Università di Roma Tor Vergata

CORSO DI LAUREA MAGISTRALE IN ICT AND INTERNET ENGINEERING

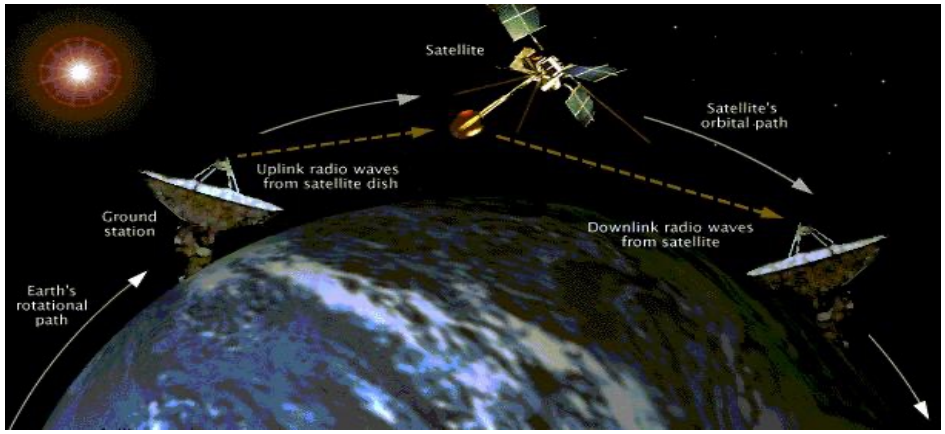
Course

Internet via Satellite

Prof. Michele Luglio

Prof. Francesco Zampognaro

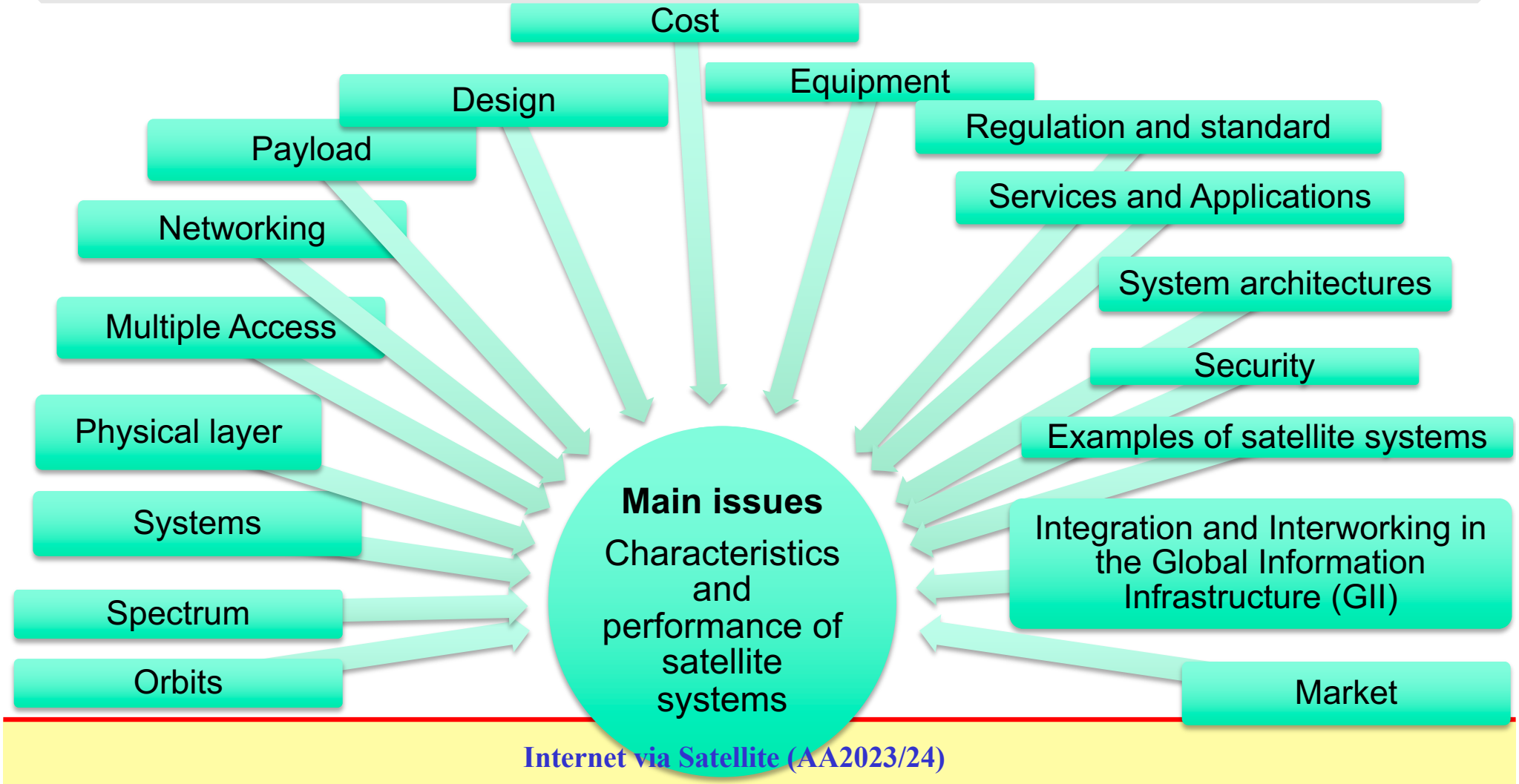
A.A. 2023/24



Course objectives

Concept

Allowing communication among users located over the Earth (in a broad sense) using a physical device (satellite) located in the sky and the radio propagation means



Short History: prehistory and science fiction

- The very first step can be considered the physical law issued in 1687 by Sir Isaac Newton,

$$F = \frac{GMm}{r^2}$$

  which actually rules how to place a satellite into space, but the actual placing took some time (about 3 centuries).
- The term satellite was referred to a smaller body (natural satellites) that revolved around a larger astronomical object. All the moons circling the planets of the solar system are satellites.
- The idea of an artificial satellite was probably first proposed by the American clergyman Edward Everett Hale in his collection 'The Brick Moon, and Other Stories', published in 1899.
- Any man made object that revolves around a larger astronomical object is called an artificial satellite.

