University of Nottingham
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COMPUTER NETWORKS

AY2022-2023 Spring Semester

COMP1047 Systems & Architecture

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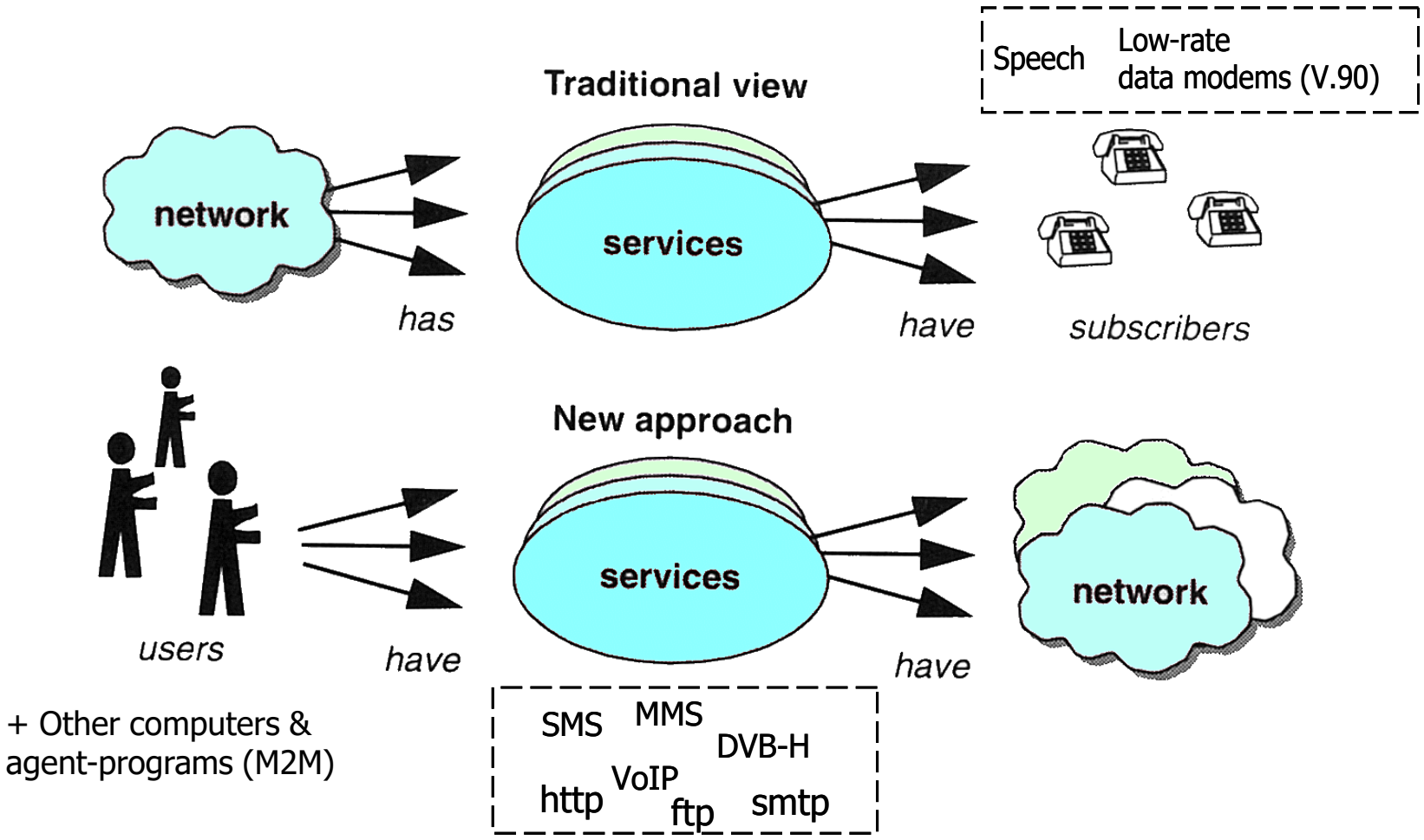
Computer Networks Part-1. Fundamental Concepts

