Lecture 2

Communications Protocols & Reference models

Communications Protocol: General introduction

Communications (network) Protocols

•set of agreed procedures & languages used in those networks

•usually specified in a hierarchy of layers

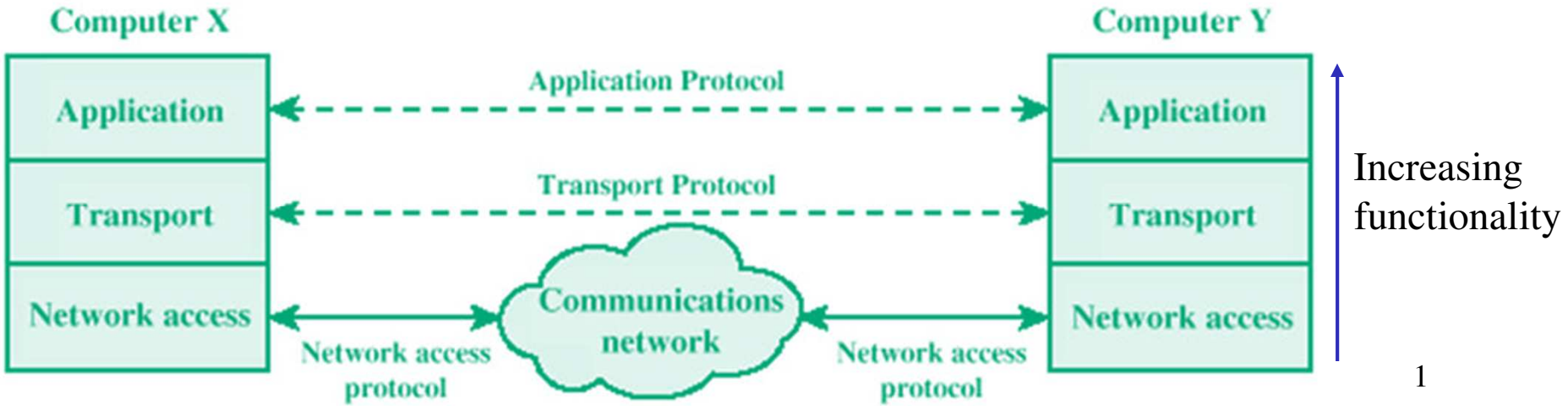
•high-level layers (carry specific applications)

– give ability for 2 systems to exchange and understand information for some particular application

•low-level (data transfer)

– how physical data transmission media is actually used independent of application

A simplified three layer model:



Protocol Characteristics & Hierarchies

Characteristics

Direct or indirect

Direct

- Systems share a point to point link or
- Systems share a multi-point link
- Data can pass without intervening active agent

Indirect

- Switched networks or
- Internetworks or internets
- Data transfer depend on other entities

Monolithic or structured

Communications is a complex task, too complex for a single protocol unit

Structured design breaks down problem into smaller units, obtaining a layered structure

