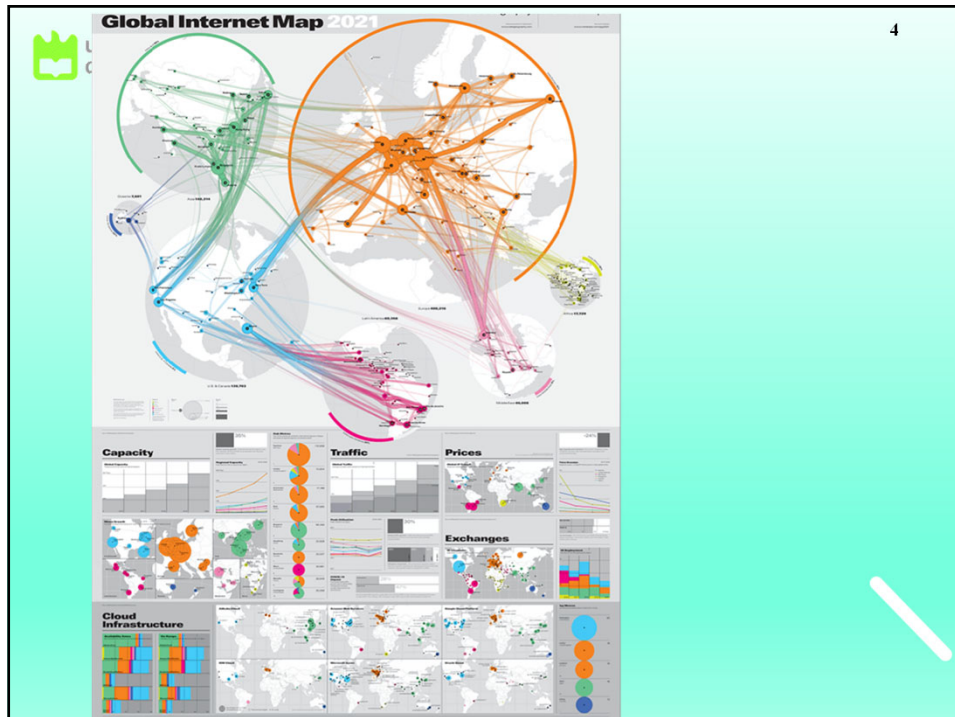


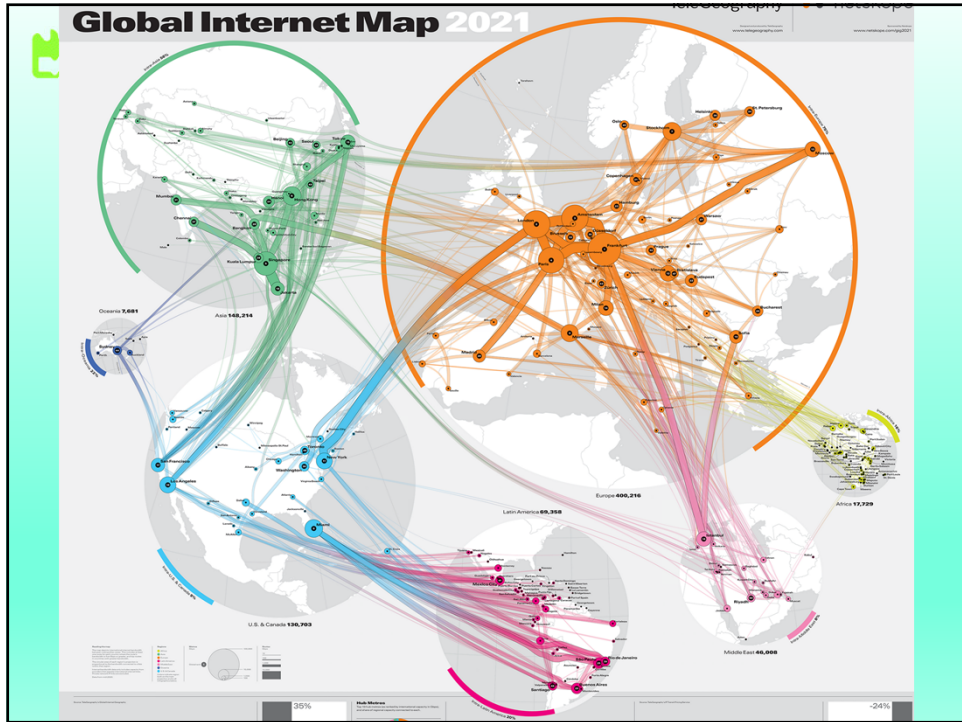
Gestão/Management

Management of Local and Global Networks Concepts and Protocols

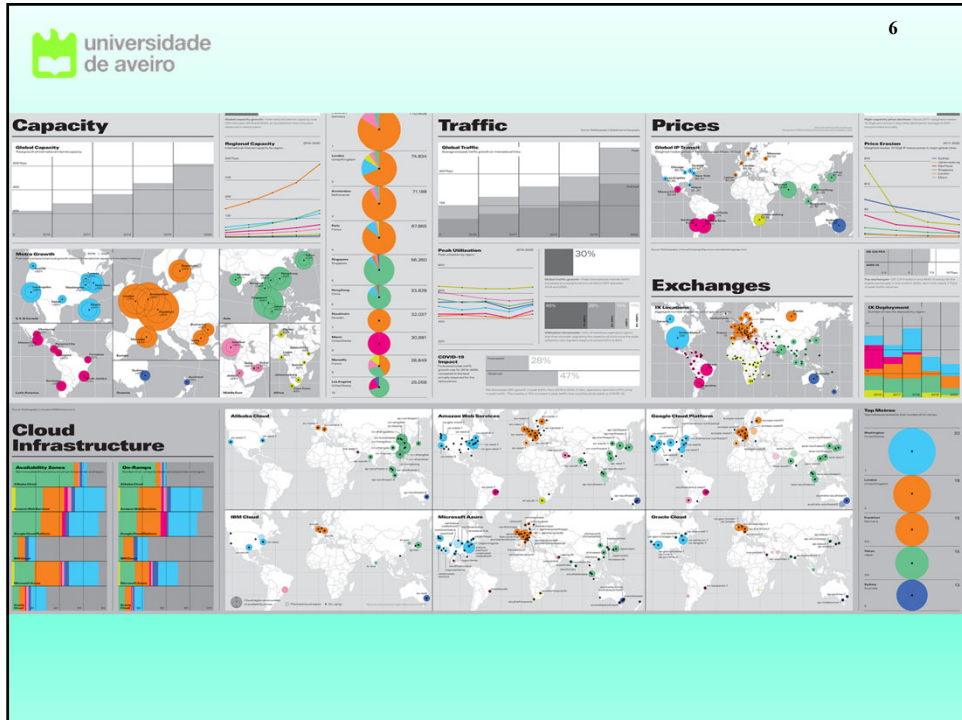
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Why Networks and Systems Management?

