Chapter 1

Data Communications and Network Management Overview

Objectives

- Telecommunications overview
- Data communications overview
- Evolution of converged networks
- Desktop processors and LAN technology
- Client-Server architecture in networking
- Internet and intranet
- Network communication protocols
- OSI and Internet standards
- Broadband networks and services
- Need for network management and NMS
- Operations, Administration, Maintenance, and Provisioning
- Network management architecture and organization
- Concept of Network Operations Center
- Perspectives of network management
- Network management system
- Look-ahead of network management technology

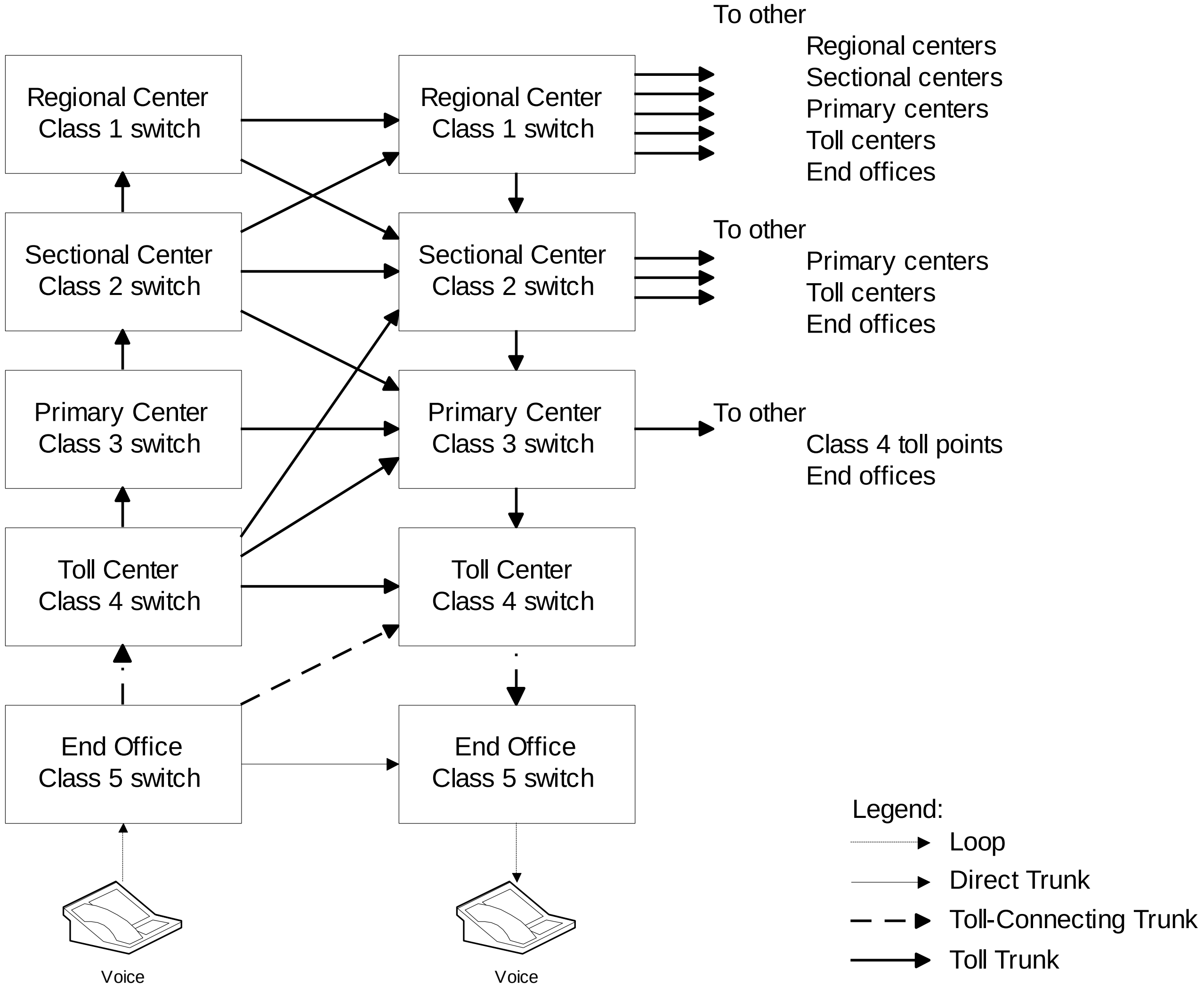
Telephone Network

- Modern network evolution from Telephone / Telecommunications Network

- Characteristics of Telephone network
  - Reliable - does what is expected of it
  - Dependable - always there when you need it (remember 911?)
  - Good quality (connection) - hearing each other well

- Reasons for QoS:
  - Good planning, design, and implementation
  - Good operation and management of network
  - Migration to new technologies –
    - e.g., From analog to digital technology

Telephone Network Model



Notes

Figure 1.1 Telephone Network Model

- Notice the hierarchy of switches
- Primary and secondary routes programmed
- Automatic routing
- Where is the most likely failure?
- Use of Operations Systems to ensure QoS

OSSs / NOC

- Operations Support Systems (OSSs) help manage the operation of networks (Operations Systems to ensure QoS)
- OSSs in telecommunications monitor:
  - Analog network parameters:
    - S/N ratio, transmission loss, call blockage, etc.
  - Digital network parameters:
    - Packet loss, Packet delay, Throughput, QoS, etc.
- Real-time management of network
- Trunk (logical entity between switches / nodes) maintenance system measures loss and S/N Trunks not meeting QoS removed before customer notices poor quality
- Traffic measurement systems measure call drops and blockage. Additional switches or routers planned to keep the call blockage or drops below acceptable level
- OSSs distributed at central offices and customer premises
- Network management done centrally from Network Operations Center (NOC)

Notes

Data and Telecommunication Network

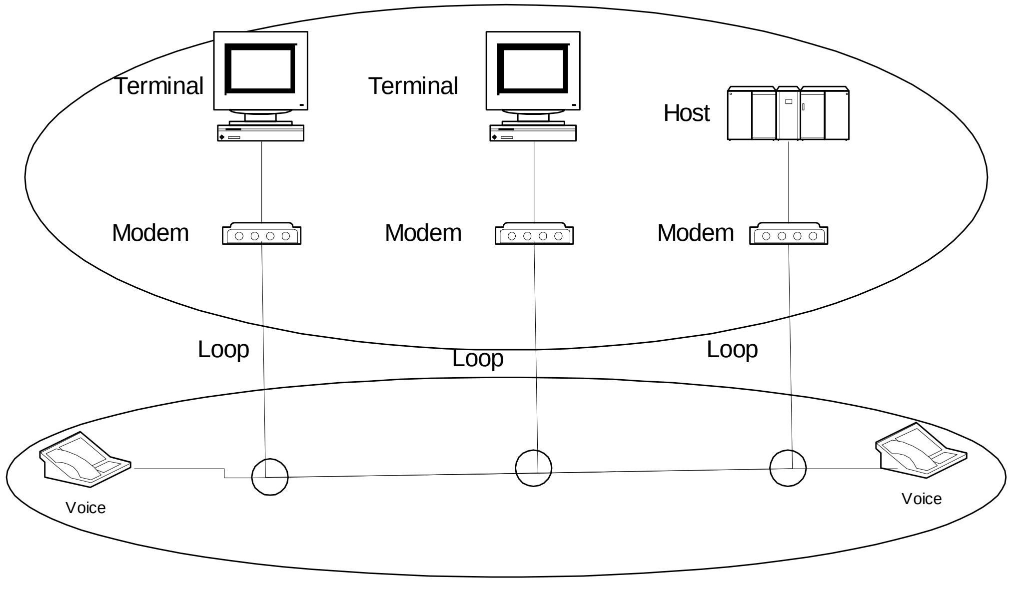


Figure 1.3 Data and Telecommunication Networks

Notes

- Computer data is carried over long distance by telephone (telecommunication network)
- Output of telephone is analog and output of computers is digital
- Modem is used to “modulate” and “demodulate” computer data to analog format and back
- Clear distinction between the two networks is getting fuzzier with modern multimedia networks

Migration to Digital Technology

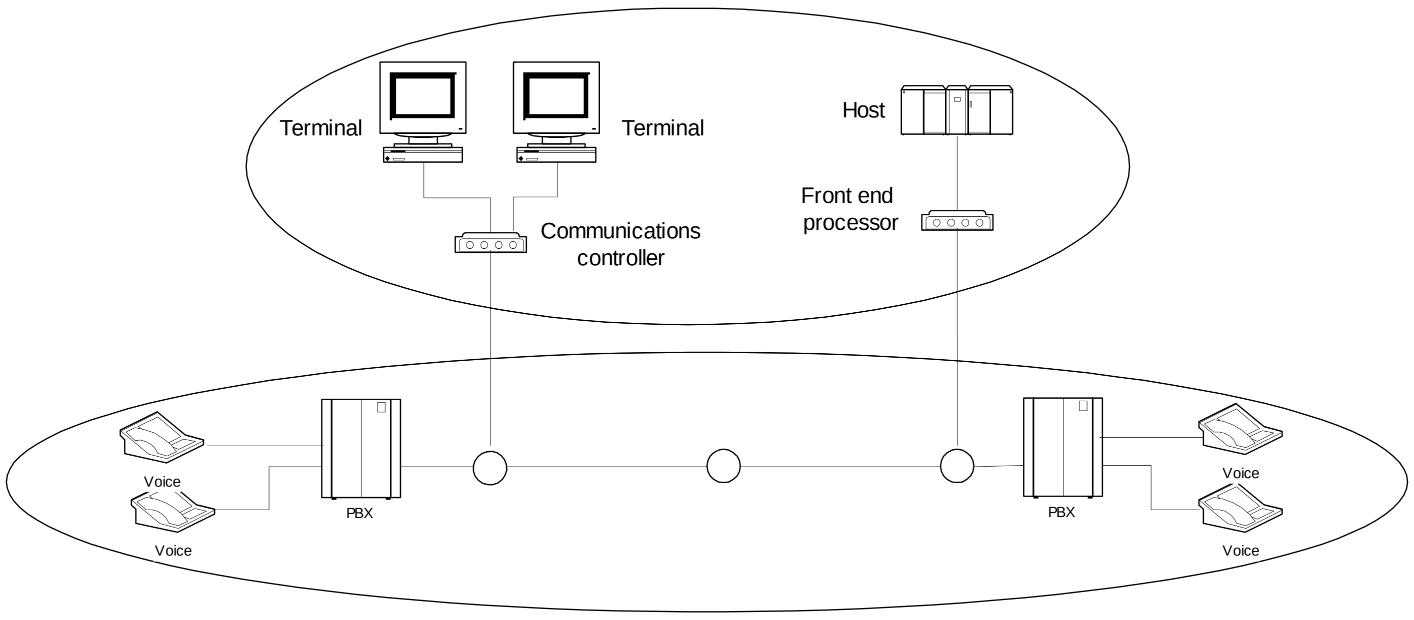


Figure 1.4 Digital Data and Telecommunication Networks

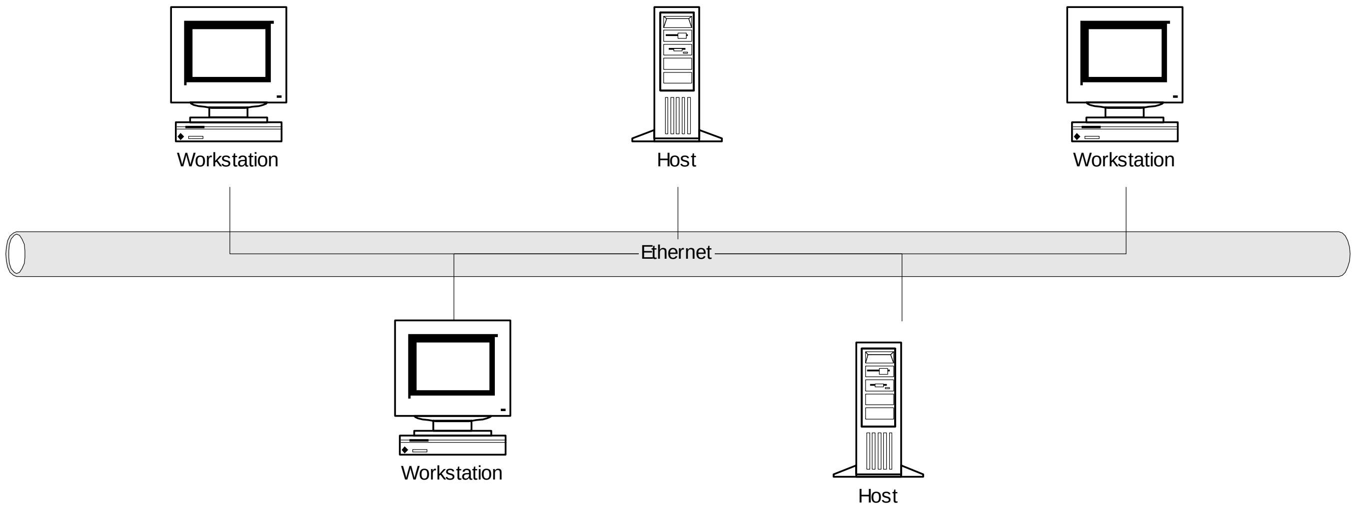
Notes

- Analog transmission migrated to digital transmission
- Analog sources converted to digital signals
- CPE (Customer Premises equipment) included digital PBX (Private Branch Exchanges)
- Analog bandwidth hierarchy migrated to synchronous digital hierarchy

An IP (Internet Protocol) PBX (Private branch exchange) is a PBX that provides audio, video, and instant messaging communication through the TCP/IP protocol stack for its internal network and interconnects its internal network with the Public Switched Telephone Network (PSTN) for telephony communication.