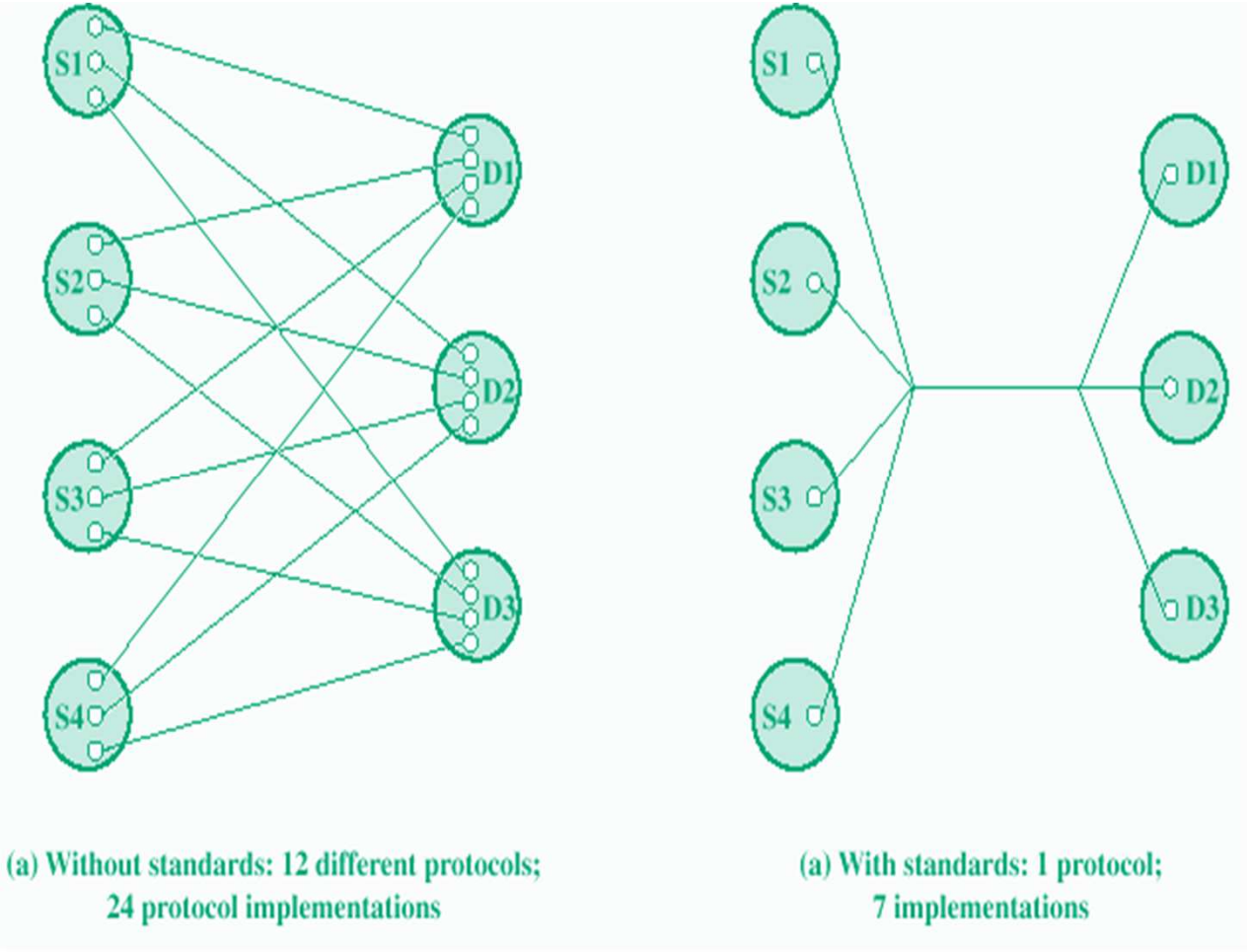
Symmetric or asymmetric

Symmetric

- Communication between peer entities

Asymmetric

- Client/server



(a) Without standards: 12 different protocols; 24 protocol implementations

(a) With standards: 1 protocol; 7 implementations

Standard or nonstandard

Nonstandard protocols built for specific computers and tasks

K sources and L receivers leads to K*L protocols and 2*K*L implementations

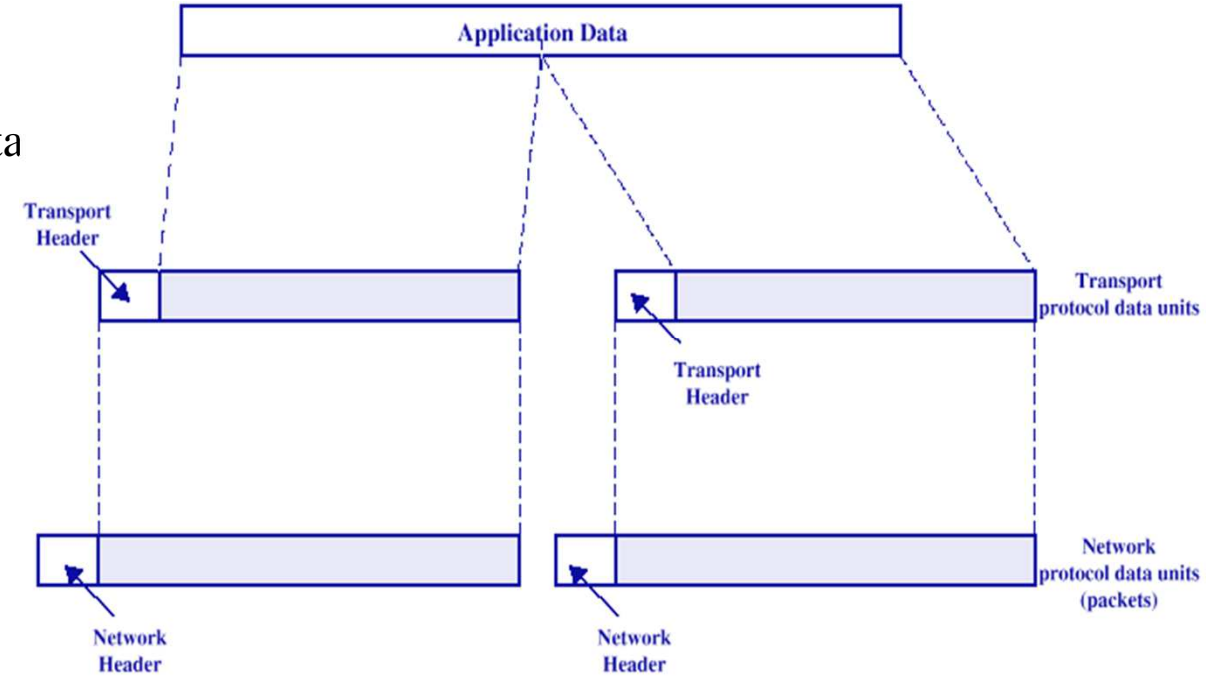
If common communications protocol used, K + L implementations needed (see figure above)

Comms Protocols Main Functions (general introduction)

Encapsulation

Add of **control** information to data

- Address information
- Error-detecting code
- Protocol control



Segmentation (fragmentation) and reassembly

Data blocks for one protocol are of bounded size

Application layer messages may be large; Network packets may be smaller

Splitting larger blocks into smaller ones is segmentation (or fragmentation in TCP/IP)

- ATM blocks (cells) are 53 octets long, Ethernet blocks (frames) are up to 1526 octets long