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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 responsibilities**
 - **Technology rapidly evolves**
 - **Management systems rapidly evolve**
 - **Lack of technical resources**

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Commercial perspective

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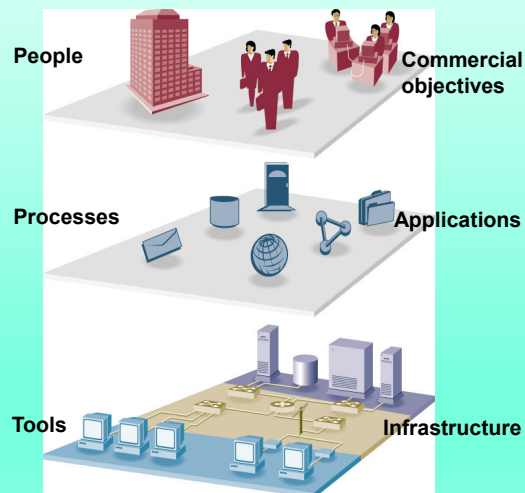
- **Problems need to be quickly solved**
- **Management systems simplify the work of multi-functional networks (e.g. VoIP in multiple networks)**
- **Persons better used – they do not need to perform repetitive tasks**
- **Companies need to optimize their structures, and network management allow resources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



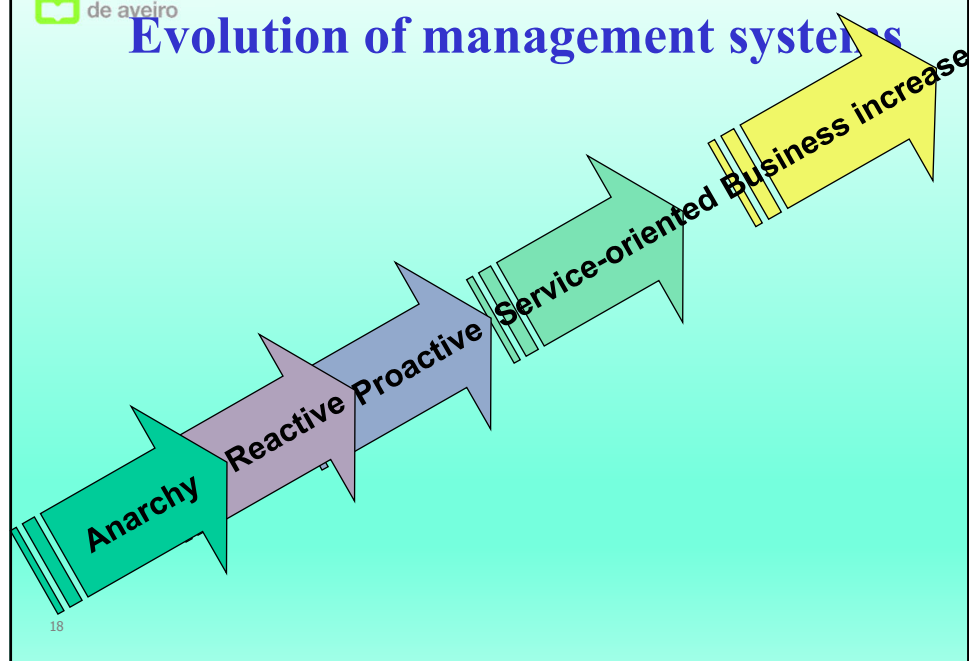
8

Network management is:

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



Evolution of management systems



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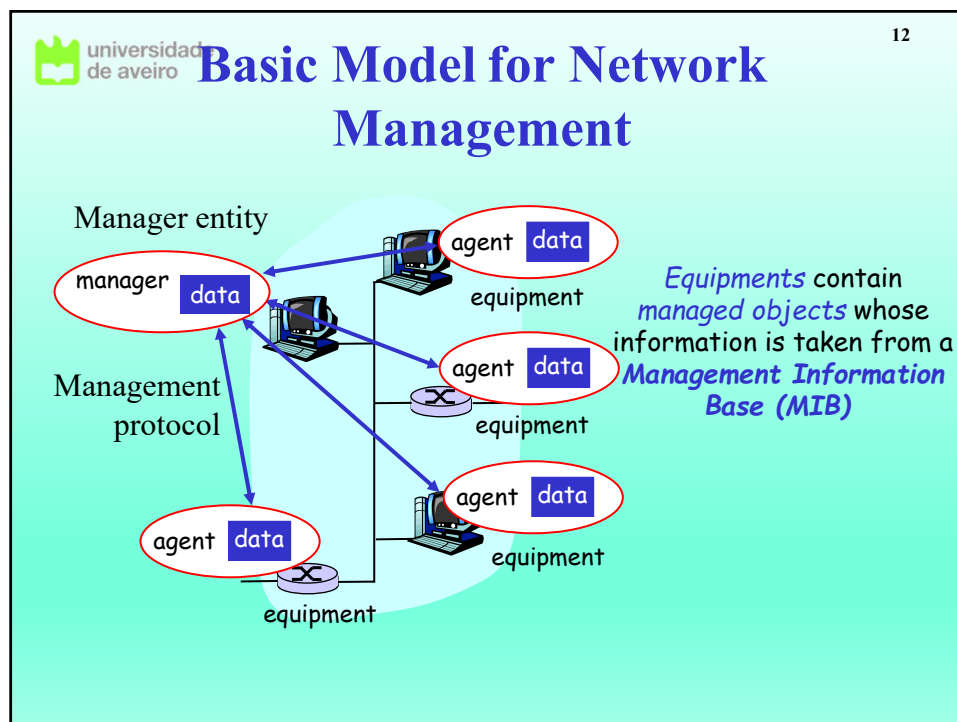
Management alternatives

11

scope	<ul style="list-style-type: none"> • Systems management – Covers all company aspects • Networks management – Covers mainly network aspects and communications systems and equipment
	<ul style="list-style-type: none"> • Dedicated protocols – dedicated for networks • Web based systems – resort to HTTP models, recently common
	<ul style="list-style-type: none"> • 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

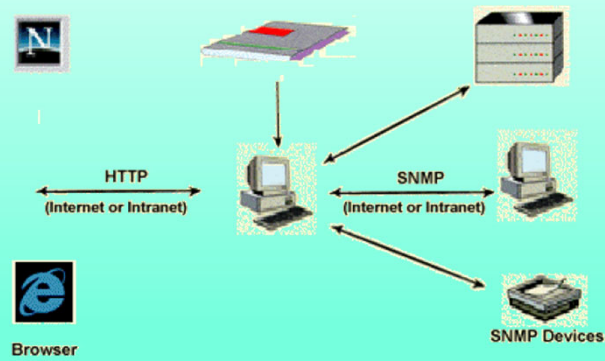
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Ver SNMP

