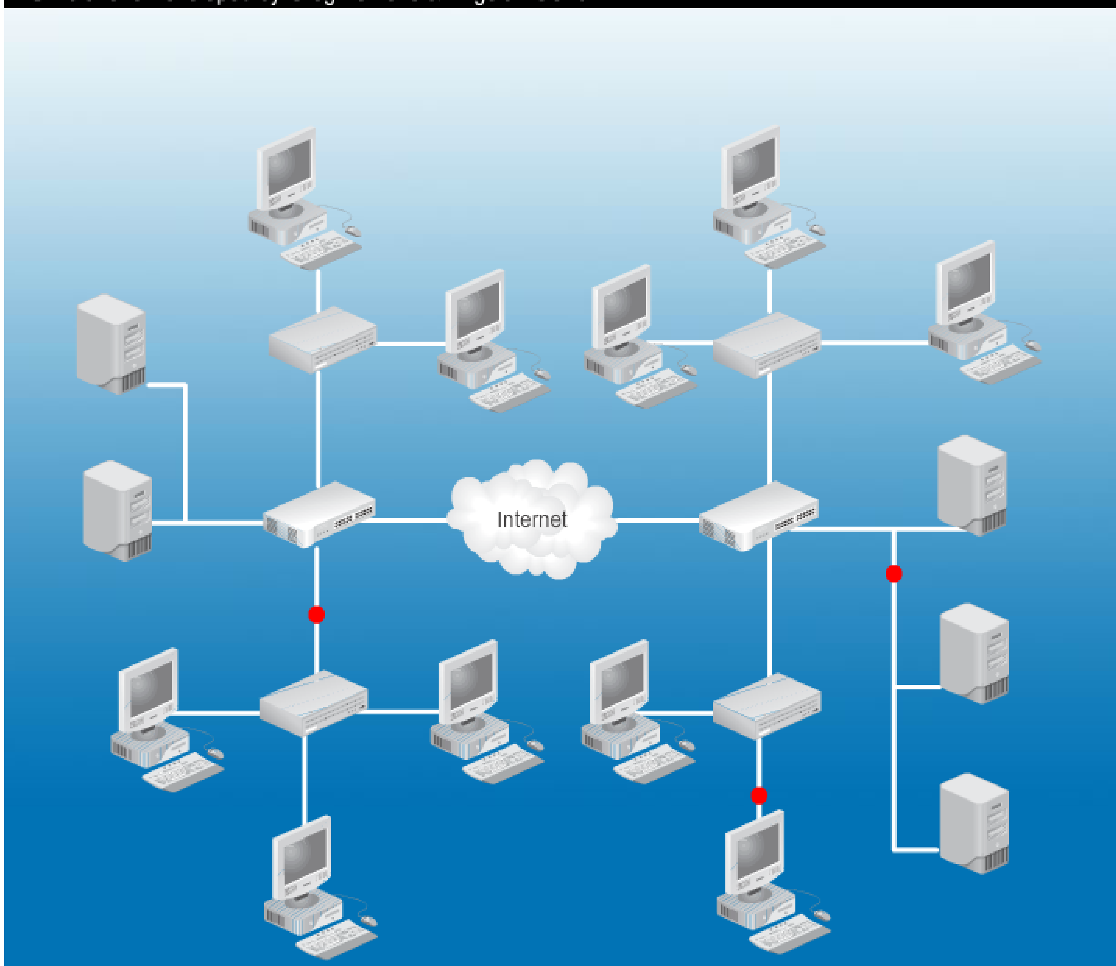
http://scisweb.ulster.ac.uk/~kevin/com320/labs/Simulations/index.swf

Guide to

Networking Essentials

Simulations Developed by Greg Tomsho & Angela Poland



Contents

OSI Model

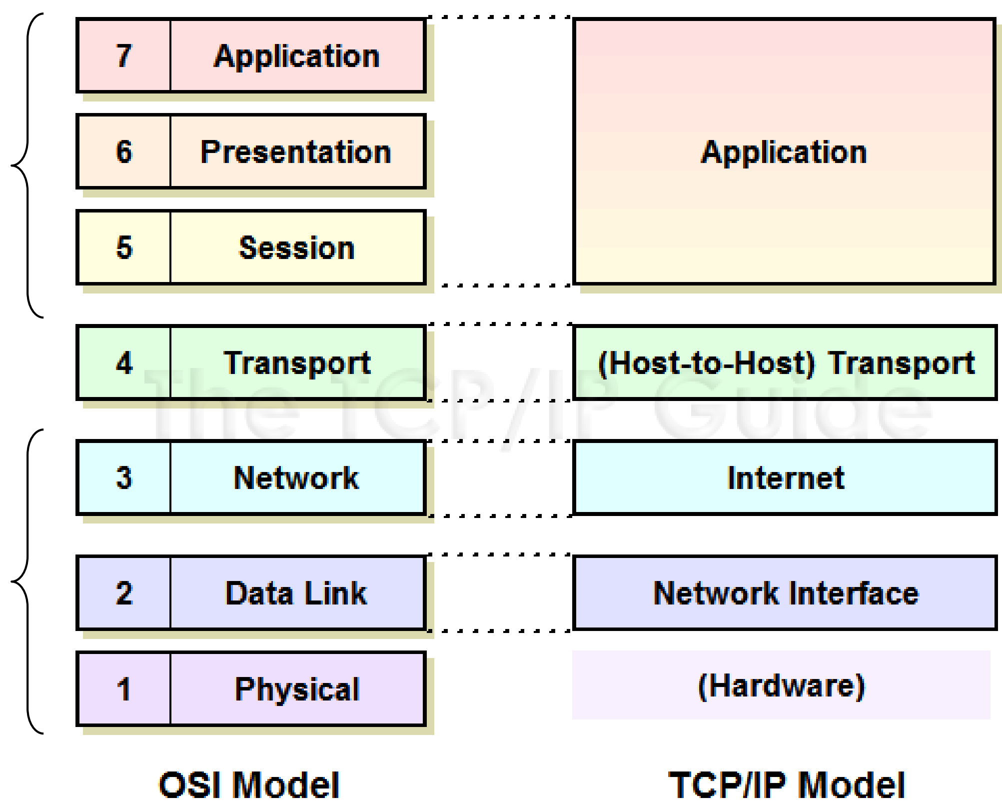
Layered OSI Architecture

- composed of 7 ordered layers
- there is fairly natural correspondence between TCP/IP & OSI layers ⇒ **TCP/IP architecture** can be explained in terms of corresponding OSI layers

application support layers – allows communication with end-user and interoperability among unrelated software systems

transport layer – links upper and lower group – ensures that what lower layers have transmitted is in a form that upper layers can use

network support layers – deal with physical aspects of moving data from one device to another – across one link and across the whole network