DCE with LAN

DCE.. Distributed Computing Environment



Fgure 1.5(a) Hosts and Workstations on Local LAN

Notes

- Driving technologies for DCE:
    - Desktop processor
    - LAN
    - LAN - WAN network

LAN-WAN Network

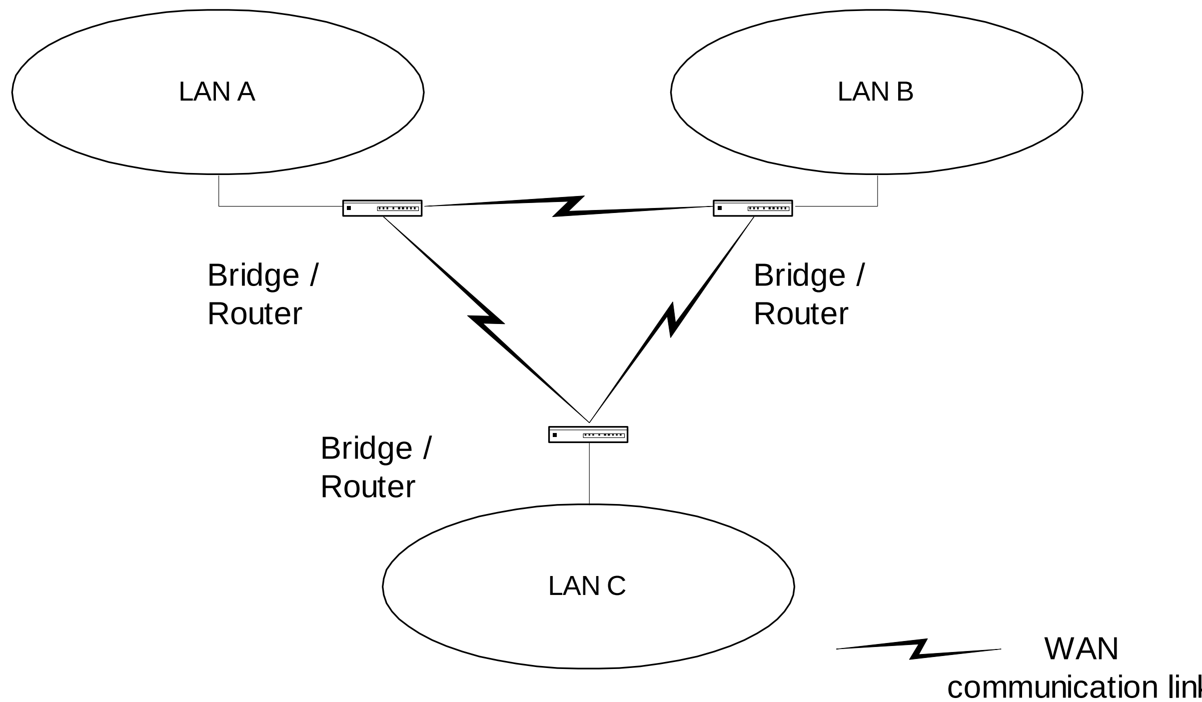


Figure 1.5(b) Remote LANs Interconnected by WAN

Notes

- Major impacts of DCE:
  - No more monopolistic service provider
  - No centralized IT controller
  - Hosts doing specialized function
  - Client/Server architecture formed the core of DCE network

Client/Server Model

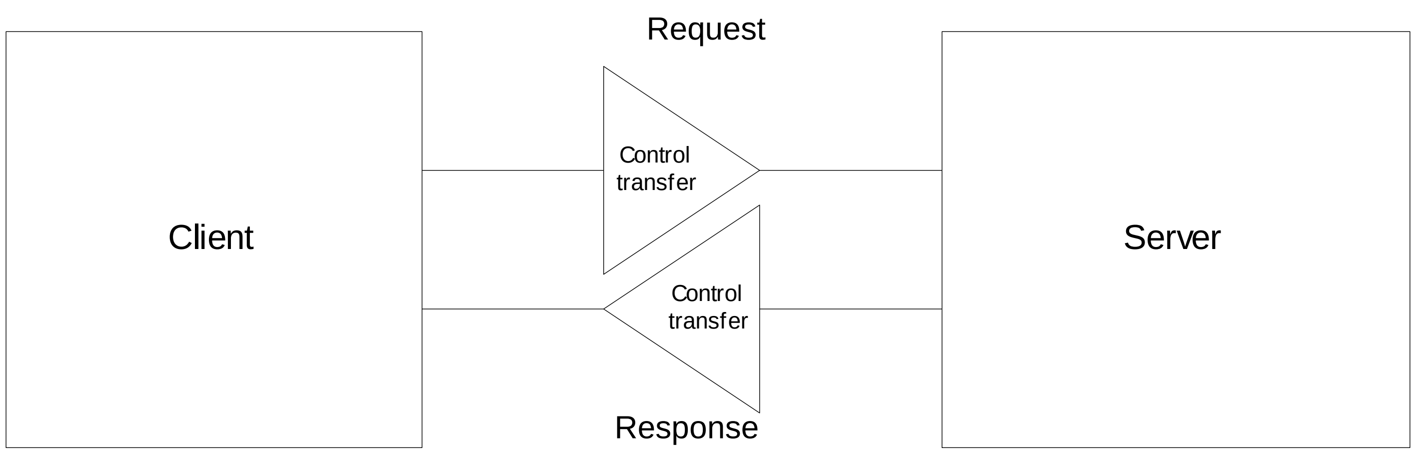


Figure 1.6 Simple Client-Server Model

Notes

- Post office analogy; clerk the server, and the customer the client
- Client always initiates requests
- Server always responds
- Notice that control is handed over to the receiving entity.

Client/Server Examples

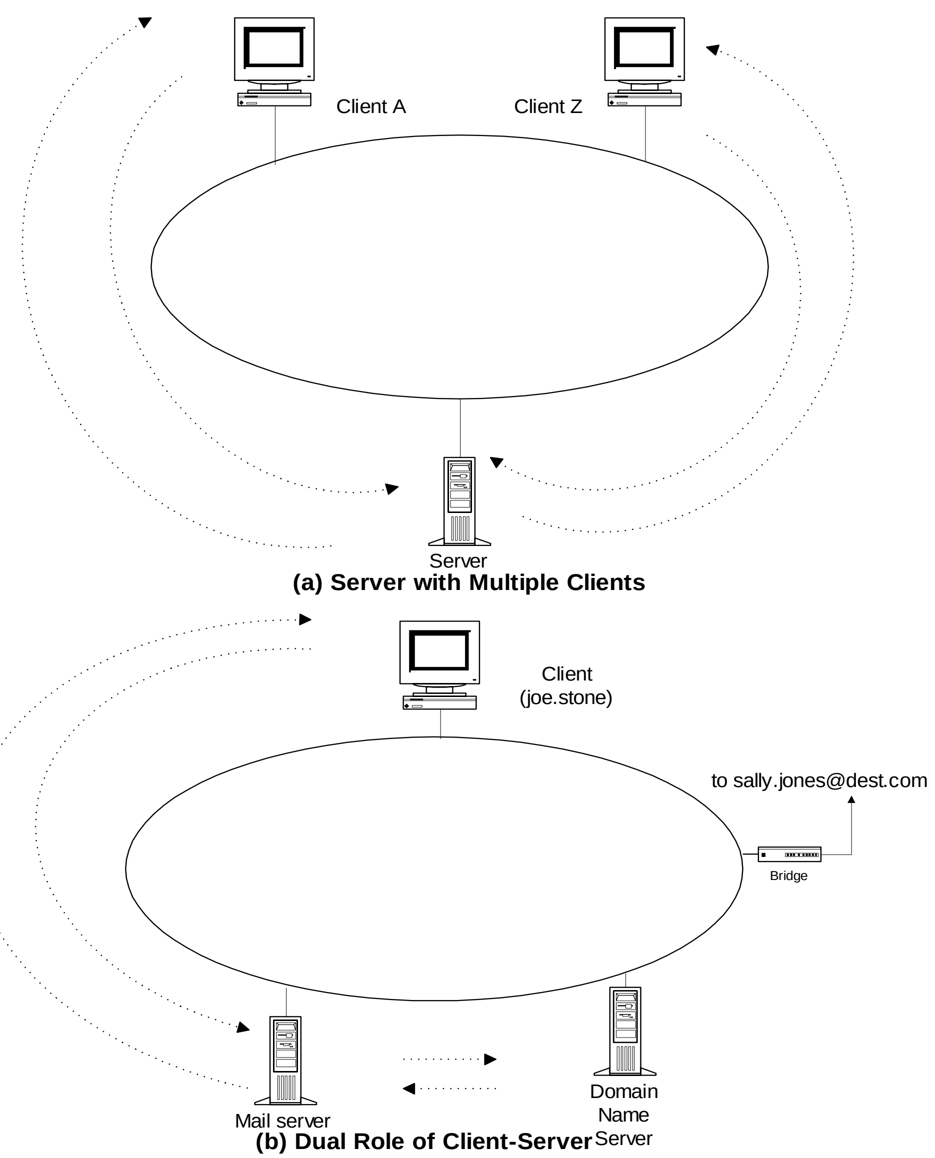


Figure 1.7 Client-Server in Distributed Computing Environment

Notes

TCP/IP Based Networks

- TCP/IP is a suite of protocols
- Internet is based on TCP/IP
- IP is Internet protocol at the network layer level
- TCP is connection-oriented transport protocol and ensures end-to-end connection
- UDP is connectionless transport protocol and provides datagram service
- Internet email and much of the network mgmt. messages are based on UDP/IP
- ICMP part of TCP/IP suite

Notes

Internet Control Message Protocol (ICMP) is an error reporting and diagnostic utility and is considered a required part of any IP implementation.

Understanding ICMP and knowing what can possibly generate a specific type of ICMP is useful in diagnosing network problems.