WEB-based management

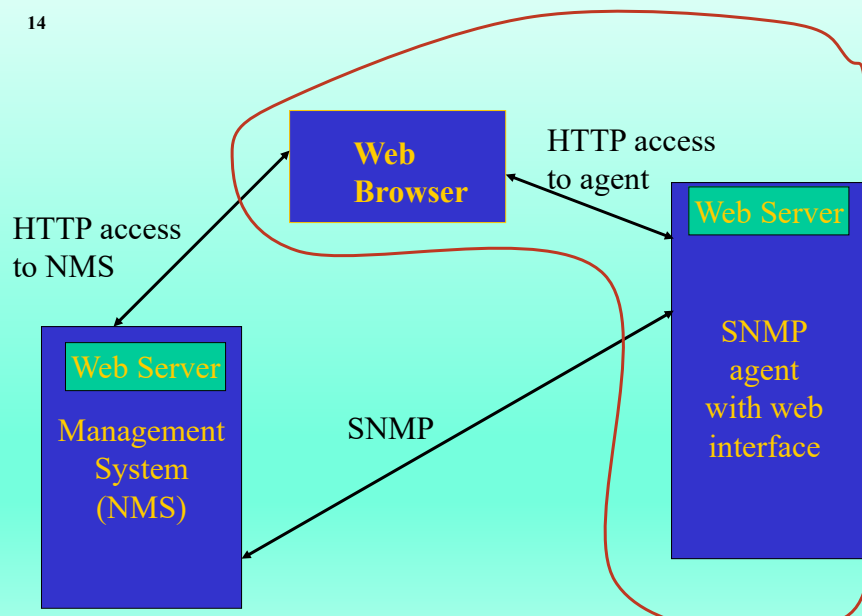


Very common:
Network and device management via web interfaces

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Web-based management concept

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Network management

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

F **AULT**

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

C **ONFIGURATION**

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

A **CCOUNTING**

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

P **ERFORMANCE**

- **Security management** – support communications network secure management

S **ECURITY**

15

Network management

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 - **Fault management** – detection, isolation, and correction of anomaly behaviors

F **AULT**

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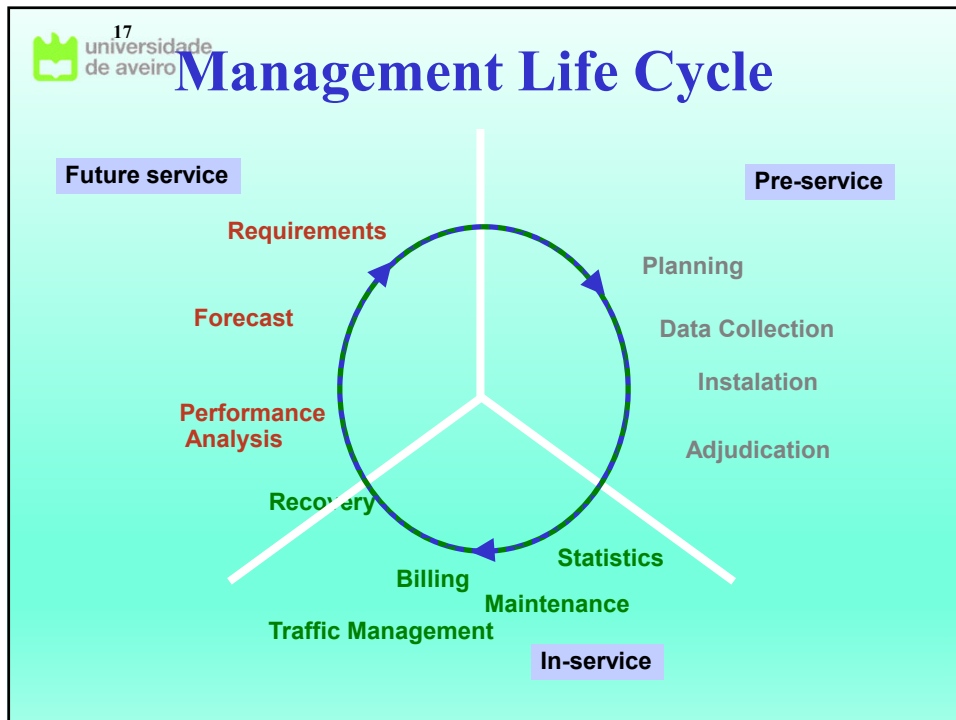
P **ERFORMANCE**

- **Security management** – support communications network secure management

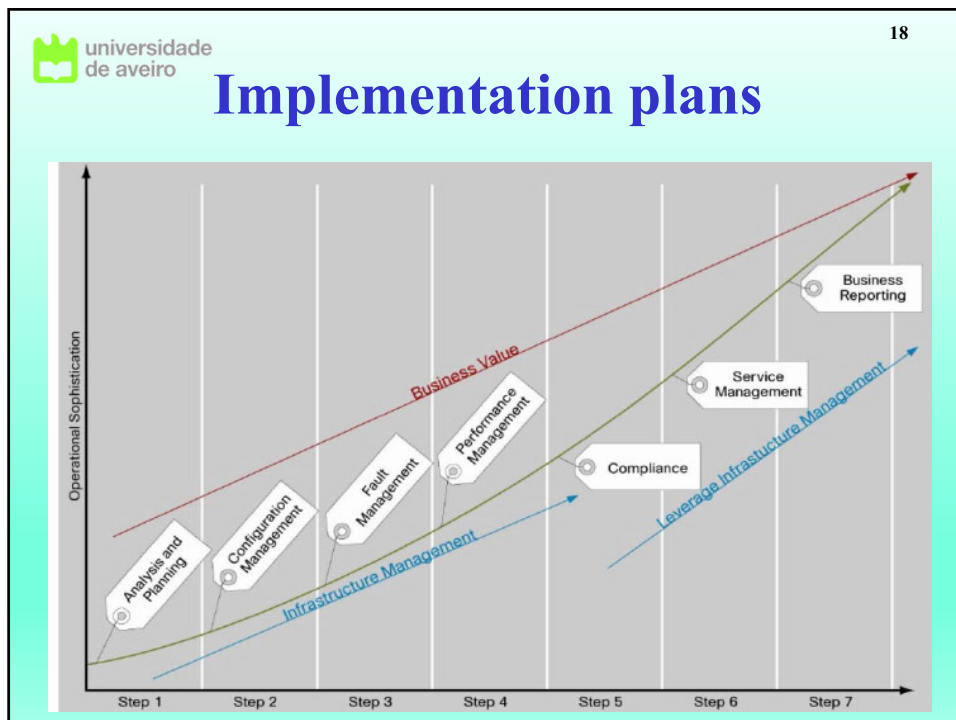
S **ECURITY**

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

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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 ⇒ common data and parameters formats allowing easy information transfer

