Structure of the Internet

- Structure and operation of the Internet
- The TCP/IP stack
- The WWW
- URL and URI
- Purpose of a web browser
- Domain names and IP addresses
- Role of HTTP in retrieving a web page
- Internet protocols that support file transfers

What the Spec says – what you need to know

The Internet and its Uses, World Wide Web (WWW), Intranet

- Understand the structure of the Internet, the role of packet switching and routers.
- Understand the difference between the Internet, the Web and an intranet.

URL, URI, Domain Names and IP Addresses

- Describe the term URL in the context of Internetworking.
- Describe the role of URIs in the context of Internetworking.
- Explain the terms domain name and IP address.
- Describe how domain names are organised.

What the Spec says – what you need to know

Internet registries and Internet registrars - Explain why such services are provided.

ISP - Understand the role of an ISP.

Domain Name System (DNS) - Understand the purpose of DNS.

Be familiar with the client–server model.

Common Standard Protocols: TCP/IP, FTP, HTTP, TELNET, POP3 & SMTP, well-known ports & client ports, HTTPS

- Describe the role of the four layers of the TCP/IP protocol stack, including sockets.
- Be familiar with
  - Telnet server for remote management of a server
  - Web server to retrieve web pages in text form
  - E-mail server to read and send e-mail
  - FTP client software and an FTP server to transfer files using anonymous and non-anonymous access.
  - Understand the role of a web browser in retrieving web pages and web page resources and rendering these accordingly.

Starter (5 mins)

Start completing the first 4 pages of the workbook.

Use your textbook as a primary resource.

A few key terms & definitions, frequently used when talking about networks & internet.

The Client-Server model

What is a server?

A server is a computer that provides and manages network resources.

Types of server:

- File server
- Print server
- Application server
- Mail server
- Web server
- Database server
- CD-ROM server

Client vs Peer

A **client** is a computer that uses a network resource, but does not provide one.

A **peer** is a computer that both uses and provides network resources.

Server-based network

→ resources, security, user management and administration, are managed centrally by dedicated servers.

In the client-server model:

- the server waits for a request from the client
- client initiates communication, server responds

Protocols

→ rules that define the ways in which different computers can be connected, and send signals to each other, to ensure that communication will be successful.

Standard protocols

A standard protocol is one which has been agreed by a standards authority – such as ANSI or the IEEE.

The need for standard protocols

Standard protocols allow data to be exchanged between computer systems developed by different manufacturers.

One example of a standard protocol is TCP/IP – this is the protocol used by all computers connected to the Internet.

Protocol layers

Communications between computers are defined in separate stages called '**layers**'.

There are two models which describe these protocol layers:

- TCP/IP protocol stack – splits communications into four main layers;
- Open systems interconnection (OSI) – splits communications into seven layers.

TCP/IP protocol stack

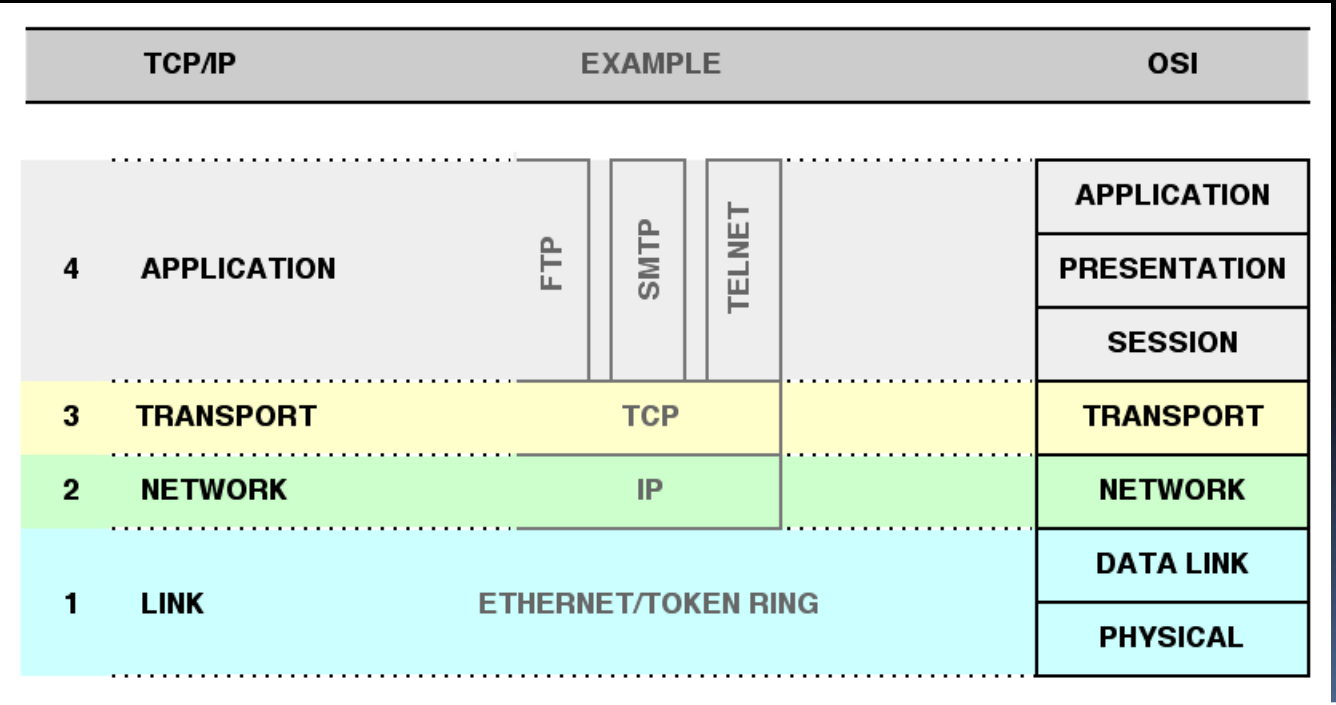
TCP/IP protocol stack splits communications into four layers:

- Application;
- Transport;
- Network;
- Link.

Note that the data is passed between these layers during transmission.

TCP/IP protocol stack

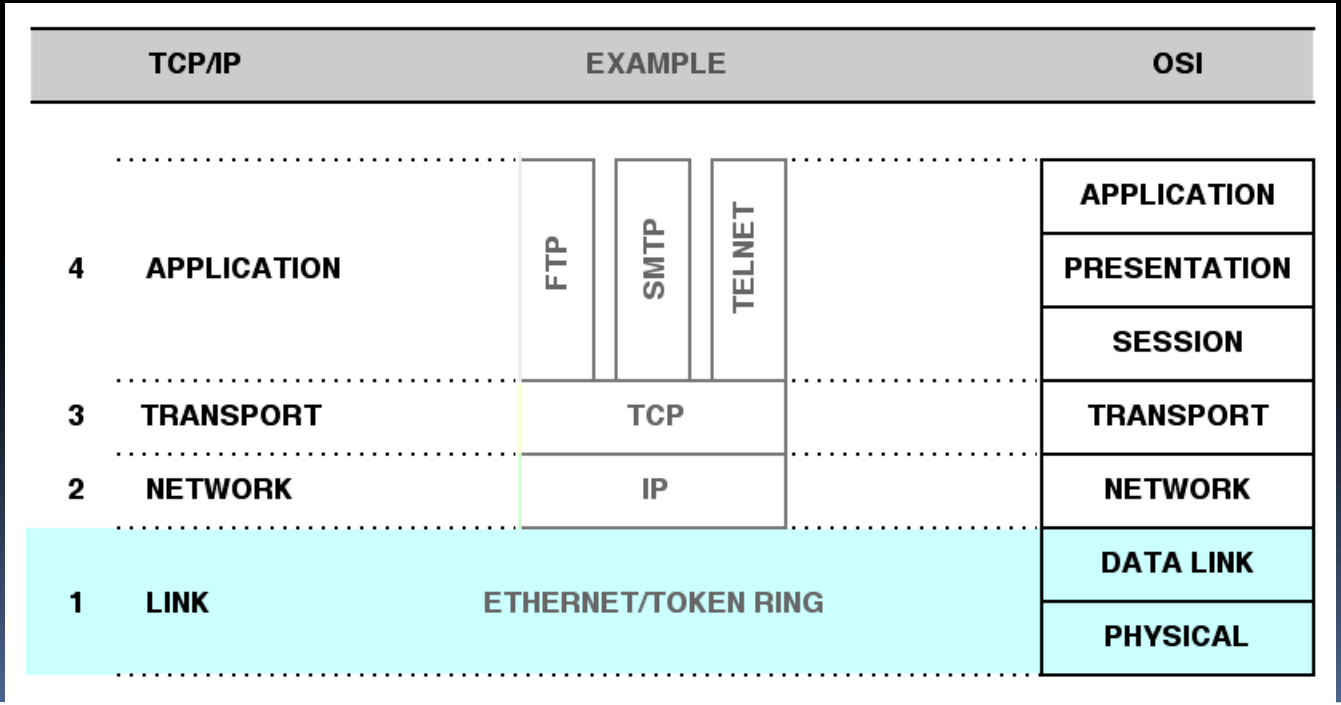
Note that the OSI model is generalised for any communications system and sub-divides some layers of TCP/IP:



Link Layer

The link layer contains protocols that define the rules for the type of cable and connectors that physically join the devices and for describing how the signals are transmitted through the communications media (e.g. the voltage of the electrical signals or the size of the light-pulse).

