



1 : Introduction to Computer Networks

IT 4506 – Computer Networks

Level II - Semester 4

Computer Network

“A computer network is a set of computers sharing resources located on or provided by network nodes.”

“... a node is either a redistribution point or a communication endpoint”

(Wikipedia)

“A computer” – Laptop, PC, Server, Mobile Phone, Tablet, Printer, IoT device, Sensor, Camera ...

In this teachers note what is meant by the term computer should be understood based on the context

1.1 Use of Computer Networks

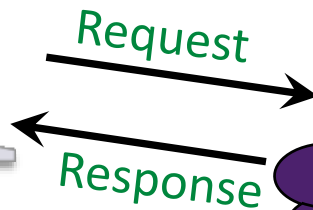
- The content of the textbook related to this topic is somewhat out of date
- No textbook can keep up with the rapid change in applications !
- This teachers note outlines the core concepts related to the topic.
 - Exploring current applications is given as an activity to the students

Resource Sharing

- How do computers interact with each other?
 - Client Server
 - Peer to Peer

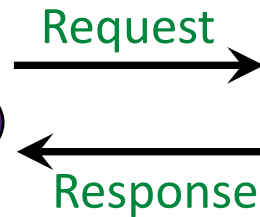
Client Server Model

Client

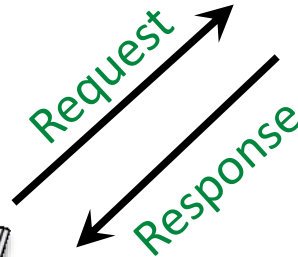


Network

Server



Client



Client - Server

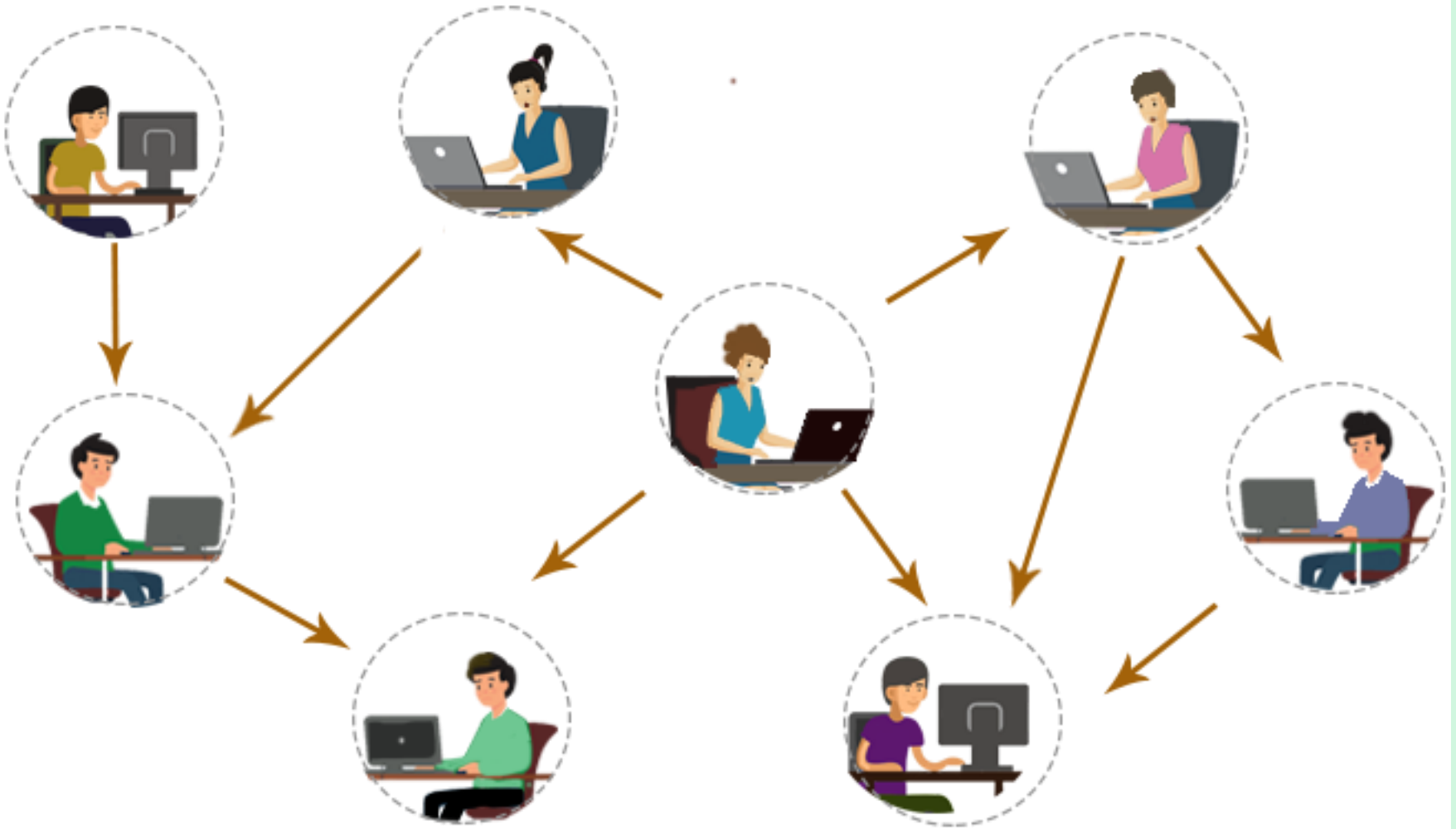
Client Server Model

- Service is provided by the Server
 - Resources are in the server
- Client initiates the communication by sending a request
 - Client requests a resource
- Server sends the response to the request
- Potentially many clients can get the service from the same server
- Note that the network is represented as a cloud since we are not interested in the exact structure of the network
- This communication model is defined based on how the end points in the network interact

Client Server Model - Examples

- The interaction between your web browser (Firefox) and a web server (www.ucsc.cmb.ac.lk) is a classic example of client server model communication
 - Firefox is the client
 - The computer identified as www.ucsc.cmb.ac.lk is the server
- Can you find other examples?

Peer to Peer Model



Peer-to-Peer Model

- There are no special entities – there are no servers
 - Peers contribute resources equally
- All participating entities (nodes) are equal – they are peers

Peer-to-Peer Model - Examples