Complex protocols ⇒ add flexibility and security capacity

Advanced protocols ⇒ 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

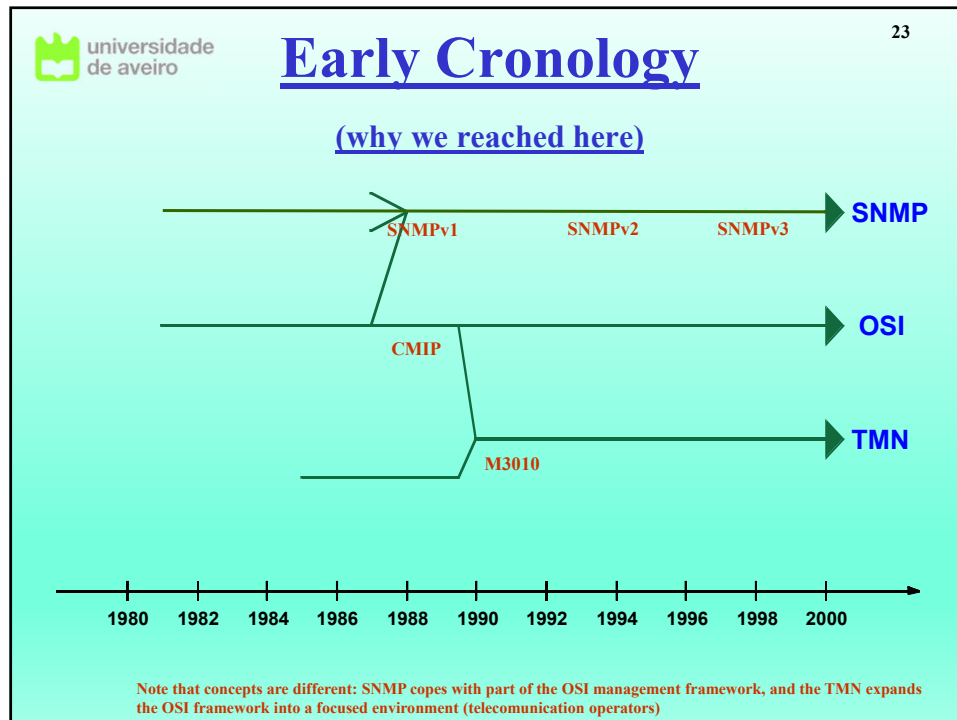
21

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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SNMP

(short review)

Simple Network Management Protocol

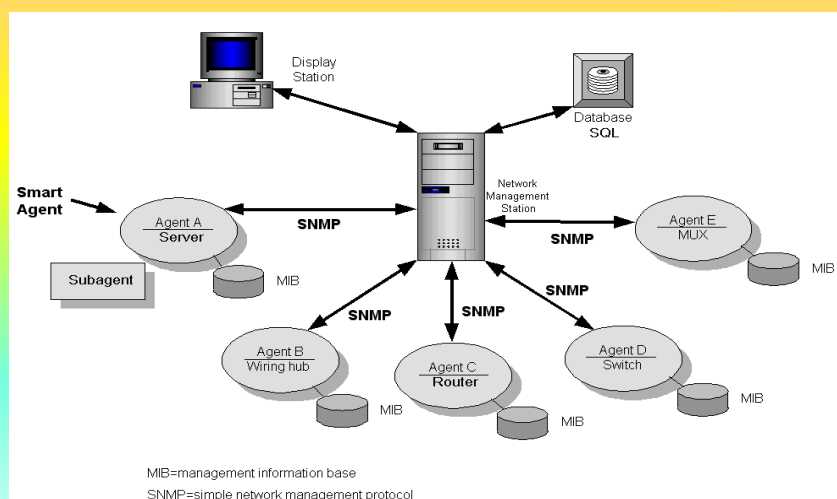
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Manager/Agent Paradigm

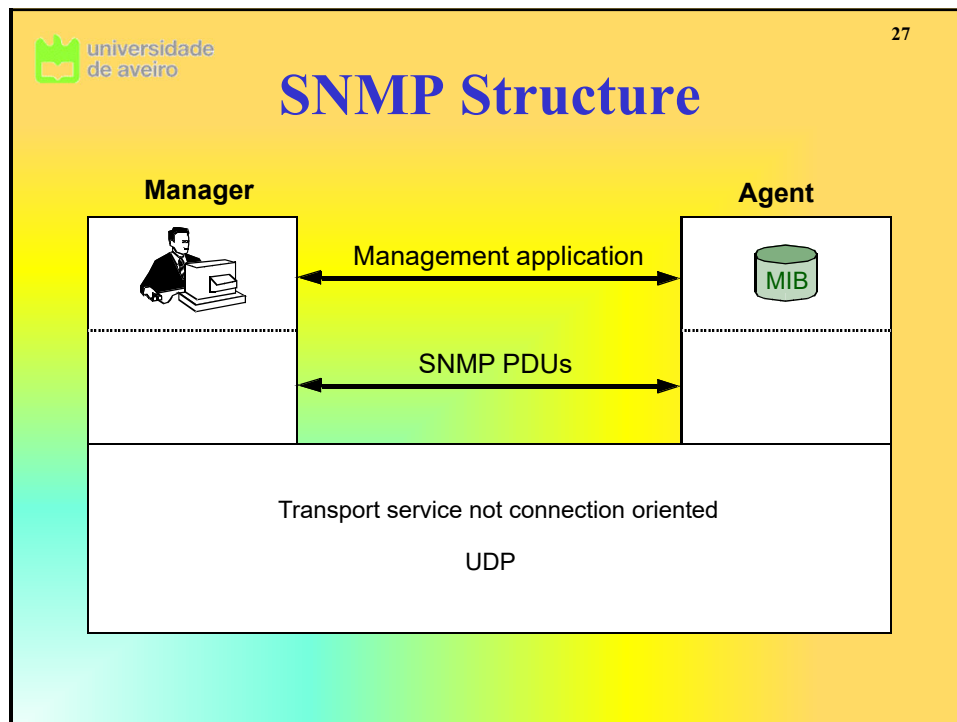
- **Manager/agent: common in all NMS (especially in SNMP/CMIP)**
- **Idea of a client/server, but many clients and only some servers**
 - (manager ↔ client; agent ↔ server)
- **The agent operates with the equipment**
 - Reports problems to the manager, to control all the equipment information
- **The 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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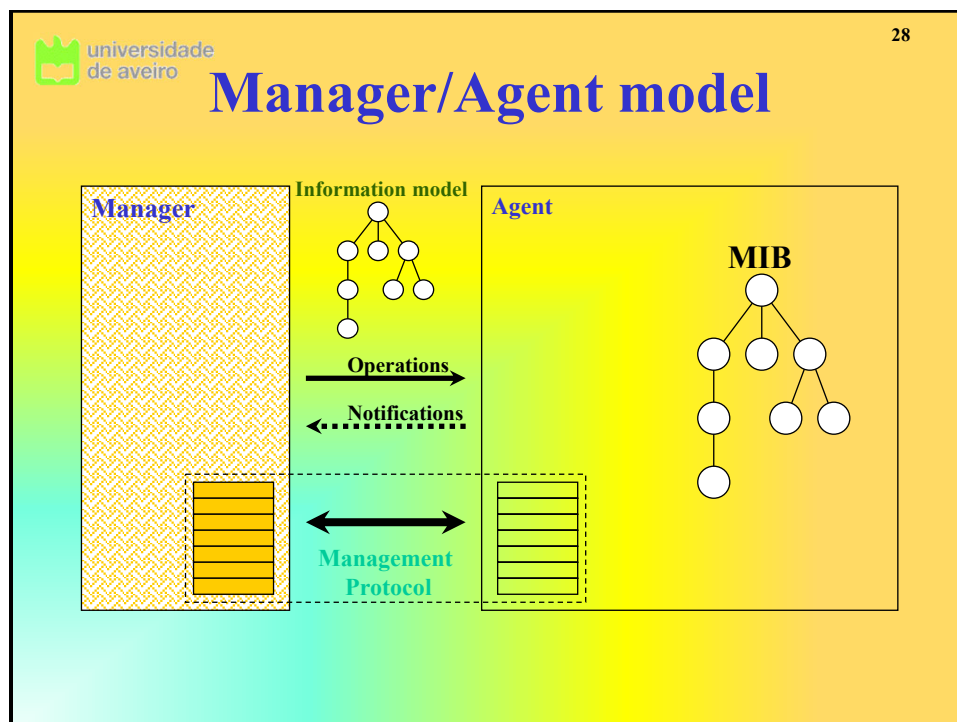
Structure of SNMP management



