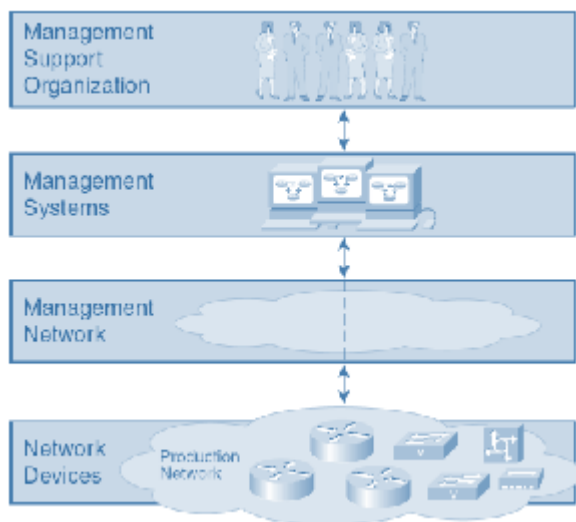


# Lecture 4

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## Network Management Components

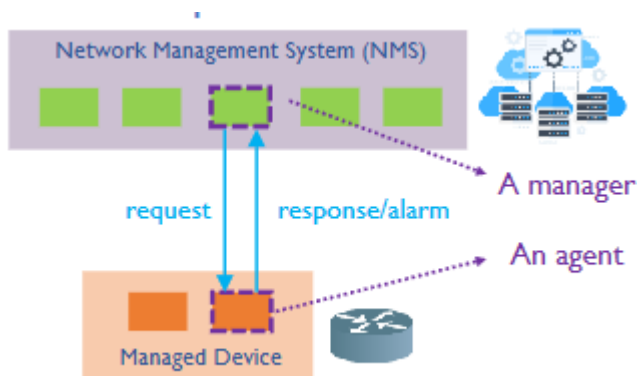
- Network devices
  - Managed devices/network elements
- Network management system (NMS)
  - An integrated set of tools for management
- Management network
  - Interconnecting managing and managed entities
- Management support organization
  - Running the network using the management technologies



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## Key Concept - "Manager" & "Agent"

- Network management system (NMS) includes *management applications*
  - Each management application is a manager
  - An NMS can involve multiple managers
- Network devices come with software component that implements a management interface.
  - These components would be known as an *agent*
  - Network devices can have multiple agents for different management functions (i.e reading data, configuring, etc.)
- Manager - agent communication
  - Manager is in charge
  - Agent plays a support role



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## Network Devices

- Also called network elements that includes the following:
  1. Switches
  2. Routers
  3. Gateways
  4. Can potentially include network operated servers.
- MUST HAVE a *management interface*
  - Allowing the management system to send messages to a device (request to configure, retrieve status data)
  - Allowing a device to send messages to the management system (response to request, unexpected event alarm, etc.)

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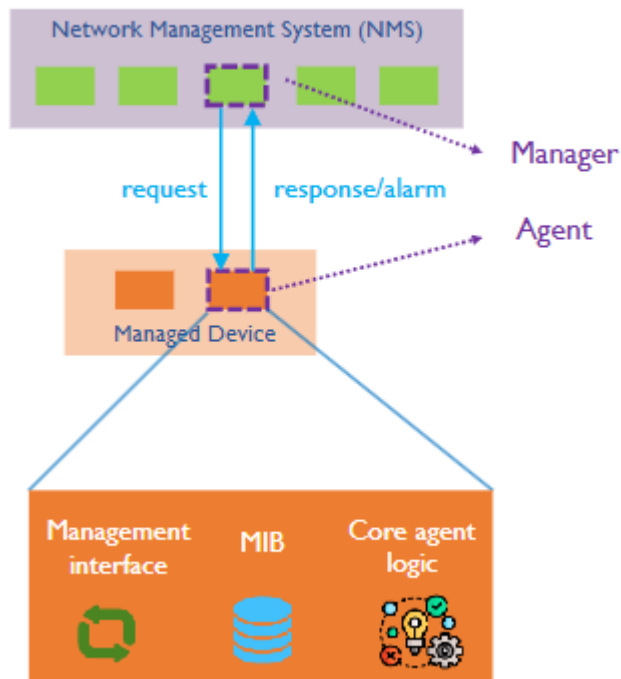
## Components of Agent