Use of checkpoints and restart/recovery

Allows for efficient control & resource use, but more overhead & processing time

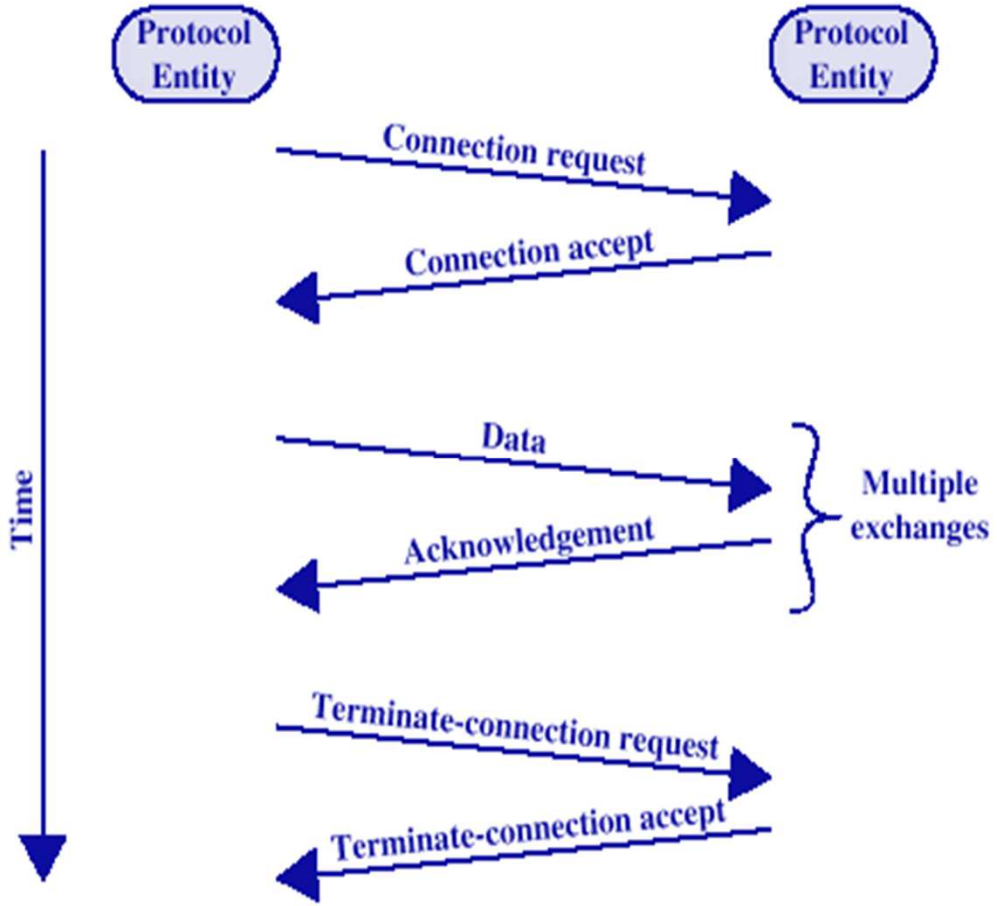
Connection control

Three phases:

- Connection Establishment
- Data transfer
- Connection termination

Sequence numbers used for

- Ordered delivery
- Flow control
- Error control



Ordered delivery

For each protocol specific data (PDUs) may traverse different paths through network

PDUs may arrive out of order

Sequentially number PDUs to allow for ordering

Flow control

Done by receiving entity: limits amount or rate of received data

- Stop and wait
- Credit systems
  - Sliding window

Error control

Guard against data loss or damage

Error detection

- Sender inserts error detecting bits
- Receiver checks these bits
- If OK, acknowledge
- If error, discard packet

Retransmission

- If no acknowledge in given time, re-transmit

Performed at various levels

Multiplexing

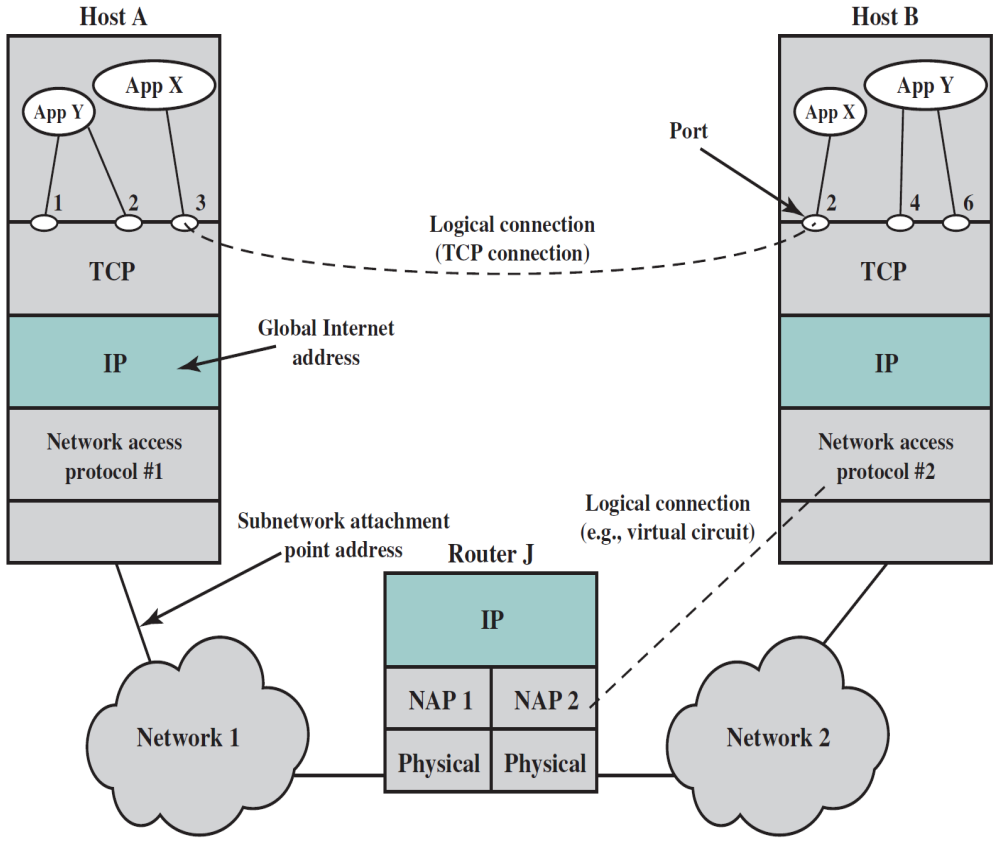
Supporting multiple connections on one machine

Mapping of multiple connections at one level

to a single connection at another

Carrying a number of connections on

one fiber optic cable



Addressing

Addressing level

Level in architecture at which entity is named

Unique address for each computer and router

Network level address

IP or internet address (TCP/IP)

OSI's Network service access point

Process within the system

Port number (TCP/IP)

Service access point or SAP (OSI) Addressing

Addressing scope

Global non-ambiguity

- Global address identifies unique system
- There is only one system with address X

Global applicability

- It is possible at any system (any address) to identify any other system (address) by the global address of the other system
- Address X identifies that system from anywhere on the network

e.g. MAC address on IEEE 802 networks

Connection identifiers

Connection oriented data transfer (virtual circuits)

Allocate a connection name during the transfer phase

- Reduced overhead as connection identifiers are shorter than global addresses
- Routing may be fixed and identified by connection name
- Entities may want multiple connections - multiplexing
- State information

