IP Fundamentals (Part 1 of 2)

Cloud Networking and Security

IP Fundamentals Objectives

- Identify organizations that set standards for networking
- Describe the purpose of the OSI model and each of its layers
- Describe the purpose of the TCP/IP Suite

Standards

- Standards are documented agreements containing precise criteria that are used as guidelines to ensure that materials, products, processes, and services suit their purpose
- Because of the wide variety of hardware and software in use today, standards are especially important in the world of networking
- Standards also help to ensure interoperability between software and hardware from different manufacturers
- Computer industry grew quickly out of several technical disciplines, many different organizations evolved to oversee its standards

Standardisation / Networking Protocols

- Prior to OSI, networking was largely either government-sponsored (ARPANET in the US or vendor-developed and proprietary standards (such as the System Network Architecture (SNA) of IBM.
- IBM published its SNA networking model in 1974 and after it was published other computer vendors created products that allowed their computers to communicate with IBM computers using SNA
- This worked but it had some negatives, it meant that larger computer vendors tended to rule the networking market

Open Systems Interconnection (OSI)

- A better solution was to create an open standardization networking model that all vendors would support
- OSI is an effort to standardize computer networking that was started in 1977 by the International Organization for Standardization (ISO), along with the International Telecommunication Union (ITU-T)
- ISO had the goal for the OSI Model:
  - to standardize data networking protocols to allow communication between all computers across the planet

TCP/IP

- A second, less formal effort to create a standardized public networking model came forth from the U.S. Defense Department
- Researchers at various universities volunteered to help further develop the protocols surrounding the original departments work
- These efforts resulted in a competing networking model called TCP/IP

So what happened next?

- By the late 1980's, the world had many competing vendor-proprietary networking models plus two competing standardized networking models
- So what happened?
  - TCP/IP won in the end!
  - OSI model, whose development suffered because of a slower formal standardization process as compared with TCP/IP
  - TCP/IP, the networking model has become the most prolific set of data networking protocols ever

OSI Model

OSI RM : **Open System Interconnection Reference Model**

- This model is a way of dividing the data communications system into smaller parts, also known as layers
- Main purpose is to enable different vendor device communication
- A layer is a collection of similar functions that provide services to the layer above it and receives services from the layer below it
- Headers allow corresponding layers to communicate information

Remembering layers:

All People Seem To Need Data Processing (Layers 7 to 1)

OSI Reference Model

Layer 7 - Application	Interfaces directly with applications running on devices
Layer 6 - Presentation	Define and negotiate data formats such as ASCII text
Layer 5 - Session	Co-ordinates interaction between end-to-end application processes. Defines how to start, control and end conversations
Layer 4 - Transport	Focuses on issues related to data delivery to another computer e.g. error recovery and flow control
Layer 3 - Network	Defines logical addressing (each device has an address) , routing (path forwarding) and path determination (work done by routing protocols)
Layer 2 - Data Link	Defines the rules (protocols) that determine when a device can send data over a particular medium
Layer 1 - Physical	Transmits and receives on the network medium Defines the electrical and physical specifications for devices

Layer 1 – Physical

- This layer defines the electrical and physical characteristic of the transmission medium. i.e. how the physical **bits** are sent –1's and 0's.
  - Transmission method
  - Cables & Connectors
  - Voltage
  - Frequency Bands
- Examples of protocols in this layer include:
  - DSL
  - Bluetooth
  - USB

Layer 2 – Data Link

- The Data Link layer is a set of rules that determine when a device can send data over a particular medium (provides node to node data transfer)
  - Data link protocols also define the format of a header and trailer that allows devices attached to the medium to send and receive data sucessfully
- Divided into 2 Sub Layers: LLC and MAC.
- LLC Logical Link Controller
  - LLC communicates with the network layer above
  - Setting up logical link

- MAC Media Access Controller
  - MAC sublayer communicates downward directly to physical layer
  - When a device should access the medium
  - Detect Collisions - **Error Detection, physical addressing (MAC addresses)**

Layer 2 – Data Link

- The header includes the source and destination **physical address**
- The data link trailer, which follows the encapsulated data, typically defines a Frame Check Sequence (FCS) field which allows the receiving device to **detect transmission errors**
- Examples of protocols in this layer include:
    - Ethernet
    - Frame Relay
    - PPP
    - WiFi