- Bitcoin network
 - “The Bitcoin network protocol allows full nodes (peers) to collaboratively maintain a peer-to-peer network for block and transaction exchange.”

https://developer.bitcoin.org/devguide/p2p_network.html

Network - Some Applications

- Video Conferencing - Zoom
- Social Networks - Facebook
- Email
- Instant Messaging – WhatsApp
- eCommerce – Uber, PickMe, etc
- Are they business applications or home applications?
- Can you name others?
- How do you use the network to work/study during the pandemic?

Mobile Users

- Connectivity
 - WiFi
 - Telecom service providers – GSM, 3G, 4G, 5G
 - Bluetooth
- Devices
 - Smartphones
 - Smart watches – Wearables
- Applications
 - Navigation
 - Fitness monitoring
 - Instant messaging
 - Others ?

Sensor Networks

- Small sensors gather information about the physical world – temperature, humidity, position, speed etc.
- Network capability – usually wireless
- You have one such device with you !

Smartphones as sensors

- Smartphones are packed with sensors
 - Camera
 - GPS
 - Accelerometer
 - Gyroscope
- When you use applications such as a navigation app, these sensors collect data and send them to central servers
 - Your phone becomes a node in a sensor network !!
- What about your smart watch??

Social Issues

- Privacy violations
- Fake news
- Social Engineering – Phishing attacks
- Other issues ?

1.2 Network Hardware and Software

Network Classification

- Transmission Technology Based Classification
 - Point to Point
 - One computer is connected to another
 - Unicast
 - Fiber link from your home to the telecom provider
 - Broadcast
 - Communication channel is shared by all the computers in the network
 - WiFi networks
 - Multicast – transmit to only subset of the computers in the network

Network Classification

- Scale Based Classification
 - Personal Area Networks (PAN)
 - Local Area Networks (LAN)
 - Metripolitan Area Networks (MAN)
 - Wide Area Networks (WAN)
 - The Interne (WAN)

Personal Area Network (PAN)

- Communication over the range of a person
 - Wireless network that connects peripherals to a computer
 - Connect headset to a mobile phone
 - Bluetooth