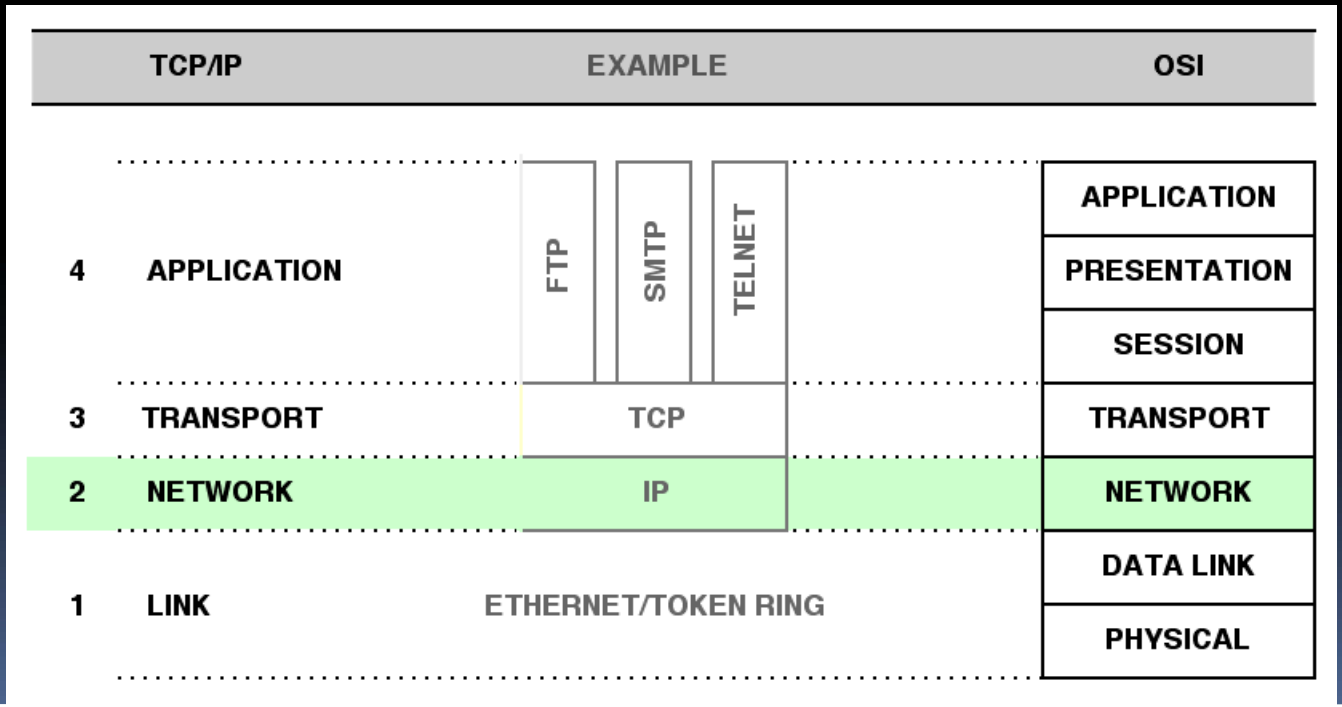
Eg device driver, interface card.



Network Layer

The network layer contains the protocols which provide the rules for identifying the source and the destination of the data packets and also the rules on how packets are forwarded (by routers) to their intended destination.

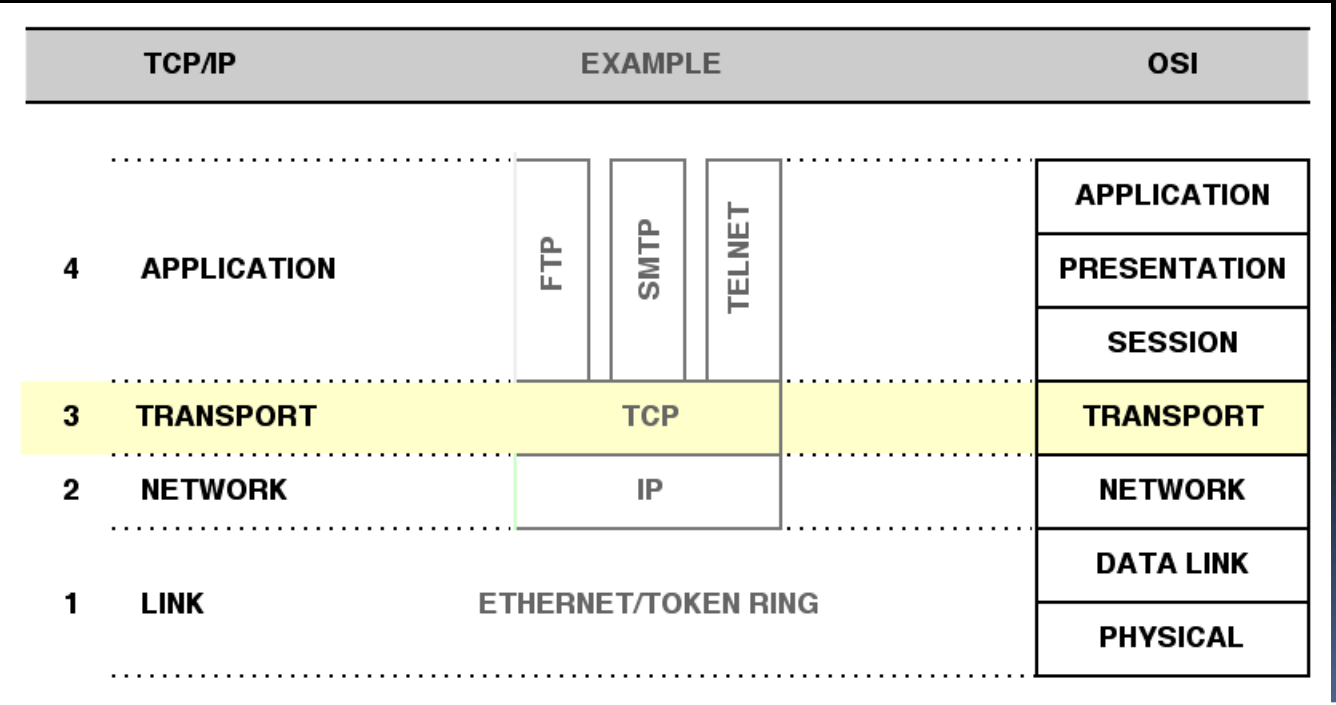
Eg IP



Transport Layer

The transport layer contains the protocols which ensure that data packets have not been corrupted when they arrive at their destination.

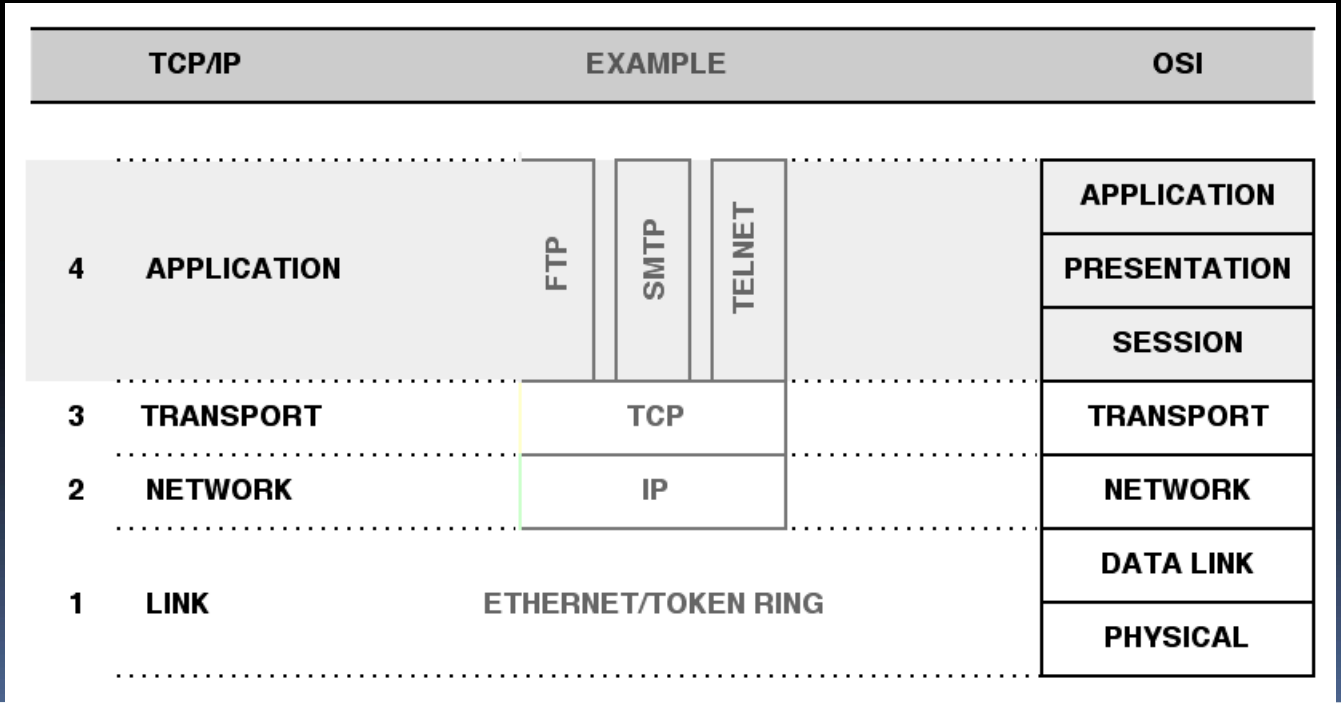
Eg TCP



Application Layer

The application layer contains the programs that are used to construct, read and (if necessary) execute the messages.