Short History: the start of the space age

- Progresses on research area of rockets, pushed mainly by military needs raised during World War II (Von Braun), allowed to develop enough powerful carriers to put an object in the space.
- The Space Age started on October 1957, when the first artificial satellite, Sputnik 1, was placed in orbit by the Soviet Union.
- Sputnik 1 emitted a radio beep, but it was enough to qualify as an orbiting satellite, and the first one in space.
- From that date satellite evolution has grown exponentially and so far thousands of satellites were launched.
- They are used for **Telecommunications**, Navigation, Earth observation (including weather and military scope), deep space observation (astronomy, astrophysics) and other purposes.

Milestones of Satellite Communication (1)

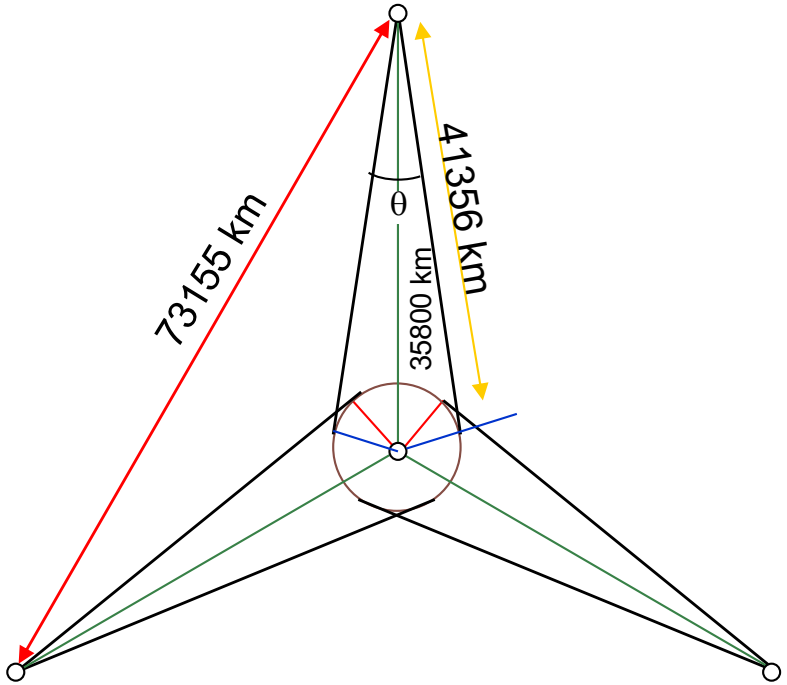
Satcom Vision and Development of Launch Technologies

Oct. '45 - Arthur CLARKE: "Extraterrestrial relays", Wireless World, p.305

- Three manned GEO space station

Oct. '54 - John PIERCE: "Telecommunications satellites"

- LEO or GEO satellites without man in space



Clarke's conception of GEO

Milestones of Satellite Communications (2)

Very first satellite and political acts

Oct. '57 - URSS: "Sputnik mission "
- First artificial satellite (non TLC): 85 kg in low Earth orbit

Jul. '61 - John. F. KENNEDY: "Policy statement on communications satellites"

20 December 1961 - The United Nations General Assembly adopts Resolution 1271, stating that global satellite communications should be made available on a non-discriminatory basis.

Birth of Satellite Communications

Aug. '62 - Law in the U.S.: "Communications Satellite Act"
- Birth of COMSAT

Aug. '64 - Inter-governmental agreement : "Interim Arrangements for a Global Commercial Communications Satellite System"
- Birth of ICSC and INTELSAT

LEO and MEO experiments

– *Pre-recorded message transmission*

– Dec. '58 - SCORE (60 kg of payload launched on ATLAS at 190 km perigee - 1500 km apogee)
Oct. '60 - COURIER (227 kg, 970-1200 km)

Milestones of Satellite Communications (3)

– *Passive reflection*

Aug. '60 - ECHO I (76 kg, 1200-1480 km)

Jan. '64 - ECHO II (248 kg, 980-1260 km)

– *Telephone and TV transmission*

Jul. '62 - TELSTAR I (77 kg, 940-5640 km)

Dec. '62 - RELAY I (78 kg, 1320-7430 km)

May '63 - TELSTAR II (79 kg, 970-10800 km)

Jan. '64 - RELAY II (78 kg, 2080-7420 km)

GEO experiments

Jul. '63 - SYNCOM II (39 kg, almost GEO: i=33°)

Aug. '64 - SYNCOM III (66 kg)

The first HEO satellite and GEO operational systems

Apr. '65 - MOLNIYA I (1020-39450 km, 12 hours)

Apr. '65 - INTELSAT I ("Early Bird")