### Agent

The software that implements the management interface for that device. This device *IS NOT* a network device, However, it represents the device when communicating with a management application (manager)

Conceptually an agent consists of three main parts:

1. Management interface
2. Management Information Base (MIB)
3. Core agent logic.



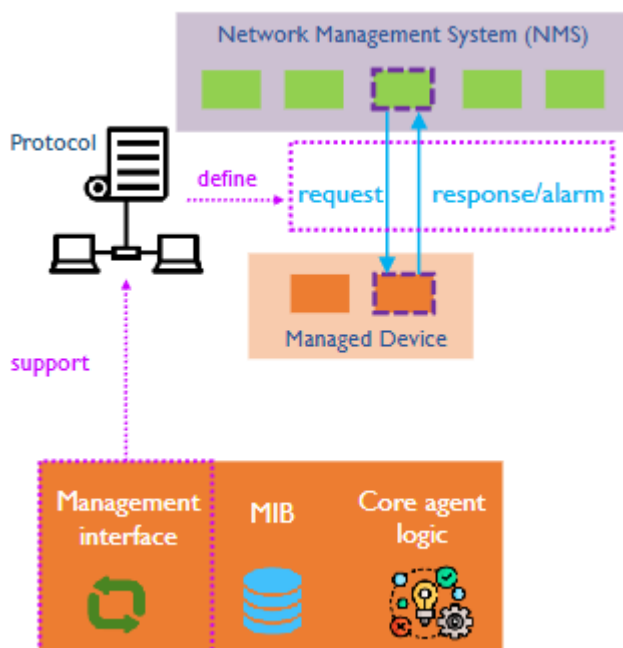
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## Agent Part 1 - Management interface

The management interface handles management communications by *supporting a management protocol* (Rules of communication) for manager-agent communication.

With the management interface:

- Management application (manager) can *open or terminate a management session* with the Agent
- Manager can make *management requests* to the agent (requests for data, change configuration, etc.)
- The *agent can send messages* to the manager (alert of loss of communication with another device for example.)



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# Management Information

An agent has a management information base (MIB)

Management information provides an *abstraction of real-world aspects of devices* for management purposes such as:

1. Version of installed software
2. Utilization of ports
3. Device temperature, voltage
4. Protocol timeout parameters
5. Firewall rules

## Agent Part 2 - MIB

MIB is a *conceptual data store* that contains a management view of the device being managed.

- Conceptual data stored in MIB - management information
- Agent MIB - information local to the device
- Manager MIB - information of all managed devices

### THE MIB IS NOT A REAL DATABASE

- An agent MIB is a "virtual" database containing management information - just a way to view and organize information.