Applications include: http, FTP, Telnet, SMTP, POP and IRC.



Spot Check

Write down:

The **link layer** contains _____ that define the rules for the _____ that physically join the devices, and for describing how _____ through the communications media .

Example: _____

Spot Check

Write down:

The **network layer** contains the _____ which provide the rules for _____ _____and also the rules on how _____ to their intended destination.

Example: _____

Spot Check

Write down:

The **transport layer** contains the _____ which ensure that _____ when they arrive at their destination.

Example: _____

Spot Check

Write down:

The **application layer** contains the _____ that are used to _____ _____ the messages.

Example: _____

What is the Internet?

Net – computer network

Inter – connections between 2 or more computers / computer networks.

- Started in 1970
- A network of computer networks = Internet = Internetwork
- Computers use a globally unique address space based on IP (Internet Protocol) and TCP (Transmission Control Protocol)

What is the Internet?

- Each continent has a backbone of very high speed links which interconnect routers located in each country.
- Router = special switches that receive incoming packets of data along one link, and send them as outgoing packets along another link
  - Large businesses & orgs connect to the national backbone via a router gateway
  - Smaller orgs & home users of internet connect to an ISP

Routers

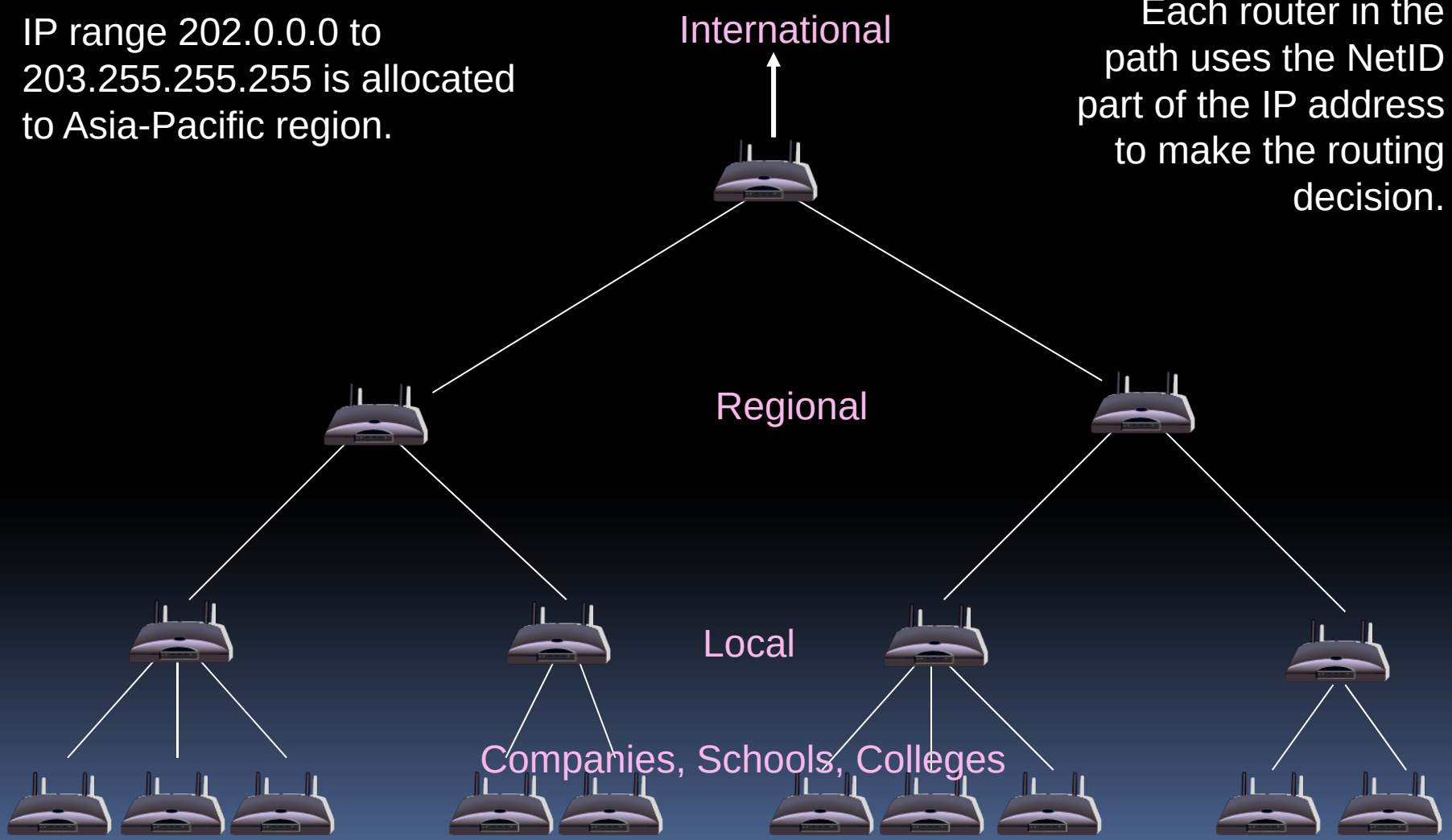
- Why are they used?
  - It is not practical to connect every host directly with every other host
  - A few hosts connect to a router, which connects to other routers etc
- How do they work?
  - They receive packets (datagrams) of data from one host / router;
  - Use the destination IP address they contain to pass on the packets
- Each router maintains a **table of other routers**, **computers and networks** it directly connects to + info about the hierarchical structure of the Internet to route a packet to the desired destination.
- Example:

Routers

Fact:

IP range 202.0.0.0 to 203.255.255.255 is allocated to Asia-Pacific region.

Each router in the path uses the NetID part of the IP address to make the routing decision.



What is the Internet?

- Gateway = allows one network to be connected to another (so that packets from one network can be translated into a form that is compatible with the other)
  - Necessary when communication channels on either side of it use different link layer protocols.
- The data transfer on the internet uses packet switching method.
- Each packet contains:
  - Source & Destination address
  - The actual data
  - The packet sequence number – used for correct re-assembling at destination
  - A checksum (parity check) – used for error checking

- Play the warriors video here (stop after 10 mins)

