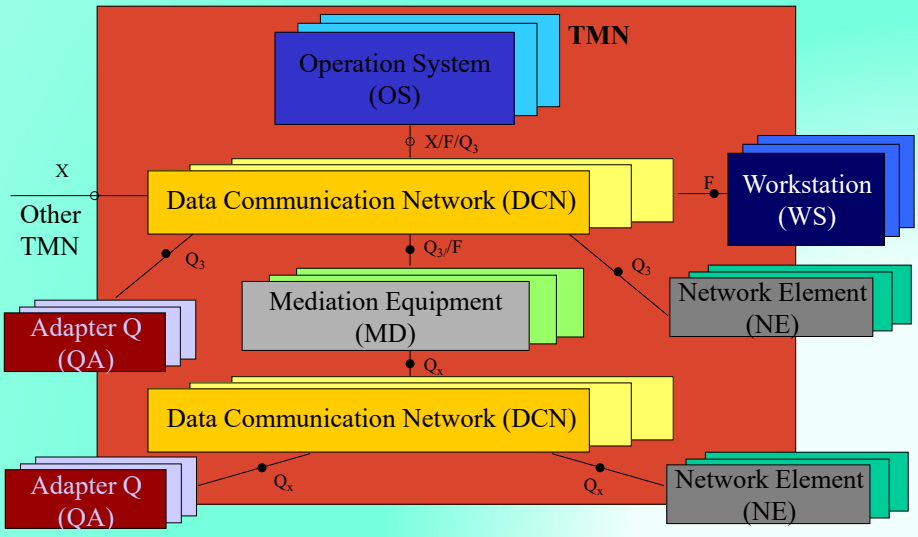
TMN Physical architecture



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Physical Architecture

Standard interfaces

- Interface Q_3
  - Operation System ↔ TMN elements connected to it
- Interface Q_x
  - Mediation Element ↔ Network element/adapter
- Interface F
  - Workstation ↔ Operation system / mediator (through a DCN)
- Interface X
  - TMN network ↔ TMN network / network with *interface* to TMN.

- **Communication protocols**
  - For each interface, the choice depends on the physical implementation.
  - It is normal to use CMIP protocol in the Q_3 interface.

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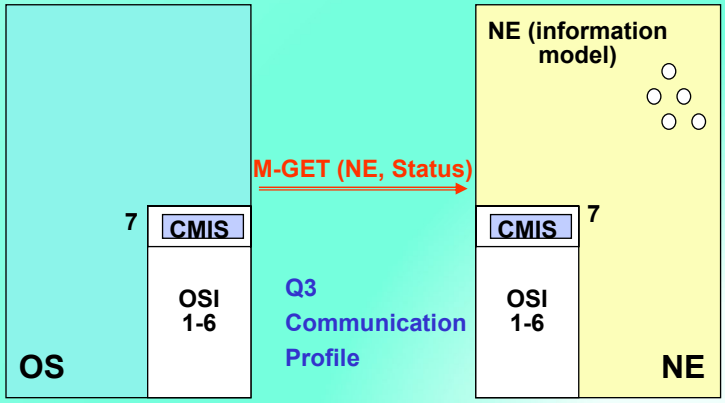
TMN: Interface Q3



Q3 Interface is supported by CMIS/CMIP!!

The scope of the available access is defined by the NE information model (its MIB)

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TMN and OSI

- TMN adds-on to OSI management
  - **Information model – new network**
  - **Organization model – extension through the concept of functional block**
  - **Communication model – Correspondence between interface - protocol**
  - **Functional model – new management functions (network)**

- Interworking TMN with other OSI systems
  - **Atenuate differences between protocols**
  - **Services functionalities and complementaring functions**
  - **Increase the OSI management potentialities or restrict the TMN management potentialities**

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