Internet Configuration

Notes

- Walk through the scenario of email from Joe to Sally

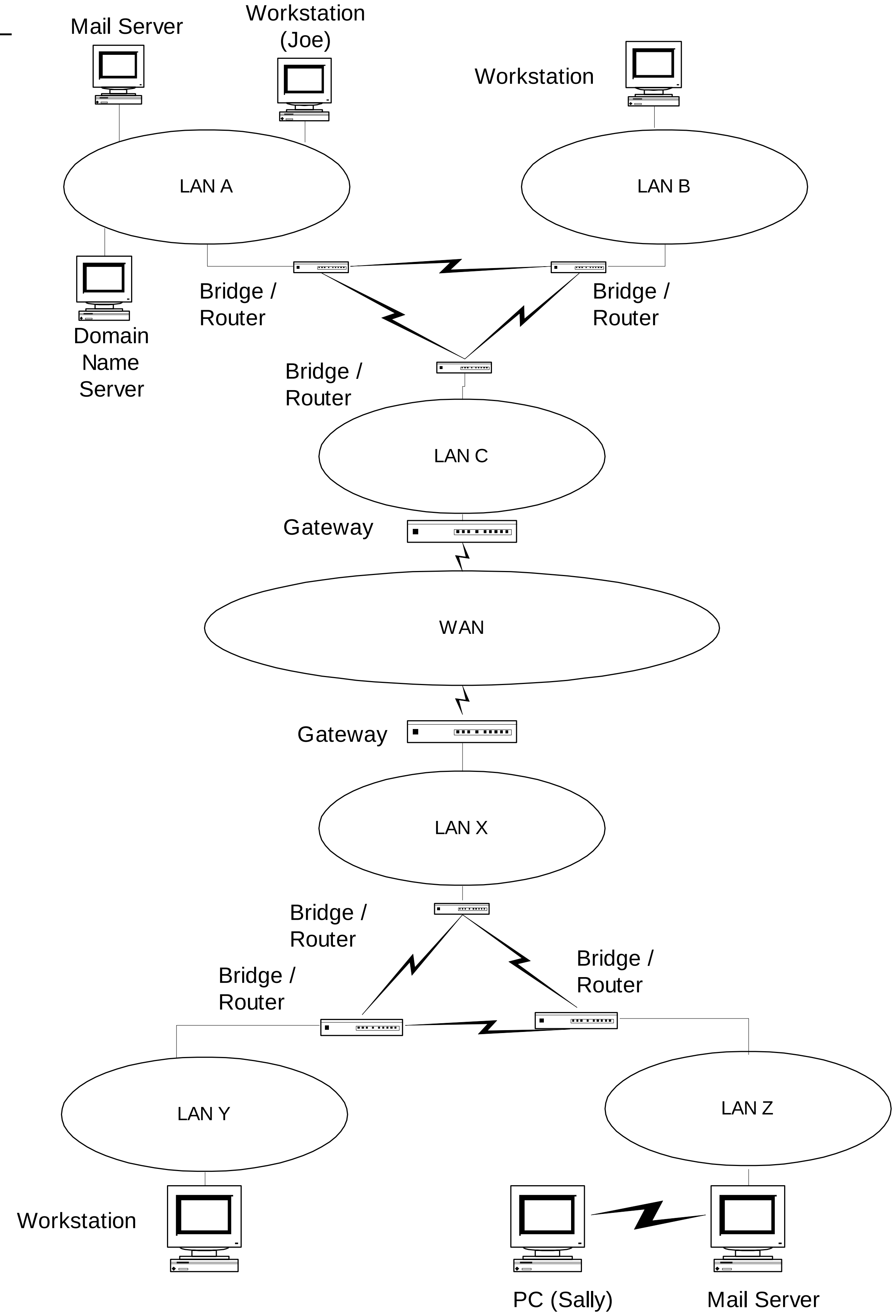


Figure 1.8 Internet Configuration

Architecture, Protocols and Standards

- Communication architecture
  - Modeling of communication systems, comprising
    - Functional components
    - Operations interfaces between them
- Communication protocols
  - Operational procedures
    - Intra- and inter-modules
- Communication standards
  - Agreement between manufacturers on protocols of communication equipment on
    - Physical characteristics
    - Operational procedures

Notes

- Examples: (Students to call out)

Communication Architecture

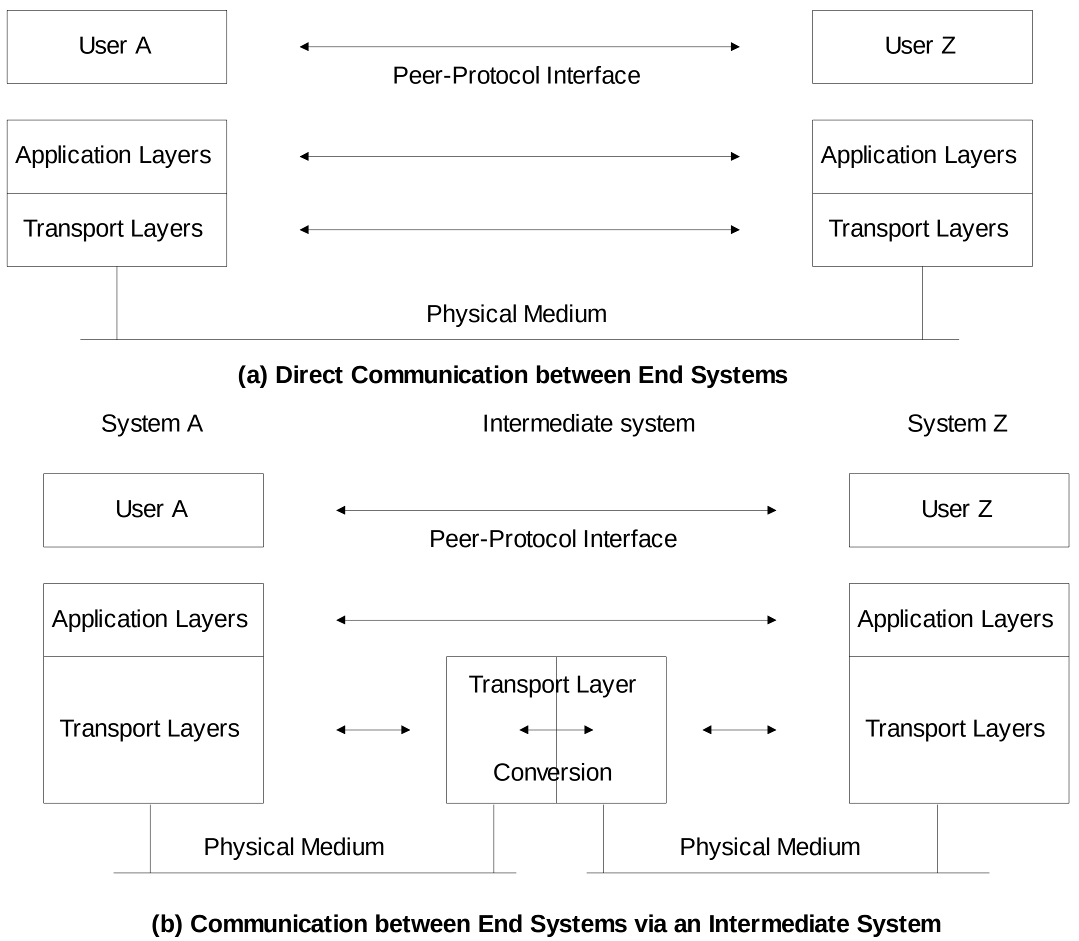


Figure 1.10 Basic Communication Architecture

Notes

- Inter-layer interface: user and service provider
- Peer-layer protocol interface
- Analogy of hearing-impaired student
- Role of intermediate systems
- Gateway: Router with protocol conversion as gateway to an autonomous network or subnet

OSI Reference Model

User / Application program

↕

Layer 7	Application
Layer 6	Presentation
Layer 5	Session
Layer 4	Transport
Layer 3	Network
Layer 2	Data link
Layer 1	Physical

↕

Physical medium

Figure 1.11 OSI Protocol Layers

Notes

- Importance of the knowledge of layer structure in NM

The **Open Systems Interconnection model** (**OSI**) is a conceptual model that characterizes and standardizes the internal functions of a communication system by partitioning it into abstraction layers.

OSI Layers and Services

Layer No.	Layer Name	Salient services provided by the layer
1	Physical	-Transfers to and gathers from the physical medium raw bit data -Handles physical and electrical interfaces to the transmission medium
2	Data link	-Consists of two sublayers: Logical link control (LLC) and Media access control (MAC) -LLC: Formats the data to go on the medium; performs error control and flow control -MAC: Controls data transfer to and from LAN; resolves conflicts with other data on LAN
3	Network	Forms the switching / routing layer of the network
4	Transport	-Multiplexing and de-multiplexing of messages from applications -Acts as a transparent layer to applications and thus isolates them from the transport system layers -Makes and breaks connections for connection-oriented communications -Flow control of data in both directions
5	Session	-Establishes and clears sessions for applications, and thus minimizes loss of data during large data exchange
6	Presentation	-Provides a set of standard protocols so that the display would be transparent to syntax of the application -Data encryption and decryption
7	Application	-Provides application specific protocols for each specific application and each specific transport protocol system

Notes

- Importance of services offered by different layers and the protocol conversion at different layers in NM