Layer 3 - Network

- 3 main functions of the Network layer:
  - **Logical Addressing** - defines how each device can have an address that can be used by the routing process
  - **Routing** - define how devices (typically routers) forward packets to their final destination
  - **Path Determination** - refers to the work done by routing protocols by which all possible routes are learned, but the best route is chosen for use
- IP is a connectionless protocol that provides best effort delivery routing of packets
- Examples of protocols in this layer include:
  - IPv4
  - IPv6
  - ICMP

Layer 4 - Transport

- Accepts data from the Session layer and formats the data into **segments** for transport across the network
- Focuses on issues related to data delivery to another computer and may ensure **Reliability**
- **Flow control** can occur at the transport layer
- May use **Connection Setup**
- Examples of protocols in this layer include:
  - TCP
  - UDP

Layer 5 - Session

- The session layer **establishes**, **manages** and **ends** conversations (called sessions)
- Includes the control of bidirectional messages so that the application can be notified if only some of a series of messages are completed
- Examples of protocols in this layer include:
  - RPC (Remote Procedure Calls)

Layer 6 - Presentation

- The Presentation layer translates data formats, so that devices with different "languages" can communicate
- Encryption and compression can be performed at this level
- Examples of protocols in this layer include:
  - Multipurpose Internet Mail Extensions (MIME)
    - Extends the format of email to support:Non-text attachments: audio, video, images, application programs etc.
  - TLS/ SSL - Transport Layer Security (TLS) and its predecessor, Secure Sockets Layer (SSL), both of which are frequently referred to as 'SSL', are cryptographic protocols designed to provide communications security over a computer network

Layer 7 - Application

- Interfaces directly with the application programs running on the devices
- Examples of protocols in this layer include:
  - HTTP (Hypertext Transfer Protocol)
  - FTP (File Transfer Protocol)
  - SMTP (Simple Mail Transport Protocol)
  - VoIP (Voice Over Internet Protocol)