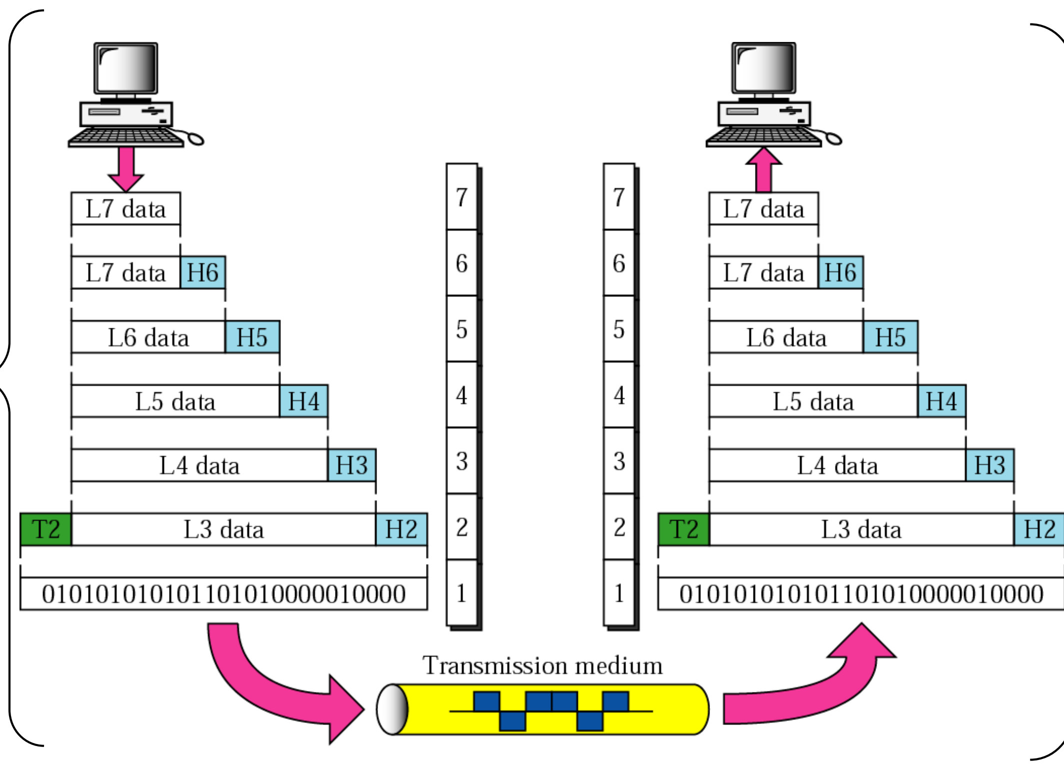


OSI Model (cont.)

Peer-to-Peer Communication over 7 OSI Layers

- **message moves <u>down through layers</u> on sending device**
- **when data reaches physical layer, it is changed into electromagnetic signal and sent along a physical link**
- **message moves <u>up through layers</u> at the receiving device**

encapsulation: packing of upper-layer data and its own control data – occurs at the source

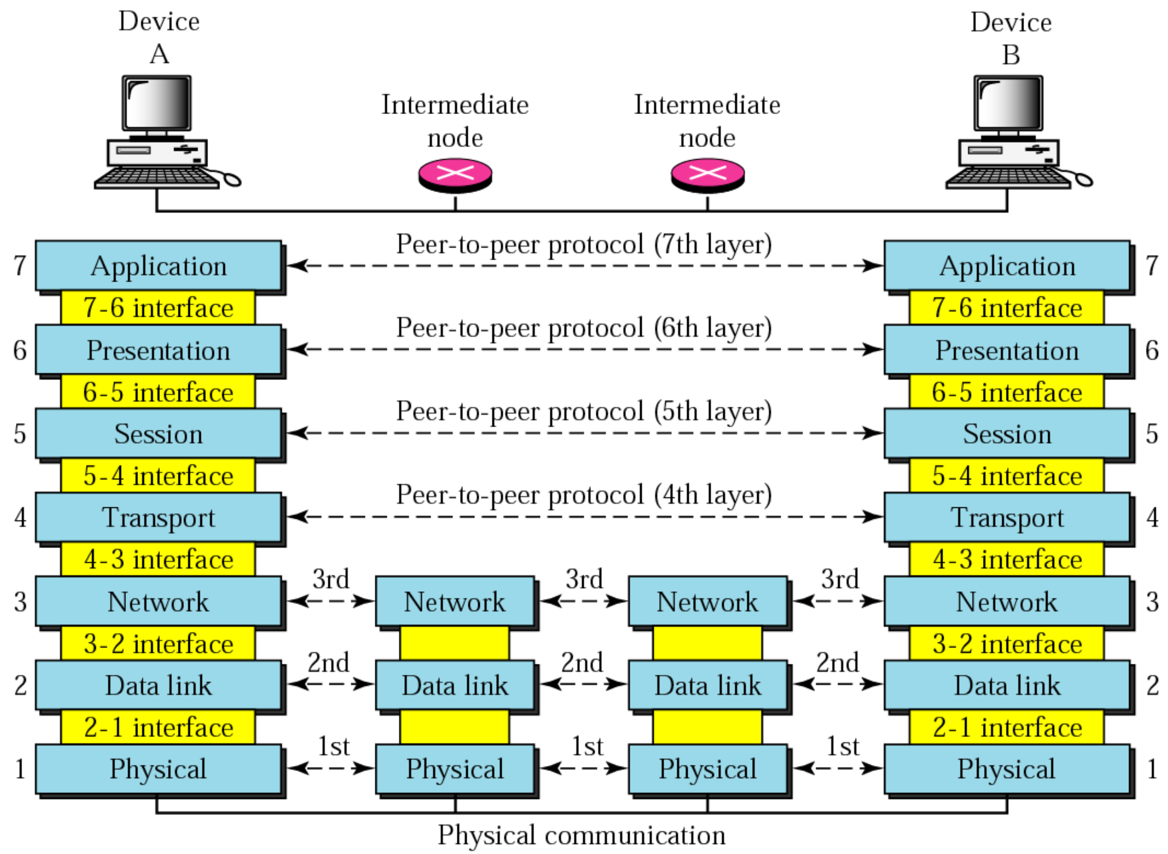


decapsulation: separation of upper-layer data from its own control data – occurs at the destination

OSI Model (cont.)