Addressing modes

Usually an address refers to a single system

- Unicast address: data sent to one machine or person

May address all entities within a domain

- Broadcast: sent to all machines or users

May address a subset of the entities in a domain

- Multicast: sent to some machines or a group of users

Transmission services

Priority

- e.g. control messages

Quality of service

- Minimum acceptable throughput
- Maximum acceptable delay

Security

- Access restrictions

Comms Protocols Hierarchies (layered structure)

- organised in layers
- higher layers use services of lower layers (concepts of service user + service provider)
- each protocol layer adds value
- no similar functions in different layers
- highest layer service is exported to user
- layered organization means
    - o– cleaner operation
    - o– easier design & modification

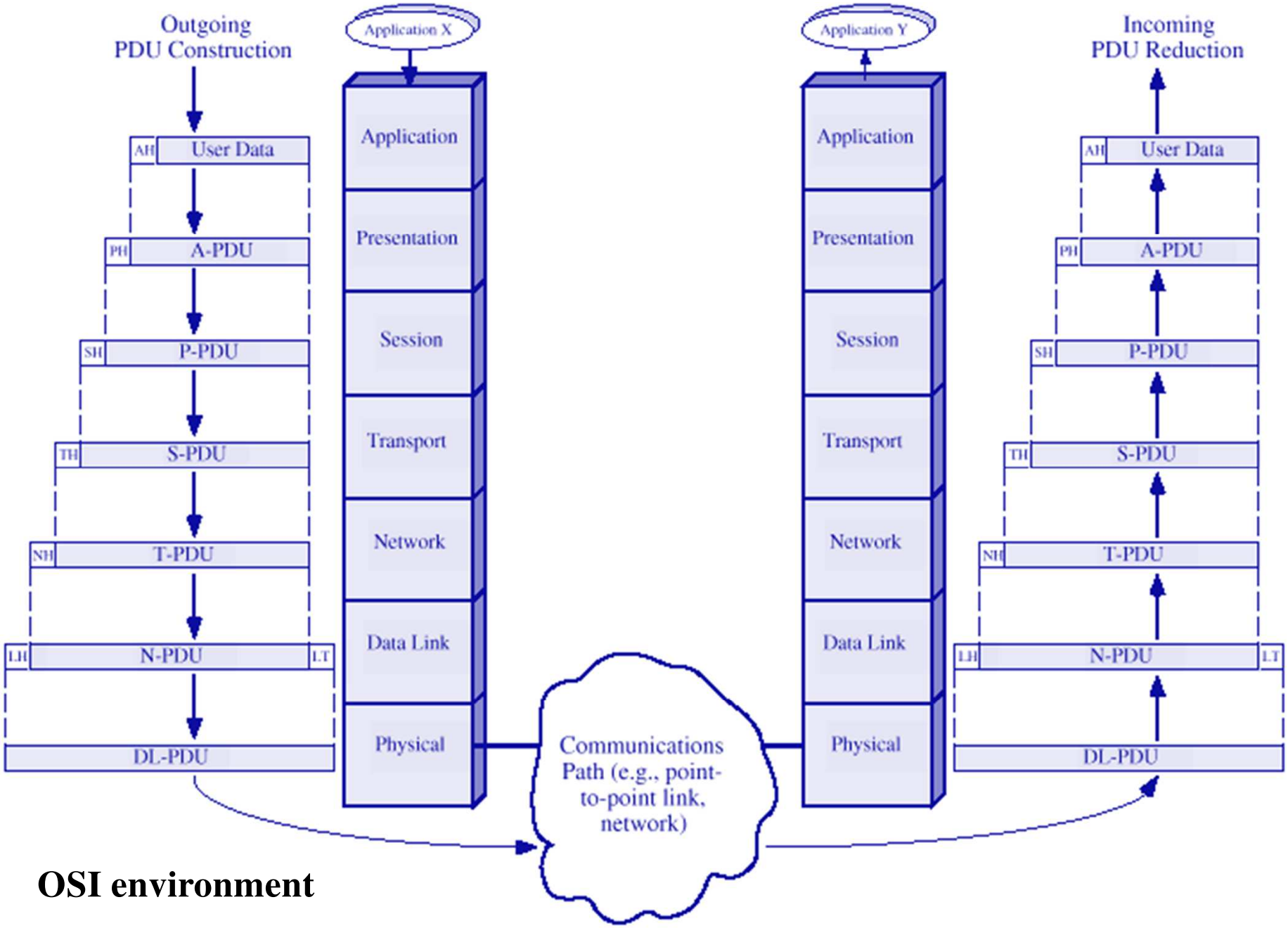
Number, name & function of layers differ from network to network (different protocol stacks)