- Starts INTELSAT GEOs for intercontinental fixed services

1972 - FIXED CONTINENTAL SERVICES

- In the U.S. regional systems start for fixed (continental) services

Milestones of Satellite Communications (4)

Commercial services development

1976 - MARISAT

- Three satellites for mobile maritime communications

1982 - INMARSAT GLOBAL SYSTEMS

- Fully operational GEO global systems, for mobile maritime service

1988 - FIRST LAND MOBILE SATELLITE SYSTEM

- OMNITRACS starts to provide in North America land mobile satellite messaging and localization services

1991 - ITALSAT (ITALY)

- The first satellite using **Ka** band, **on board** processing, **multibeam** coverage

1992 - GEO Satellites for mobile telephony (1st war in the gulf)

1998/2000 - IRIDIUM/GLOBALSTAR

- Global mobile services with hand held terminals

2012 – KaSat (Eutelsat, first *High Throughput* Satellite)

2020 – Megaconstellations (hundreds/thousands of satellites in LEO orbit)

Why to use satellites?


Costs independent on distance (within one satellite coverage)


Collecting and broadcasting characteristics


Particularly suitable and cost effective for multicasting

- Disruptive to feed CDN nodes
- Efficient to distribute security keys


Irreplaceable in areas with scarce or no infrastructures


Irreplaceable in case of disaster


Suitable for large coverage areas and long range mobility

From being a problem due to delay


Relatively short deployment time

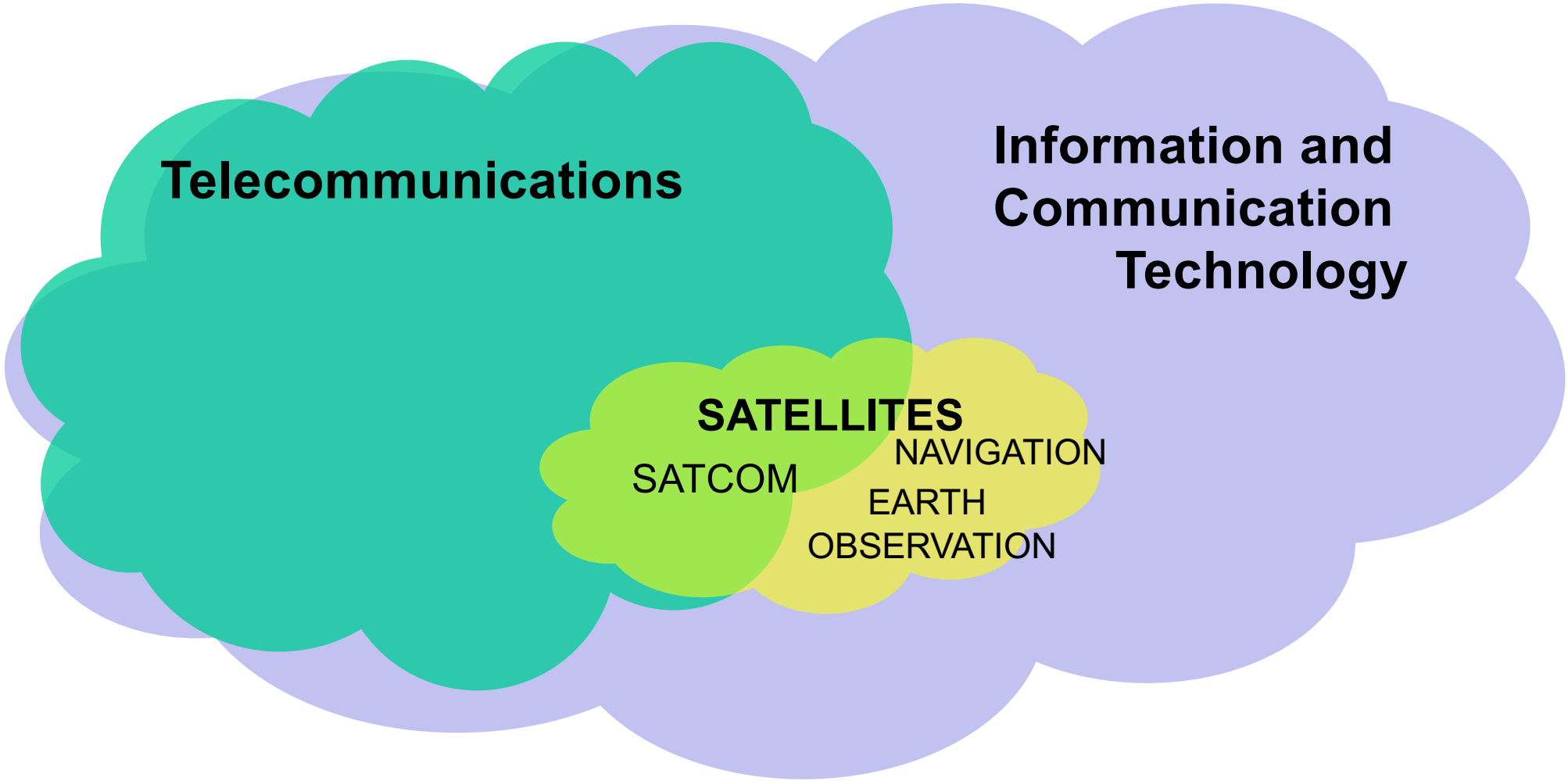

Flexible architecture


Bypass very crowded terrestrial networks


With the same infrastructure both fixed and mobile services

to being the element that can meaningfully contribute to achieve the "zero latency" and to efficiently face the multi-domain issue

Market in Market



Why an Internet via Satellite course?