Peer-to-Peer Communication over 7 OSI Layers

- **at intermediate nodes (routers), data is pulled only up to network layer, so that next hop could be determined**



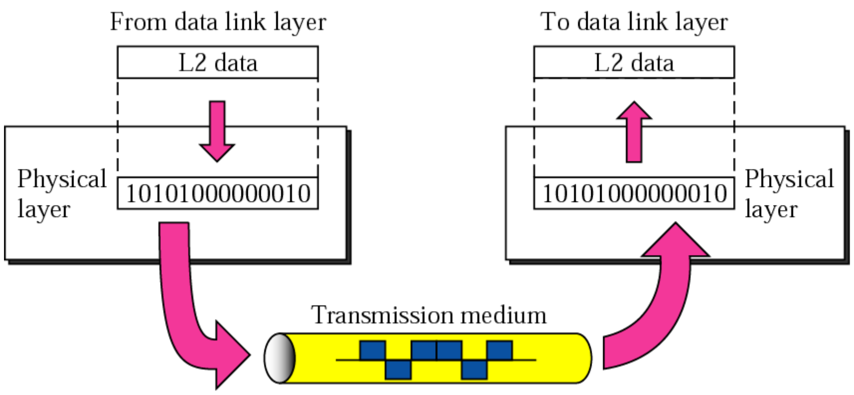
At a router, data is both received and sent
⇒ both encapsulation and decapsulation are performed.

OSI Model: Physical Layer

1. Physical Layer

- **coordinates transmission of bit-stream over physical medium, including**
  - **representation of bits: to be transmitted, bits must be encoded into signals – electrical or optical; P.L. defines type of encoding – how 0s & 1s are changed to signals (e.g. 1 = +1V, 0 = -1V)**
  - **bit length / data rate: P.L. defines how long a bit lasts and, accordingly, number of bits sent each second**

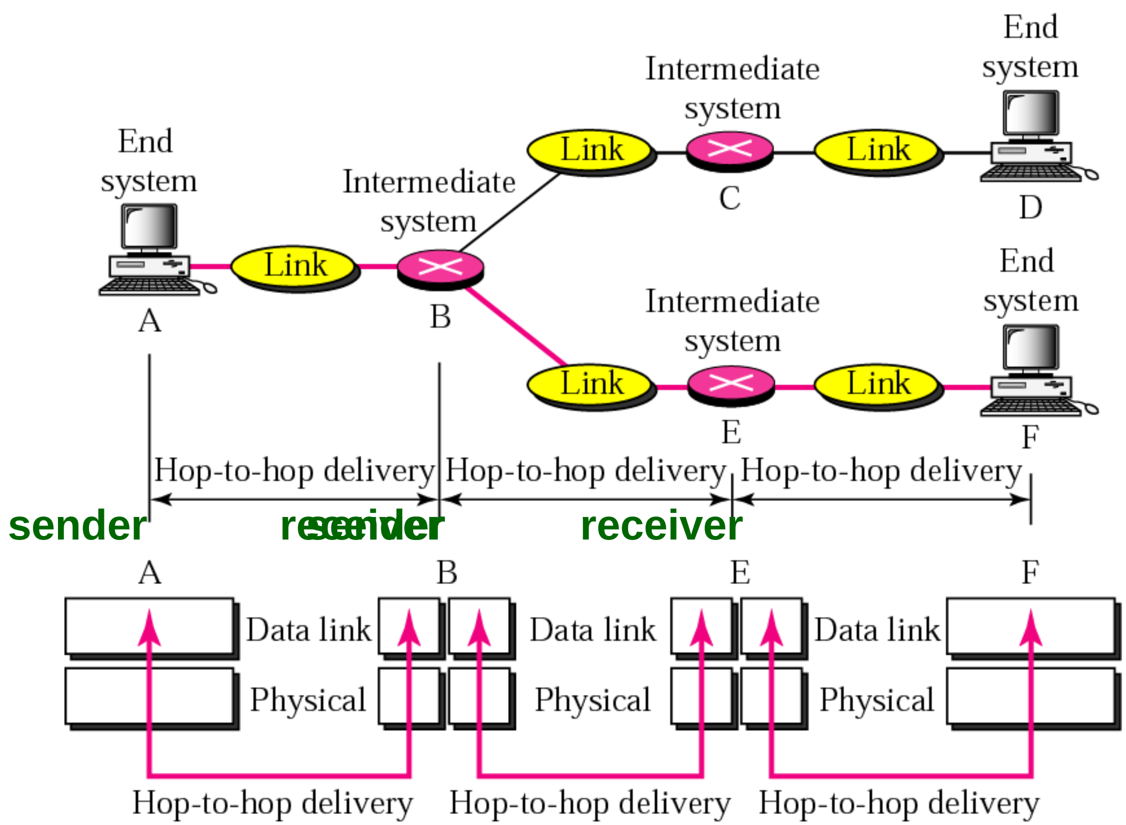
(different values for copper wire, coaxial cable, fiber-optics, …)