OSI Reference Model

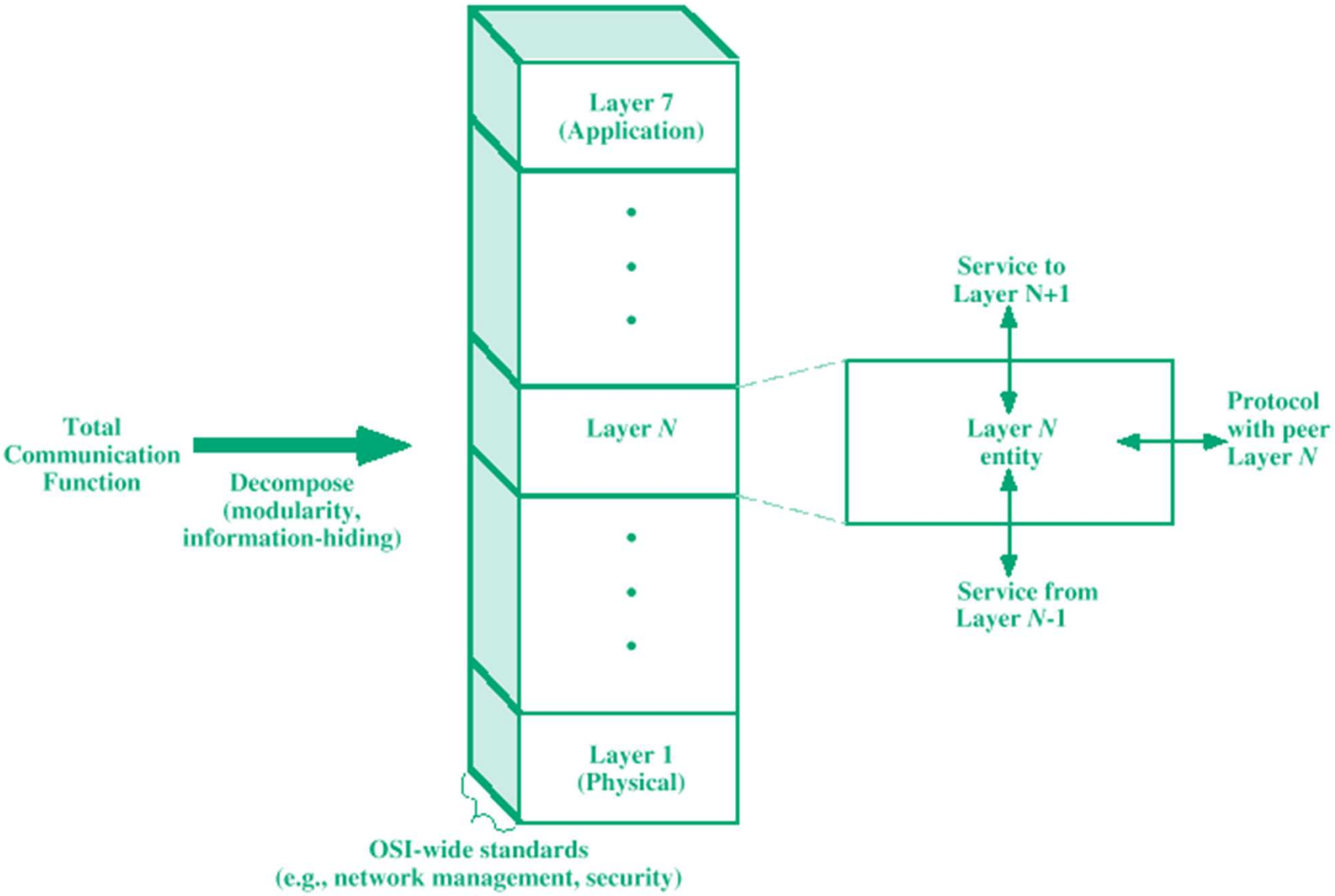
ISO Open Systems Interconnection Reference Model, ISO 7489

- a basic reference model
  - o– common basis for standards development
  - o– perspective on existing standards
  - o– specifies external behavior of systems, using **reference interfaces** – provide openess
- 7 layer model
- objective is to be a common base for any exchange of information
- physically info moves down - across - up
- logically each layer converses with peer
- each layer relies on the next lower layer to perform more primitive functions
- each layer provides services to the next higher layer
- changes in one layer should not require changes in other layers

(see next figure)



OSI environment



OSI as framework for standardization

Elements of Standardization

Protocol specification

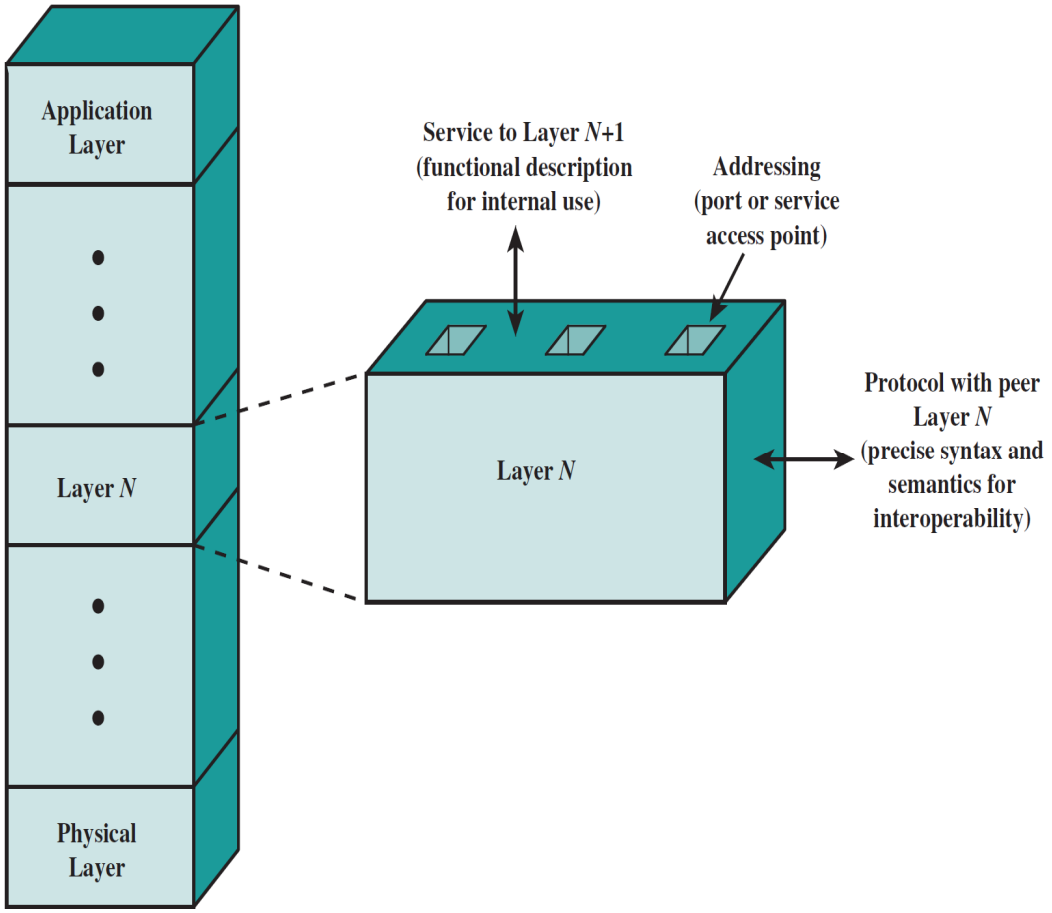
- Operates between the same layer on two systems
- May involve different operating system
- Protocol specification must be precise
  - Format of data units
  - Semantics of all fields
  - Allowable sequence of PDUs