- Niche but very important market
- 45000 employees in Europe (Satcom experts are required)
- Three Main Sectors
  - Satellite Services (55%)
  - Satellite Manufacturing 16% (e.g. Boeing, Loral, Lockheed Martin, Thales Alenia, Airbus)
  - Ground Equipment Manufacturers (29%)

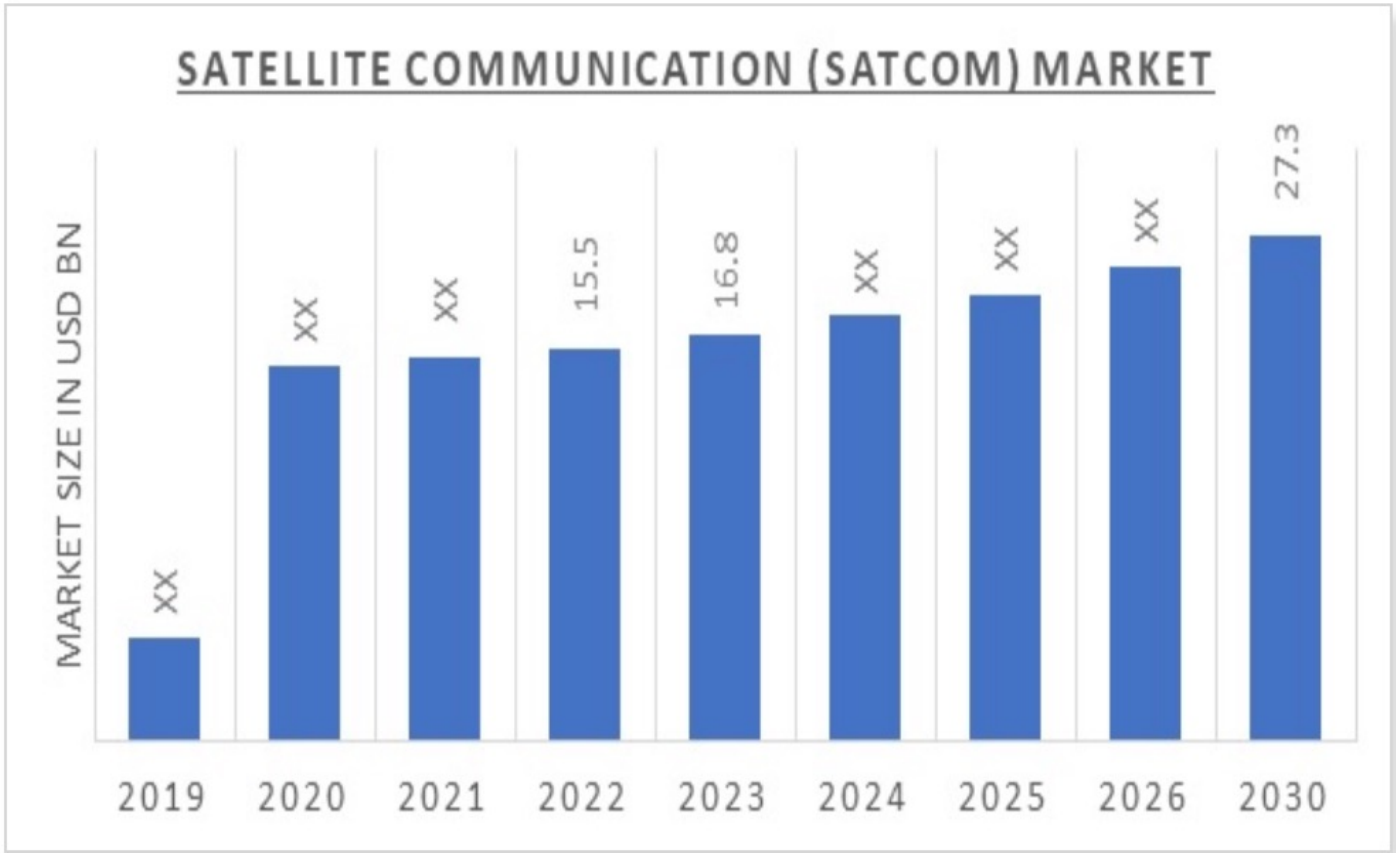
		Europe	Italy
Revenues (M€)		10000	1500
Employees		28000	6000
Activity share	manufacturer		66%
	services		34%