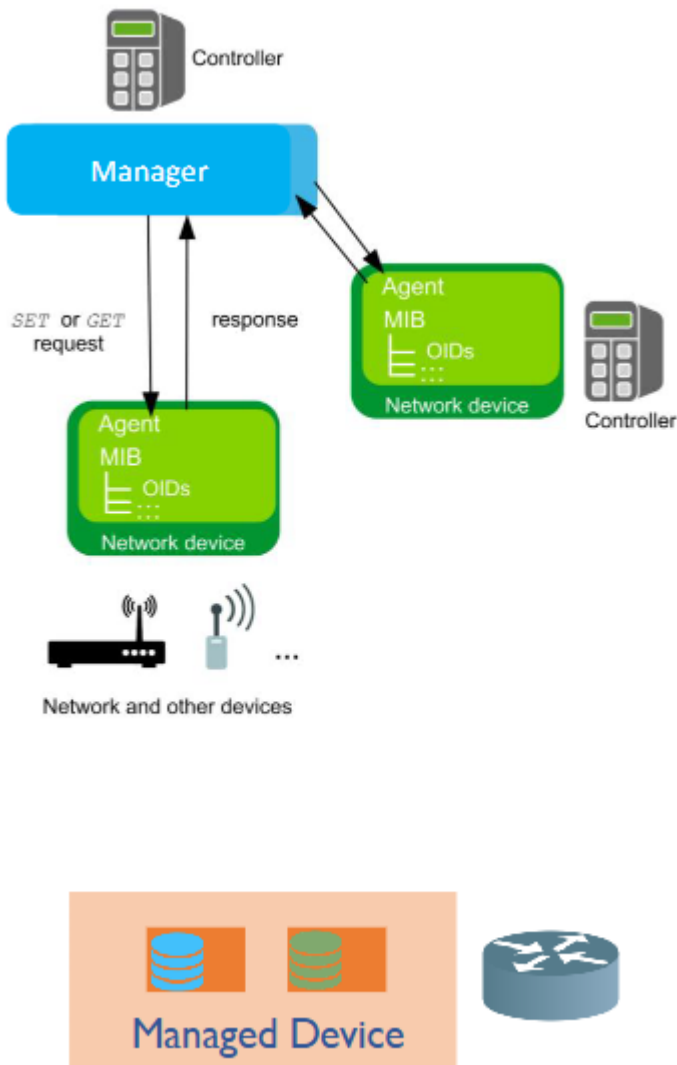
### EXAMPLE OF MIB:

- Ports of a router represented as a table in an imaginary database
- Each port having a corresponding entry in the table
- Columns contain conceptual attributes corresponding to actual properties of the port.

*If a device has multiple agents, each agent could have a different MIB - different views and abstraction of information*

MIB provides a foundation for network management operations

- Management operations are based on management communications
- Management communications are about exchanging information

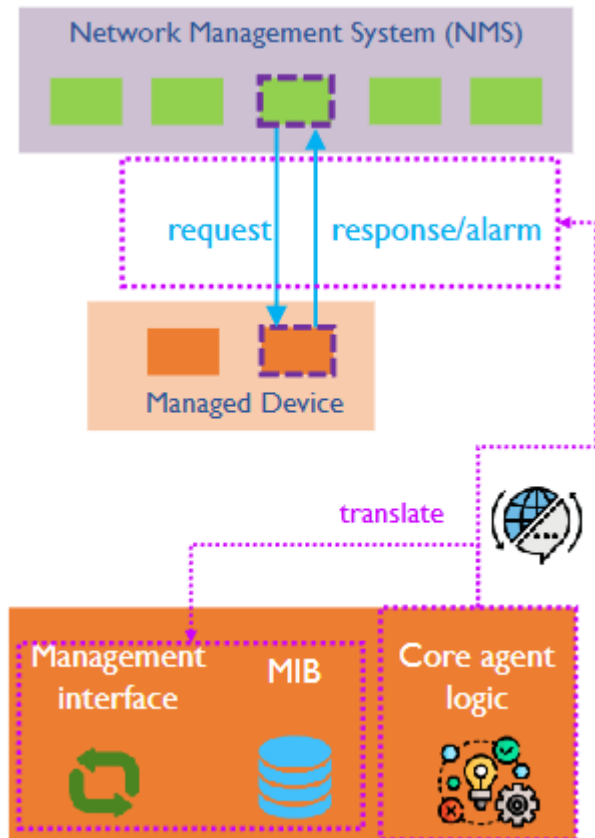


## Agent Part 3 - Core Agent logic

The core agent logic *translates* between the operation of the management interface, the MIB, and the actual device.