PDU Communication Model

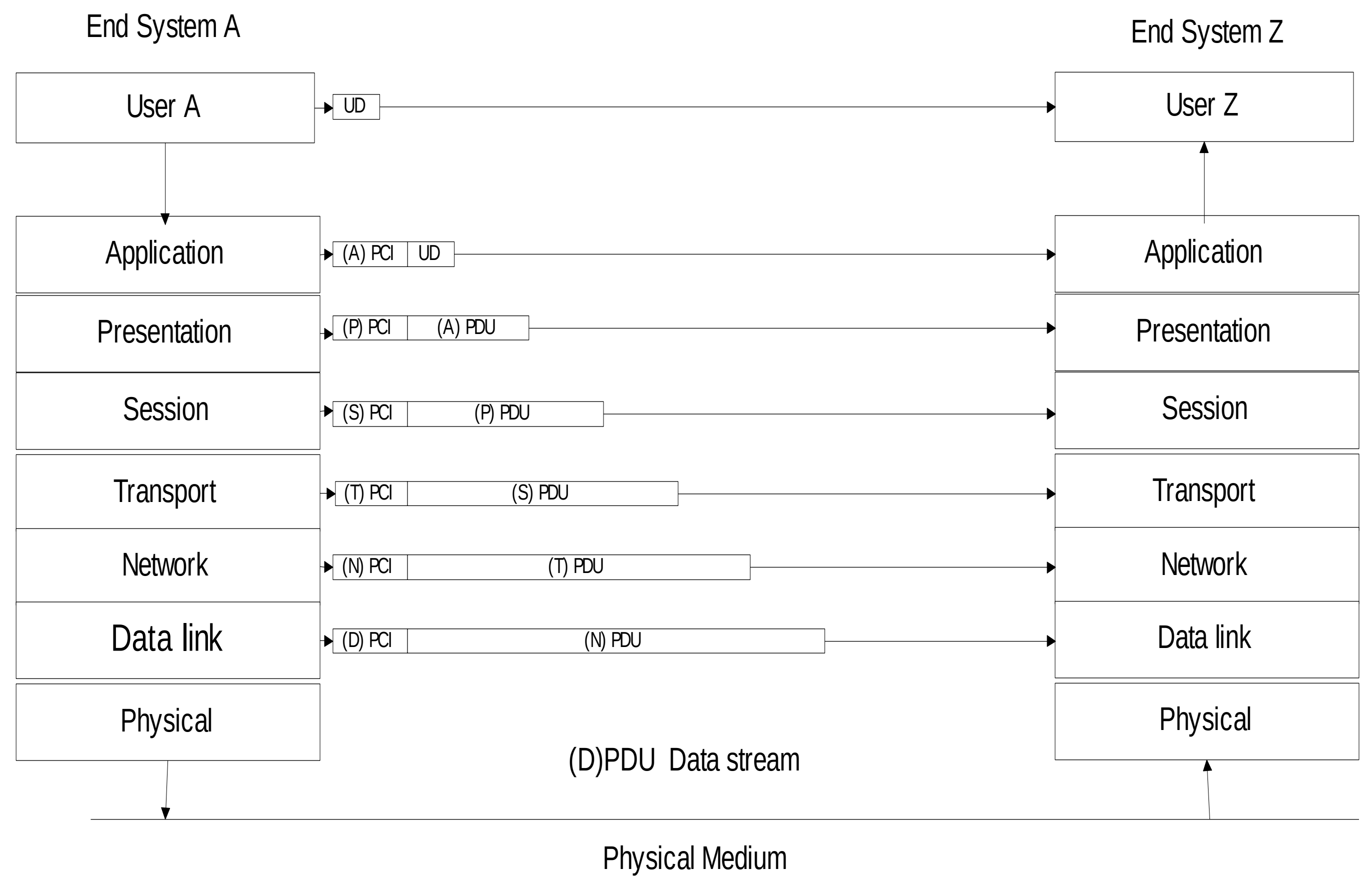
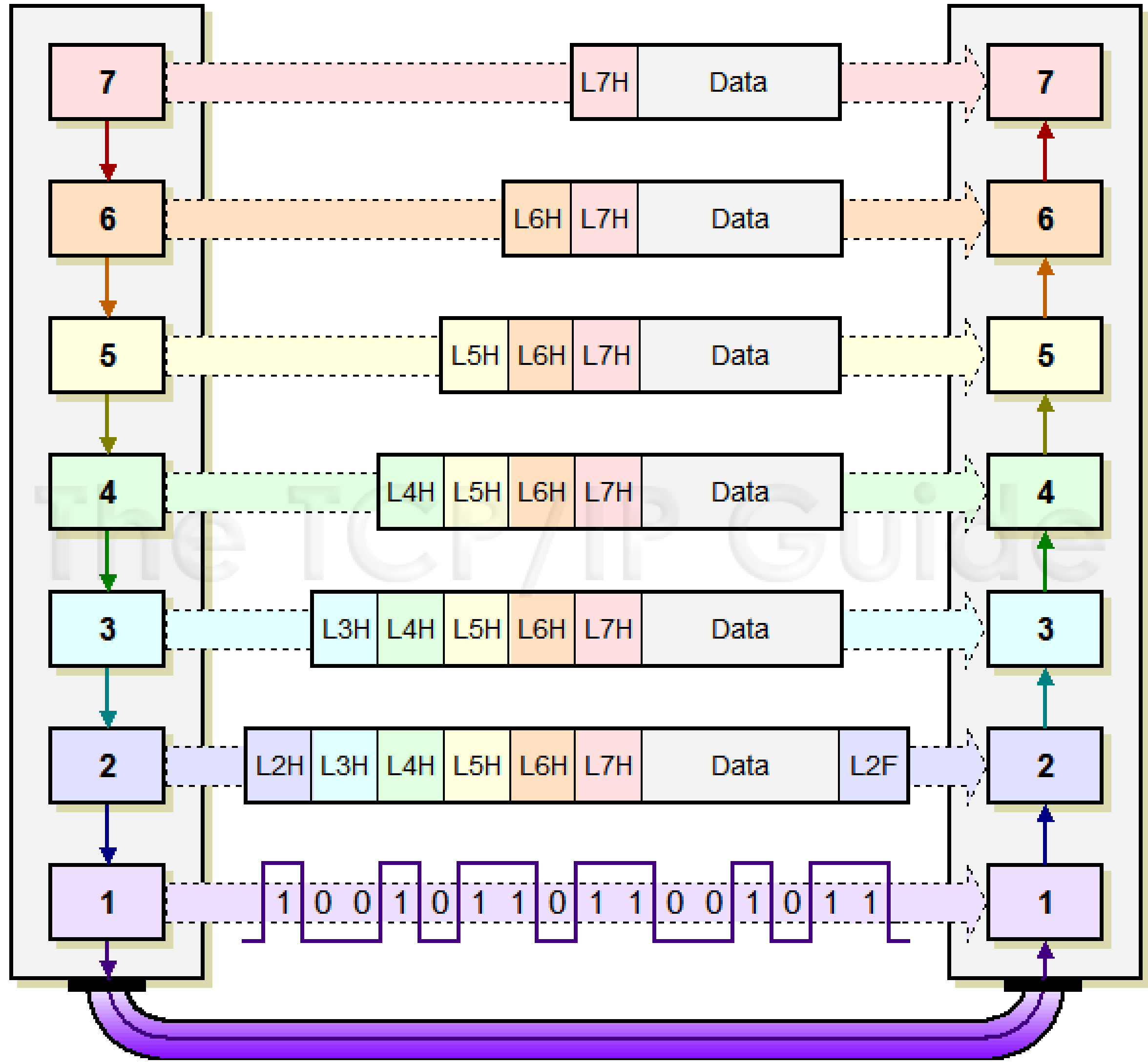


Figure 1.13 PDU Communication Model between End Systems

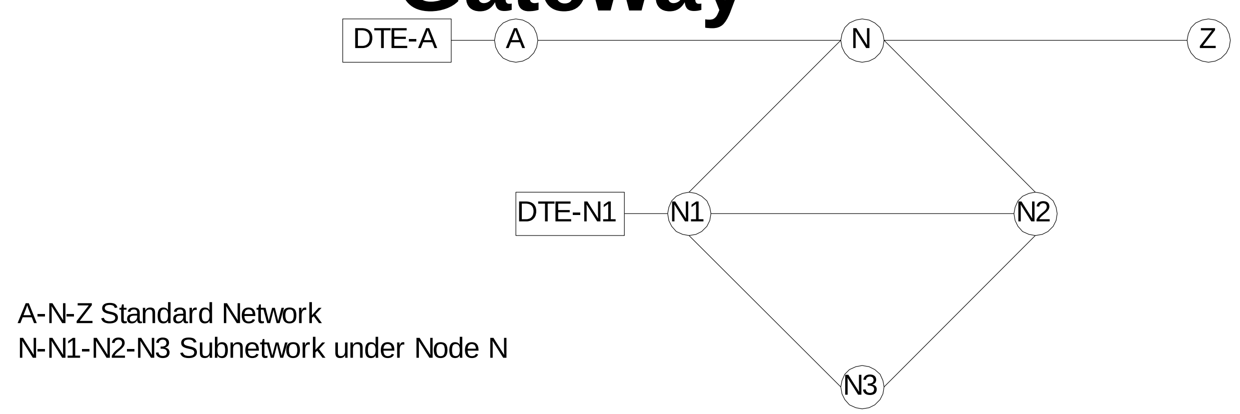
Notes

- What is the relevance of PDU model in NM?

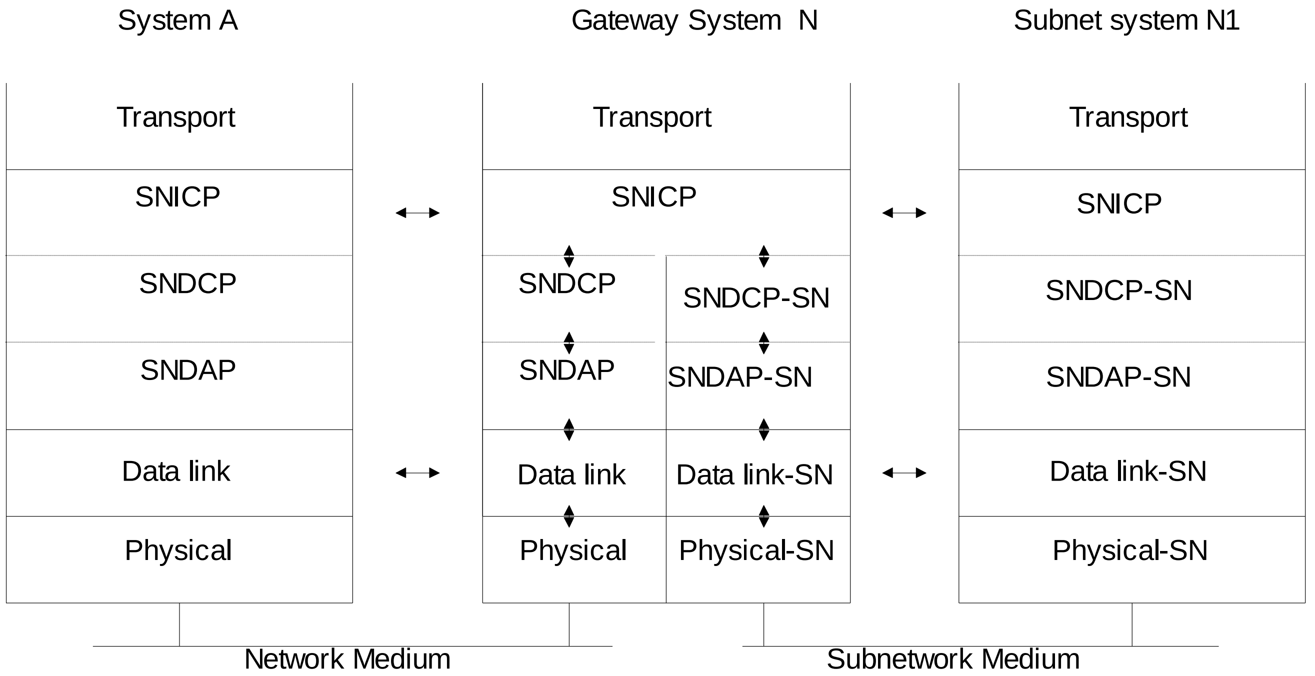


At any particular layer N, a PDU is a complete message that implements the protocol at that layer. However, when this "layer N PDU" is passed down to layer N-1, it becomes the data that the layer N-1 protocol is supposed to service. Thus, the layer N protocol data unit (PDU) is called the layer N-1 service data unit (SDU). The job of layer N-1 is to transport this SDU, which it does in turn by placing the layer N SDU into its own PDU format, preceding the SDU with its own headers and appending footers as necessary. This process is called data **encapsulation**, because the entire contents of the higher-layer message are encapsulated as the data payload of the message at the lower layer.