Evolution of Networks

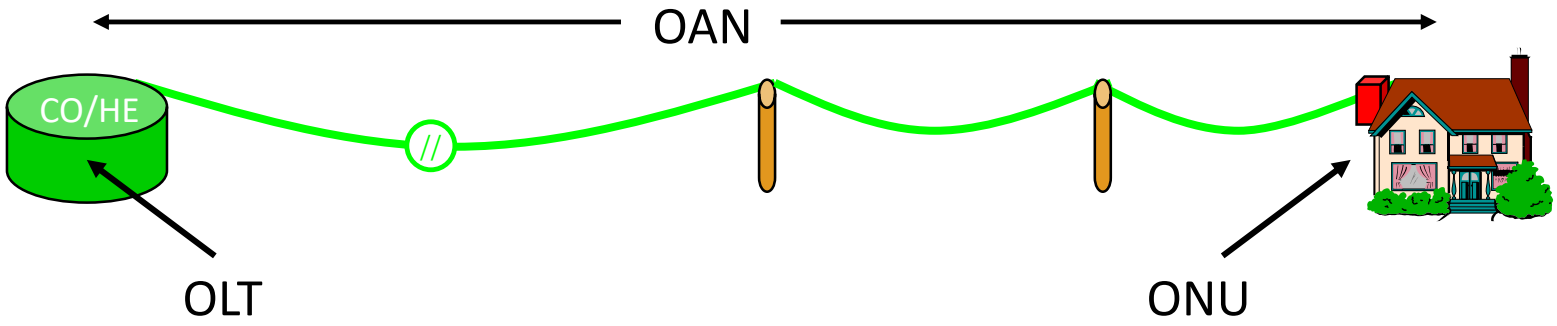


- **The paradigm shift in Networks**

Fibre To The x - FTTx

- The industry today has earmarked the penetration of fibre into the access network as "*FTTx*" (Fibre To The x)
- The FTTx covers a number of technologies and protocols
  - For example: some of today's digital subscriber line (DSL) and hybrid fibre coax (HFC) networks qualify as FTTx networks due to their use of fibre in the access, as does a passive optical network (PON)
  - Hence, it is best when referring to a deep fibre penetration network to refer to its actual architecture
- The most common architectures are
  - ***FTTHome*** (***FTTH***)
  - ***FTTBuilding*** (***FTTB***)
  - ***FTTCurb*** (***FTTC***)
  - ***FTTNode*** (***FTTN***)

Fibre To The x - FTTx



- An OAN in which the ONU is on or within the customer's premise
- Although the first installed capacity of a FTTH network varies, the *upgrade capacity of a FTTH network exceeds all other transmission media*

OAN: Optical Access Network *ONU: Optical Network Unit* *OLT: Optical Line Termination*

Networks Classification

Communication networks are classified according to the distance over which they operate.

The networks are sources of directly generated data:

[1] *Wide Area Networks (**WAN**s):* The subscribers are geographically wide apart and are interconnects across metropolitan, regional and international boundaries.

[2] *Metropolitan Area Networks (**MAN**s):* A data network designed for a town or city.

[3] *Local Area Networks (**LAN**s)*: The subscribers are geographically close together (that is, in the same building) or in the same area.

[4] *Campus Area Networks (**CAN**s):* The subscribers are within a limited geographic area, such as a university campus or business area.

[5] *Home Area Networks (**HAN**s):* A network contained within a user's home that connects a person's digital devices.

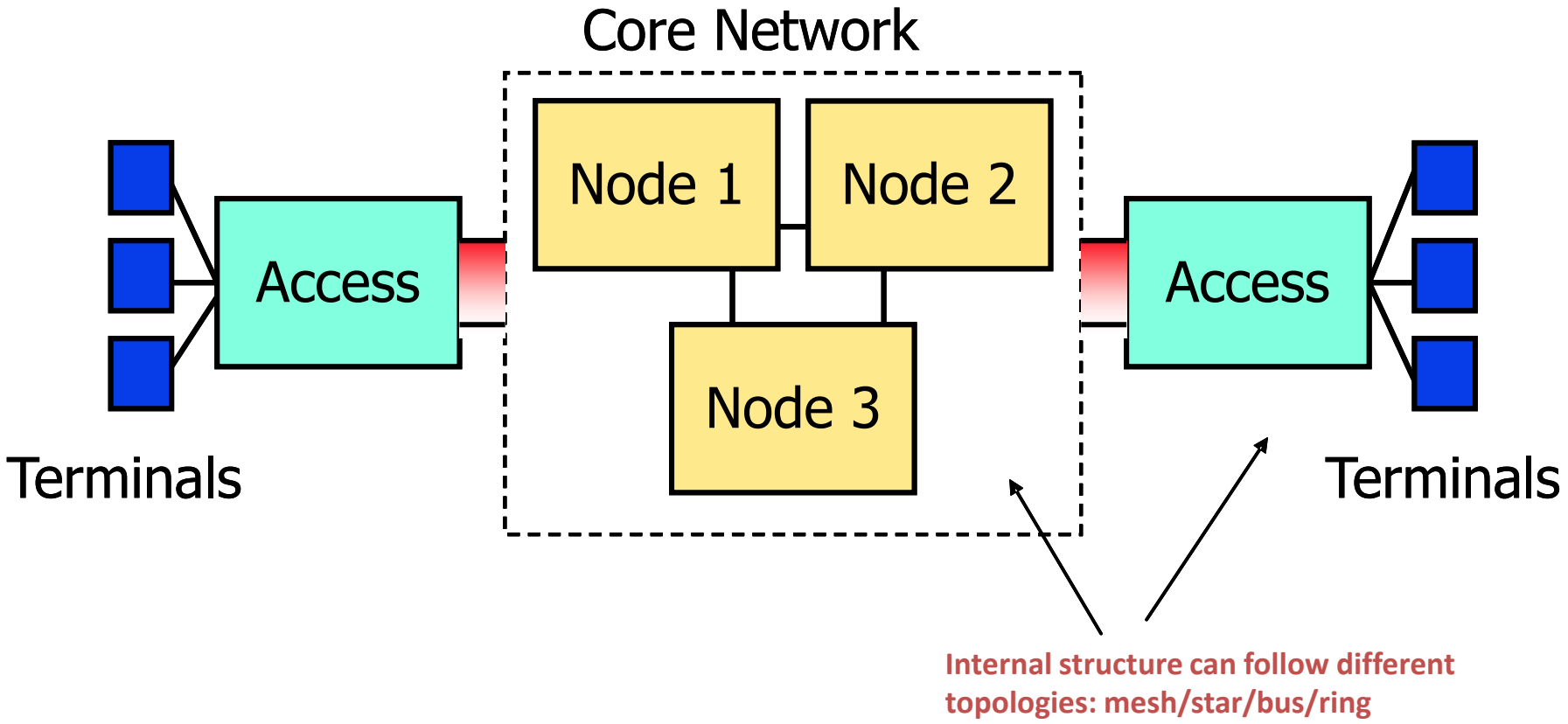
[6] *Personal Area Networks (**PAN**s):* A network for interconnecting electronic devices within an individual person's workspace.