EXAMPLE:

1. Manager sends a request to "retrieve a counter" into an Agent
2. The core agent logic *receives the request through the management interface*
3. Core agent logic *checks MIB* for the referred counter.
4. Core agent logic translates the request into an operation that reads out the corresponding hardware register of the device.



## Managed Object vs. Real Resource

A *managed object (MO)* is a chunk of management information that represents one of the real-world aspects of a network device.

An MO could represent:

1. Device fan along with its operational state
2. Port along with a set of statistical data
3. Firewall rule

The *real-world object* that an MO represents is generally referred to as the "real resource"

- Same real resource can be abstracted in different ways corresponding to different and possibly coexisting MOs

Q: can you give an analogy of different abstractions of the same object?

A person's title will change depending on who you ask with each title representing a different abstraction of the same object

## Network Management System (NMS)

- NMS provides the tools to manage a network including the following:
  - Network monitoring application & network analyzers
  - Service Provisioning systems
  - Device management applications

- Intrusion Detection systems

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## Distributed Network Management

An NMS is not always on one host

*Distributed network management:* - NMS runs on and is distributed across several hosts.

- Benefits of distributed management:
  1. Scalable: more hosts = greater processing, I/O and storage capacity.
  2. Robust: if one fails, NMS can still be running
  3. Delay and overhead: managing from location close to a local network (similar to cloud vs. edge computing.)

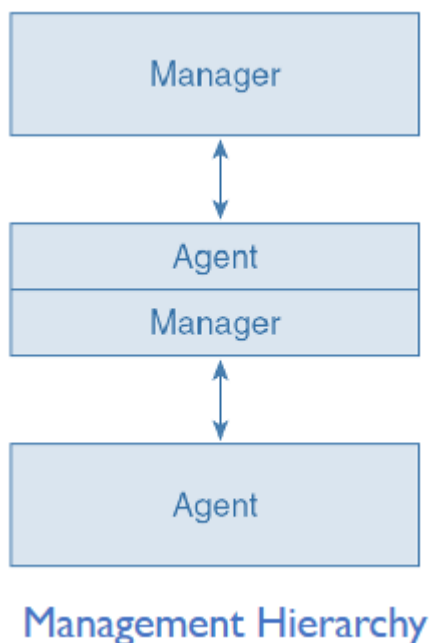
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## Management Proxy and Hierarchy

Proxy: Node acting on behalf of other nodes

A network device may act as a management proxy to another. - Plays the agent role in interacting with the management system. - Plays the manager role in interacting with another device.

This eventually forms a *management hierarchy* and the entity in the middle does not have to be a device. - possible a sub- or local management system.



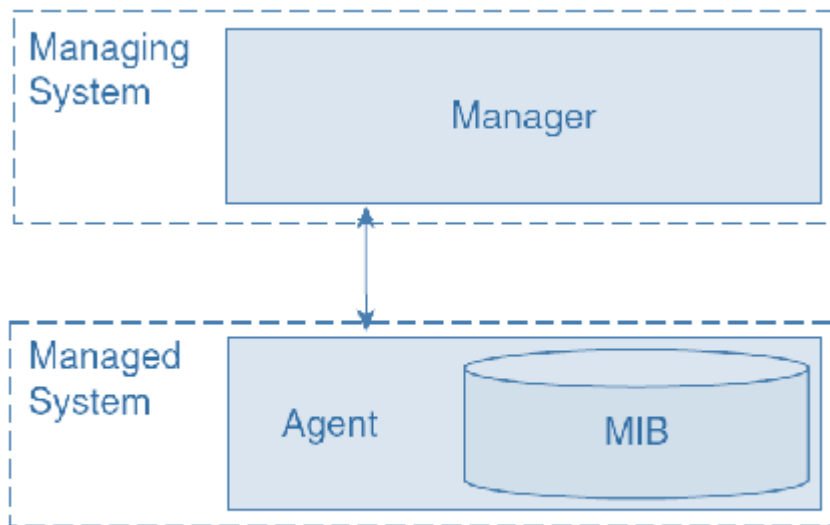
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## Manager - Agent - MIB Relationship

- Fundamental relationship among manager, agent, and MIB
- The manager operates on the abstraction of the agent provided through the agent's MIB:
  - Sends requests to the Agent
  - Receives responses from the Agent

- Asks the agent to be notified of events

Agent: proxy for managed device NMS: proxy for the real-world organization responsible for managing the network.