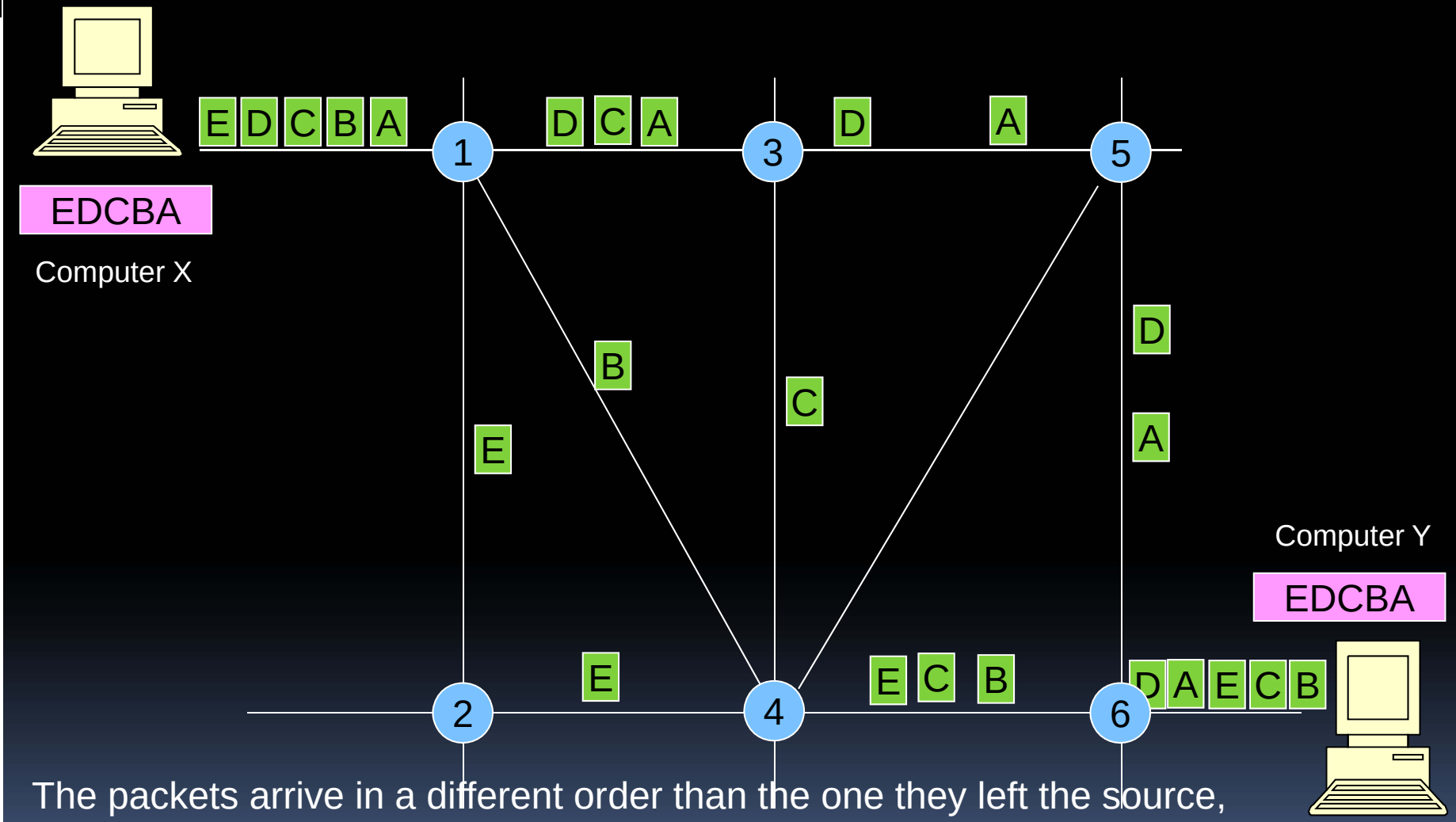
The end-to-end principle

- X and Y = end points of the communication
- *"The 2 end computers are in control of the communication. The Internet sends the packets between them."*
- Advantages:
  - Sending application (X) and receiving application (Y) – able to survive network failure (so X resends a packet that encountered error)
  - Packets can be rerouted around failures
  - Internet can grow easily – control resides in the end points, not the Internet
  - No requirement for Internet routers to notify eachother, as endpoint connections are formed / dropped.
  - Integrity + security of packets – handled by the end points

What's in a packet?

- Source address
- Destination address
- Data to be sent
- Sequence number
- A checksum

A packet switched network



The packets arrive in a different order than the one they left the source, but the sequence information carried over with each packet helps re-assembled the original data.

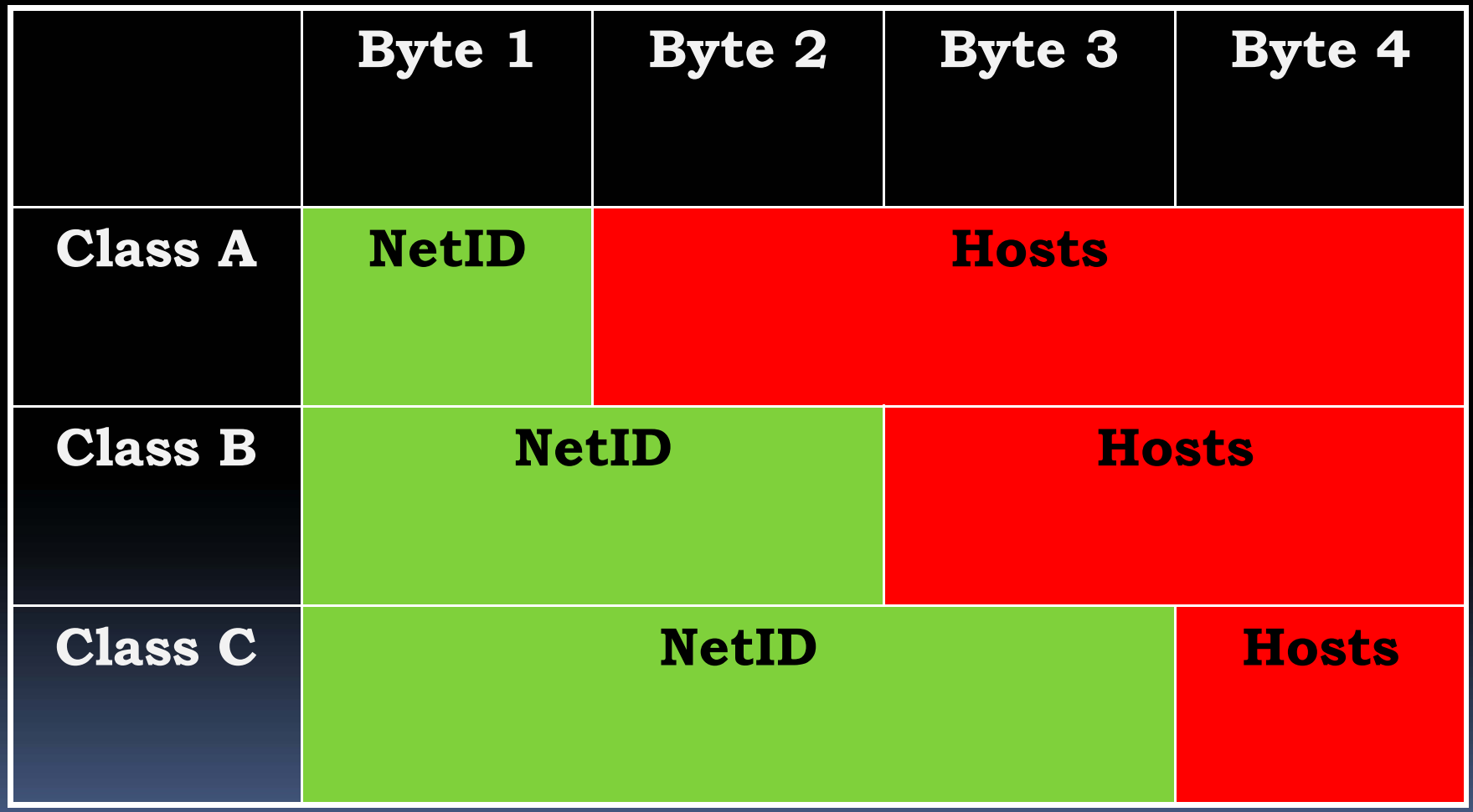
The IP address

- Unique address that identifies a computer / electronic device on a network.
- IPv4 = numbering system used for IP addresses
  - Format: nnn.nnn.nnn.nnn -> how many different addresses?
- Address structure: 31 bytes (32 bits)

0, over 4

  - Example: 192.100.11.4
    - Network ID is 192.100.11.0
    - Host ID is 4.

Network classes and IP addresses



Task

Look at:

http://computer.howstuffworks.com/question549.htm

And fill in the gaps in your booklet.

Internet – WWW - Intranet

1. What is WWW?
2. What is the Internet?
3. What role does packet switching play in the Internet?
4. What is a router and why is a router used?
5. Describe:
    a) The end-to-end principle
    b) The open architecture networking principle
    c) The single logical address principle
6. What is an Intranet and how is it different from Internet?

URL, URI, URN

- W3C – the www consortium
- IETF – internet engineering task force

URL – identifies a resource by its network location. Find out:

- When it was introduced
- What it specifies
- Describe the 3 parts ("how", "where", "what")

URN – identifies a resource by its name

URI – specifies how to access a resource on the internet; it includes URL and URN

Domain names

As Internet began to grow, it had proved a lot harder to use IP addresses directly to send info along networks / internet -> use of DNS (Domain Name System – NOT server!).

DNS server – translates fully qualified domain names into IP addresses.

Example:

ags.bucks.sch.uk

vs.

195.112.56.0

DNS hierarchy

- First level:
  - Generic world wide domains - .com, .edu, .net, .org, .int
  - Generic US only - .gov, .mil
  - Country - .uk, .ca, .fr, .es, .it, .ru, .gr, .ch etc
- Second level:
  - Type of organisation - .co, .ac, .sch, .gov

Questions
– fill in the gaps in your booklet

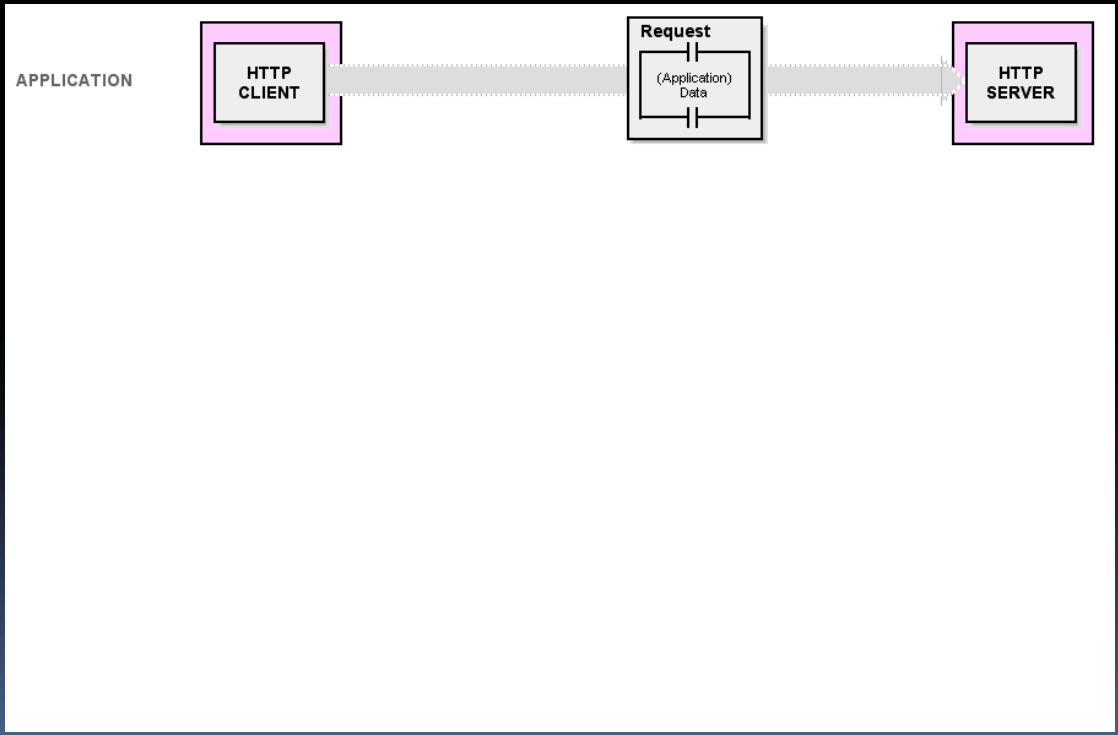
1. When was DNS invented?
2. Name three top-level domain names other than country names.
3. Explain the difference between a domain name and a fully qualified domain name.
4. What is the purpose of a DNS server?
5. Give an example of a URL.
6. What is the difference between URL and URI?
7. Find out what Internet registries and Internet registrars are, and why such services are provided.
8. Explain the role of an ISP.