2. Data-Link Layer

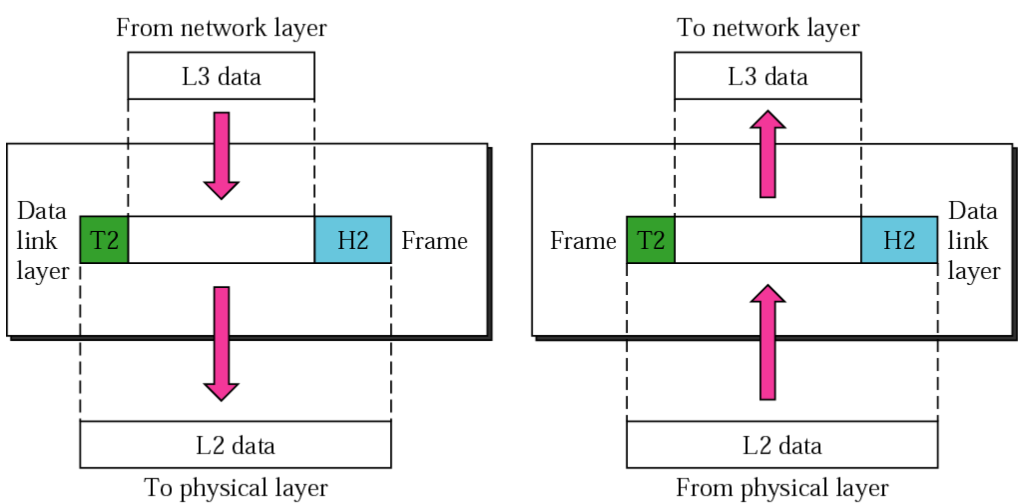
The data link layer transforms the physical layer, a raw stream of bits, to a reliable link between two devices on the same network.

It makes the physical layer appear error-free to the upper layer.



OSI Model: Data-Link Layer

- **framing**: The D.L.L divides the stream of bits received from the network layer into manageable data units called frames.
- **physical addressing**: The D.L.L adds a header to the frame to specify the NIC address of appropriate receiver on the other side (of wire).
- **error control**: The D.L.L adds reliability to the physical layer by adding a trailer with information necessary to detect/recover damaged or lost frames.
- **access control**: When 2 or more devices are connected to same link, the D.L.L determines which device has control over the link at any given time.
- **flow control**: If rate at which data are absorbed by receiver is less than sender's transmission rate, the D.L.L imposes a flow control over sender.



http://scisweb.ulster.ac.uk/~kevin/com320/labs/Simulations/index.swf

Guide to

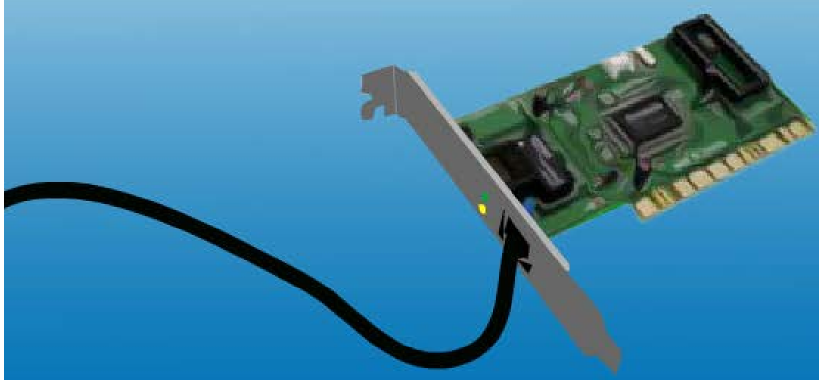
Networking Essentials

Simulations Developed by Greg Tomsho & Angela Poland

Replay Play Pause Menu

Summary:

How a NIC Works



This simulation gives you an idea of how a NIC and its driver works.

For incoming data, bit signals travel along the medium and are received by the NIC.

The received bits are formatted into a frame.

The CRC is calculated and compared to the the CRC in the frame trailer. If they don't match, the frame was damaged or changed and the frame is discarded. This situation is rare but can happen in electrically noisy environments or if the media is poorly terminated.

If the CRC is okay, the destination MAC address is checked. If it matches the NIC's burned in address or is a broadcast, the frame is processed; otherwise it is discarded.

Once the MAC address is verified, the frame header and trailer are stripped creating a packet which is sent to the network protocol for further processing. The NIC's job is done.

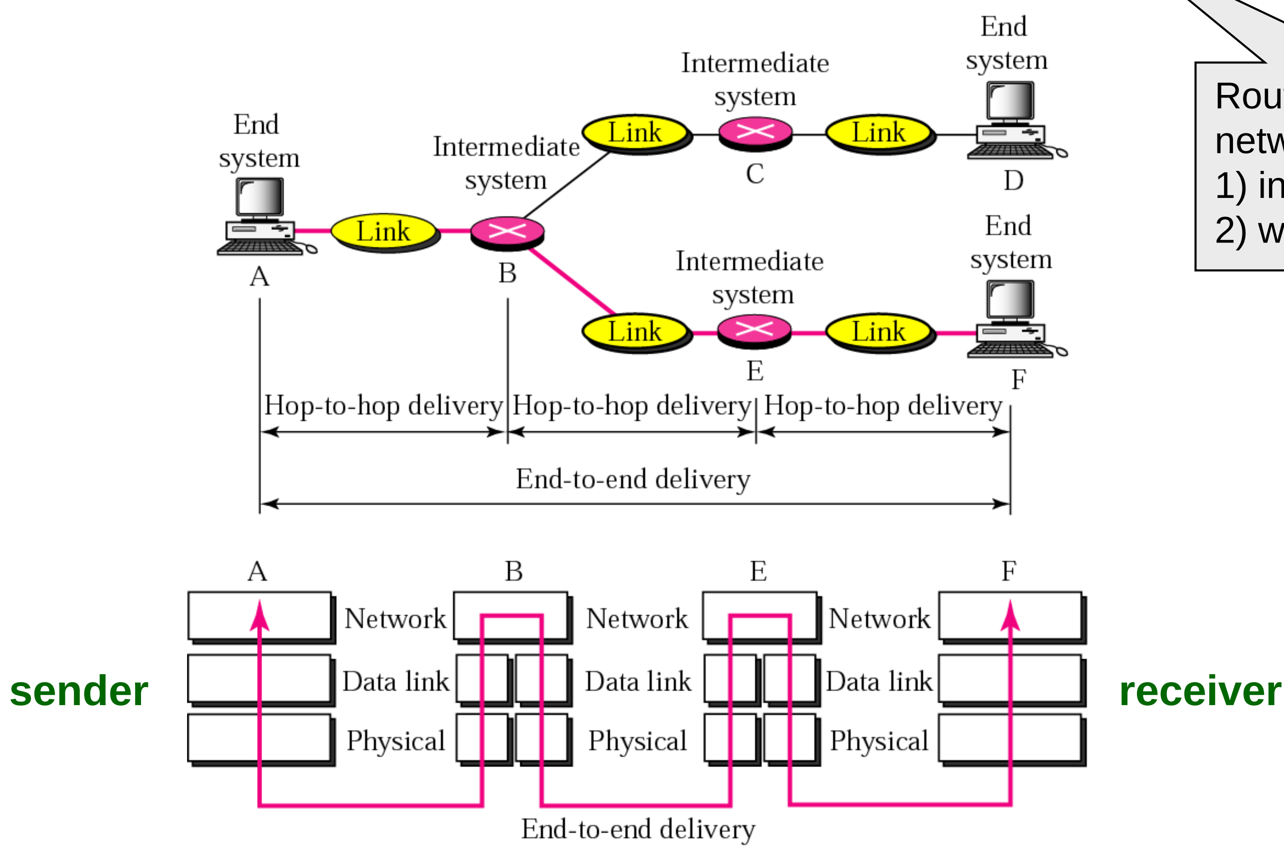
Now, for outgoing data, the reverse process occurs.