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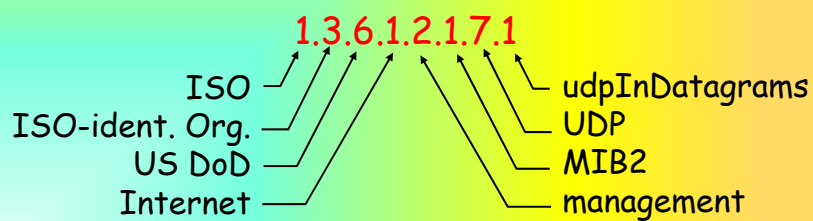
28

Names (numbers) SNMP

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

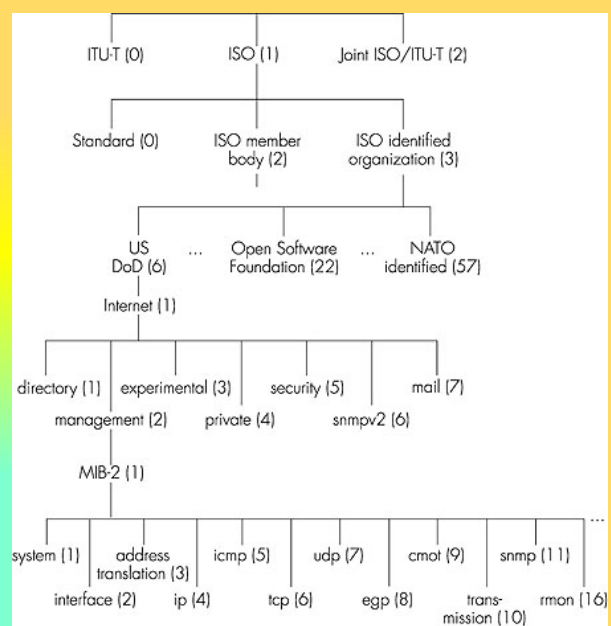
Answer: ISO Object Identifier tree:

- 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 ⇒ 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, bandwidth 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 ⇒ 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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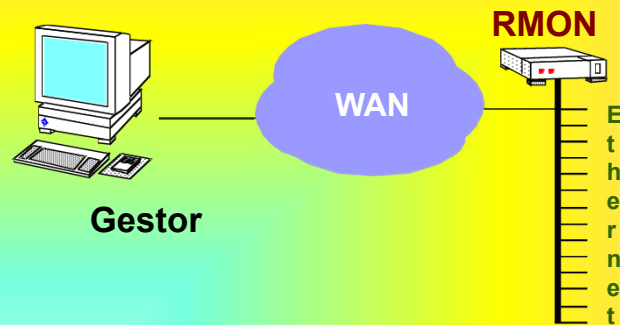
SNMP: security and authentication

- 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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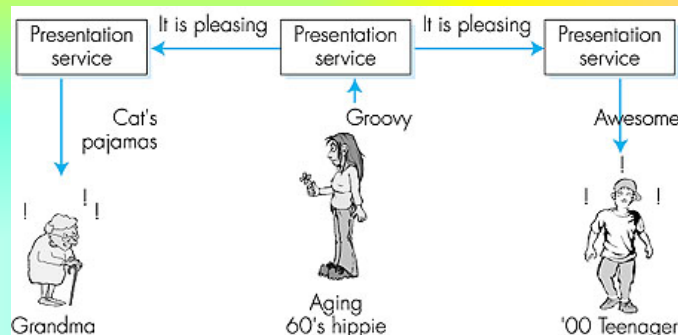
RMON

- **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**

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The presentation problem?

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



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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

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TLV Coding

Idea: Data must be auto-identified

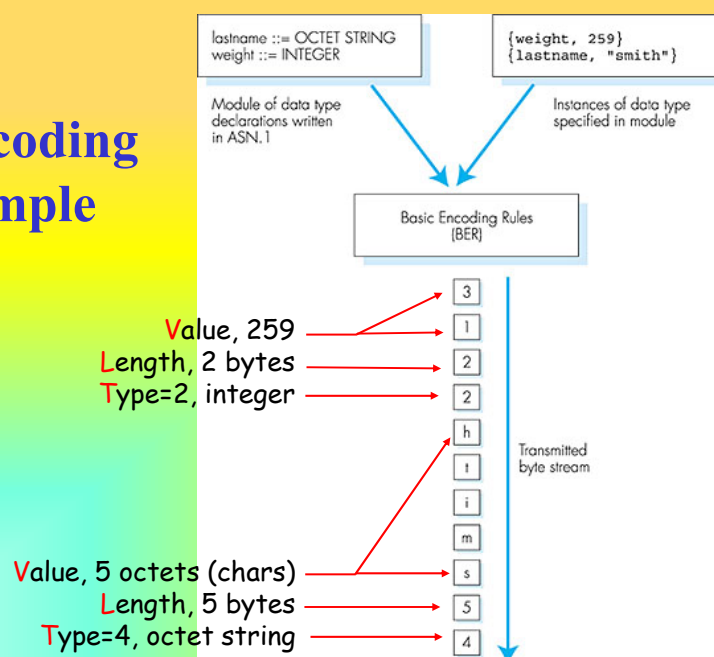
- **T**: data type, (ASN.1-defined)
- **L**: data length in bytes
- **V**: data, coded according with ASN.1 syntax.

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

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Elements of systems based on policies

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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.

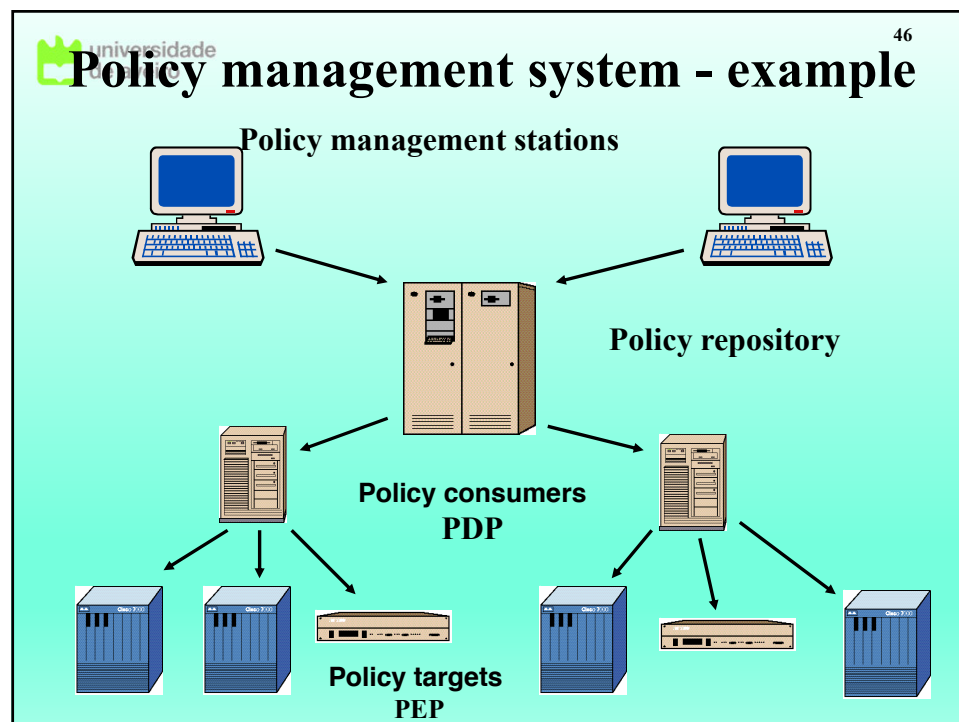
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Policy management system - example