SatCom Market figures

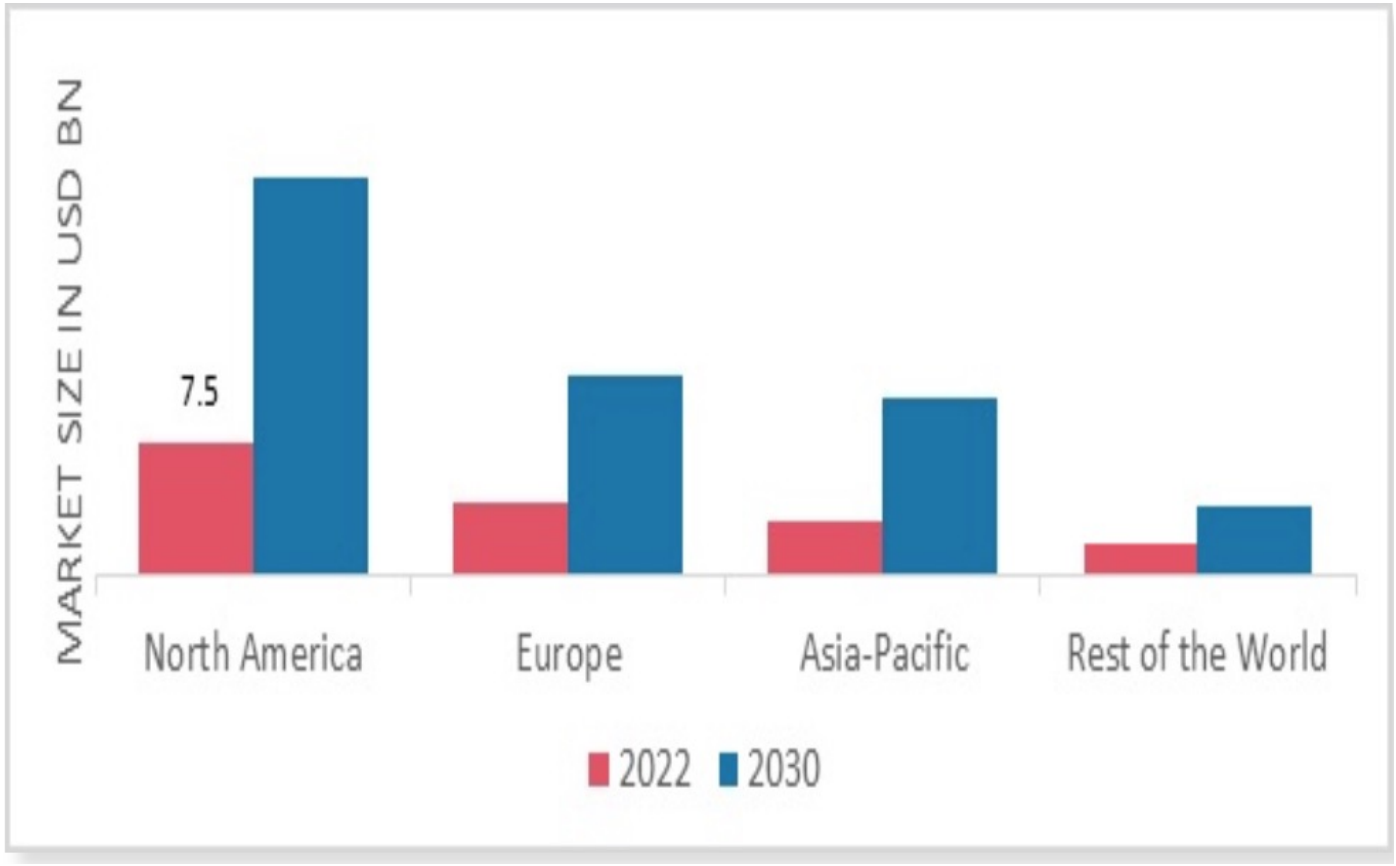
- SatCom one of the most successful applications of space technologies.
- Market size valued at USD 15.5 billion in 2022, USD 16.8 billion in 2023 and USD 27.3 billion in 2030.
- Annual growth rate (CAGR) of 8.44% (2023-2030)
- Market trends
  - Internet of Things