Gateway



(a) Network configuration



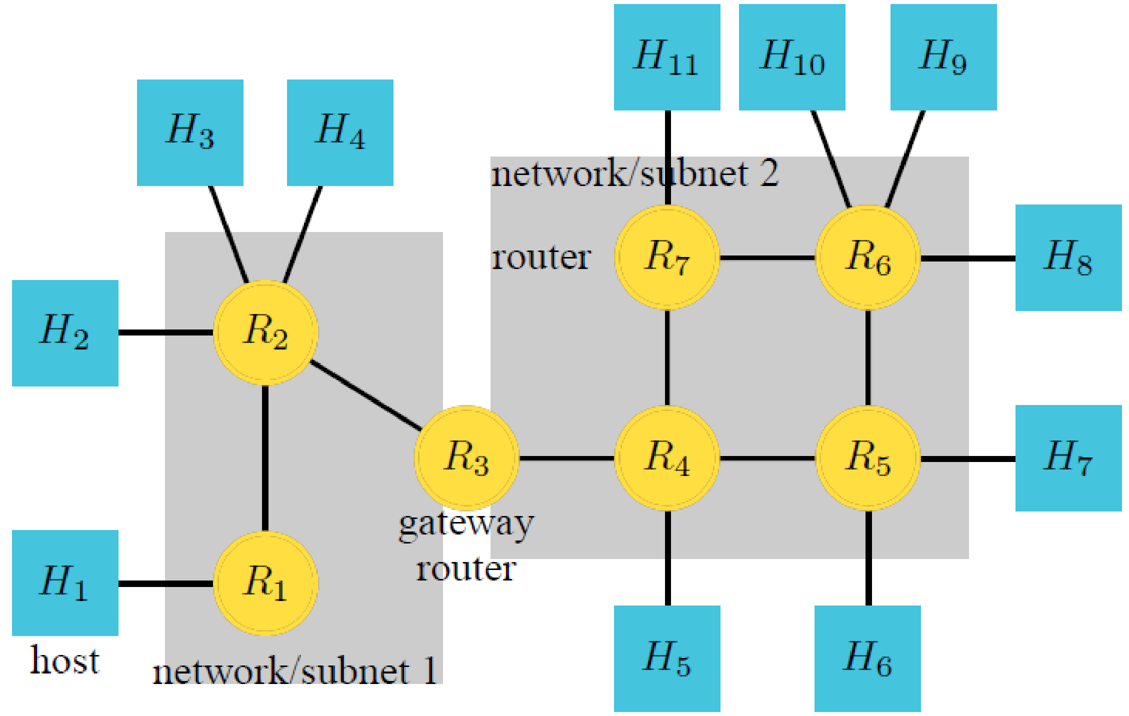
(b) Protocol Communication

Figure 1.16 Gateway Communication to Private Subnetwork

Notes

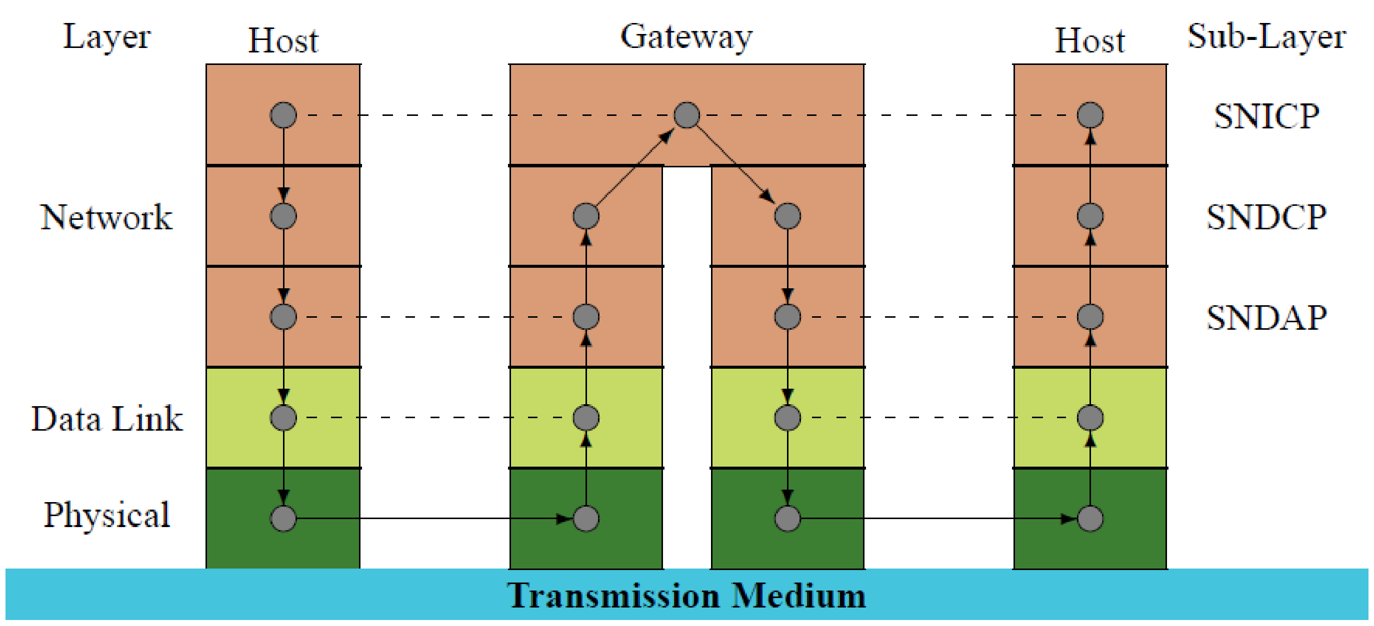
- cc:mail from a station in Novel IPX network to an Internet station with SMTP email

A Network

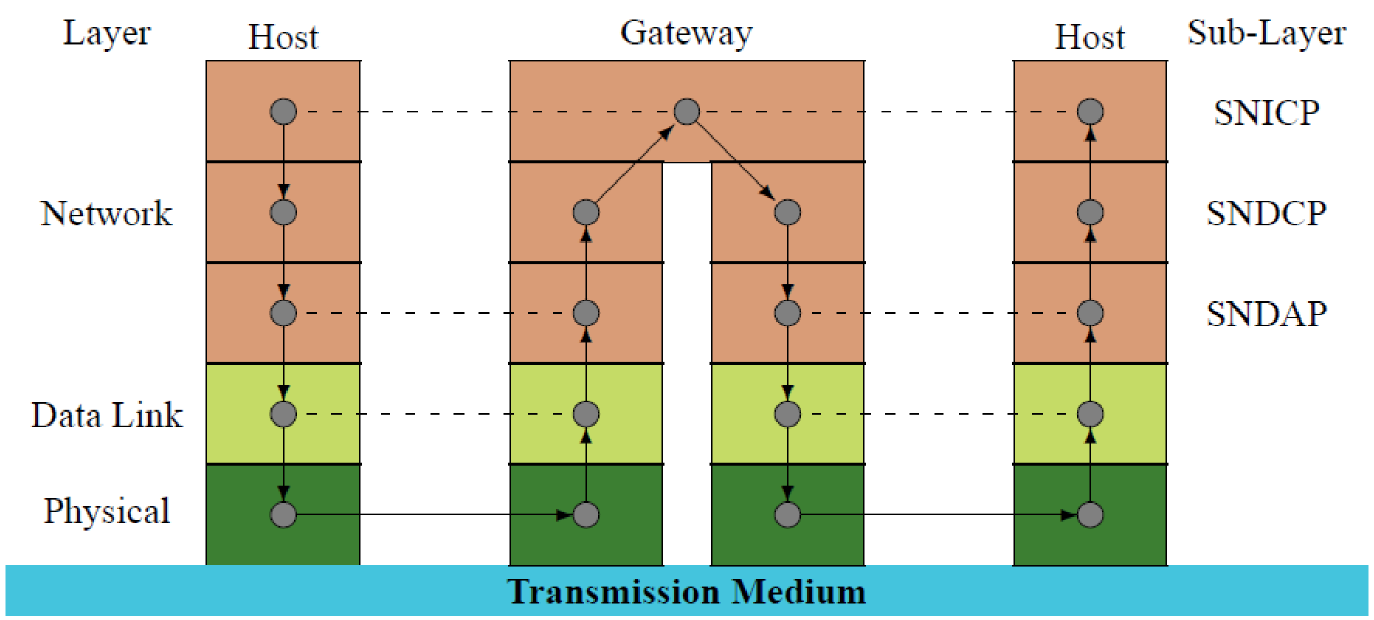


- **gateway** links networks together to form **internet**
- **routing** plans path through network

The OSI Internetworking Model



- **Subnetwork Independent Convergence Protocol (SNICP)**
- **Subnetwork Dependent Convergence Protocol (SNDCP)**
- **Subnetwork Dependent Access Protocol (SNDAP)**



- **Subnetwork Independent Convergence Protocol (SNICP)**
- **Subnetwork Dependent Convergence Protocol (SNDCP)**
- **Subnetwork Dependent Access Protocol (SNDAP)**

Network Layer in 3 sublayers:

1. Subnet Independent Convergence protocol SNICP: provides global functions like addressing

2. Subnet dependent Convergence protocol SNDCP. The SNDCP layer primarily converts, encapsulates and segments external network formats (like Internet Protocol Datagrams) into sub-network formats (called SNPDUs).

3. Subnet dependent Access protocol SNDAP: provides the interface to access a particular network

OSI and Internet

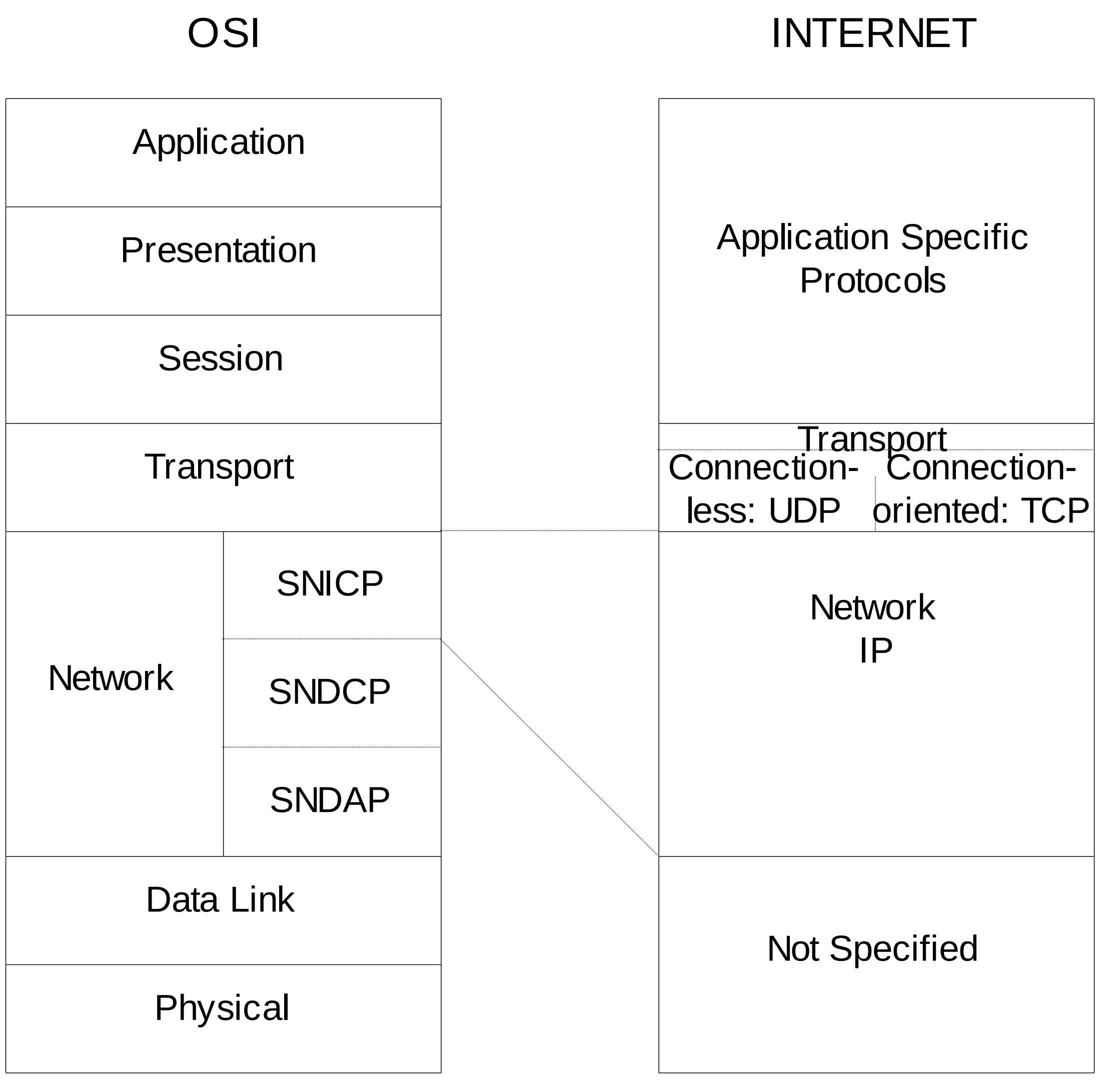


Figure 1.17 Comparison of OSI and Internet Protocol Layer Models

Notes

- Simplicity of Internet; specifies only layers 3 and 4
- Integrated application layers over Internet
- Commonality of layers 1 and 2 - IEEE standard

Application Protocols

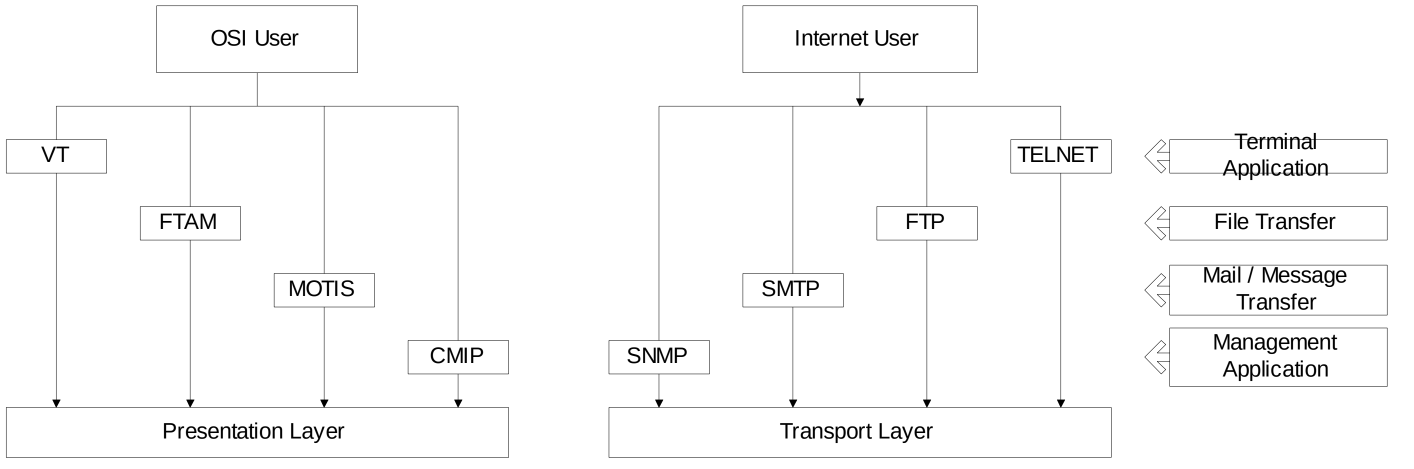


Figure 1.18 Application Specific Protocols in ISO and Internet Models

Notes

Internet user	**OSI user**
Telnet	Virtual Terminal
File Transfer Protocol	File Transfer Access & Mgmt
Simple Mail Transfer Protocol	Message-oriented Text Interchange Standard
Simple Network Management Protocol	Common Management Information Protocol