OSI Model: Network Layer

3. Network Layer

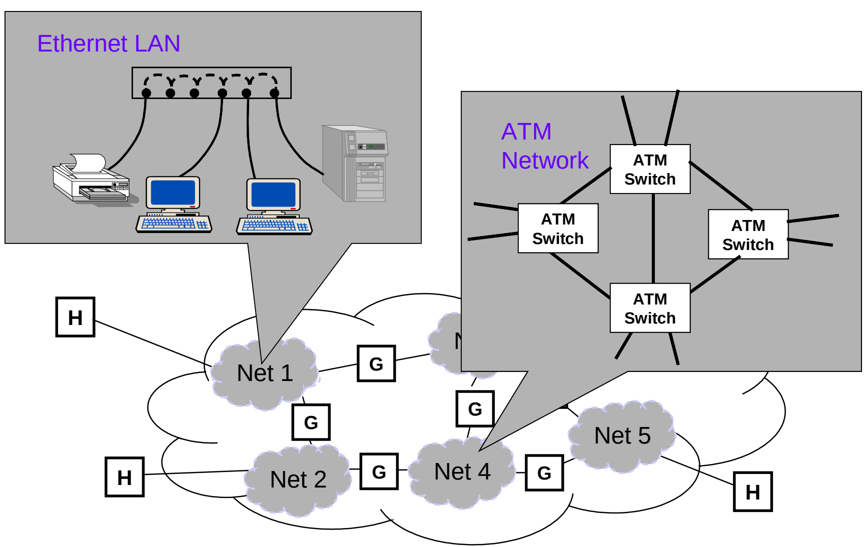
While the data link layer oversees the delivery of packets between two devices on the same network,
the network layer is responsible for the source-to-destination delivery of packet across multiple networks / links.

Routing over multiple networks:
1) in min time, AND
2) with min overhead.



OSI Model: Network Layer

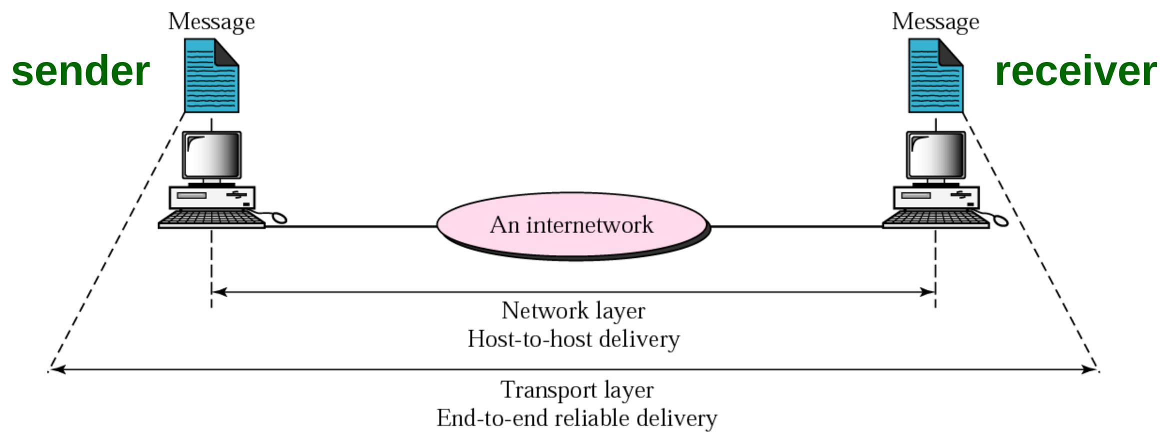
- **logical addressing**: **The physical addressing implemented by the data link layer handles the addressing / delivery problem locally – over a single wire. If a packet passes the network boundary another addressing system is needed to help distinguish between the source and destination network.**
- **routing**: **The N.L. provides the mechanism for routing/switching packets to their final destination, along the optimal path – across a large internetwork.**
- **fragmentation & reassembly**: **The N.L. sends messages down to the D.L.L. for transmission. Some D.L.L. technologies have limits on the length of messages that can be sent. If the packet that the N.L. wants to send is too large, the N.L. must split the packet, send each piece to the D.L.L, and then have pieces reassembled once they arrive at the N.L. on destination machine.**