Source: https://www.marketresearchfuture.com

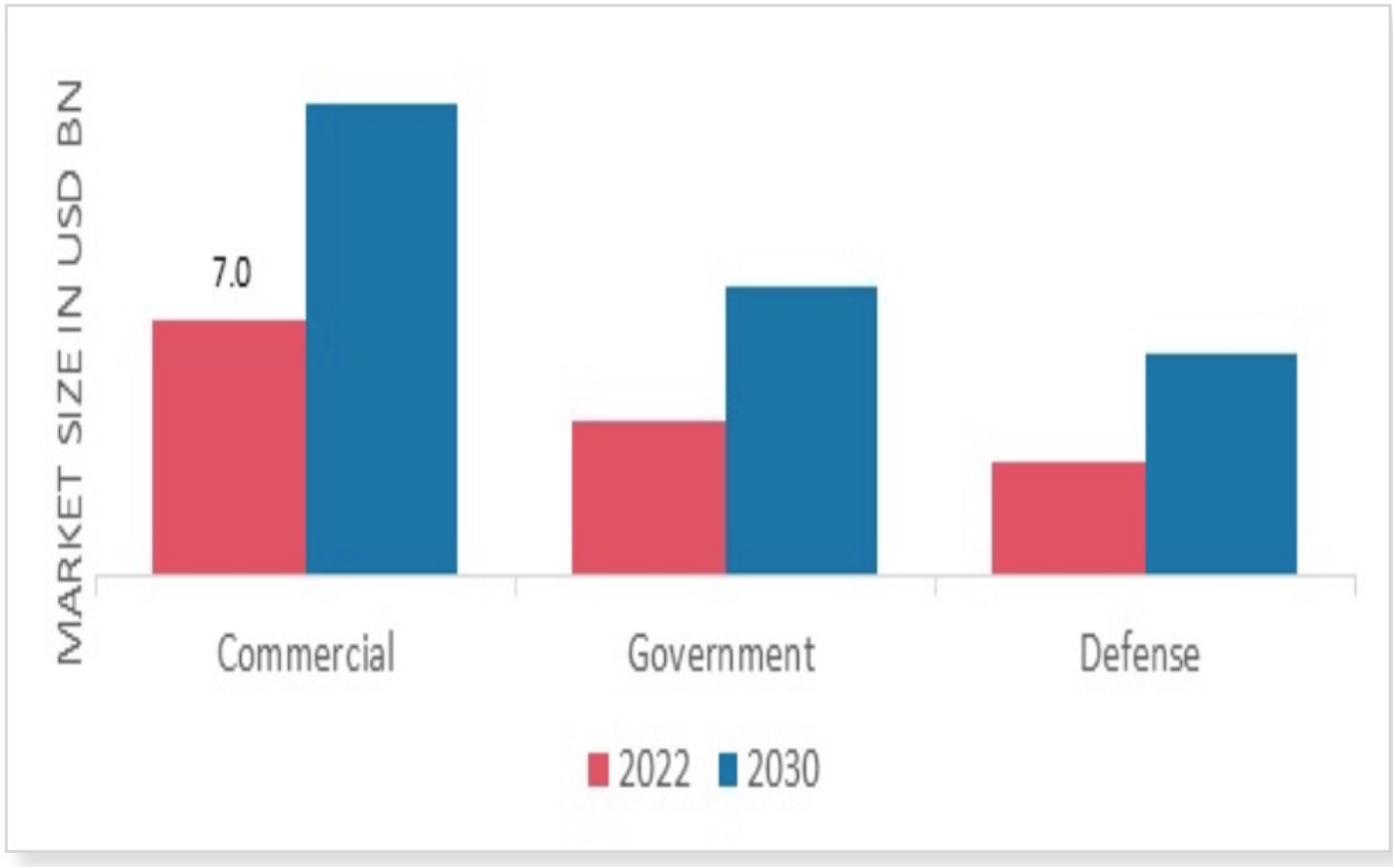
Revenues per year



Revenues per geographic area



Revenues per segment



Revenues share for FSS operators

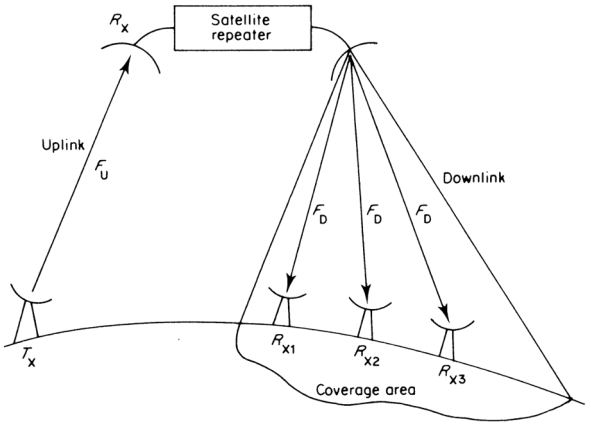
	video applications	VSAT, data, value-added services and others	Internet	Governmental
Eutelsat	72%	28%		
SES Americom	DTH Satellite Outsourcing (23%)	28%	media & entertainment (29%);	20%
SES New Skies	28%	57% (including voice)	15%	
SES Astra	80%			
Telesat	46%	Carrier (5%); Consulting (6%);	22%	Subsidiaries (21%)
Intelsat	Media (38%)	Satellite-Related Services/Other (2%)	47%	13%

SatCom Market

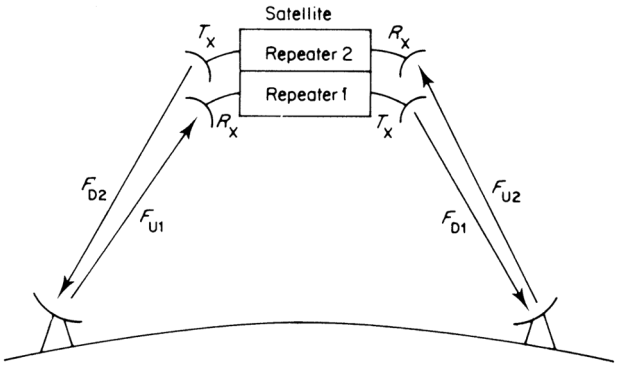
- SATCOM represent today more than 60% of the overall satellites sells.
  - Navigation and Earth Observation share the rest of the business
- In Europe SATCOM is by far the most important business sector for the manufacturing satellite industries (about 5.5 B€/year representing about 40% of the overall World market)
- The revenues produced by downstream satellite-driven services are about 10 times more than those relevant to the manufacturing activities

Satellite Networks Basic Features

- Favorable attributes of the satellite
  - *Coverage* potentially offered to large regions
  - *Direct-to-user* services
  - *Promptness* of service implementation
  - Service and traffic capacity *reconfiguration*
- Classification of direct-to-user services
  - One-way services (i.e. *broadcasting*)
  - Two-way services (i.e. *communication*)