Networks Classification

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

Indication of Physical Size of Various Networks

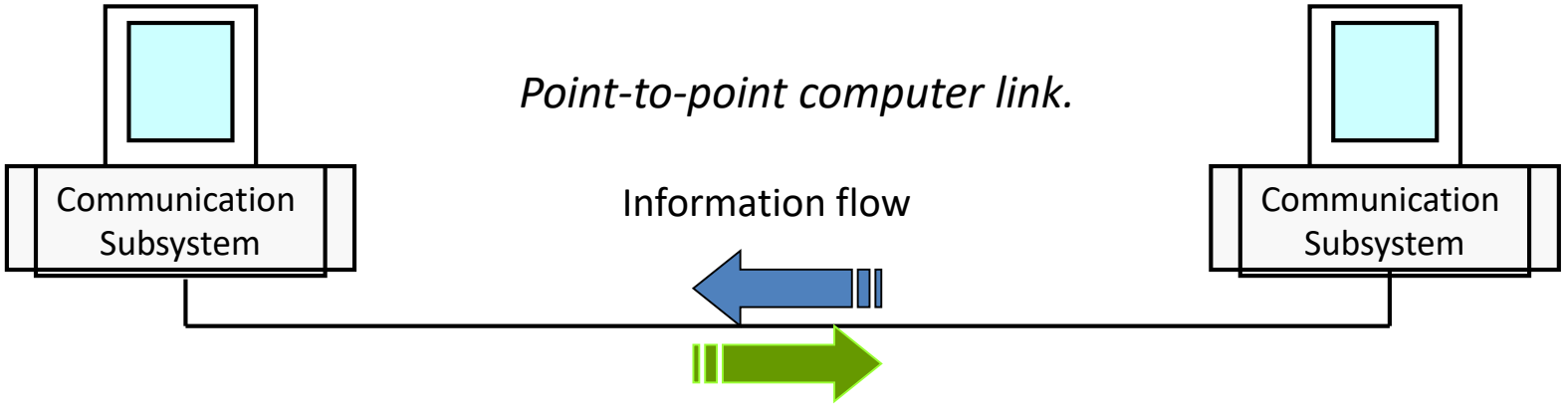
Networks Model