tcp/ip communications…

NETWORKS

TCP/IP Communication

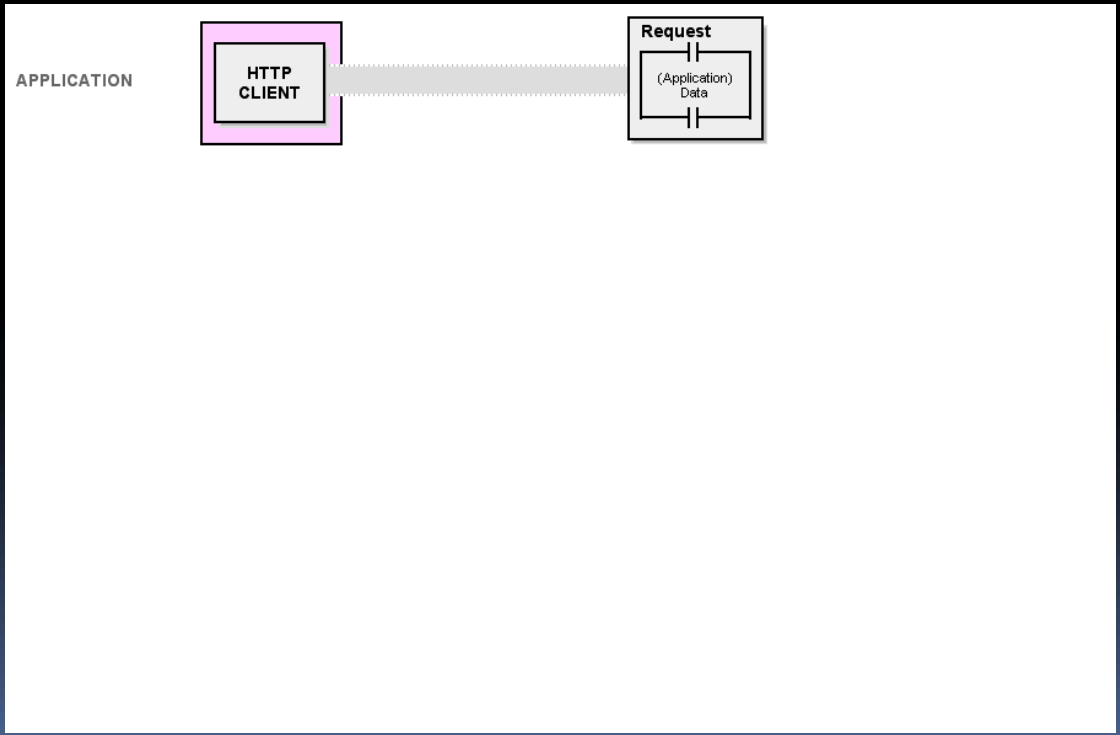
The following slides show what happens when a http client requests a page from a http (Web) server. It is not as in the diagram below where the message is sent straight between the browser application and the Web server…



TCP/IP Communication

What actually happens is:

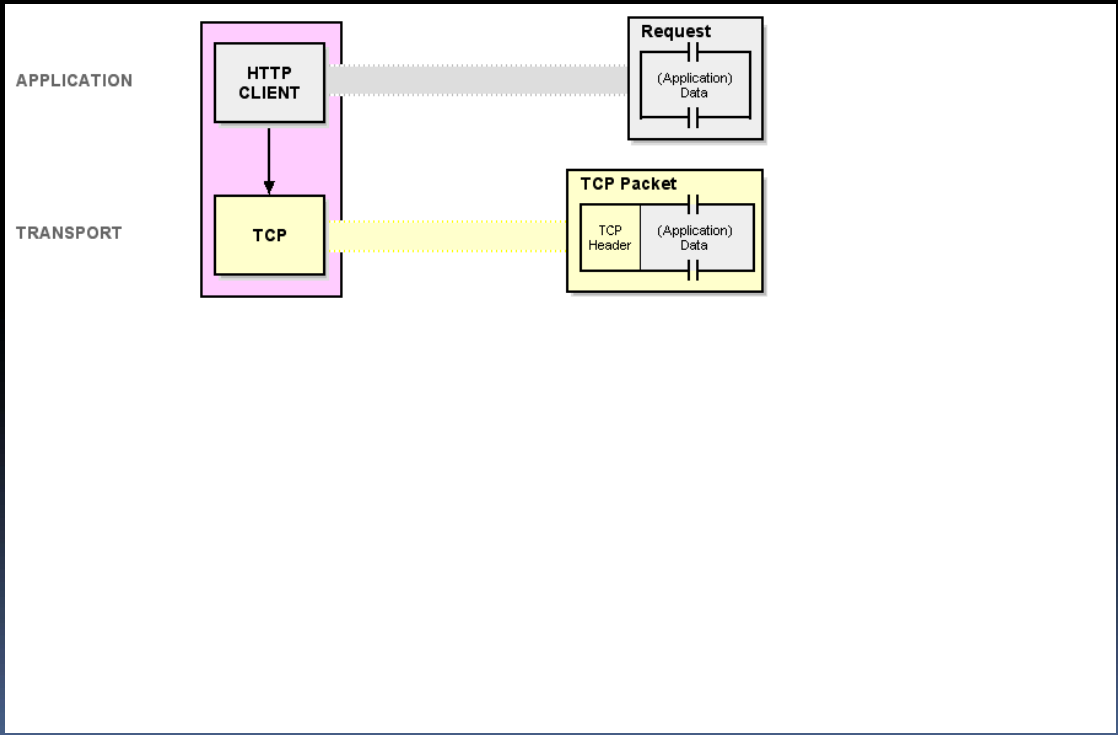
The client makes a request by generating a message…



TCP/IP Communication

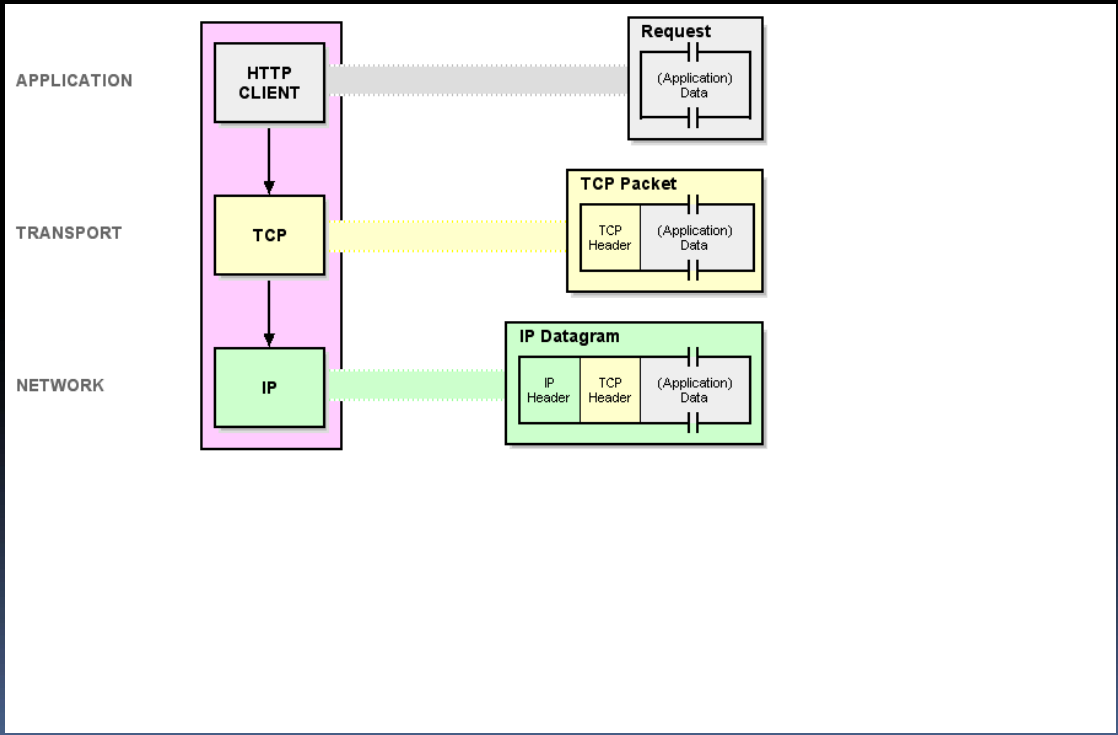
The message is passed to the transport layer, where the message is broken into packets and a TCP header is added to each packet.