Broadband Network

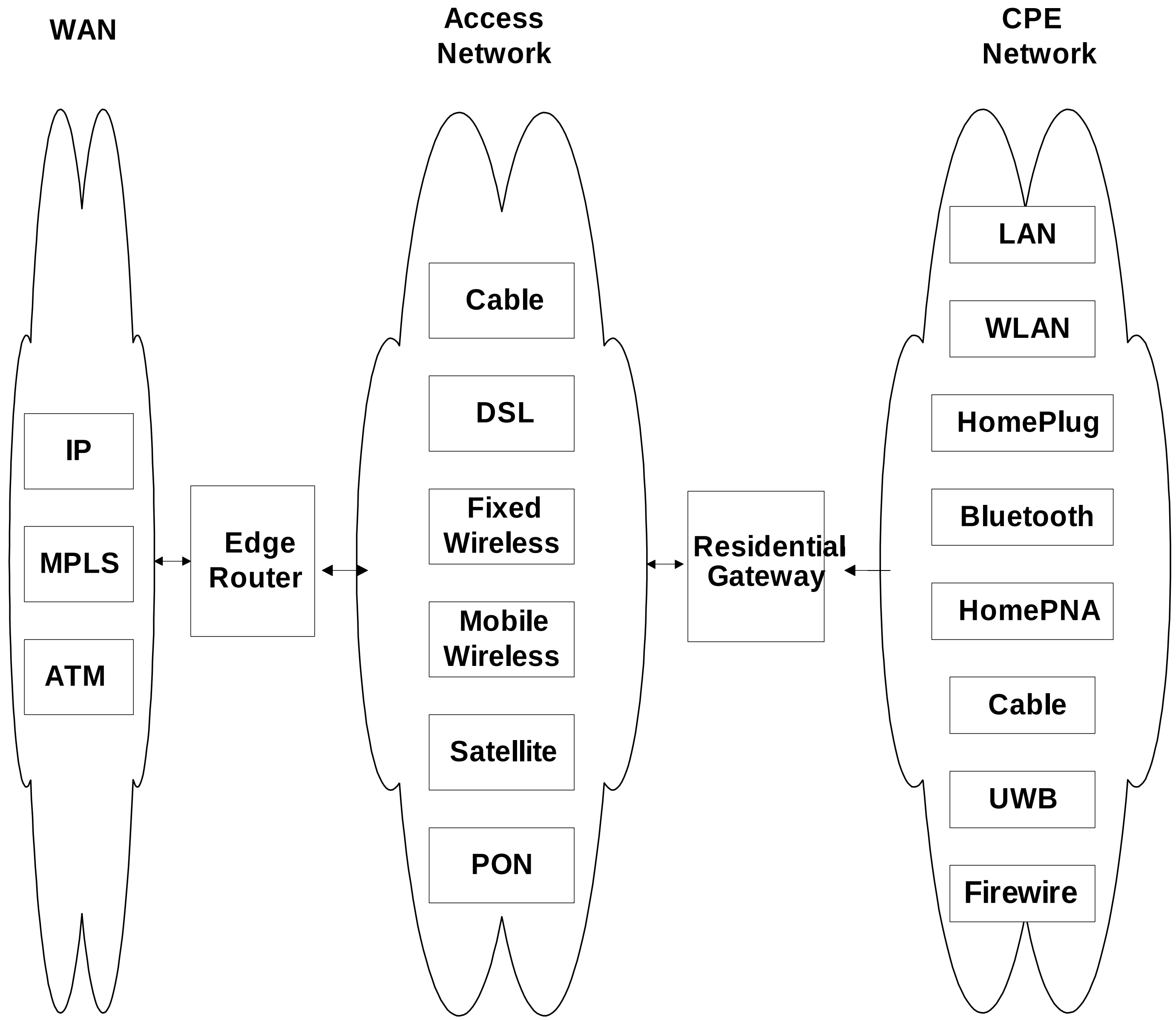
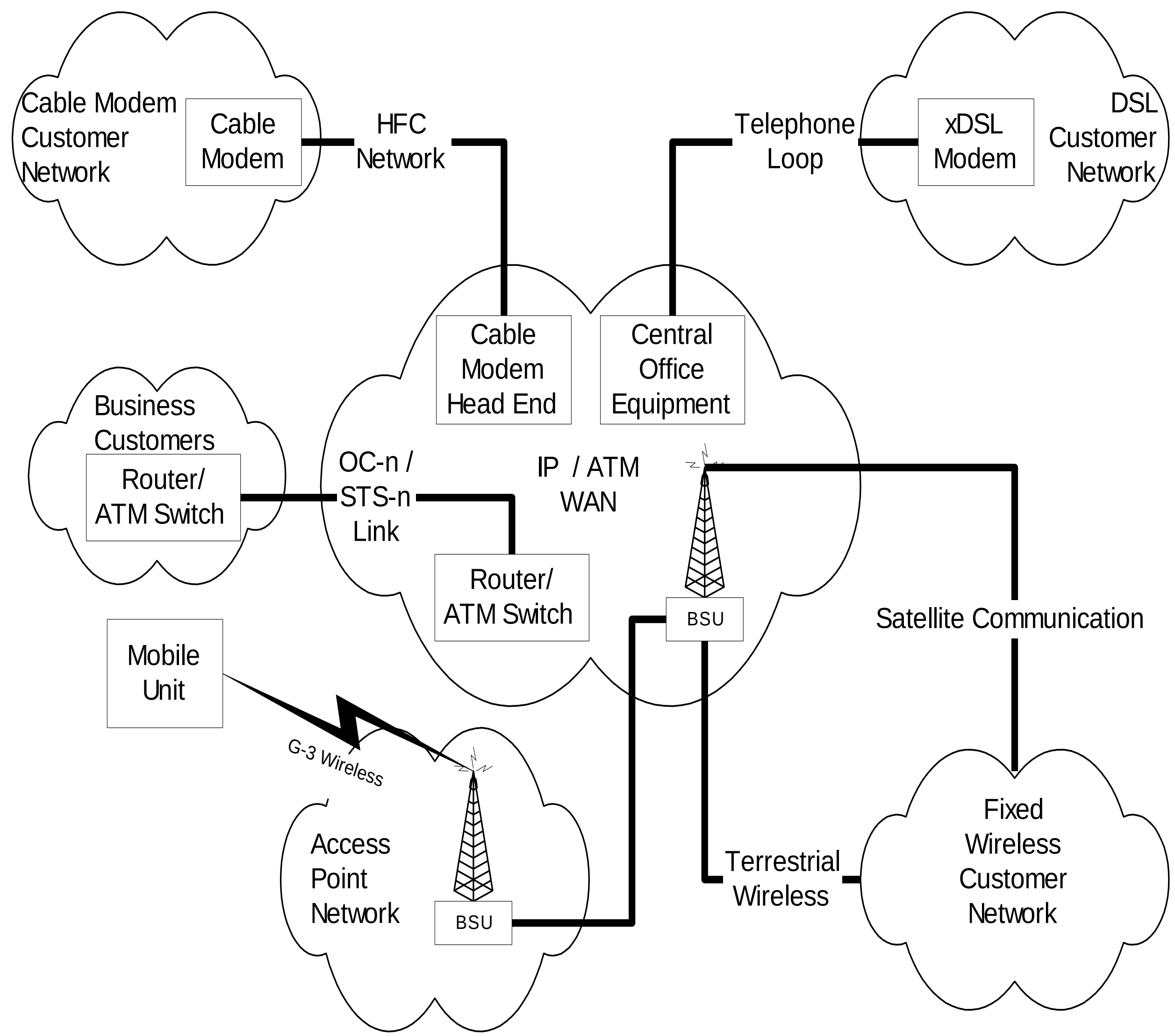


Figure 1.19 Broadband Network Segments and Technologies

Notes

Broadband Access Networks



Figue 1.20 Broadband Access Networks

Notes

Centrally Managed Network Issues

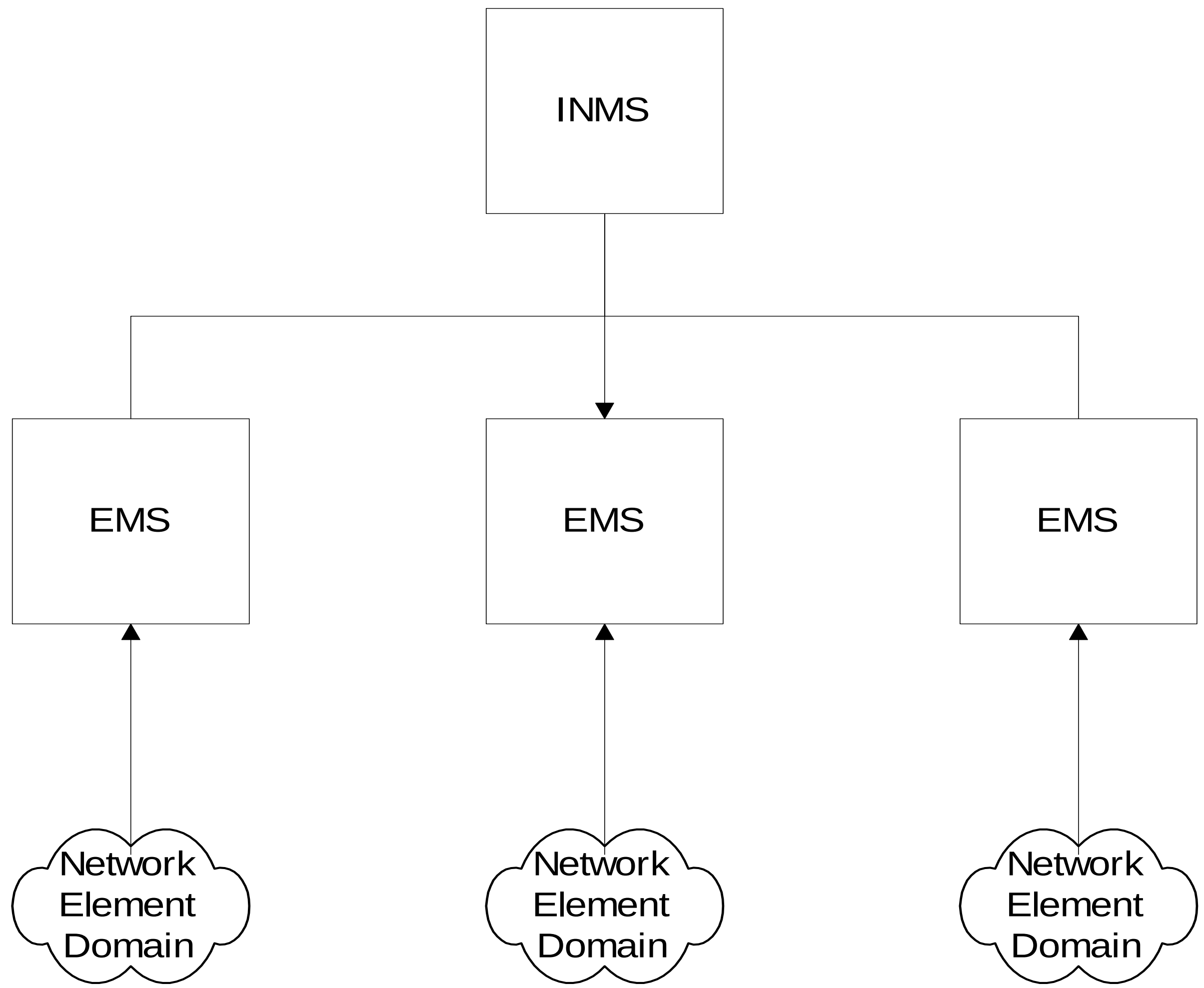


Figure 1.21 Case History 2: Centrally Managed Network Issues

Notes

Some Common Network Problems

- Loss of connectivity
- Duplicate IP address
- Intermittent problems
- Network configuration issues
- Non-problems
- Performance problems

Notes

Challenges of IT Managers

- Reliability
- Non-real time problems
- Rapid technological advance
- Managing client/server environment
- Scalability
- Troubleshooting tools and systems
- Trouble prediction
- Standardization of operations - NMS helps
- Centralized management vs. “sneaker-net”

Notes

Network Management

Network Management can be defined as Operations, Administration, Maintenance, and Provisioning (OAMP) of a network and its services.