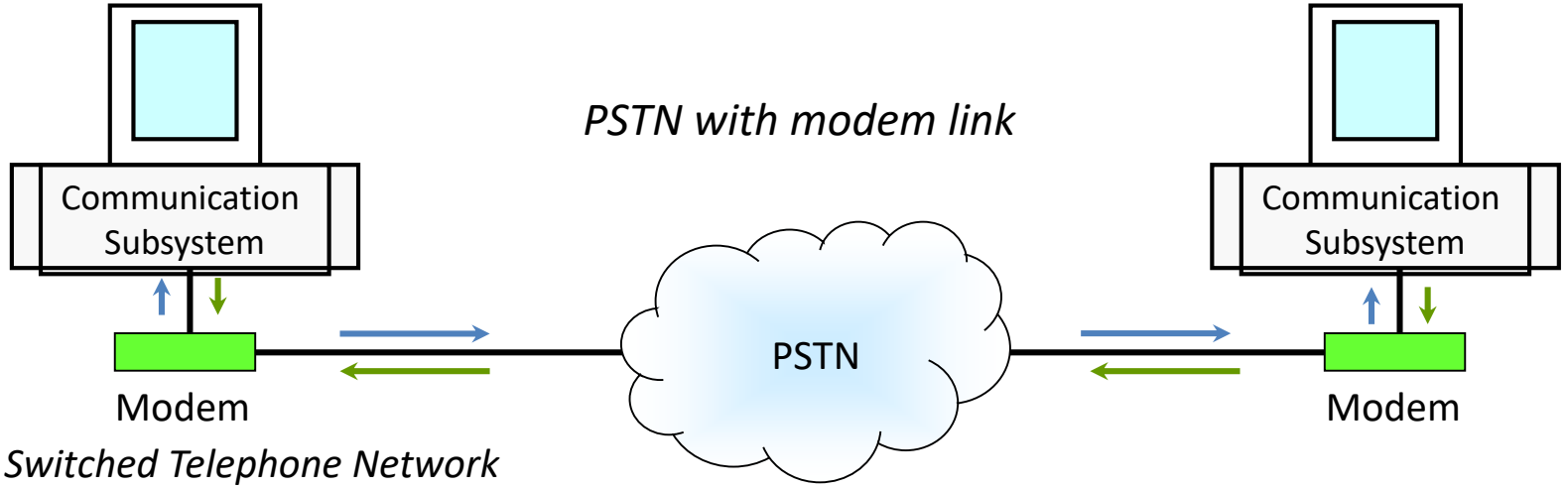


General network model for voice and data

Simple Computer Networks

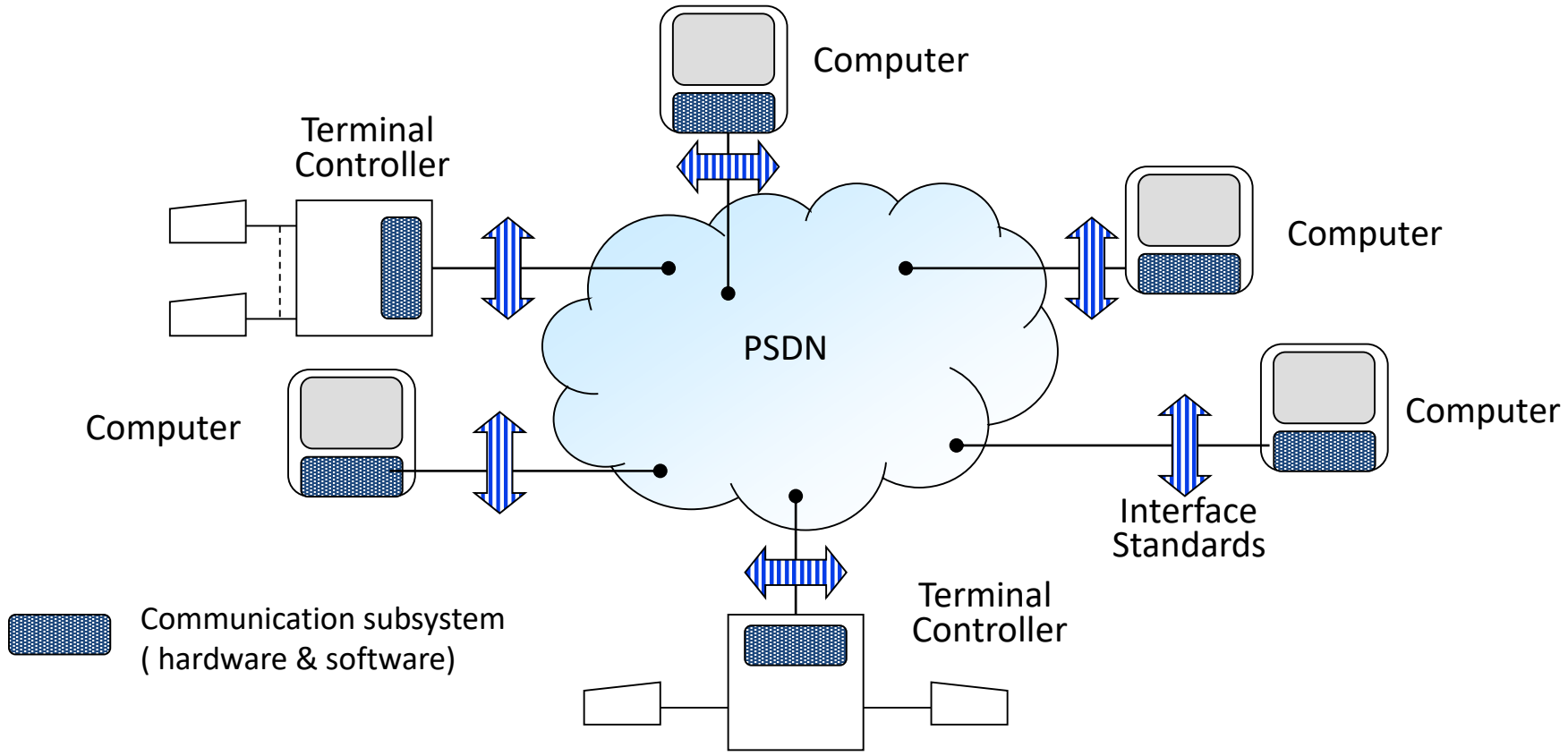
- Simple computer networks are illustrated below