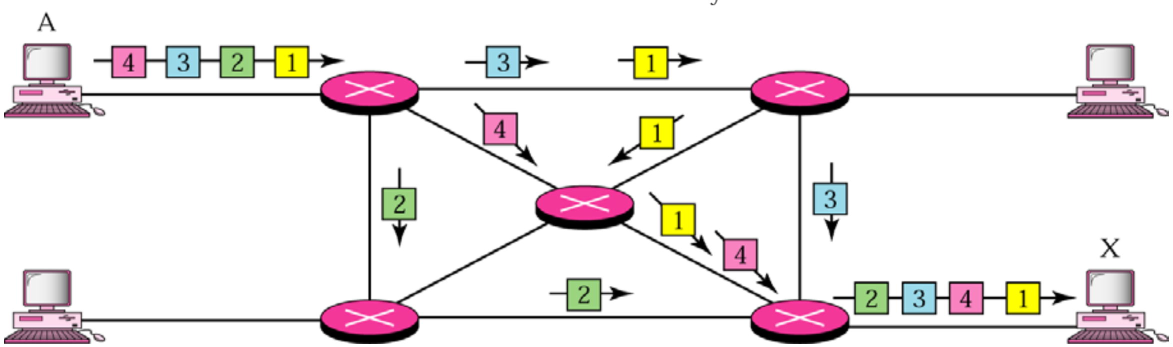


4. Transport Layer

The transport layer is responsible for
process-to-process delivery of an entire message.

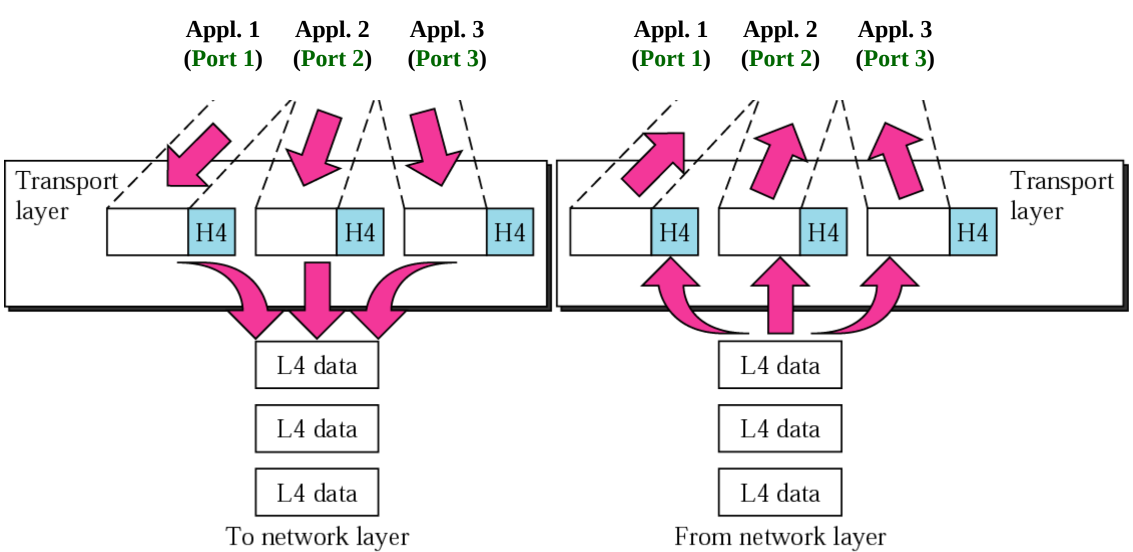
While network layer gets each packet to the correct computer, transport layer gets the entire message to the correct process on that computer.





OSI Model: Transport Layer

- **port addressing**: Computers often run several processes at the same time. Hence, process-to-process delivery means delivery not only from one computer to the other but also from a specific process on one computer to a specific process on the other. The T.L. header therefore must include a type of address called a **port address**.
- **segmentation and reassembly**: A message is divided into segments, each segment containing a sequence number. These numbers enable the T.L. to reassemble the message correctly upon arrival at the destination, and to identify and replace packets that were lost in the transmission.
- **flow & error control**: Flow & error control at this layer are performed end-to-end rather than across a single link.

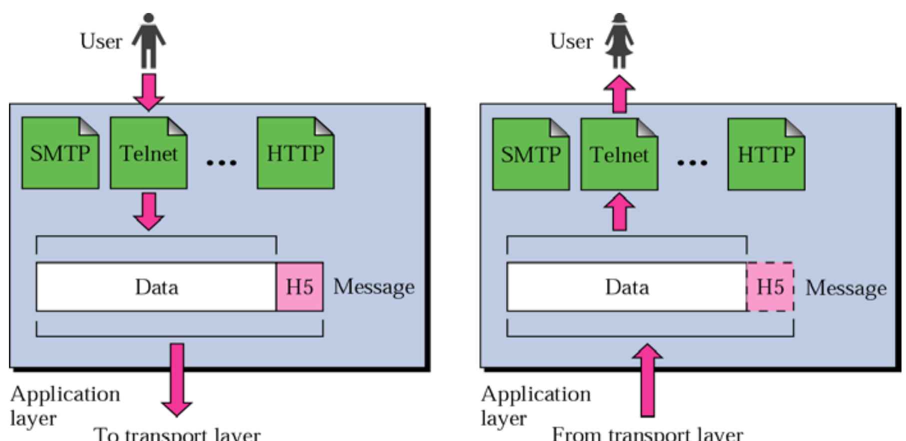


OSI Model: Application Layer

Application Layer (i.e. OSI Session + Presentation + Application Layer)