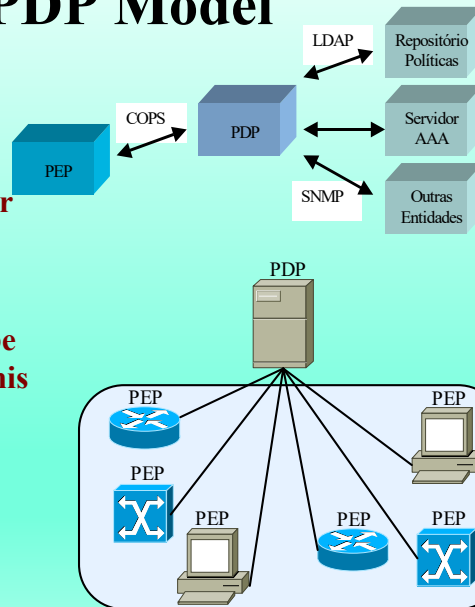
46



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PEP-PDP Model

- **Model uses (may use) different protocols**
 - **Abstraction levels differ**
- **Increasing trend**
 - **Software defined networking (SDN) can be seen as a variation of this concept**
(OpenFlow is a protocol for SDN)



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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

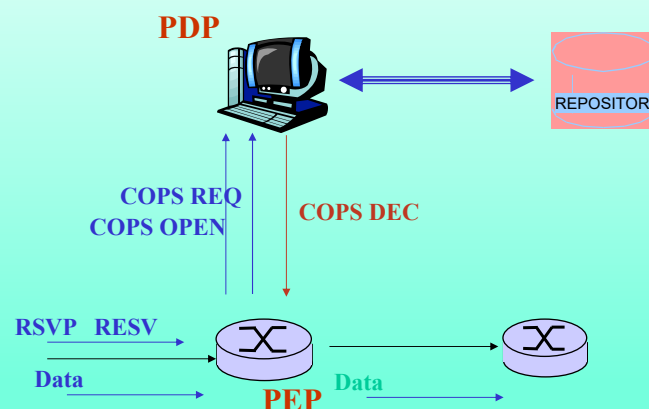
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COPS Session

- 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 protocols (LAN-oriented)

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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

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

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CMIS/CMIP

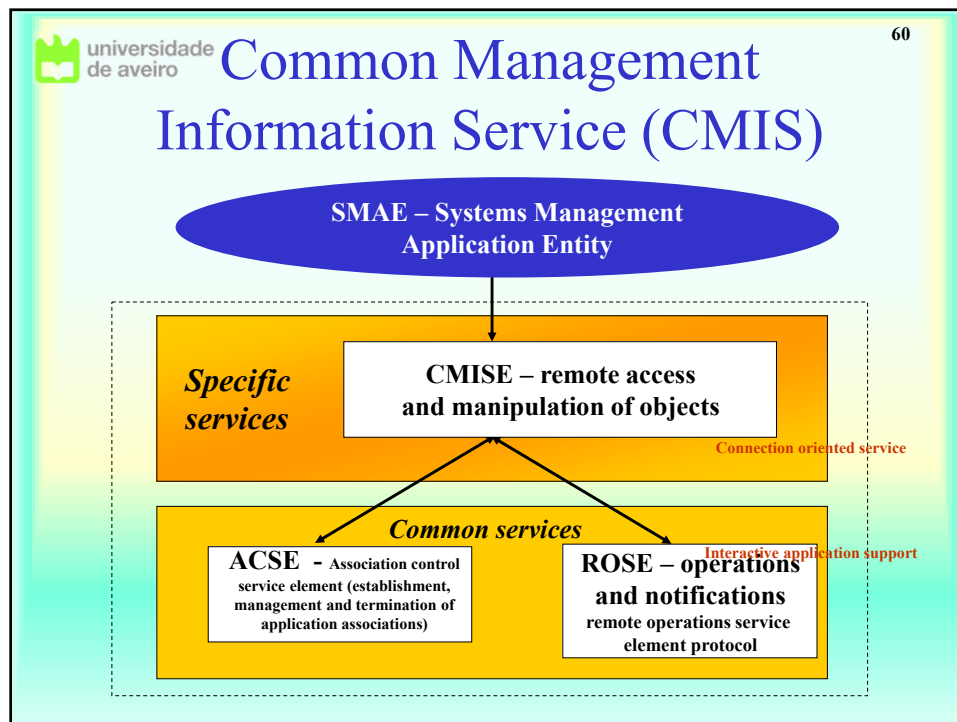
- **Approach object-oriented - objects**
 - **Have attributes**
 - **Generate events/notifications (reliably)**
 - **Execute operations**
- **Objects with same attributes, notifications and operations belong to the same class**
- **Objects inserted in multiples hierarchies, with different inherits and 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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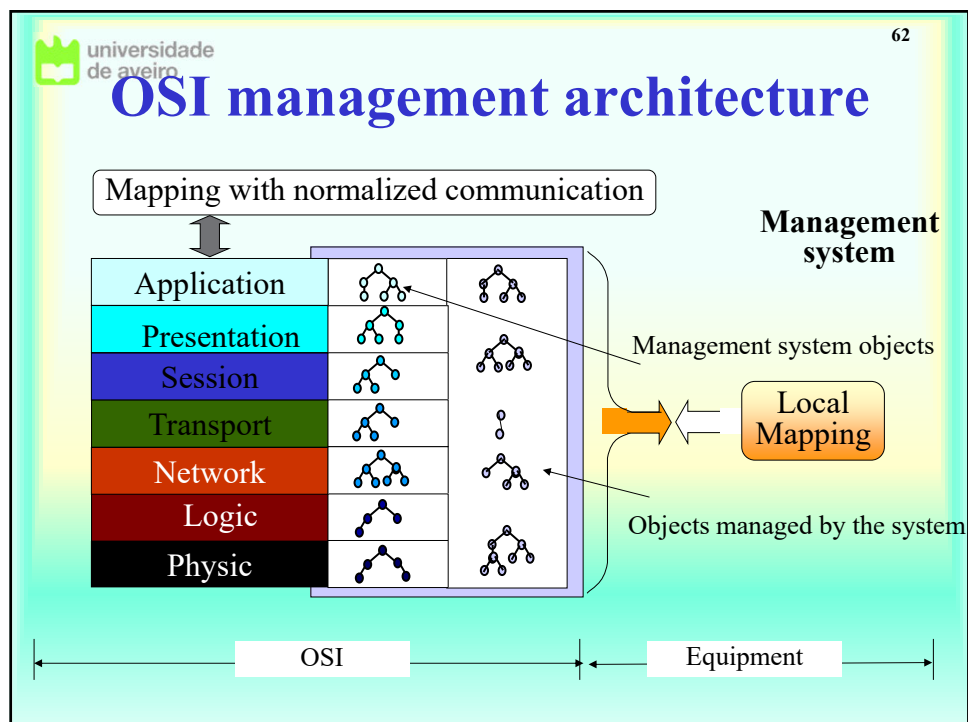
CMIP - GDMOs