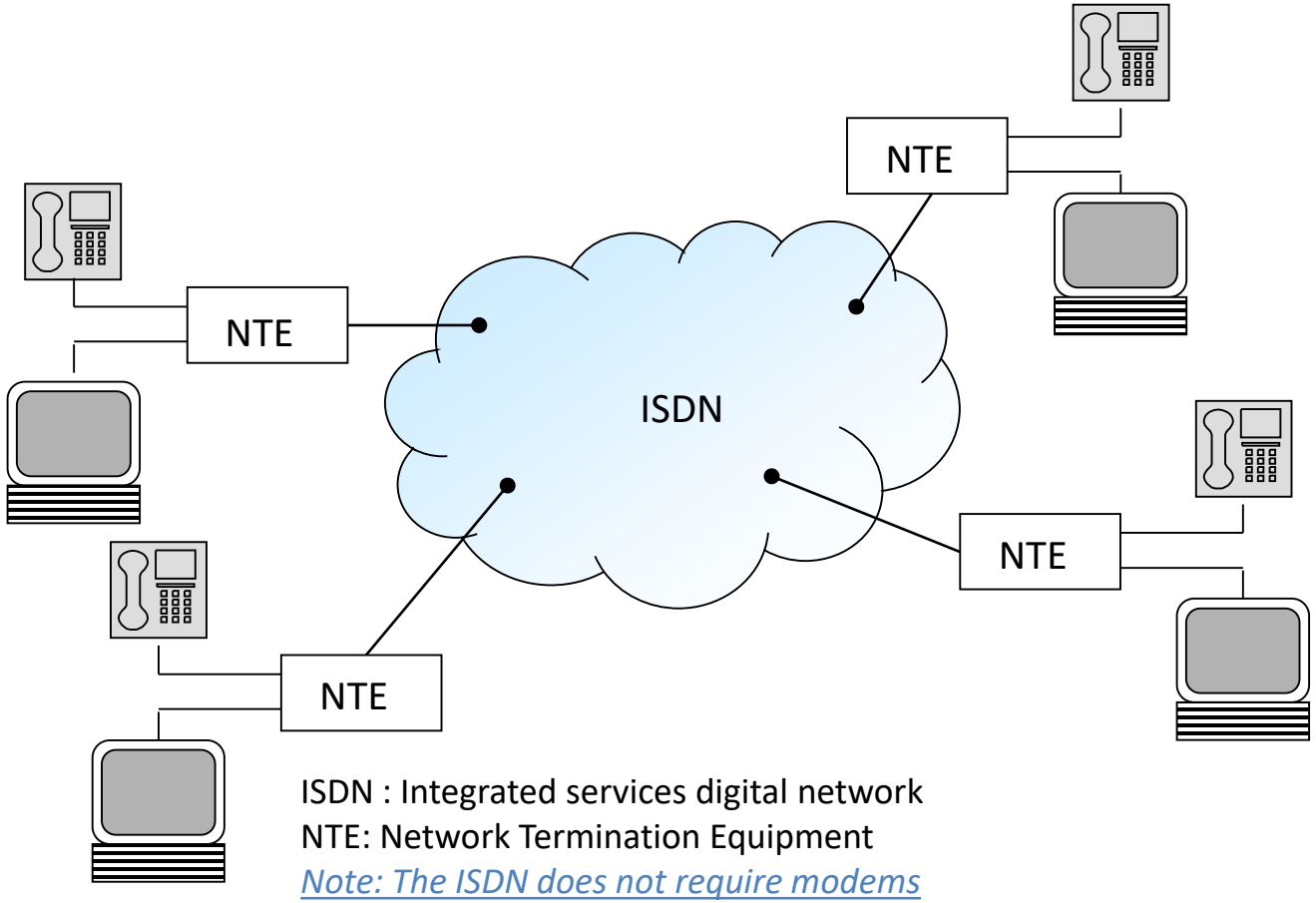
PSTN: Public Switched Telephone Network

Public Switched Data Network (PSDN)



- The Public Switched Data Network (PSDN)

Integrated Services Digital Network (ISDN)