Service definition

- Functional description of what is provided

Addressing

- Referenced by SAPs



Physical Layer

- "access actual media"
- Describes media interface and use
  - o– type of media
  - o– physical connection
  - o– how transmit & receive information
  - o– bit synchronisation
  - o– media dependent signals

Data Link Layer

- "manage individual (data) links between systems"
- Direct data link management
  - o– framing
  - o– addressing
  - o– sequencing & windowing
  - o– error detection & correction
  - o– access control
  - o– link management
  - o– node to node flow control

Aplicaţie/Application	7
Prezentare/Presentation	6
Sesiune/Session	5
Transport	4
Reţea/Network	3
Legătură de date/Data Link	2
Fizic/Physical	1

Network Layer

- "manages networks of links"
- provides for info transfer over a network
  - o– addressing
  - o– message forwarding
  - o– routing
  - o– congestion control
  - o– flow control
  - o– billing & accounting
- similar functions to Data Link / Transport layers
  - – segmentation, multiplexing, sequencing, error control

Transport Layer

- "end to end data transfer"
- reliable, universal transport service
  - o– multiplexing
  - o– addressing
  - o– connection management
  - o– message segmentation
  - o– sequencing
  - o– error control
  - o end to end flow control

Aplicaţie/Application	7
Prezentare/Presentation	6
Sesiune/Session	5
Transport	4
Reţea/Network	3
Legătură de date/Data Link	2
Fizic/Physical	1

Session Layer

- "dialog control"
- manages logical communication sessions
  - o– dialog discipline (half vs full duplex)
  - o– grouping
  - o– checkpoint & recovery
  - o– resource management

Only used by some applications

Presentation Layer

- "common format & language for messages"
- define format of data exchanged
  - o– data format transformation and security issues
    - -code conversion
    - -compression
    - -encryption
    - -screen formatting
  - o– protocol conversion
  - o– database management

Aplicaţie/Application	7
Prezentare/Presentation	6
Sesiune/Session	5
Transport	4
Reţea/Network	3
Legătură de date/Data Link	2
Fizic/Physical	1

Application Layer

- "application services & access mechanisms"
- defines interface for any applications
- defines network management functions
- defines specific general-purpose applications – VT, FTAM, X.400, X.500

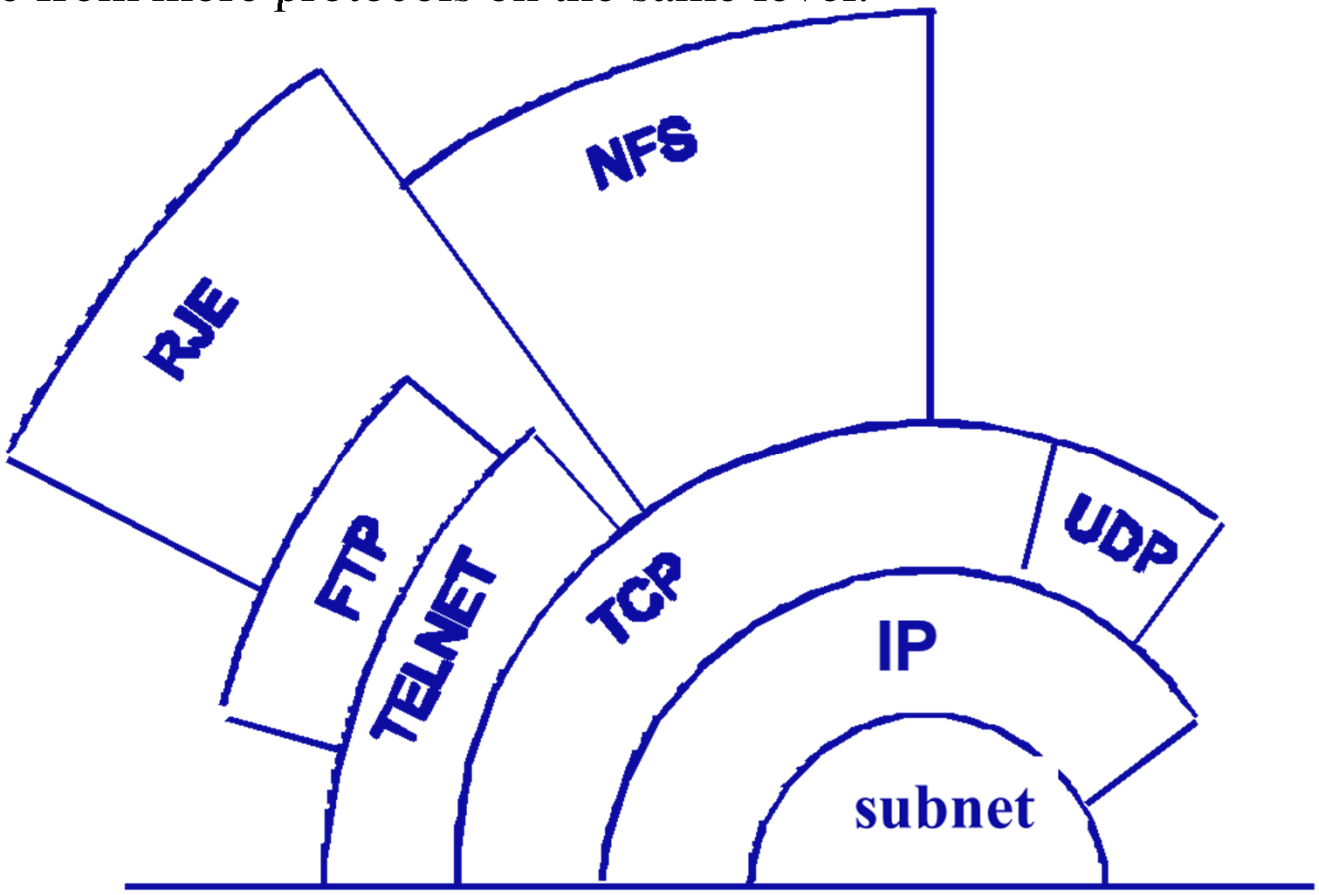
It's a Reference Model , so:

- not all functions, not all layers, need be used in an application
- "layered models are a very good way to design network protocols, but a very poor way to implement them" Van Jacobsen
- in practice, often merge layer functions, see the three layer model
- are many different actual protocols in use
- but still a good reference model, excellent support for teaching

TCP/IP Reference Model (DoD DARPA)

May be considered TCP/IP a reference model? Sure it is a model, the 'de facto' standard for today implementations! Used by the Internet

A hierarchy of levels; also communications between non-adjacent levels; can choose of one from more protocols on the same level.



TCP/IP Protocol Architecture

Application Layer

Communication between processes or applications

-remote access RLOGIN
-file transfer FTP, TFTP
-electronic mail SMTP
-information retrieval NIR
-network management SNMP

End to end or transport layer (TCP/UDP/…

End to end transfer of data

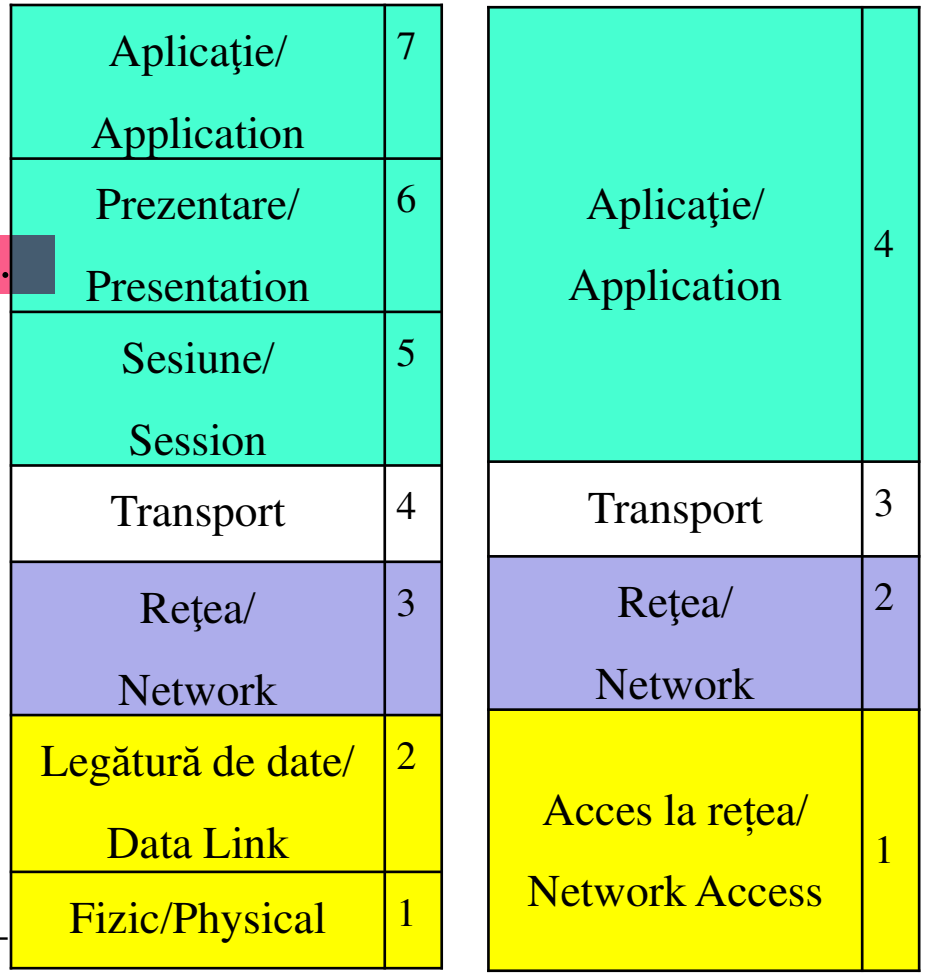
May include reliability mechanism (TCP)

Internet Layer (IP)