Manager/Agent Reference Diagram

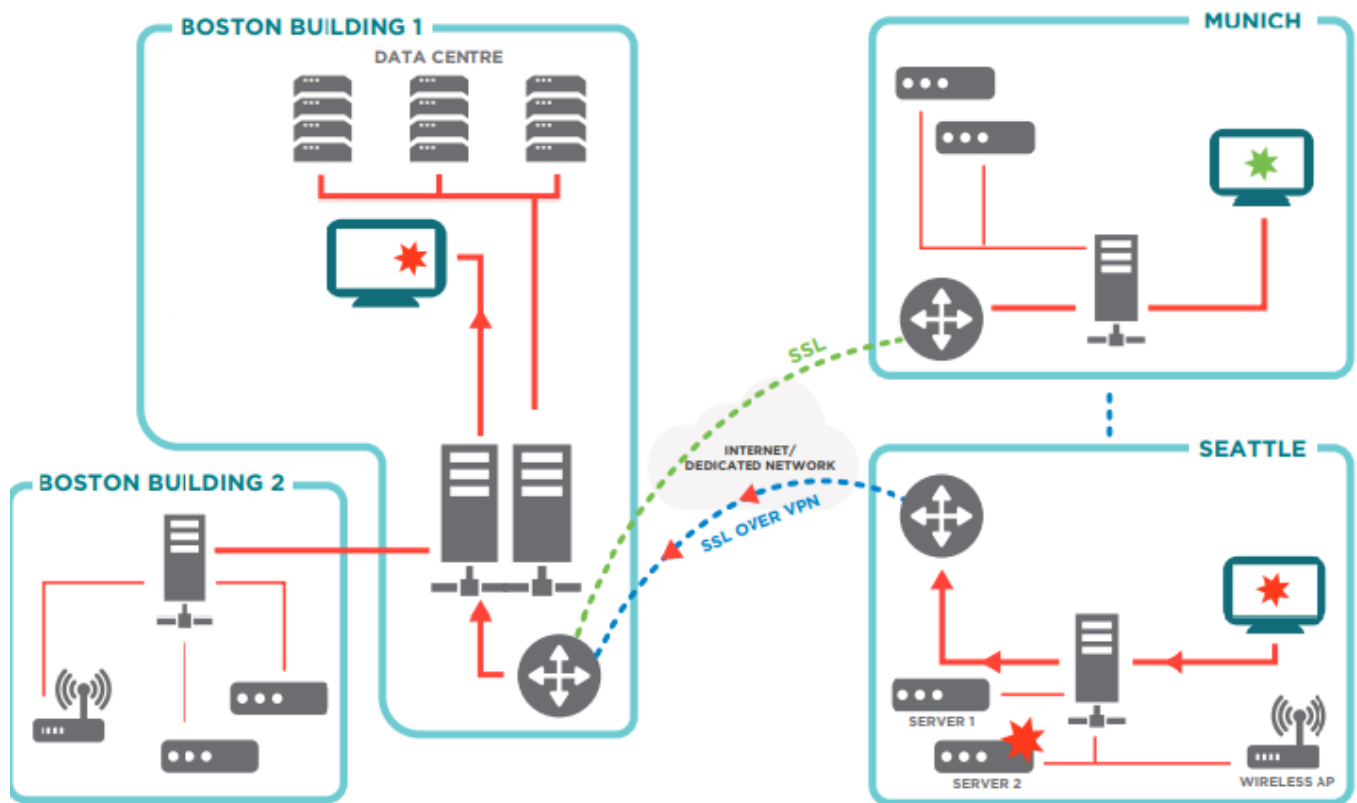
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## Concept of Management Network

Managers and agents need to communicate and NMS on different hosts need to be able to communicate with each other.