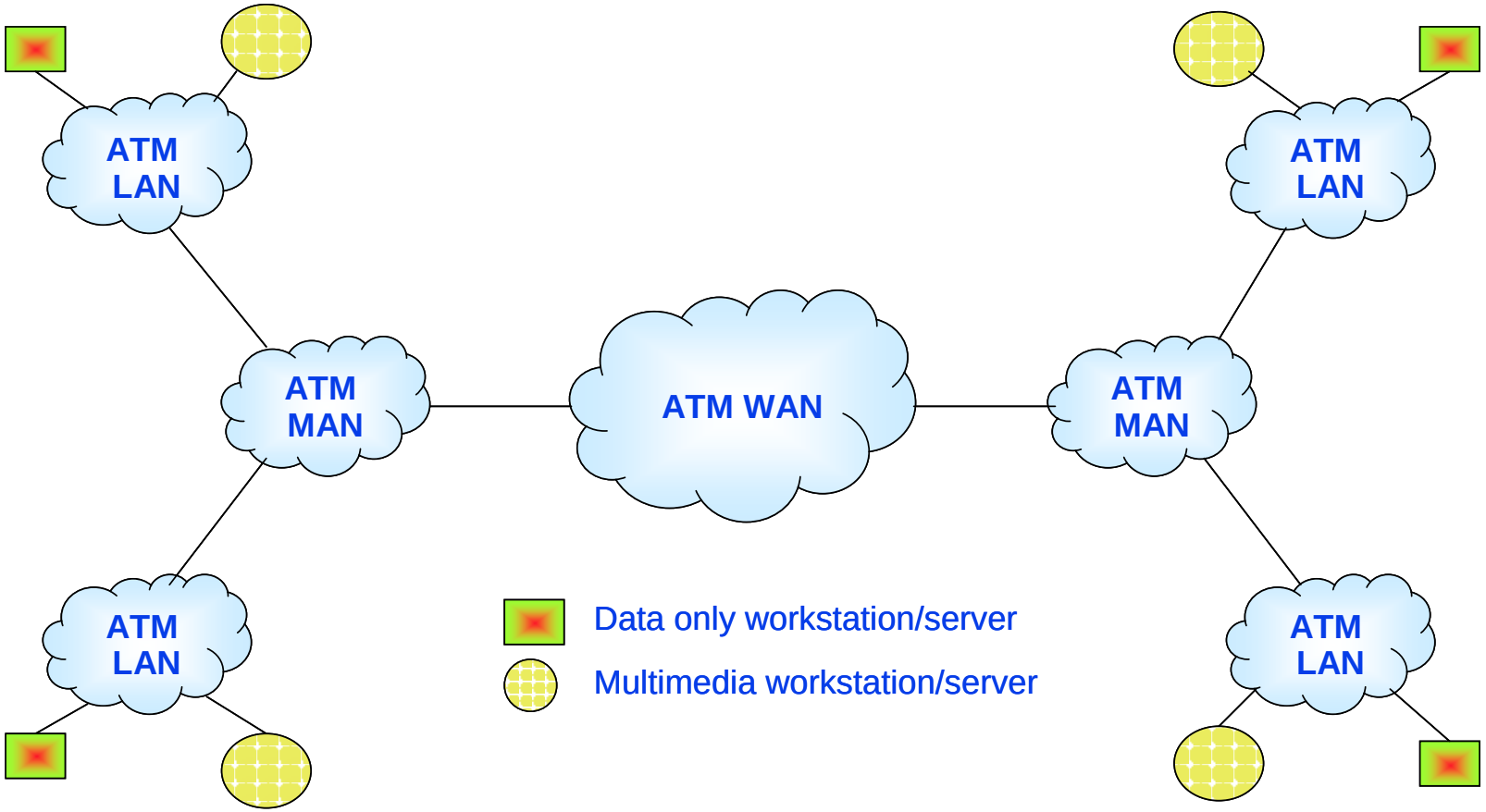
ISDN : Integrated services digital network
NTE: Network Termination Equipment
Note: The ISDN does not require modems

- The Integrated Services Digital Network (ISDN)

Broadband Multiservice Networks

- Development of a new generation networks - *Broadband Multiservice Networks*
  - The term "*Broadband*" is used because of the high transmission rates
  - The delivery of seamless Video, Voice and Data services over wired and wireless networks to multiple devices offering one connected world to subscribers
- A new approach for transmission and switching - *Asynchronous Transfer Mode (ATM)*