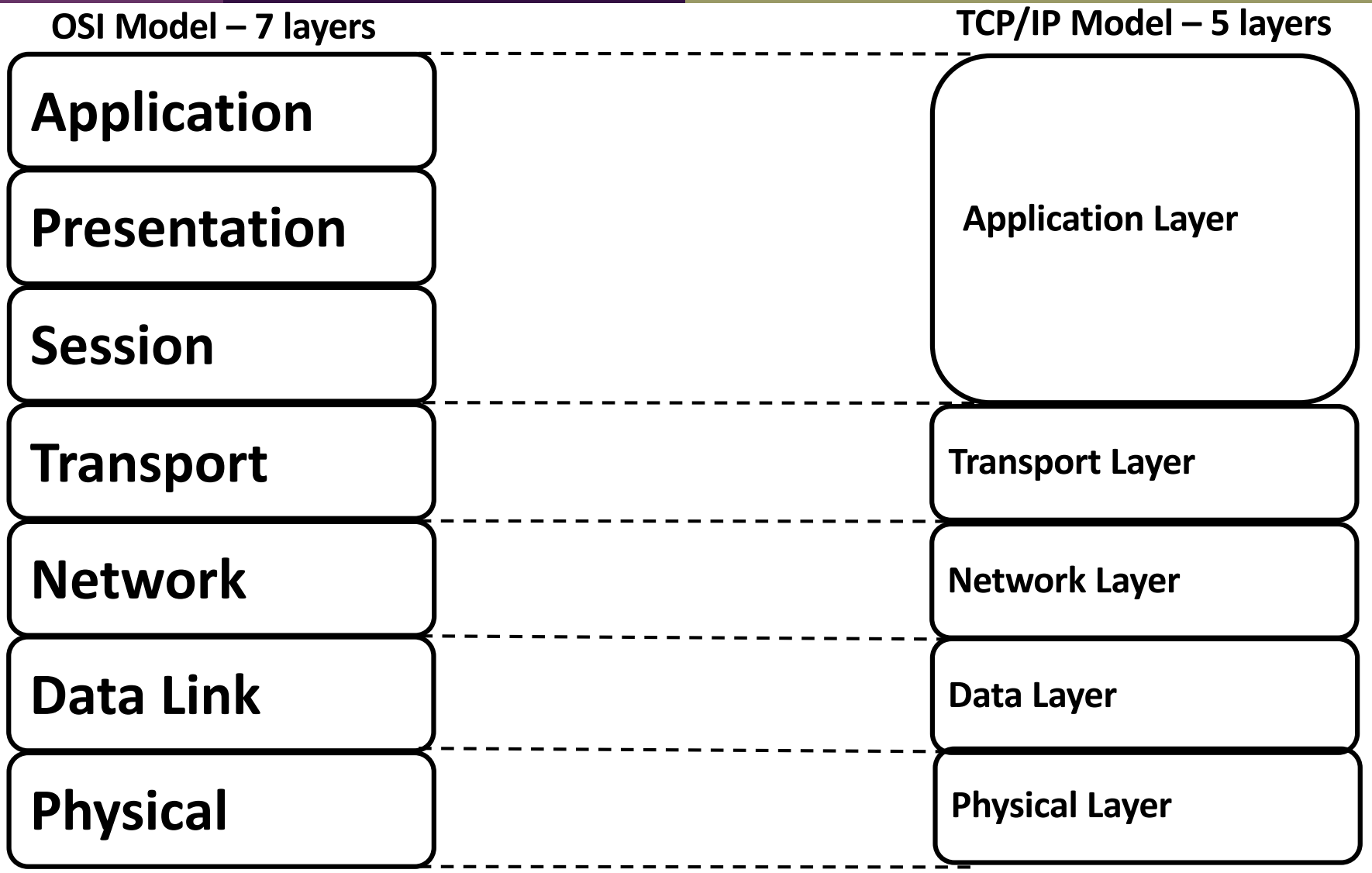
OSI

- The layers break a large, complex set of concepts and protocols into smaller pieces, making it easier to talk about, easier to implement with hardware and software and easier to troubleshoot
- Today, OSI is considered a reference model only, however, we use it all the time to discuss and compare networking devices and protocols
- TCP/IP Suite is the most common networking model used today