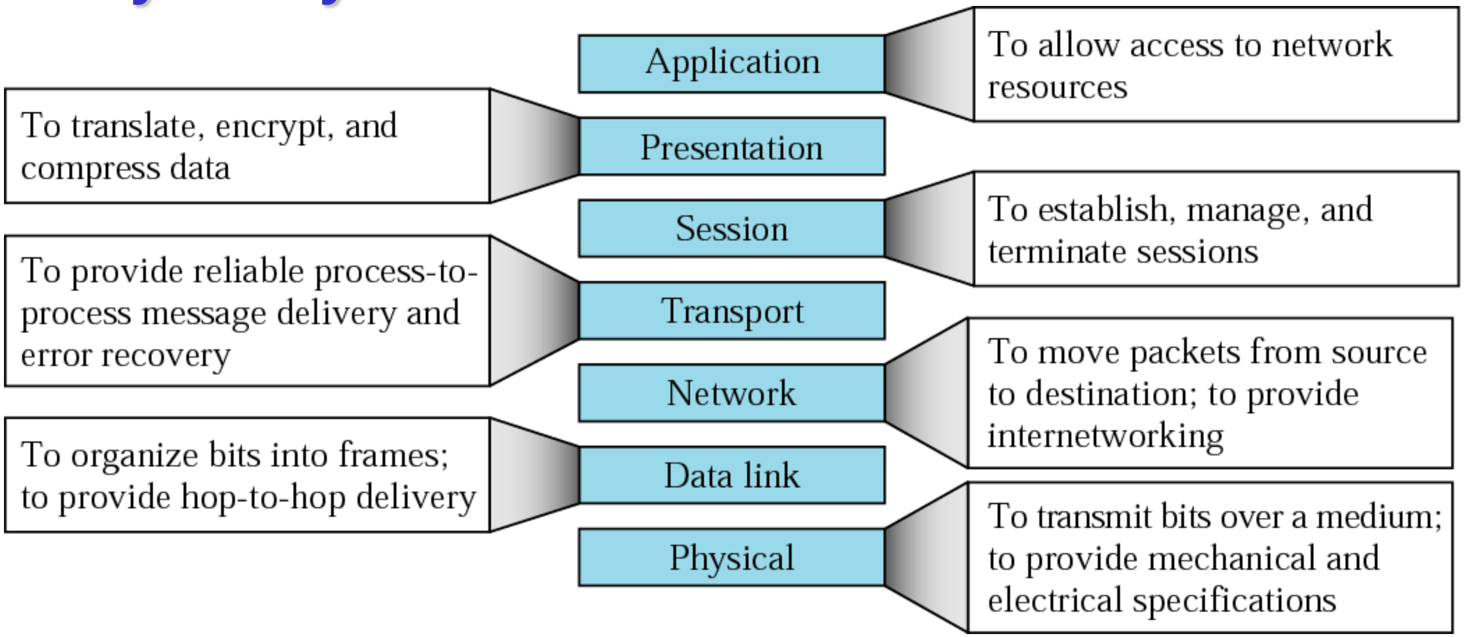
The application layer provides the actual service / interface to the user.

- **synchronization**: If a system is sending a large file, insert checkpoints every 100 pages to ensure that each 100-page unit is received and acknowledged independently. Thus, if a crash happens during the transmission of page 523, only pages that need to be resend are 501 to 523.
- **encryption**: To carry sensitive info., a system must be able to ensure privacy. Encryption transforms the original information to another form, while decryption reverses the received message back to its original form.
- **compression**: Data compression reduces the number of bits contained in a file – it is particularly important in the transmission of multimedia.



OSI Model: Summary

Summary of Layers



Why 7 Layers?

- **physical and application layer = bottom and top**
- **data link layer – bundles all link-dependent details**
- **network layer – responsible for hop-to-hop routing**
- **transport layer – responsible for end-to-end flow control**
- **session & presentation layer – provide some useful features; these can be easily provided in application layer**

OSI Model: Summary

Why did OSI Model Fail in Practice?

(1) Bad Timing

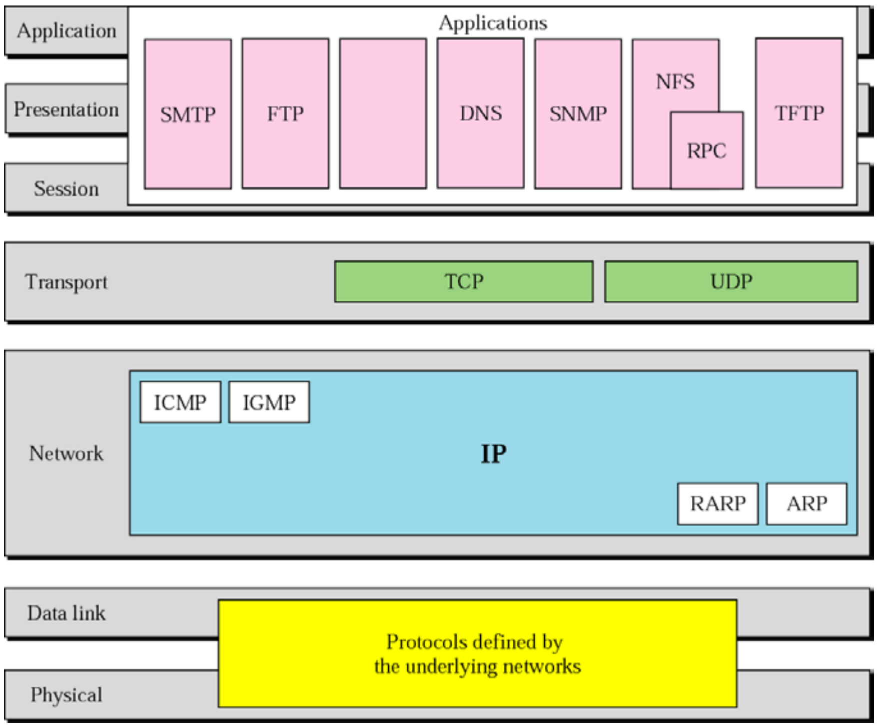
- although essential elements of OSI model were in place quickly, final standard (model + protocols) was not published until 1984
- by the time it took to develop OSI protocol standards, TCP/IP network architecture emerged as an alternative for open system interconnection
- free distribution of TCP/IP as part of Berkeley UNIX system ensured widespread use and development of numerous applications at various academic institutions