This header contains the source and destination Port numbers which identify the applications that the message is being sent between…



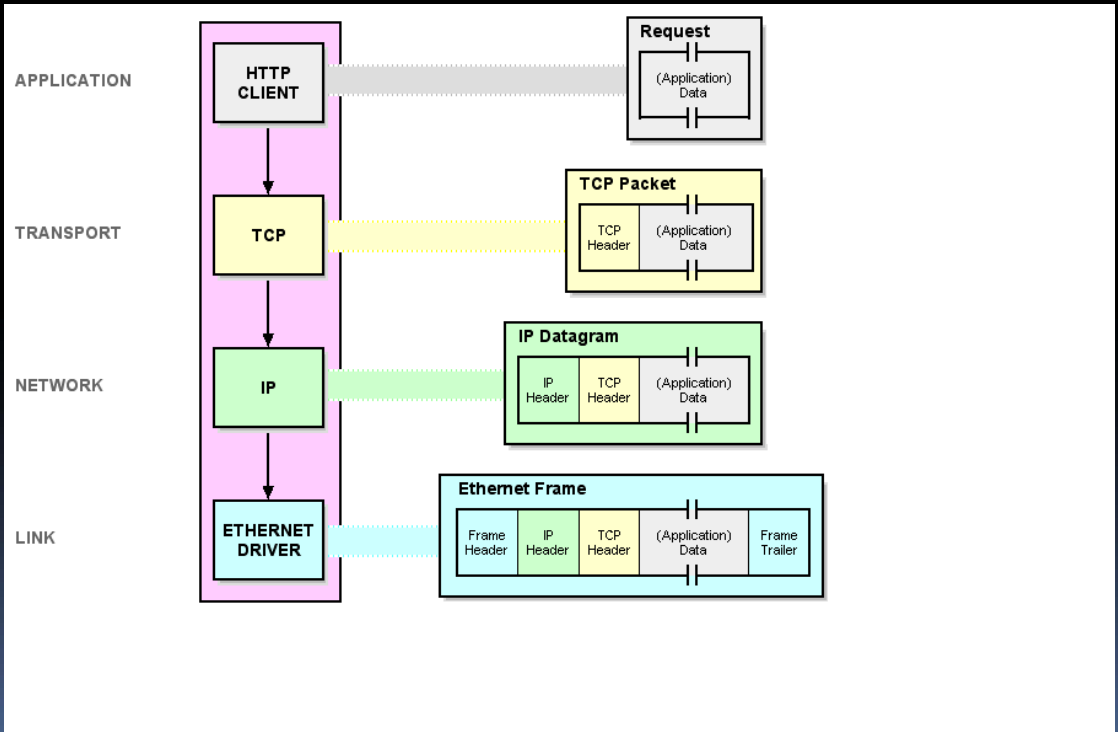
TCP/IP Communication

The TCP packet is passed to the Network layer, which adds an IP header that contains the source and destination IP addresses of the message…



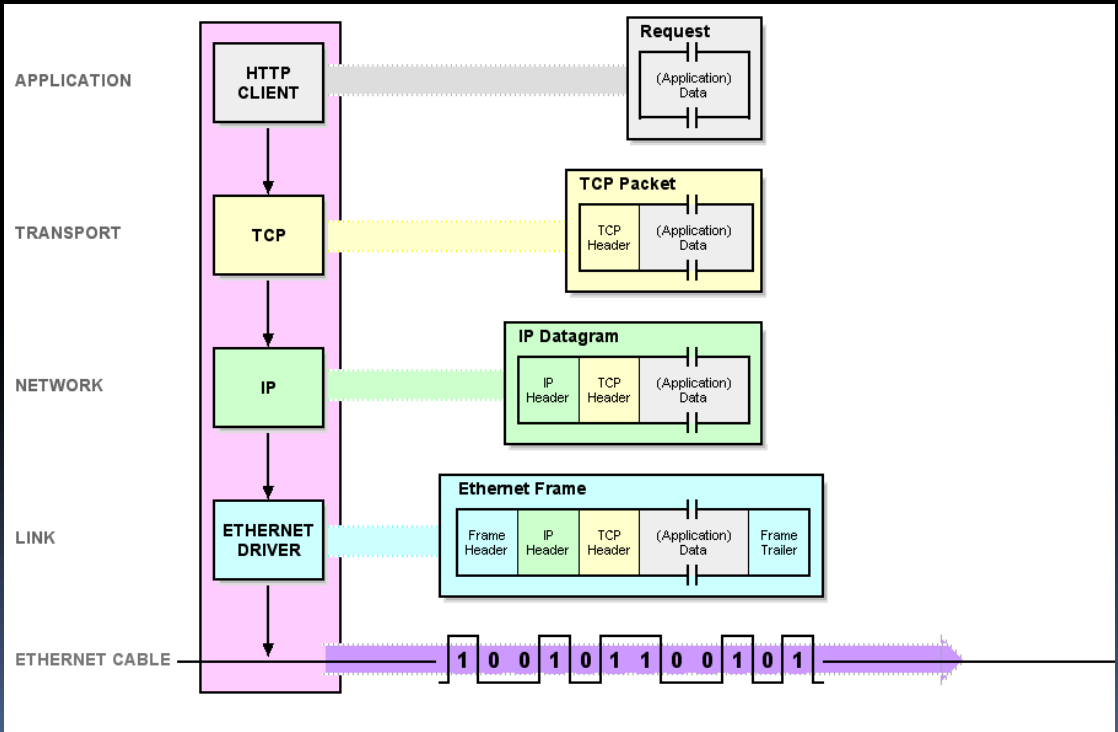
TCP/IP Communication

The IP datagram is then passed to the link layer which (if it is an Ethernet network) converts the packet into a Frame by adding a Ethernet Header that contains the MAC source and destination addresses and an Ethernet Trailer that contains a checksum to ensure that the frame is transmitted correctly…