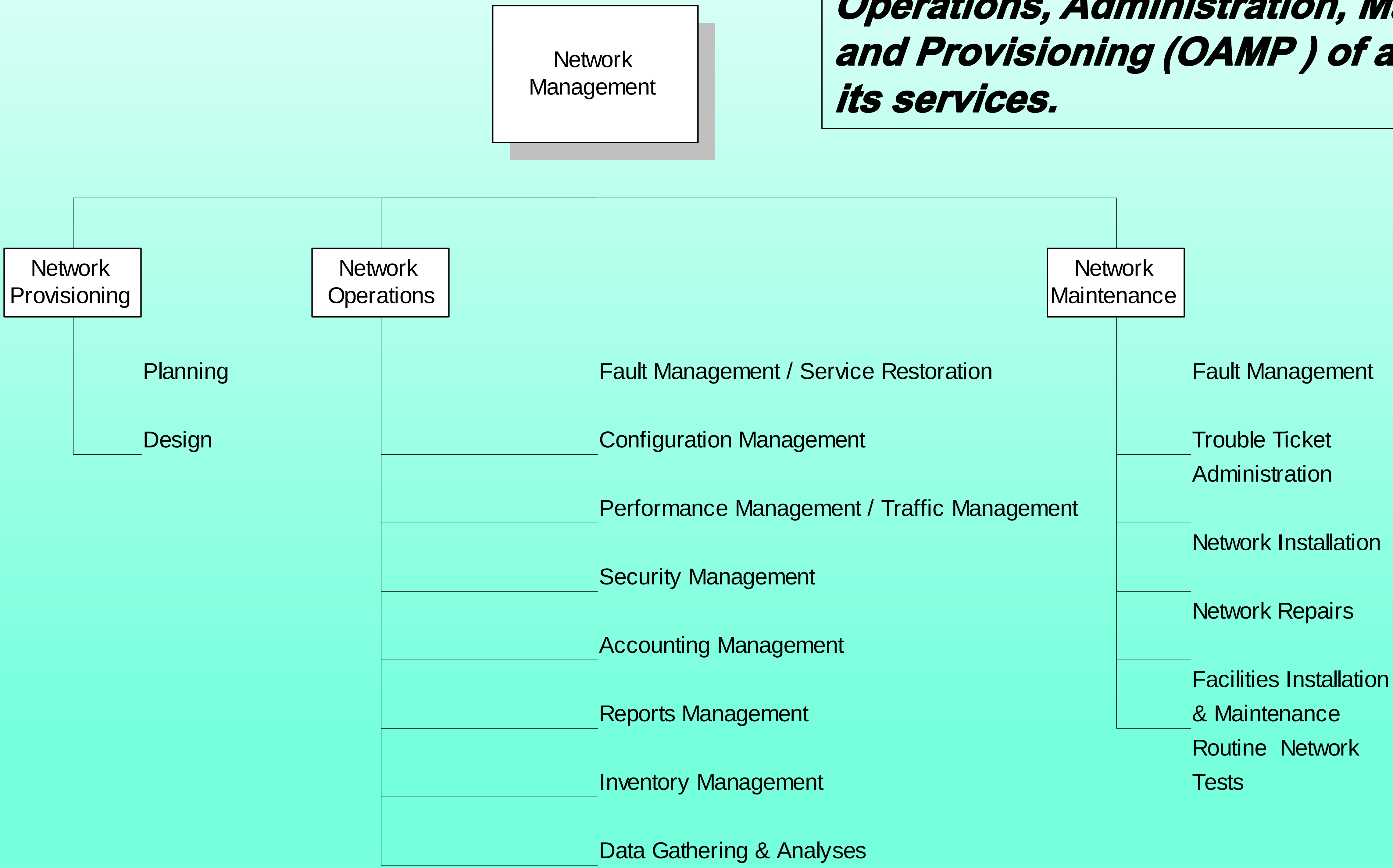


Figure 1.22 Network Management Functional Groupings

NM Functional Flow Chart

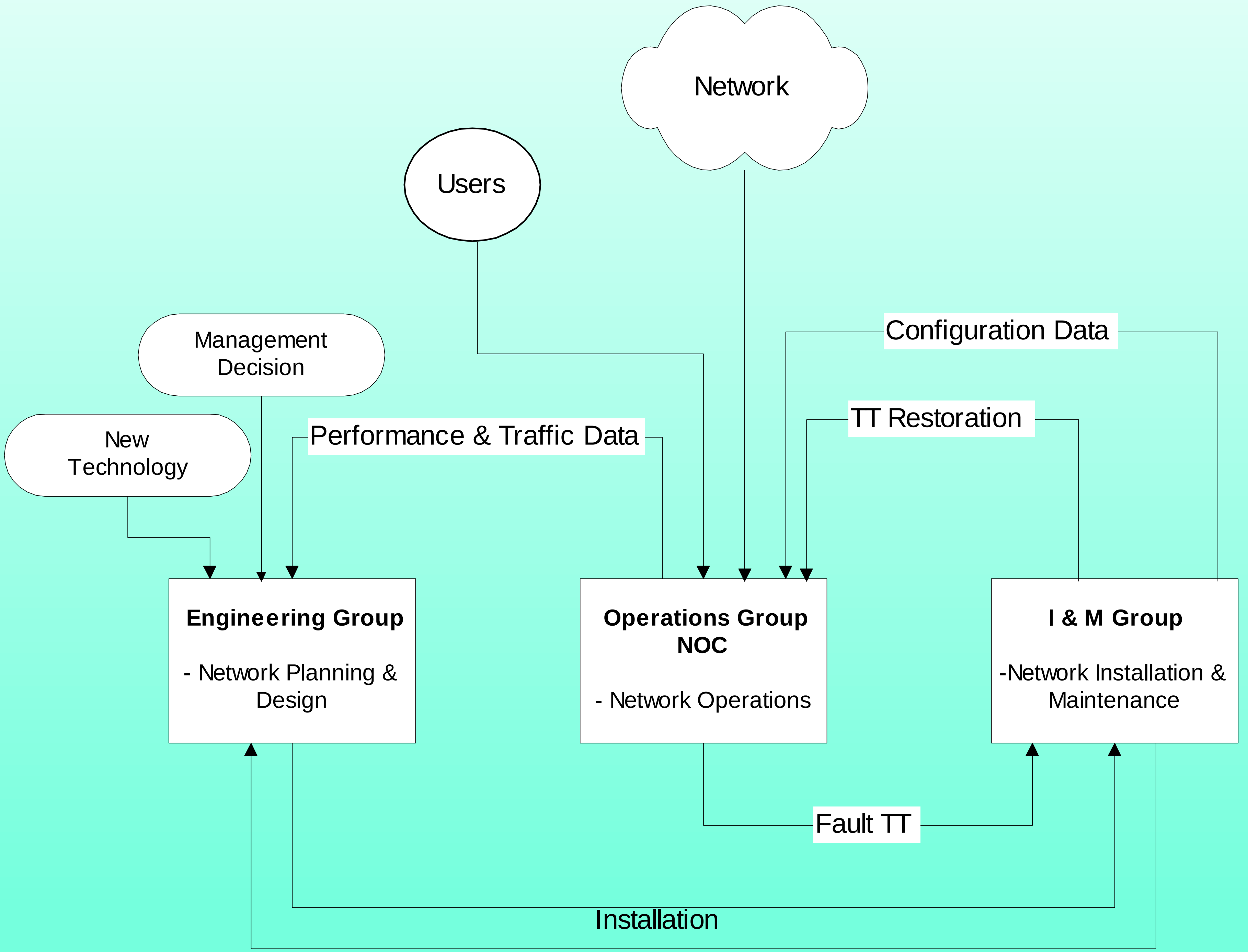


Figure 1.23 Network Management Functional Flow Chart

NETWORK MANAGEMENT ARCHITECTURE AND ORGANIZATION

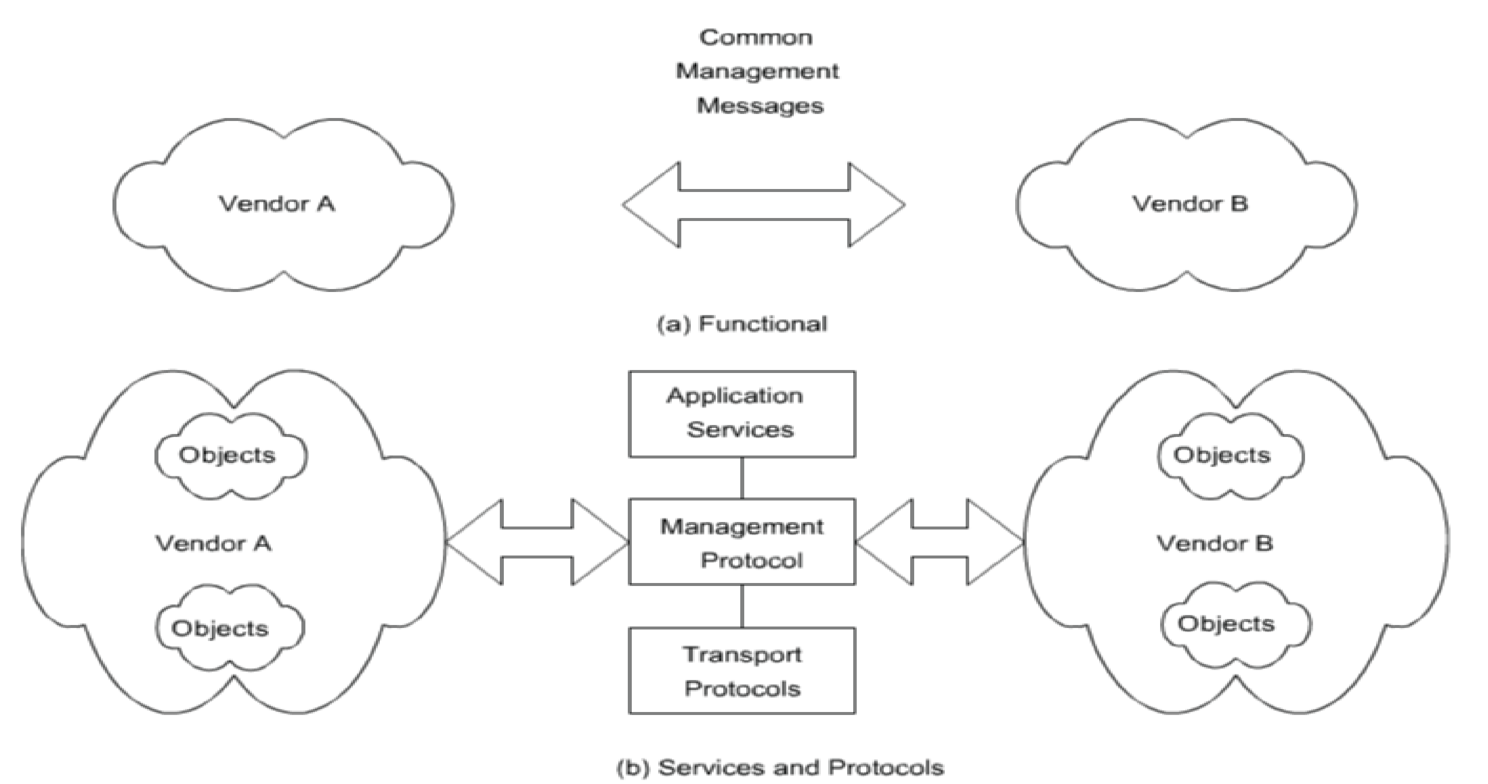


Figure 1.24 Network Management Dumbbell Architecture

Data networks

- Network management dumbbell architecture for interoperability is shown in Figure 1.24(a) where two vendor systems A and B exchange common management messages [management information data (type, id, and status of managed objects, etc.) + management controls (setting and changing configuration of an object)].