- **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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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
- Light
- Limited functionalities
- Bulk capacity 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

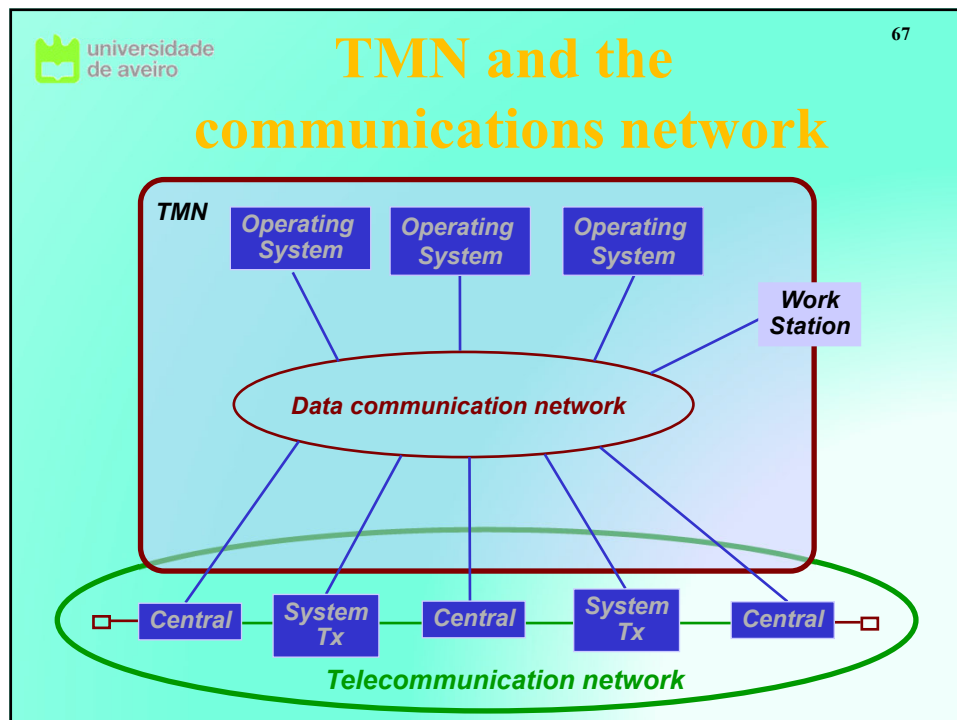
Telecommunications Management Network

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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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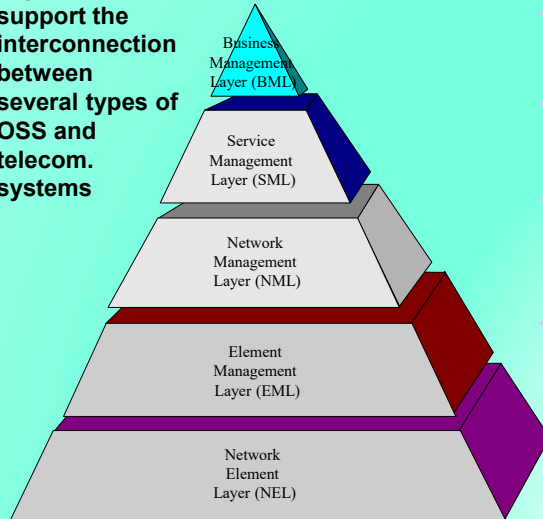
TMN

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

Multi-layer model



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

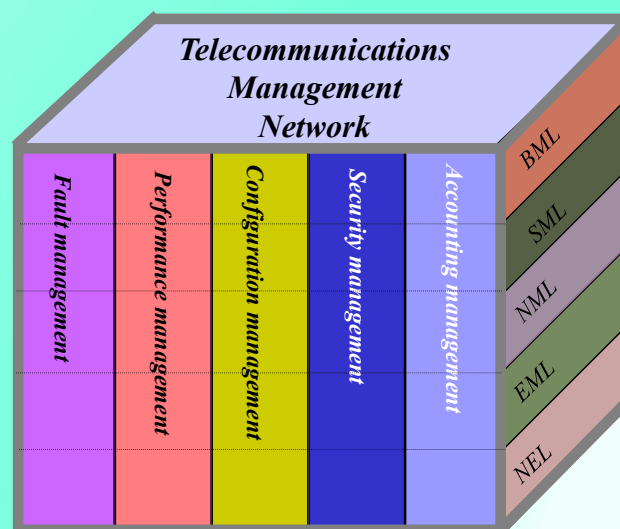
Performs functions for the handling of services in the network: definition, administration and charging of services, scalability policies, service restore, monitoring and report of SLAs availability. performs functions for distribution of network resources: configuration, control and supervision of the 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.

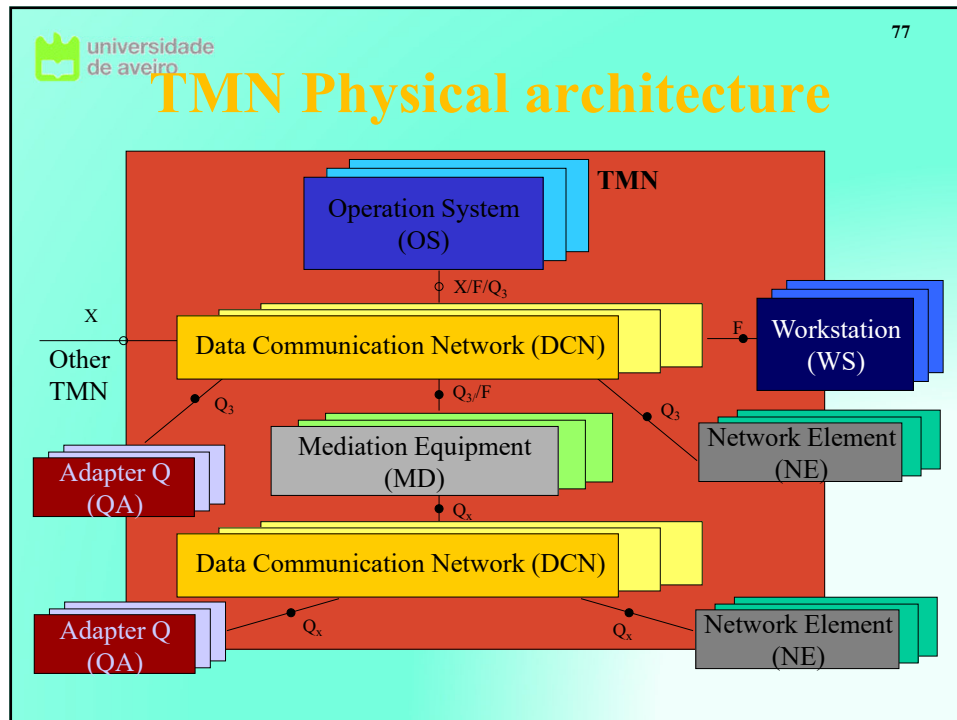
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TMN Matrix