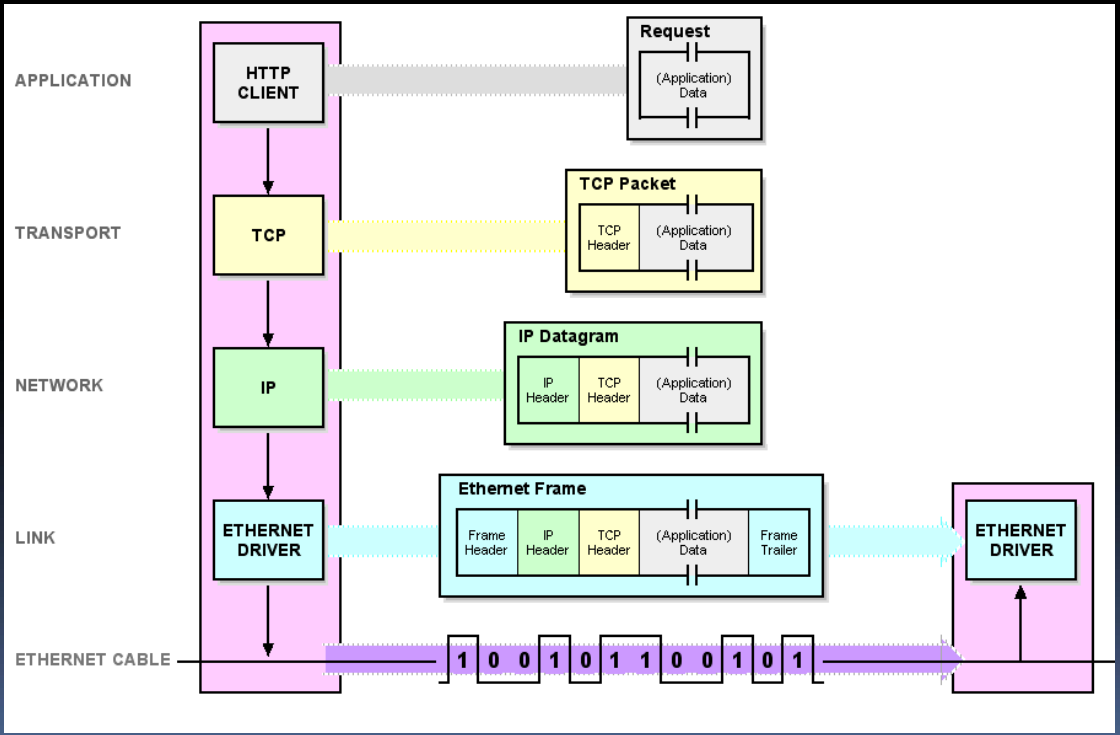
TCP/IP Communication

The frame is transmitted along the Ethernet cable as a series of binary digits…



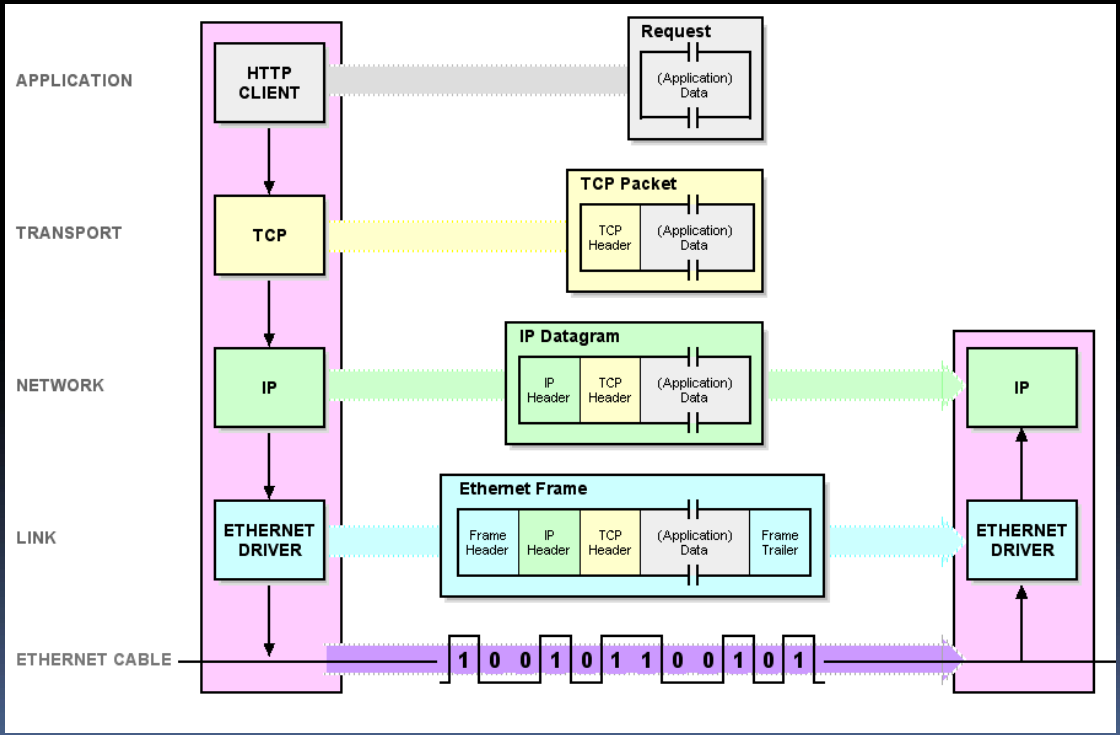
TCP/IP Communication

The server's Ethernet card examines the frame at the link layer…



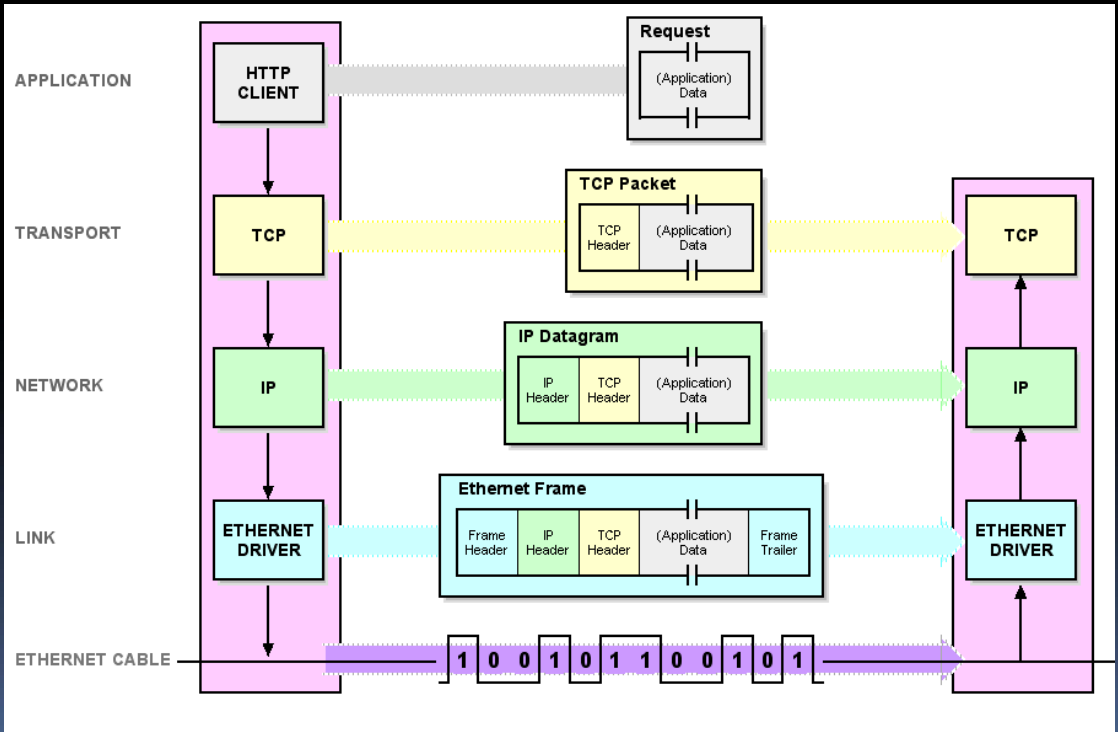
TCP/IP Communication

If the frame destination is the server's MAC address, then the server passes it up to the Network layer, otherwise the server ignores the frame…



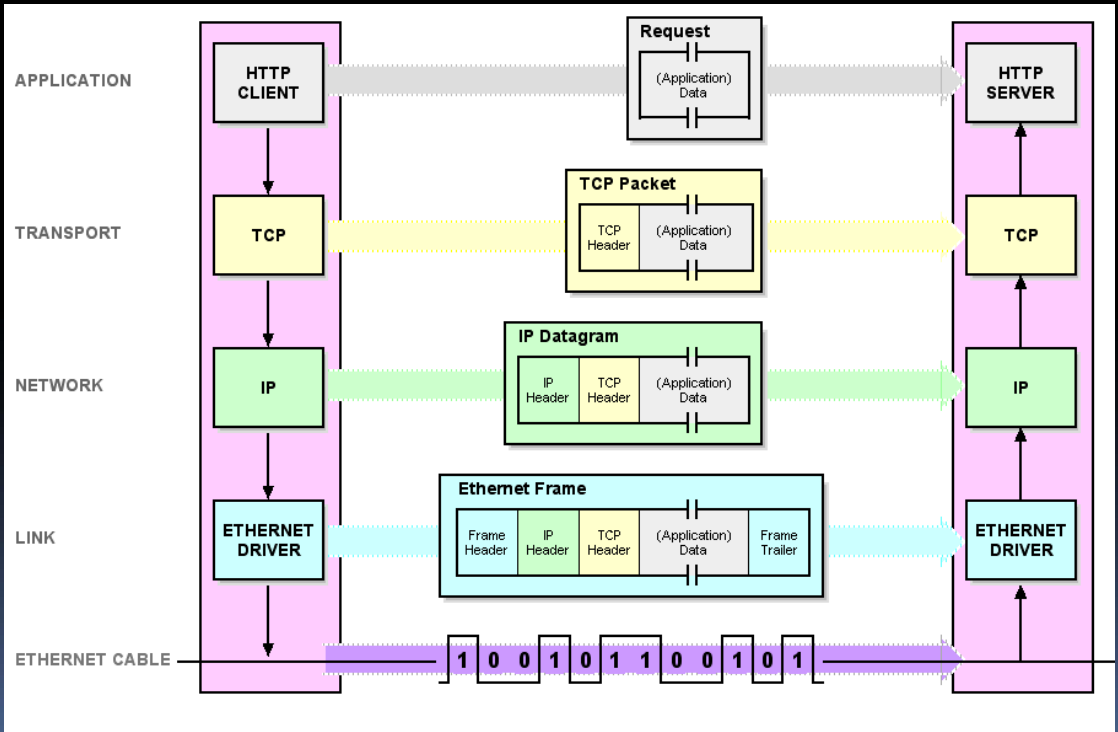
TCP/IP Communication

The destination address is checked at the Network layer and the datagram is passed to the Transport layer. (Note that if the server is also acting as a router, then the datagram might be forwarded – if appropriate)…