- Interoperability according to dumbbell architecture is achieved in 3 levels presented in Figure 1.24(b):
  - Application services are the management-related applications such as fault and configuration management. Management protocols are CMIP for the OSI model and SNMP for the Internet model. Transport protocols are the first four OSI layers for the OSI model and TCP/IP over any of the first two layers for the Internet model.

Common Management Information Protocol (CMIP) is **a network management protocol** built on the Open Systems Interconnection (OSI) communication model.

The related Common Management Information Services (CMIS) defines services for accessing information about network objects or devices, controlling them, and receiving status reports from them.

NM Components

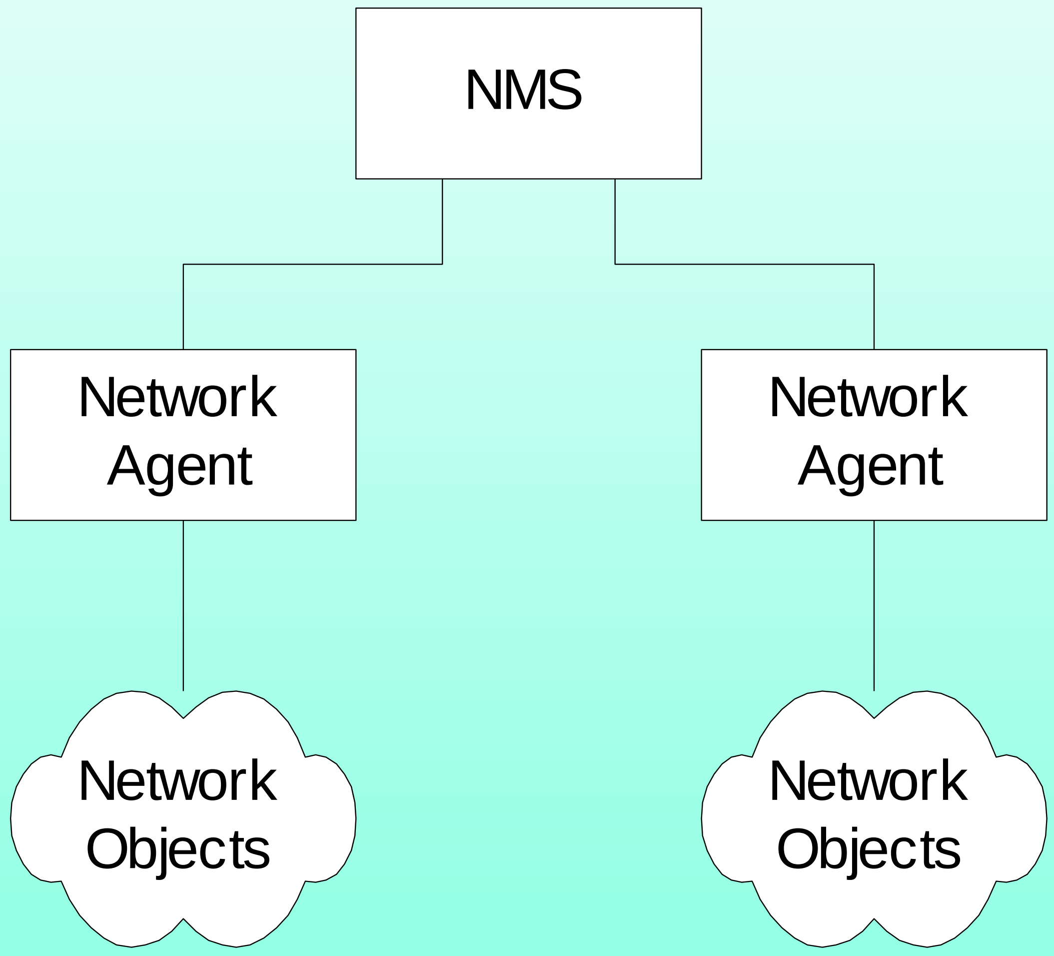


Figure 1.25 Network Management Components

- Figure 1.25 models ***a hierarchical configuration*** of two network agents monitoring two sets of managed objects.

- The agent could be an embedded (software) agent in a network element or an EMS (**element management system** –not embedded, standalone system) communicating with (software) agents embedded in the network elements.

- An NMS is at the top of the hierarchy.

- Each network agent monitors its respective objects. Either in response to a polled query from the NMS or triggered by a local alarm, the agent communicates to the NMS the relevant data

- Managed objects can be
  - Network elements (hardware, system)
    - Hubs, bridges, routers, transmission facilities
  - Software (non-physical)
    - Programs, algorithms
  - Administrative information
    - Contact person, name of group of objects (IP group)

Interoperability Ctd.

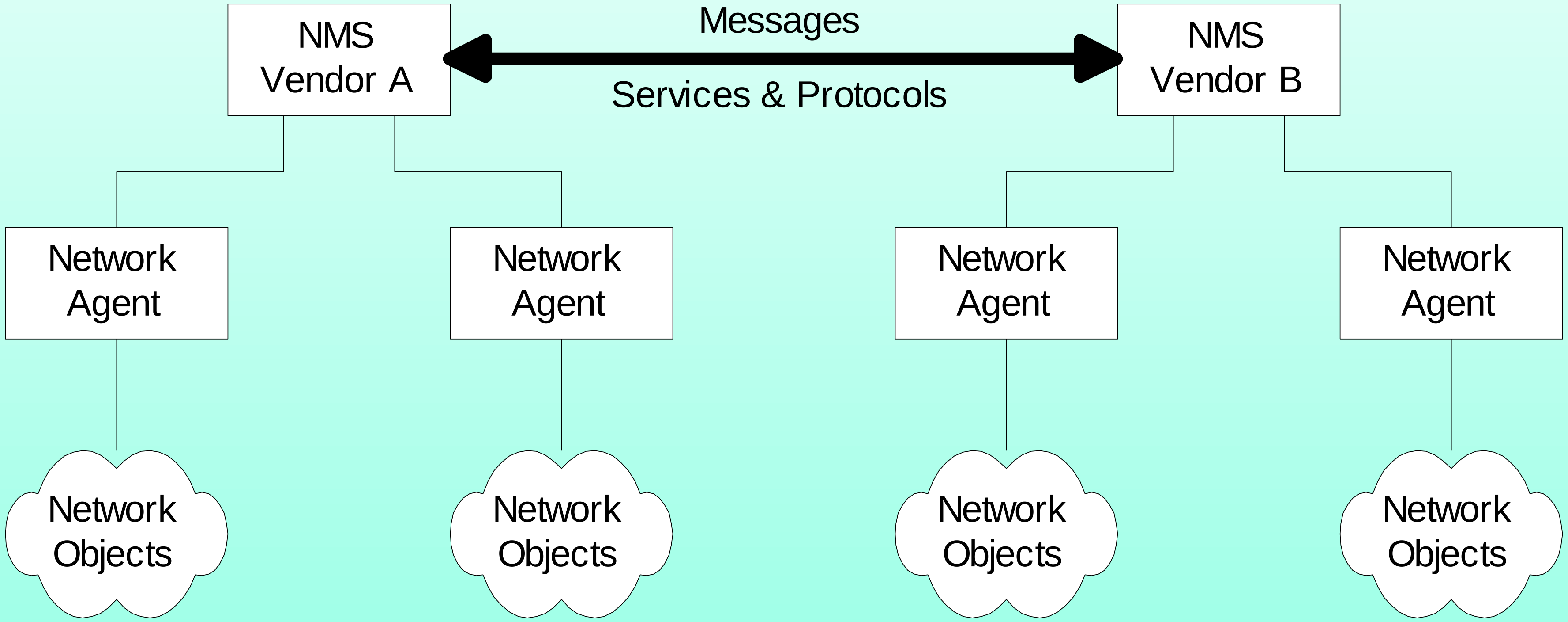


Figure 1.26 Network Management Interoperability

Peer networks can communicate network management messages and controls between each other, as shown in Figure 1.26.

An example where such a configuration could be implemented would be two NMSs associated with two telecommunication networks belonging to two network service providers. As the two NMSs communicate with each other, each NMS can superimpose the data from the other and present an integrated picture to the network administrator.

Network Management Perspectives

The NMS primarily manages the networks that transport information. However, from a user's perspective, networks are means to an end, namely to have access to information across the networks. Examples include :

- Users' needs require a total solution to manage the networks, system resources, and applications that run on systems. Applications could be specific user applications, or general-purpose: file servers, database servers, and DNSs..
- An IT manager is interested in more than managing networks, systems, and applications. He or she would like to automate other functions such as back up of databases and programs, downloading of software updates from a central location, and a host of other support functions.

Network Management can be seen from different perspectives

- Network Management (**Infrastructure**)
- Service Management
- Service and Network Provisioning
- Application Management
- e-Commerce Management
- Inventory Management
- Integrated Management
- Business Management
- Information Management
- Management Protocols
- Management Technologies

Infrastructure Perspective

- Domains :
  - many types of classification:
    - a geographical domain
    - Vendor
    - technology (IP-based products, telecommunication products, broadband communication products, and digital transport products such as SDH)
  - could each define a domain managed by a separate NMS, as well as a different administrative group
- Protocols
- Technologies
- Transmission Media
- Transmission Modes
- Service Functions

Service Perspective

- Communication Services
- Computing Services
- Content Services
- IT Services
- Application Services

Notes

Status and Future Trends

- Status:
  - SNMP management: Current NMSs are based on SNMP protocol (transport of management information for SNMP management, is TCP/IP-based)

  - Limited CMIP management: One of the limitations of SNMP-based management system is that values of managed objects should be defined as scalar values. OSI-based management protocol, CMIP (Common Management Information Protocol), is object oriented. However, it has not been successful due to the complexity of specifications of managed objects and the limitation of large memory in computer systems in the past.

  - Operations systems While the EMS, NMS, and enterprise management system are designed to manage the network and network resources, OSSs (Operations Support Systems) support the operation of network and service management systems.

    - Provisioning System :The logical and physical network has to be provisioned to provide the desired service to the customer. An OSS, provisioning management system, does this function using several other OSSs such as the inventory management system, the service order system, and the element and NMSs. Provisioning management includes circuit provisioning, service provisioning, and network provisioning.
    - Inventory Management System includes inventory of equipment and facilities.
    - …..

Status and Future Trends

- Status:
  - Polled systems :
    - Another limitation of SNMP-based management is that it is a poll-based system: NMS polls each agent as to its status, or for any other data that it needs for network management. Only a small set of transactions is initiated by a management agent to an NMS as alarms. To detect a fault quickly, or to obtain good statistics, more frequent polling of agents needs to be done by the NMS, which adds to network traffic overhead. There is an alternative solution to this problem, which is deployment of remote monitors as discussed in Chapter 8.

Status and Future Trends

- Current Focus:
    - Object-oriented approach: Object-oriented technology has reached a matured stage, and the hardware capacity to handle object-oriented stacks is now commercially available. Thus, object-oriented network management is being reconsidered
    - Service and policy management
    - Business management
    - Web-based client management
- Future Trends
    - Web-based management?
    - XML based management