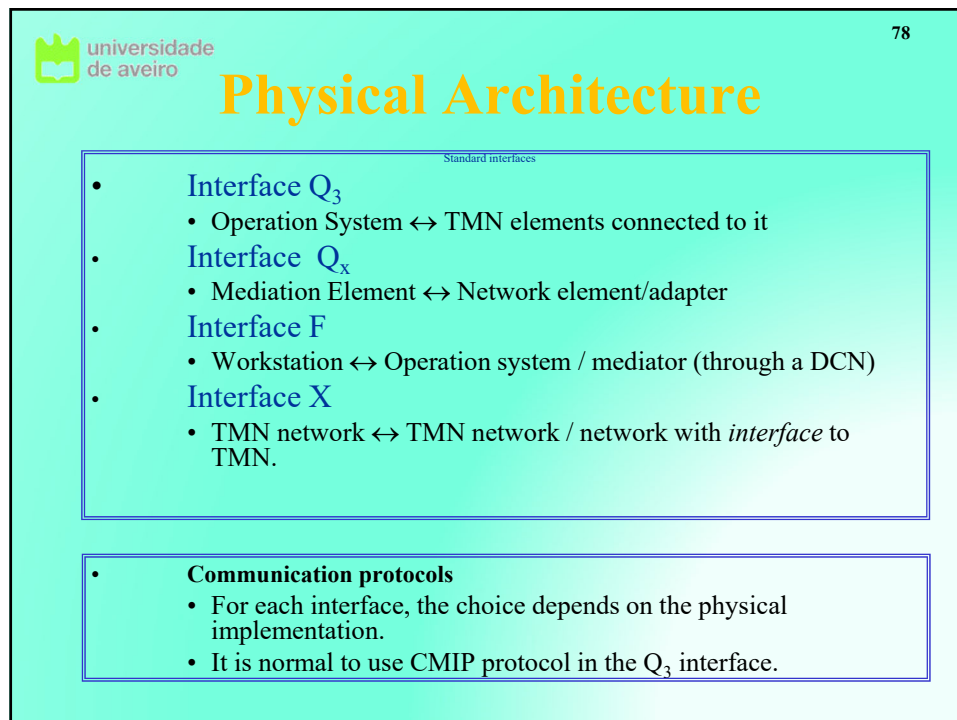


Depicts the FCAPS functionality along the TMN layers

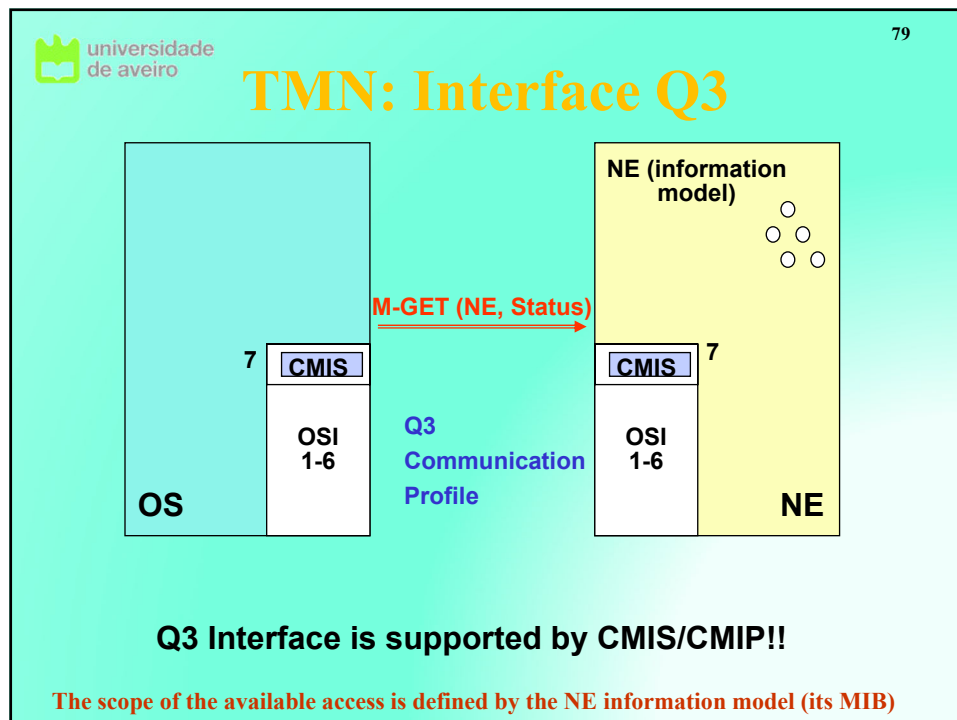
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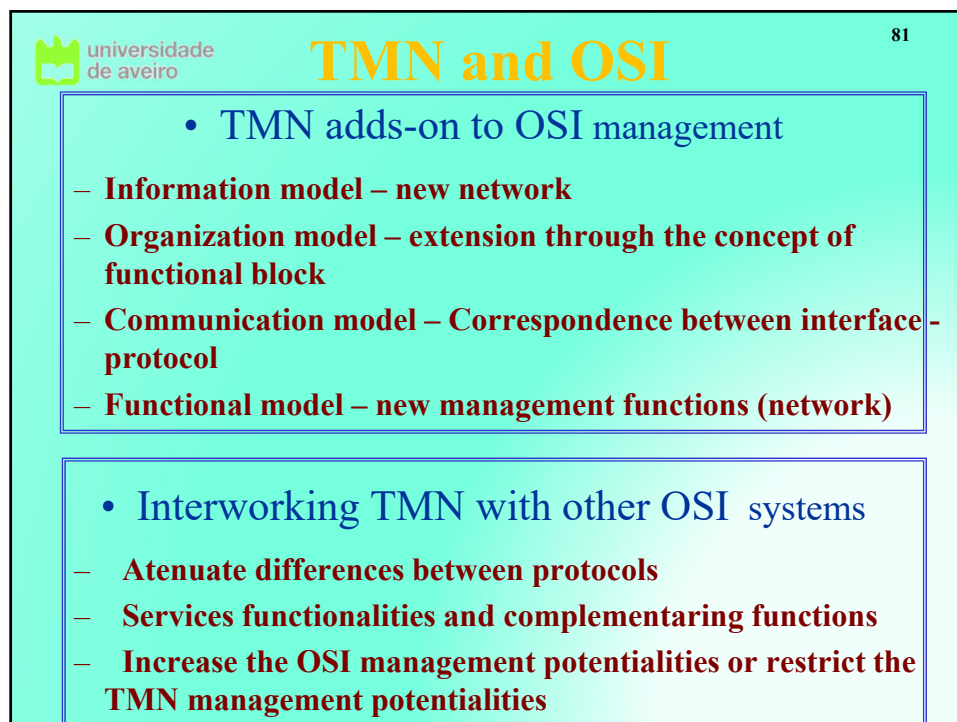
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