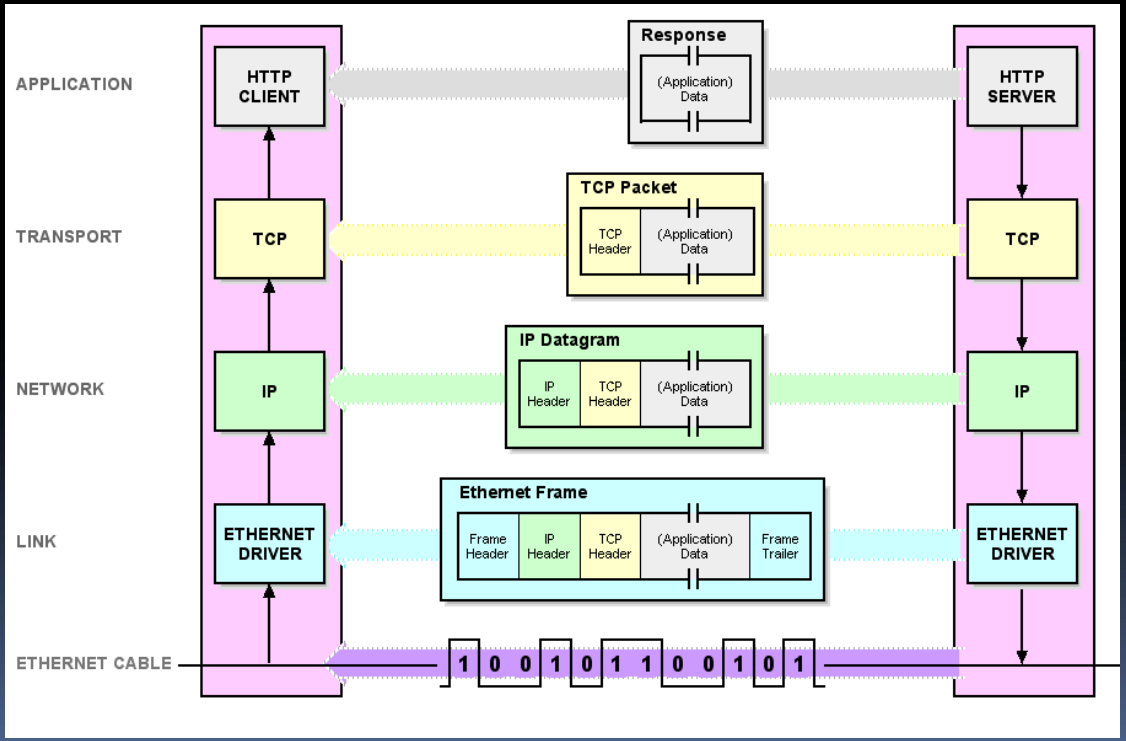
TCP/IP Communication

The transport layer recalculates the checksum in the TCP header, to ensure that the packet has been transmitted correctly. It then reassembles the packets into the original message, examines the destination Port number and passes the message to the appropriate application.



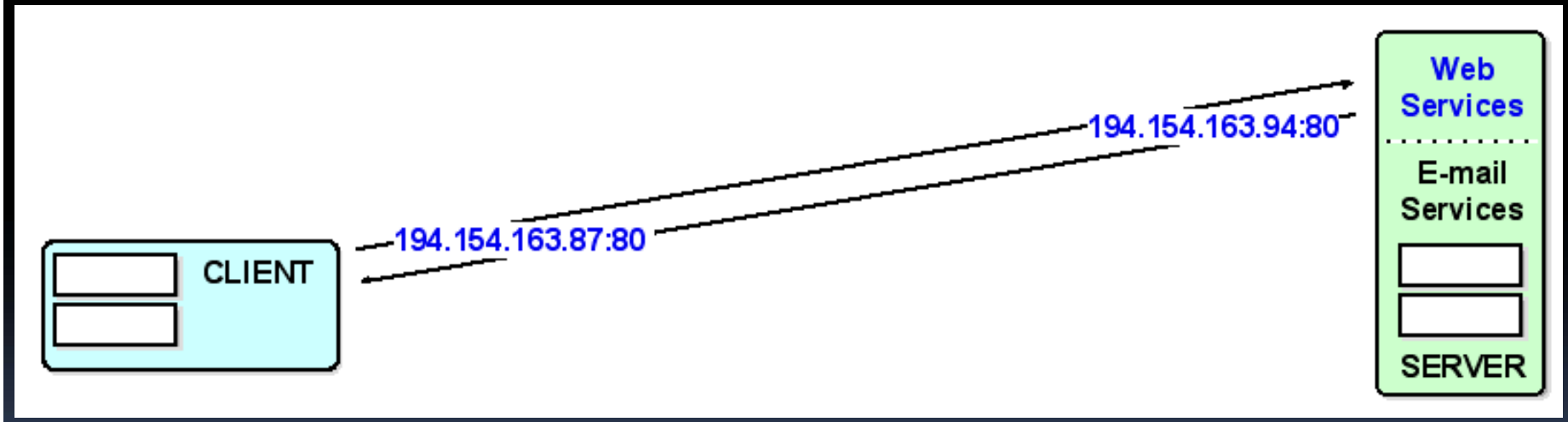
TCP/IP Communication

When the server responds, the same process is repeated, but in reverse!!



Sockets

A socket is a combination of an IP address and a port number that enables a client and server to set up a two-way communications pathway directly between processes (applications).



The client is communicating with the Web server using

Port 80

Port numbers

- Client port numbers are temporary used by client processes
  - Range is 1024 to 4095
- Other well known port numbers:
  - 20 – FTP server, file transfer data
  - 21 – FTP server, file transfer control
  - 80 and 8080 – web server
  - 25 – SMTP server
  - 110 – POP3 server
  - 23 – Telnet server

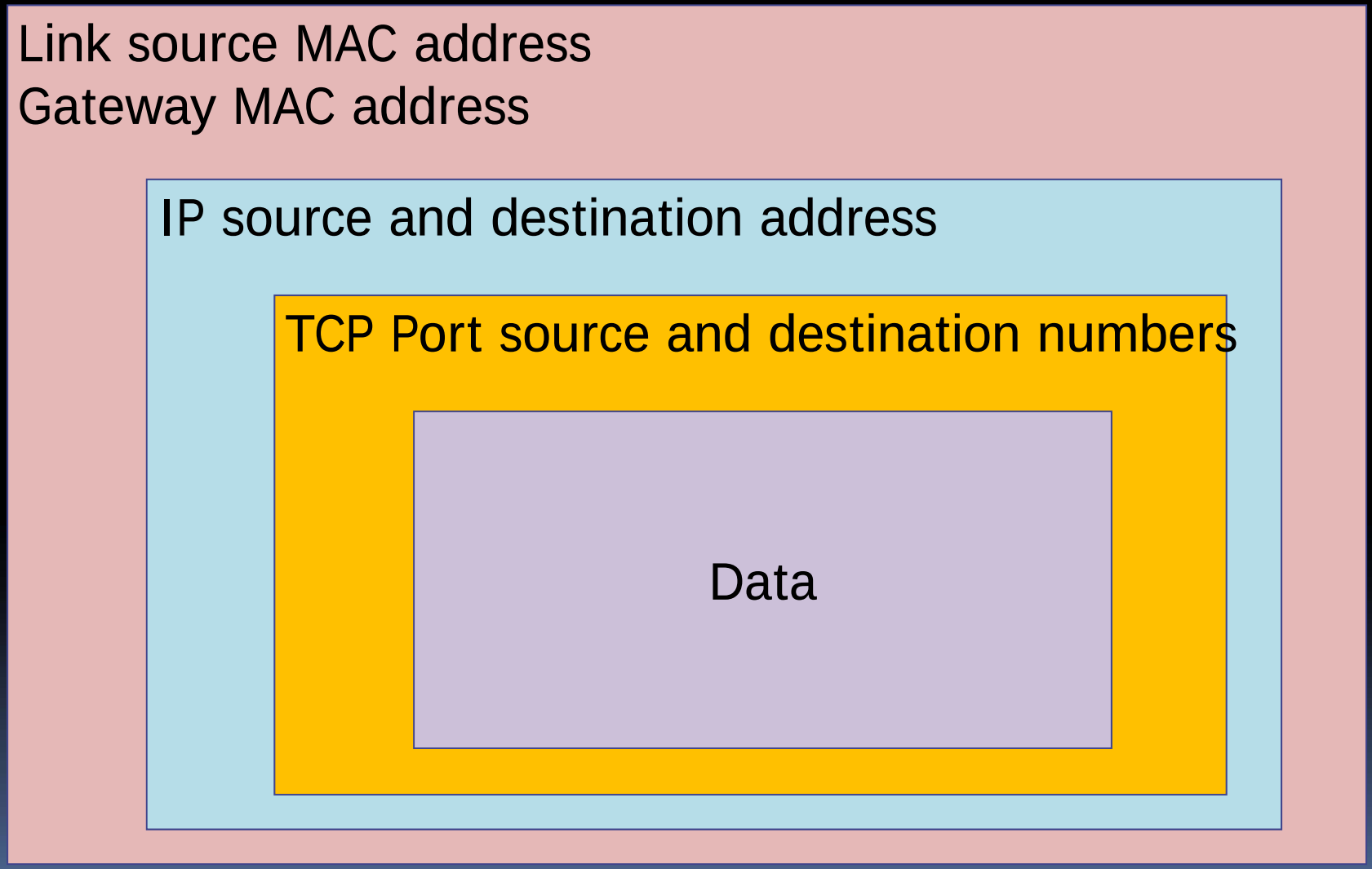
Task

Find out about the following protocols:

1. HTTP & HTTPS
2. FTP
3. Telnet
4. POP3 and SMTP
5. HTTPS

You need to be familiar with the above, and not go into too much detail (so perhaps a definition and an explained example - how it works)

Encapsulation – how a packet is bundled



Task

Finish off the workbook – fill in all blanks.