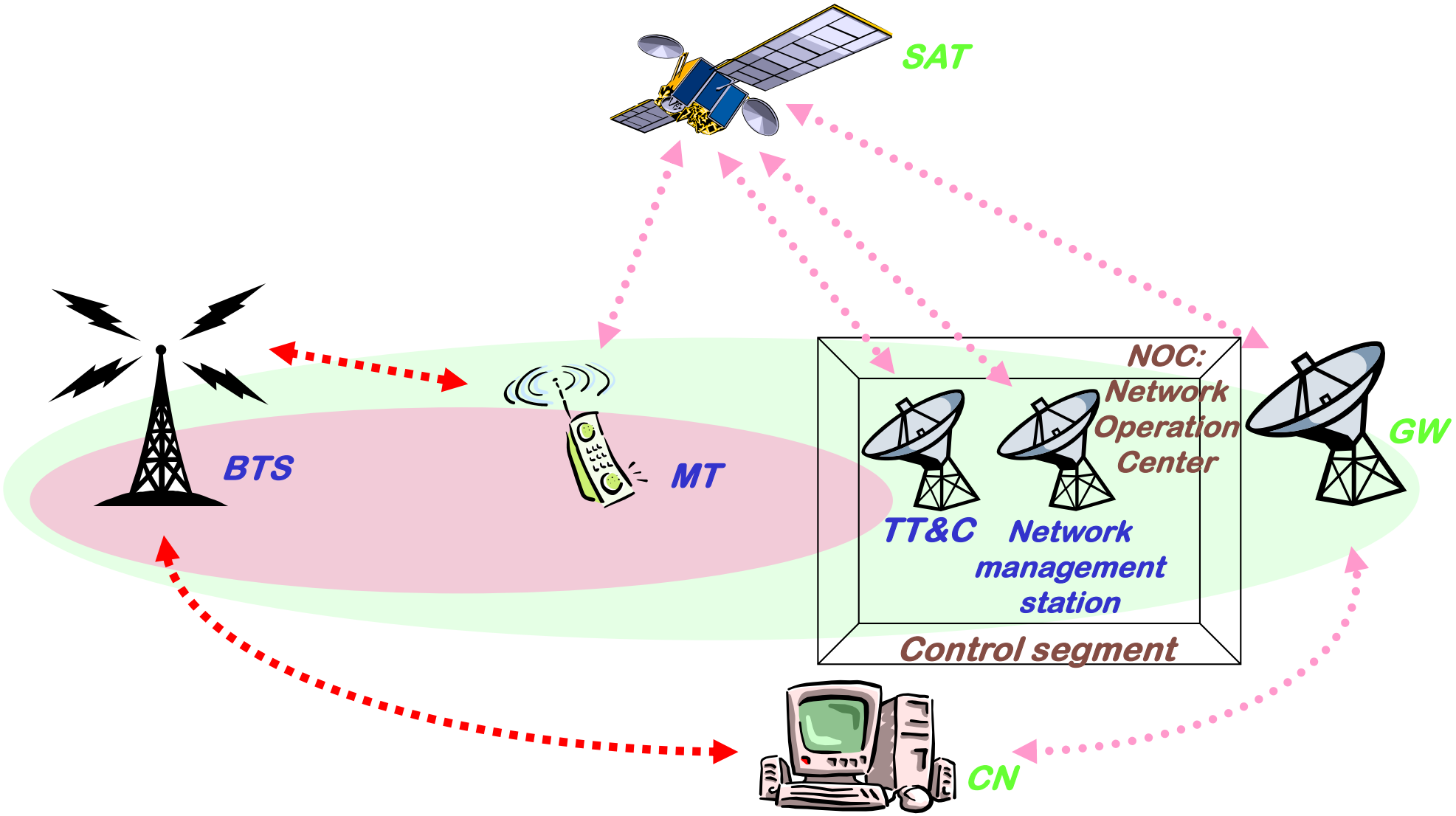


One-way

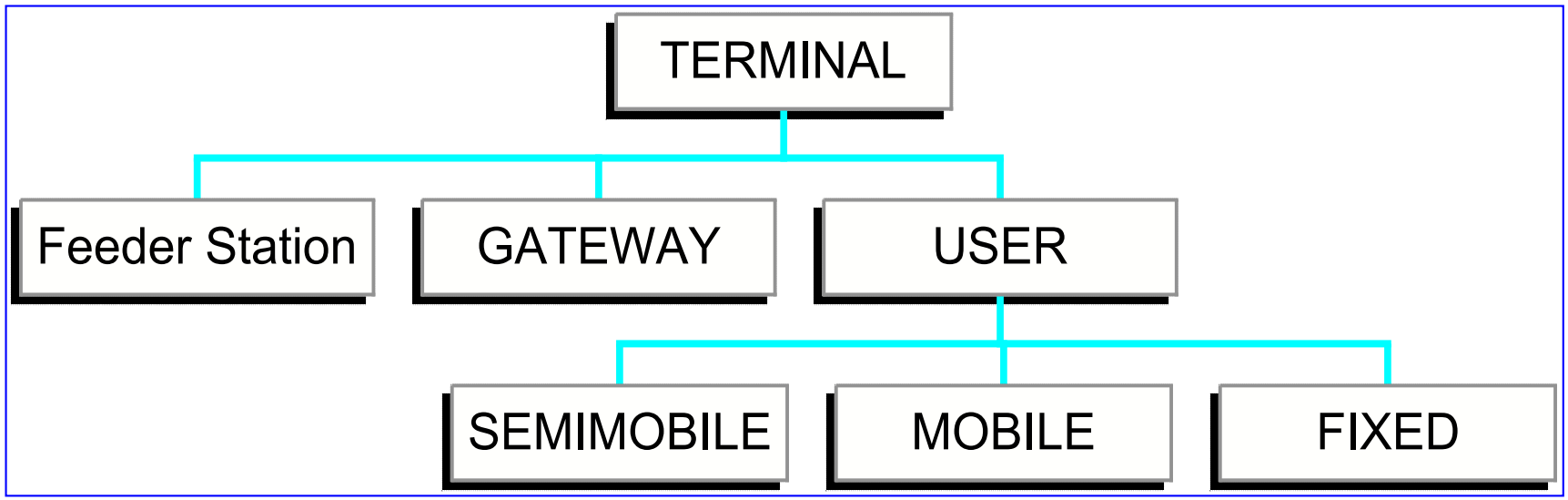


Two-way

Satellite System Components

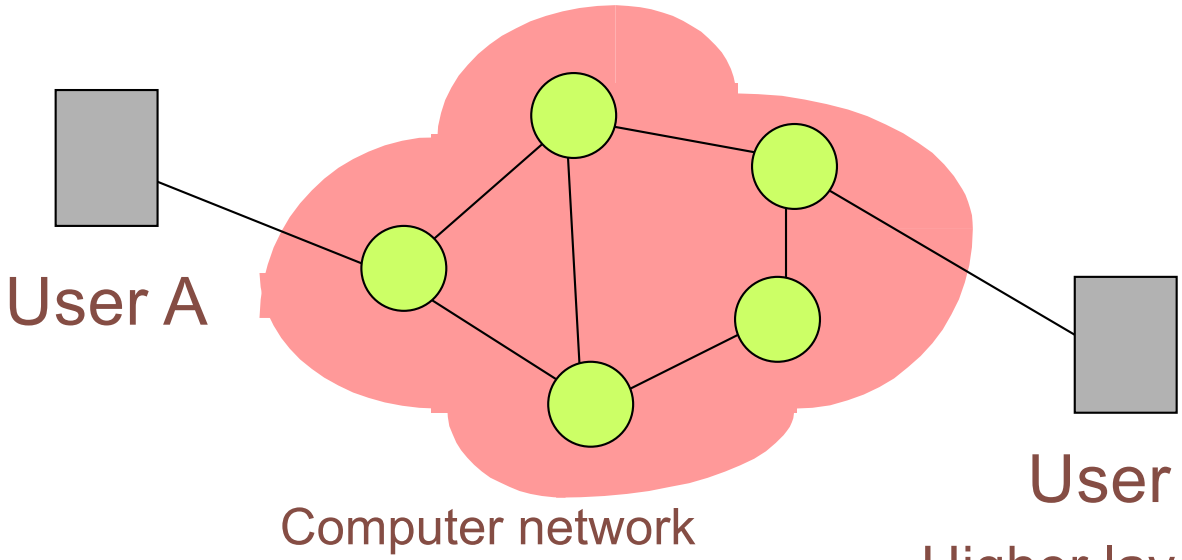


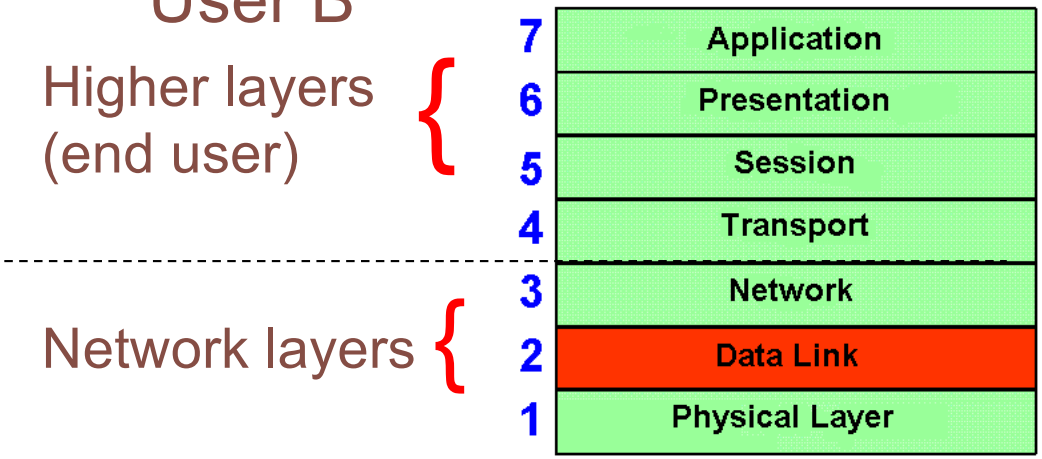
Terminals


TERMINAL
Feeder Station
GATEWAY
USER
SEMIMOBILE
MOBILE
FIXED

Course structure

The OSI Protocol Stack: Reference Model





The OSI Protocol Stack: Reference Model

Application	semantics of information being exchanged between application processes
Presentation	isolates application processes from differences in representation and syntax of data transmitted
Session	manages the set-up of connections between end-users
Transport	controls the end-to-end reliable delivery of data
Network	manages the transference of information: circuit switching and packet switching (connectionless or connection oriented)
Data Link	manages the transfer of information between consecutive nodes (access, error control and retransmissions)
Physical Layer	related to the transmission in the medium (e.g., transmission power, codes, modulations).

Internet protocol suite

OSI Model	IP Protocol Suite	IP Layers Functions	Examples
Application	Application	Handles the details of the particular application (refers to any Internet protocols higher than the transport layer)	Telnet, FTP, SMTP, HTTP
Presentation			
Session			
Transport	Transport	Provides flow and delivery of data, (connection oriented)	TCP (reliable), UDP (unreliable)
Network	Internet	Performs routing of packets (unreliable, connectionless)	IP, ICMP, IGMP
Data Link	Network Interface	Handles all the hardware details of physically interfacing with the transmission means	Ethernet, Token Ring
Physical Layer	Physical		