Broadband Multiservice Networks



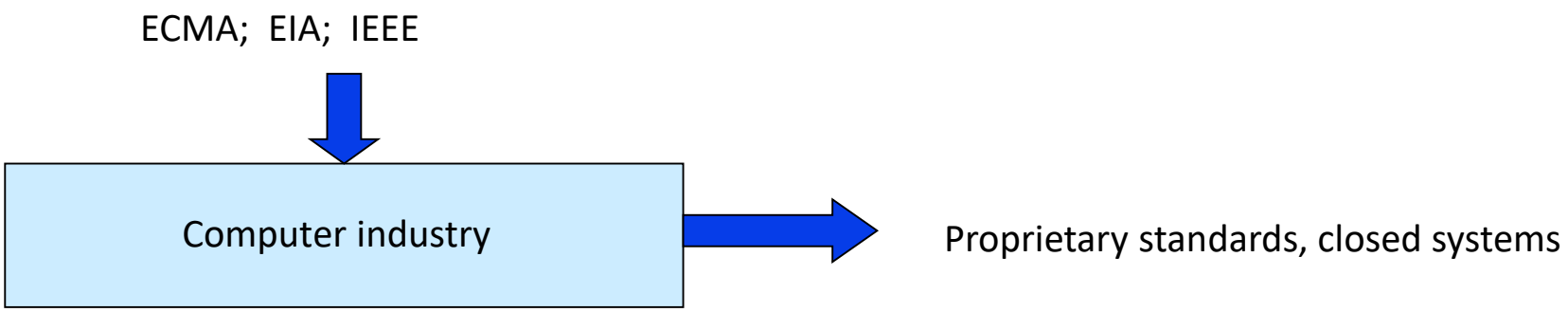
- Broadband multiservice networks

Networking Standards

Two phases - The evolution of networking standards

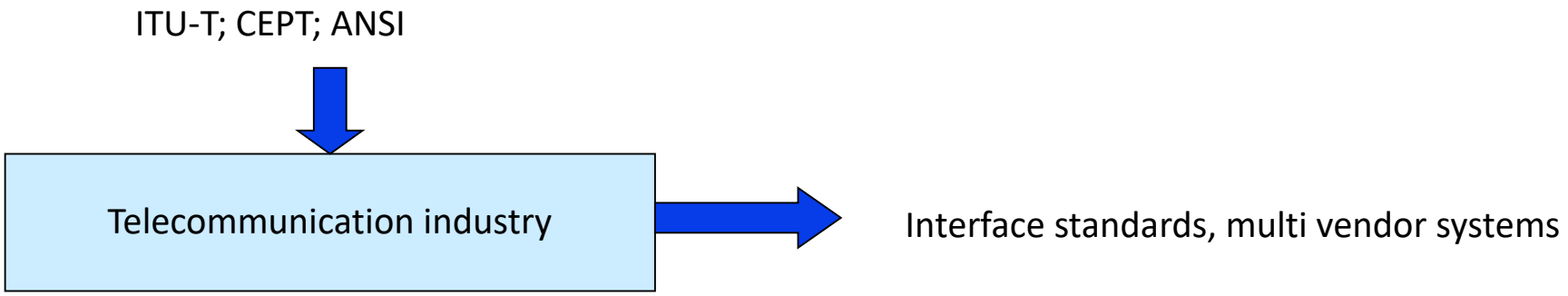
- Reflected the political, financial and manufacturing issues
- Continuous evolution of standards for interoperability

Phase 1-a: Computers



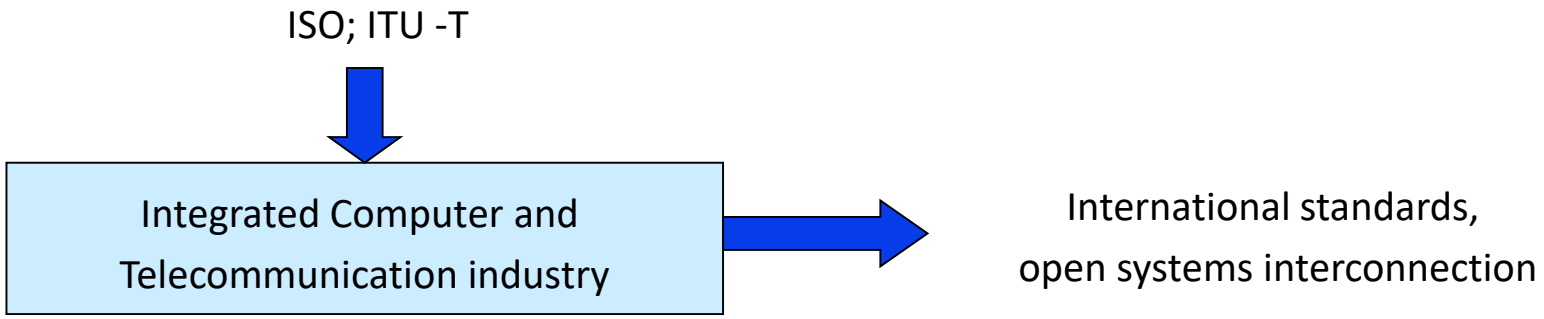
During this phase the multiplicity of standards and the availability of closed systems without inoperability led to high prices for services and the limited availability of services to the society.

Phase 1-b: Computers



The telecommunication industry had the time to organise its affairs around standards that led to inoperability and a world market, leading to low prices and relative high use of services.
Low costs had been achieved by leveraging low cost semiconductor IC through volume.

Phase 2:



In this current phase the computer and telecommunications industries are working together to deliver international standards for greater interoperability.

This has lead to a low cost, broad range of services ranging from plain old telephones to mobile video and hopefully to more services and even lower cost.

Standards bodies

ECMA	European Computer Manufacturers Association
EIA	Electrical Industries Association
IEEE	Institution of Electrical and Electronic Engineers
ISO	International Standards Organisation
ITU – T	International Telecommunication Union –Telecommunication Sector
CEPT	Conference European of Post and Telecommunications
ANSI	American National Standards Institute

IEEE 802 Standards for LANs

IEEE 802.3	for Ethernet
IEEE 802.11	for WiFi
IEEE 802.15.1	for WPAN (Wireless PAN) based on Bluetooth
IEEE 802.16	for WiMAX (Worldwide Interoperability for Microwave Access)

Service

- To manage the complexity and attain the objective of transporting data from A to B, each layer is structured and relies upon on its predecessor
- In transferring data from computer A to computer B the users request a service
- This service will be delivered by the protocols active in that particular service
- *Services* between adjacent layers are defined by a set of Primitives (operations) and Parameters
- The primitives specify the functions to be performed
- The parameters communicate data and control information
- The service defines what operations the layer should perform for the users but *it does not prescribe* how these operations will be implemented
- A layer N+1 sees the lower layers as service providers

Service

- In the actual operation, the service primitives are now focus on the task
- For example, the service primitives for a simple connection oriented service as below

Service Primitive	Meaning
LISTEN	Waiting for an incoming connection.
CONNECT	Establish a connection with a waiting peer.
RECEIVE	Waiting for an incoming message.
SEND	Send a message to the peer.
DISCONNECT	Terminate the connection.