Routing of data

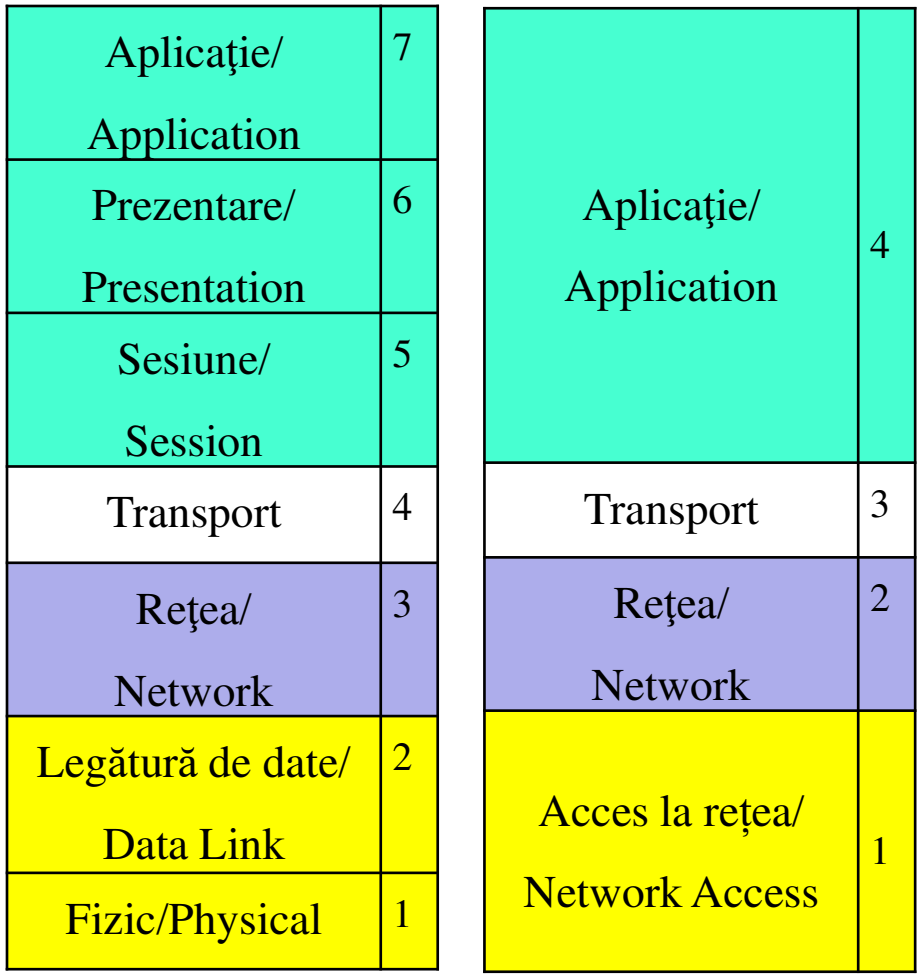
Address resolution

Routing protocols

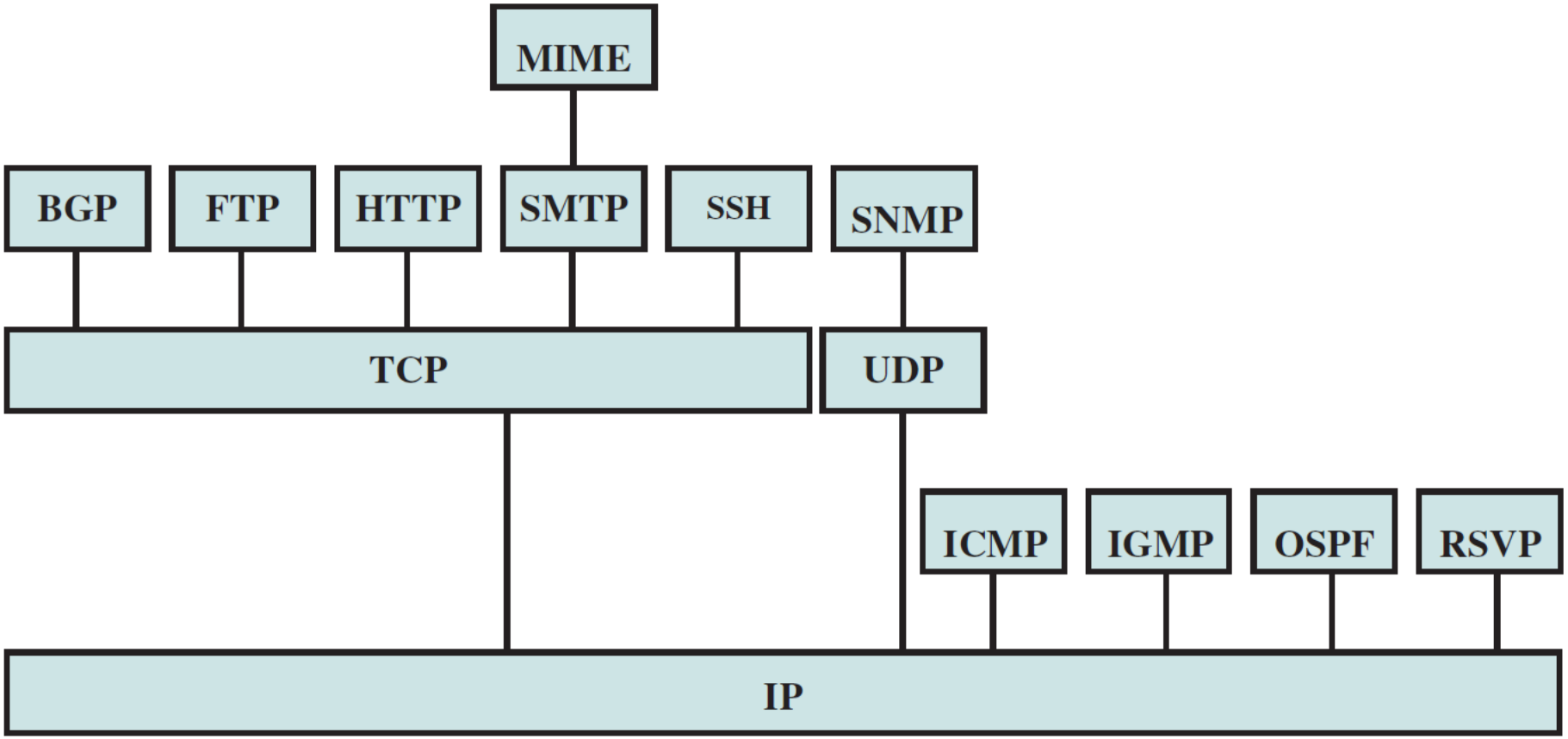


Subnet Level

- Net access
  - Logical interface between end system and network
- Physical access
  - Transmission medium
  - Signal rate and encoding



Some of the components of the TCP/IP protocol suite are depicted in next slide



BGP	=	Border Gateway Protocol	OSPF	=	Open Shortest Path First
FTP	=	File Transfer Protocol	RSVP	=	Resource ReSerVation Protocol
HTTP	=	Hypertext Transfer Protocol	SMTP	=	Simple Mail Transfer Protocol
ICMP	=	Internet Control Message Protocol	SNMP	=	Simple Network Management Protocol
IGMP	=	Internet Group Management Protocol	SSH	=	Secure Shell
IP	=	Internet Protocol	TCP	=	Transmission Control Protocol
MIME	=	Multipurpose Internet Mail Extension	UDP	=	User Datagram Protocol

Comparison of the protocol hierarchies