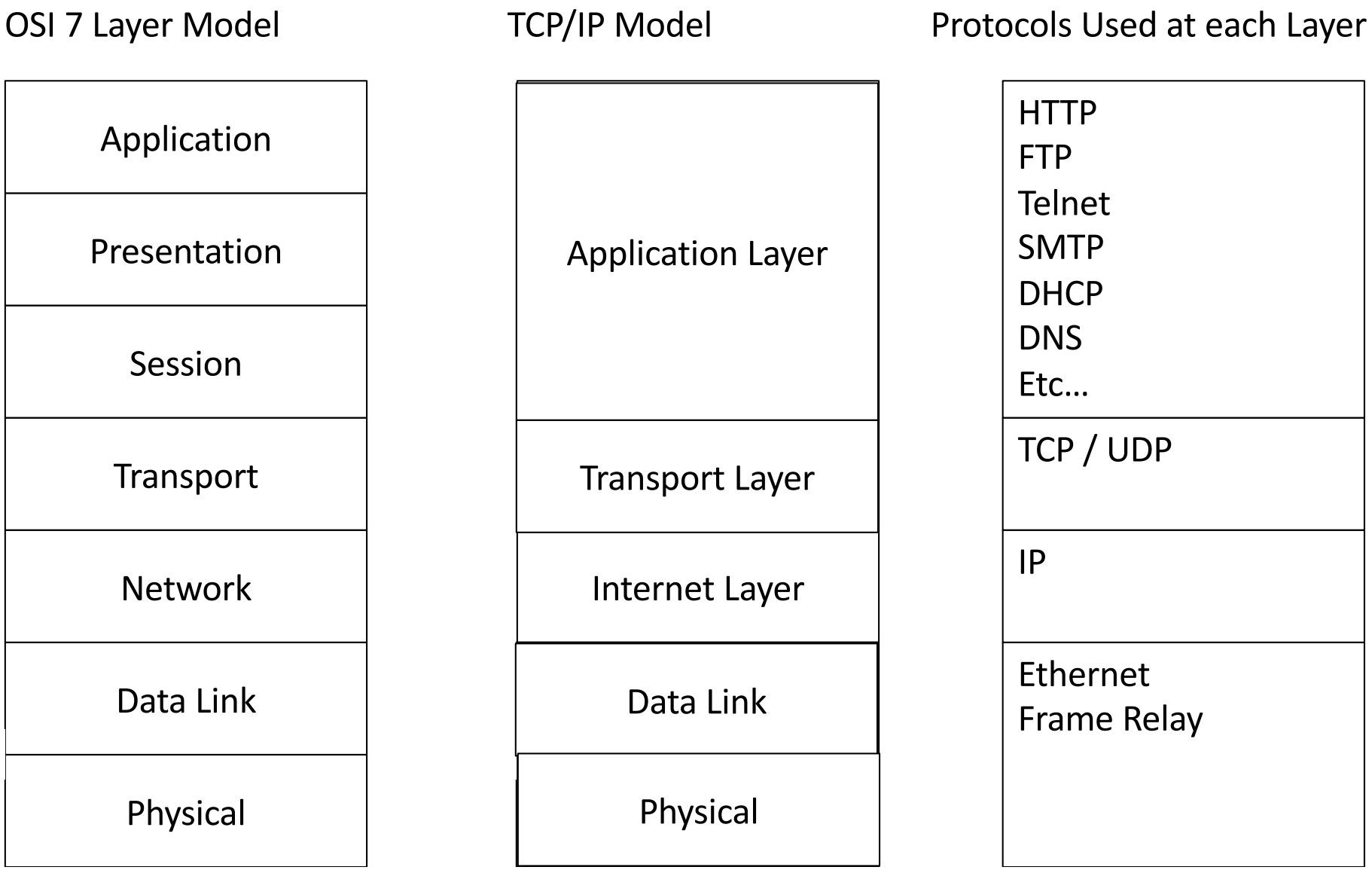
TCP/IP

- TCP/IP: Transmission Control Protocol / Internet Protocol
- TCP/IP is another name for the Internet Protocol Suite
- It comprises of a full suite of communication protocols used in networks
- It was called TCP/IP suite after the two most popular protocols within the suite. It does not mean you have to use TCP at Layer 4 and IP and Layer 3
- Your OS on your computer implements the TCP/IP model