Protocol

- The operation of modern communication systems is based on the concept of the *"protocol"*
- A format definition of the term "*protocol*" for *communications* follows

A SET OF RULES AND PROCEDURES THAT DEFINE THE MESSAGES TO BE EXCHANGED , THEIR FORMAT AND WHEN TO SEND WHAT.

In order to operate across national boundaries and equipment suppliers, the standardisation of procedures is a MUST. Standardisation bodies include:

ISO (International Standard Organization)
ITU-T (International Telecommunication Union)
IEEE (Institution of Electrical and Electronic Engineers)
others…

Protocol

- The internal *structure of a protocol* (known also as *protocol architecture*) is based on a layered model
- Consider a simple example, that of sending a data file from computer A to computer B
- To achieve this objective a number of functions must be performed in computer A, computer B and in the network connecting the two computers
- Some of these functions

[1] Addressing the data destination computer

[2] Connection /session control

[3] Data transmission across the network

[4] Data segmentation, concatenation and blocking

[5] Control of the flow of data across the network

[6] Data routing

[7] Error detection and control

Mathematically, protocols can be seen as finite state machines.

Protocol

- *A protocol* is a set of rules
- controlling the format, the meaning of the frames, the meaning of packets and messages exchanged by the peer entities within a layer
- The entities implement protocols so that they realise the service definitions

- *The protocol specifications*

[1] must be precise

[2] may involve different operating systems

[3] operates between the same layer between two systems

- *Key features of the protocols*

[1] syntax – data formats, signal levels

[2] semantics - control information, error handling

[3] timing - speed matching, sequencing

Protocol

- ***Possible functions of a protocol***

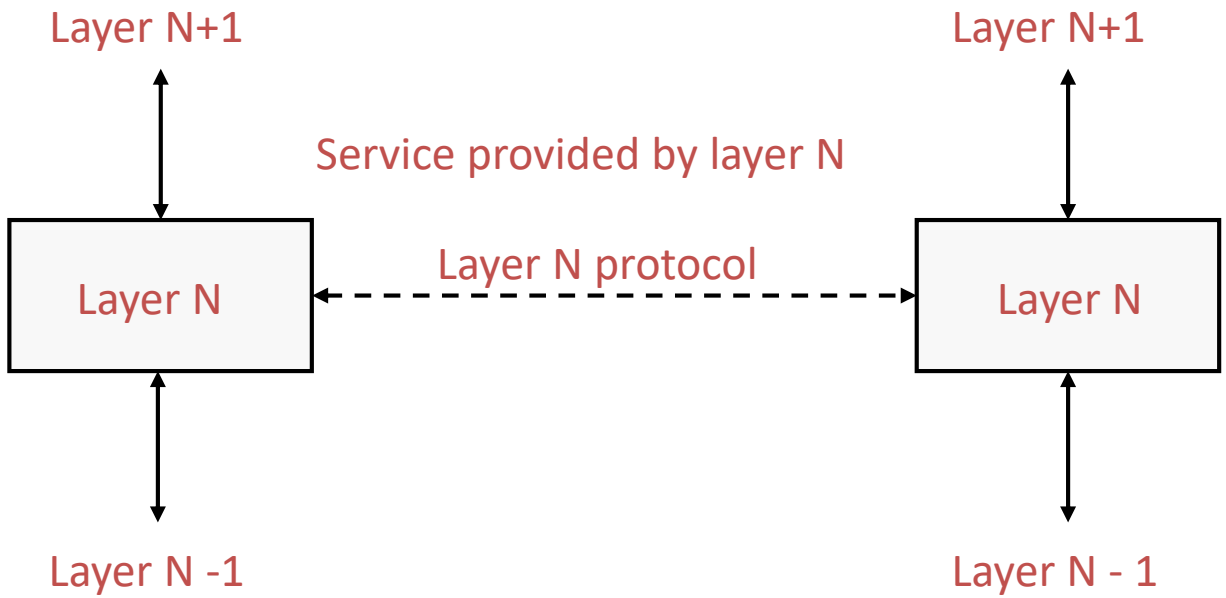
[1] addressing
[2] connection control
[3] flow control
[4] encapsulation
[5] segmentation and concatenation
[6] transmission of data
[7] error detection and control
[8] routing

- The complexity of the communication task in each protocol level is reduced by using *multiple protocol layers*
- The key features of the multiple protocol layer

[1] Each protocol is implemented independently
[2] Each protocol is responsible for a specific subtask
[3] Protocols are grouped in a hierarchy

- A structured set of protocols is called a *communications architecture* or *protocol suite.*

Relationship between a Service and a Protocol



- The relationship between a service and a protocol

Protocol

- Over the evolution of data communications there have been a fair number of protocols
- But today the most important protocols in general use are

[1] TCP/IP protocols suite

[2] OSI reference model

The details will be discussed later.


Thank you