- Management network: the network interconnecting NMS and managed devices
- Production networks: the network providing services to the end user.
- Management and production networks can be physically separate networks or the same physical network.





## Connecting NMS to Network Devices

Network devices can be connected with/without a management Network and here are the following methods to do so:

### 1. Direct connections

- Network devices have a management/console port (typically a serial interface)
- A technician can directly connect a craft terminal to a device.

Issues: - Needs on-site physical access to the device - Impractical to go from device to device in a large scale network.

### 2. Connecting through a terminal servers

- Terminal server will have a set of serial interface ports, each connecting with one network device and a port for the craft terminal to connect to.

Issues: - Still needs on-site physical access to the terminal server - Would also still need to go between terminal servers

### 3. Terminal server with Ethernet port and IP address

- On-site connection to the terminal server no longer needed
- preliminary management Network

Issues: - Keeping track of which devices are connected to what terminal server and their respective ports.

### 4. Connecting to network devices through regular Ethernet ports(In-band Management Network)

- Skips the need for terminal servers
- Connects to network devices using regular Ethernet ports and IP address.

#### In-band management network

Same network infrastructure and port for management and production networks (mixing network management data traffic and production data traffic)

#### 5. Connecting to network devices through management Ethernet ports (out-of-band Management Network)

- Also skips terminal servers
- Connects to network device using Ethernet ports and IP addresses dedicated to network management purposes.

#### Out-of-band Management network

Different ports for management and production networks (separating management data traffic from production data traffic.

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## In-band vs Out-of-band Management Network

- In-band: *same network* shared by production and management traffic
- Out-of-band: *dedicated* management network

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## Dedicated Management Network: Pros & Cons

To determine whether management networks are beneficial, we would need to look at the trade offs.

Which (dedicated or shared management network is better in:

- Reliability:
  - Out-of-band because it removes the possibility of having a highly congested production traffic flow from losing management traffic which is necessary to manage production traffic in the first place.
- Quality of service (QoS) for production traffic:
  - Out-of-band works especially considering that management traffic is quite unpredictable since sometimes it will have a higher traffic rate than normal which would potentially interrupt production traffic flow.
- Ease of network planning:
  - Out-of-band: It enables us to separate the planning for how management and production traffic would go around.
  - However it is also fair to consider in-band management because it simplifies the entire process because you would have less factors to consider overall.
- Security:
  - Out-of-band: prevents unauthorized access from making changes on the management side which can potentially cause the entire network to go down.
- Cost:

- In-band would be cheaper to implement as less time and effort would be needed in setting up the entire network infrastructure since it will all be bundled together.
- 

## the Non-Technical aspects

### Network Management Fundamentals - Pages 93-97

*Organizational aspect* of network management: - Management support organization - Important to telecommunications service providers and large enterprises - Smaller businesses may not have a management support organization (but just one network administrator).

For large networks: *network operation center (NOC)*

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## Management Support Organization - Tasks

- Overall task: managing the network Manager
    - Monitoring the network for failures
    - Diagnosing failures and carrying out repairs
    - Provisioning new services
    - Adding and removing users to and from the network
    - Tracking network performance, taking preventative measures
    - Planning network upgrades
    - Planning network topology and network buildout
- 

## Management Support Organization - Structure

- Management support organization divided into different units
  - Each performing a distinct function
  - Minimizing interactions between different units and dependencies causing finger-pointing situations

Example structure:

- Network planning: Analyzing network usage and traffic patterns, planning network buildout and service rollout.
- Network operations: Keeping the network running and monitoring the Network
- Network administration: Physically deploying the network and services on it, may include field technicians (combining A and M in OAMP)
- Customer management: Interacting with customers