Comparing OSI and TCP/IP Models

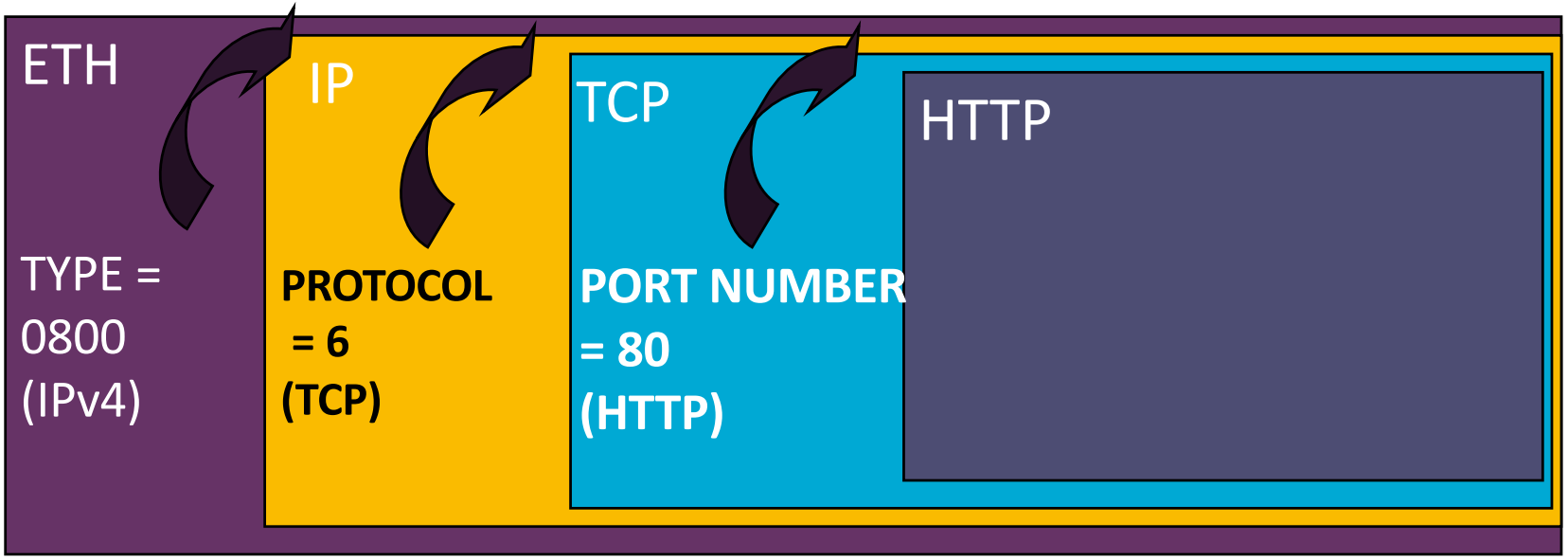


Common Computer Layered Models & The Associated Protocols

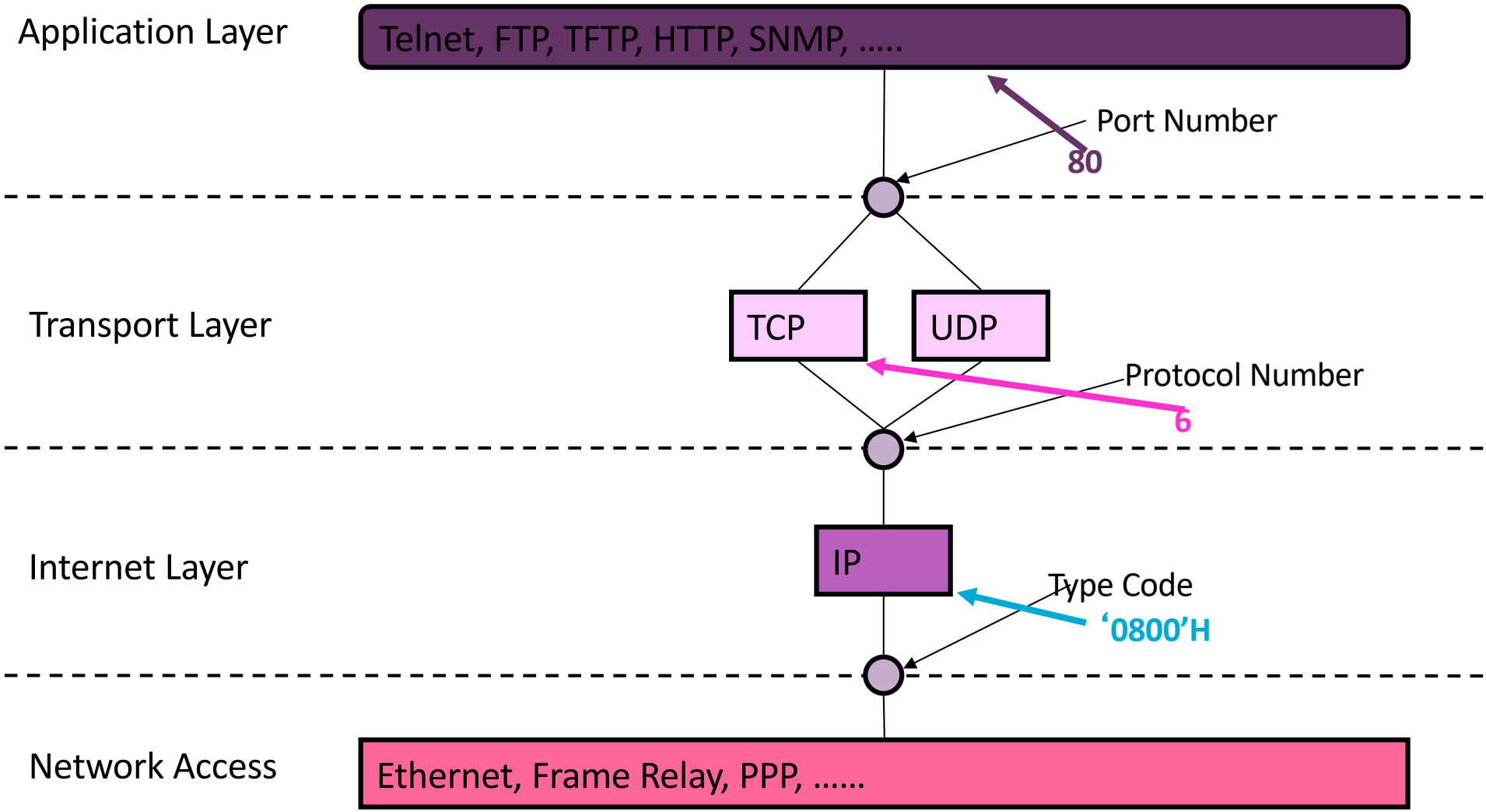


Header Linking

- Ethernet Type Code identifies IP Layer Protocol
- IP contains a Protocol Number field that identifies which Transport Layer Protocol
- Transport Layer, (TCP and UDP) have a Port Number field which is used to identify Application Layer Protocol

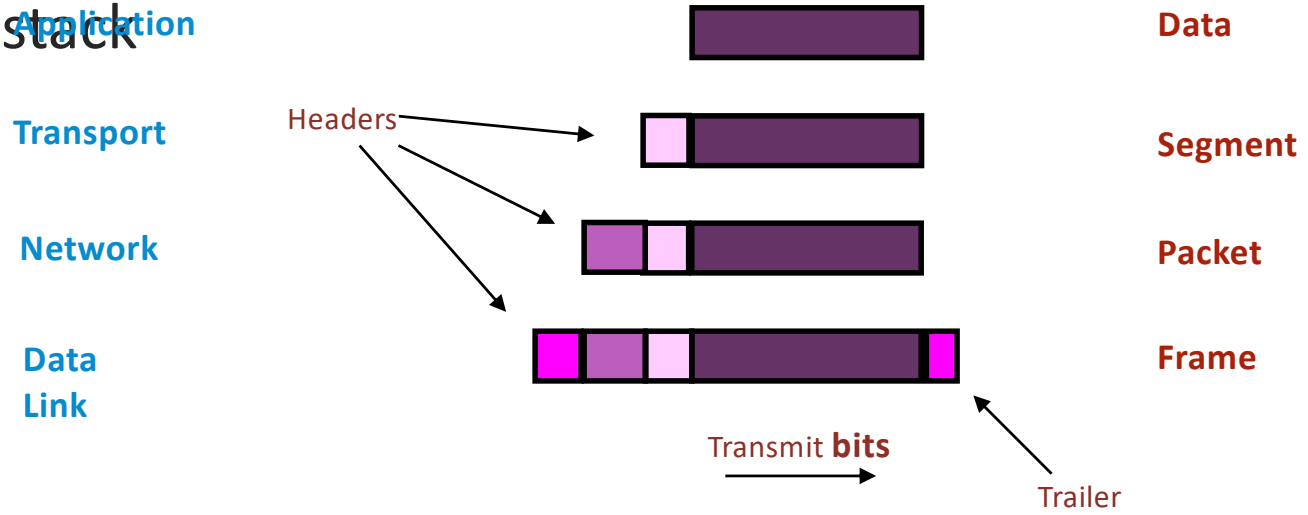


TCP/IP Layer Communication



5 steps of data encapsulation

- The term encapsulation refers to the process of putting headers (and possibly trailers) around some data before network transmission
- This is done as you come down the protocol stack
- A PDU can include different information as it goes up or down the stack



De-encapsulation

- The term de-encapsulation refers to the process of removing headers and trailers to get the data

- This is done as you go up the protocol stack

Overview of modern LAN's

- You can use a small LAN for many purposes, even without a WAN connection:
- LANs are high-speed, low-error data networks that cover a small geographic area
- **File sharing:** Each computer can be configured to share all or parts of its file system so that other computers can possibly read or write files on another computer
- **Printer sharing:** Computers can share their printers as well
- **File transfers:** A computer could install a file transfer server, thereby allowing other computers to send and receive files to and from that computer e.g. FTP Server could be setup on network