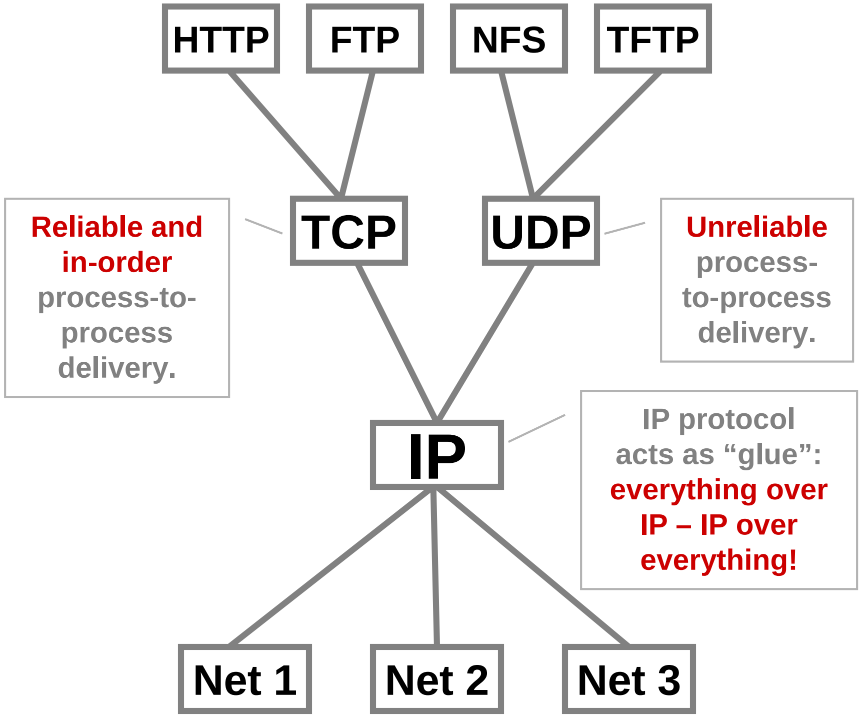
(2) Complexity and Inefficiency

- 7-layer OSI model was specified before there was much experience in designing large-scale OSI networks – some design choices were made in absence of concrete evidence of their effectiveness
- some functions, e.g. error control, appear in several layers (data link, transport, application) $\Rightarrow$ overall efficiency reduced

Internet Model

Internet Model and Hourglass Protocol Stack

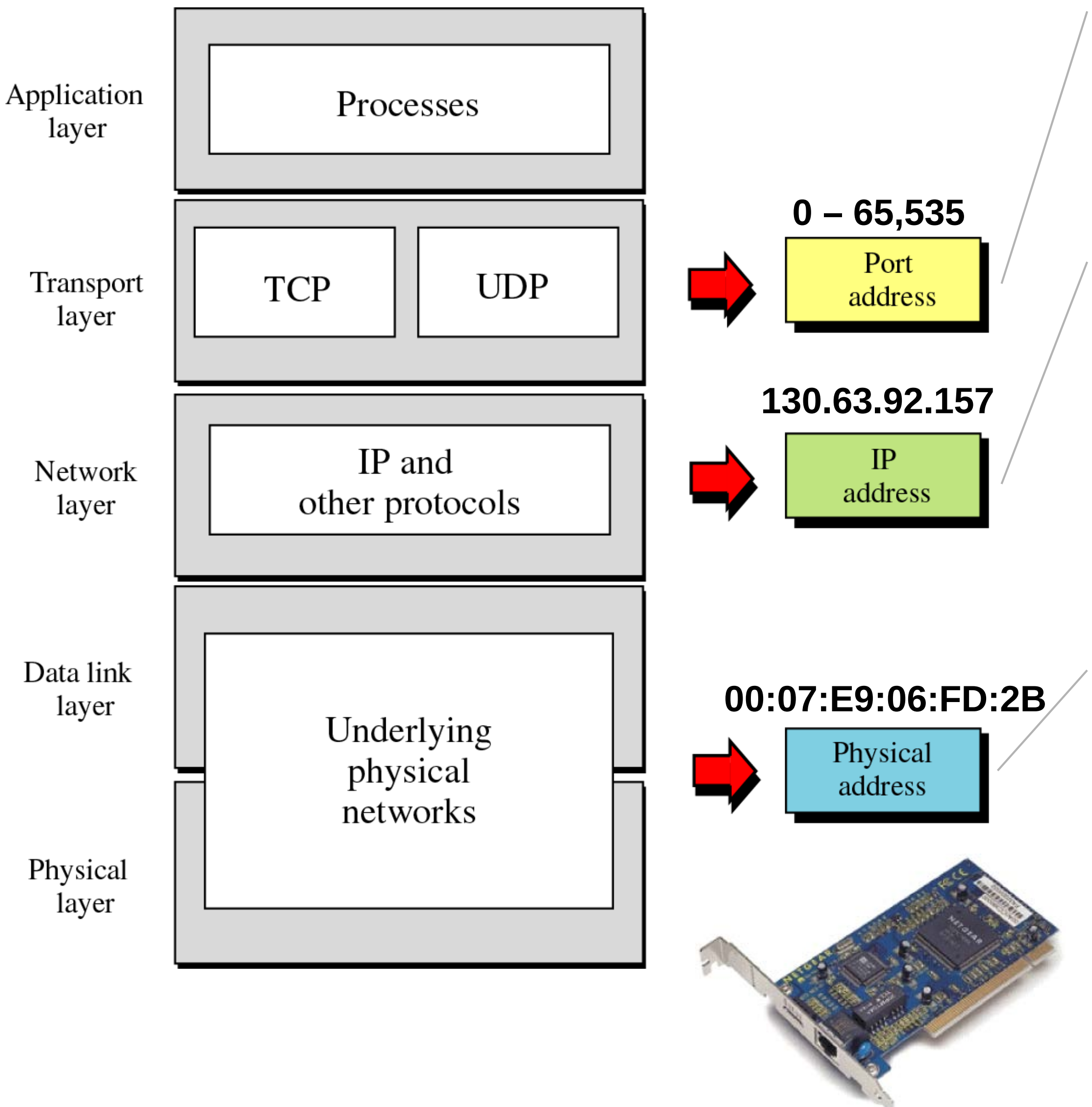




The operation of one single protocol at the network layer (IP protocol) over various networks provides independence from the underlying network technologies. IP over anything, anything over IP!

Internet Model (cont.)

Addresses in TCP/IP Model



- **locally unique logical address** used to differentiate between applications sharing the same IP address

- **globally unique logical address** used to located corresponding node in the entire Internet
- hierarchical addresses that can be easily aggregated in routing tables ⇒ **fast routing !**

- **globally unique** NIC address used to located corresponding node on a LAN
- each NIC on a subnetwork may have different manufactures ⇒ we cannot aggregate physical addresses in routing tables ⇒ **large networks cannot use these addresses to identify hosts !**