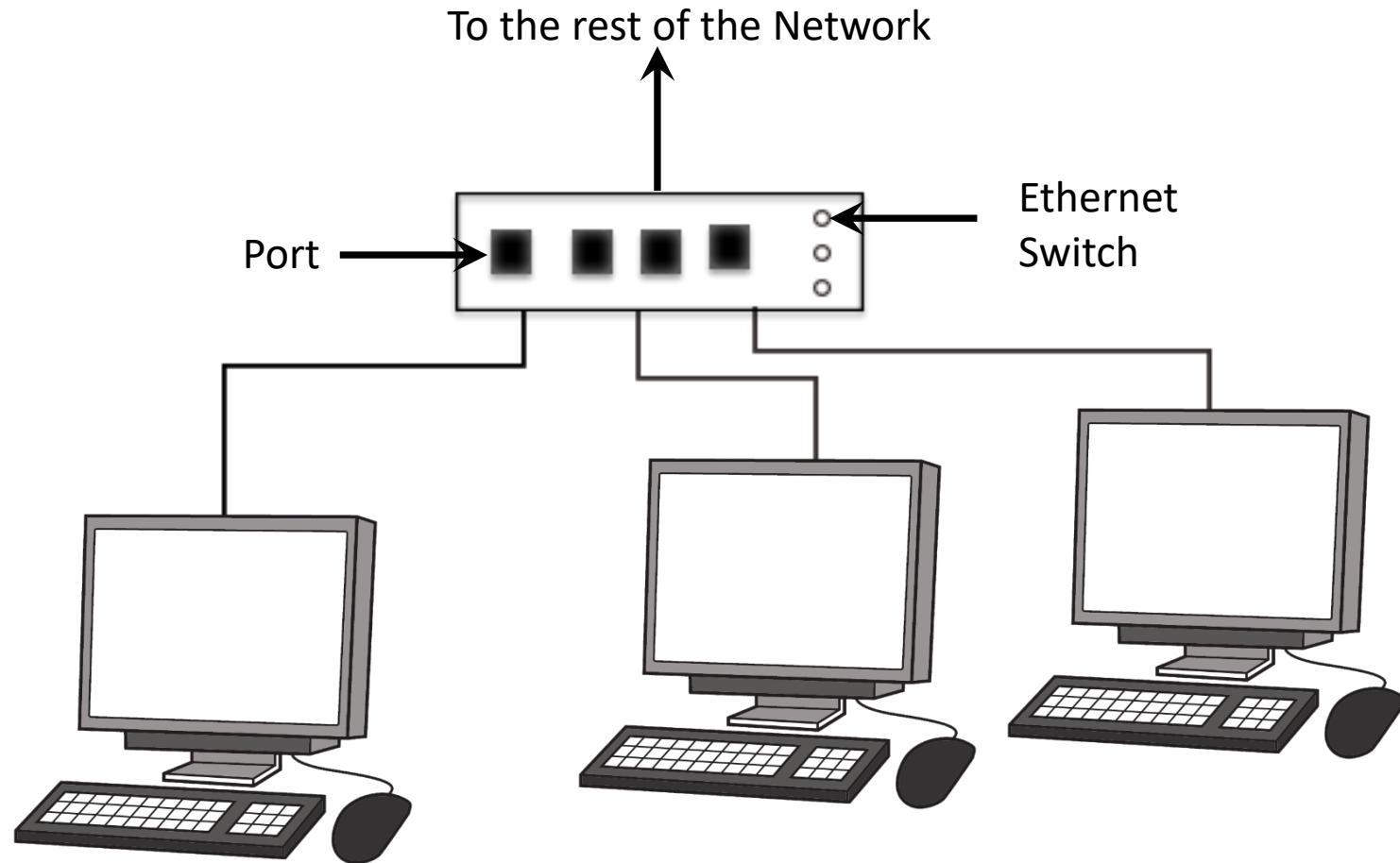
PAN



Local Area Network (LAN)

- Operates within a single building like a home or an office
 - If used by a business or a company they are called enterprise networks
- Wireless – WiFi – 802.11
 - Devices connect through an Access Point
- Wired – Ethernet
 - Devices are connected to a Hub or a Switch through ports
 - A computer is connected to a port
 - A Hub receives a packet of data from one port and sends it to all the other ports.
 - A switch receives a packet from one port and relays it to another based on the destination address in the packet

Local Area Network (LAN)



Virtual Lan - VLAN

- Divides one large physical LAN into several logical LANs
- Assign “colors” to ports in a switch.
 - Ports with the same color act as they are in one LAN
- Use case
 - Different departments in an office can have their own VLANs despite the fact that computers are connected to a single physical LAN (switch)

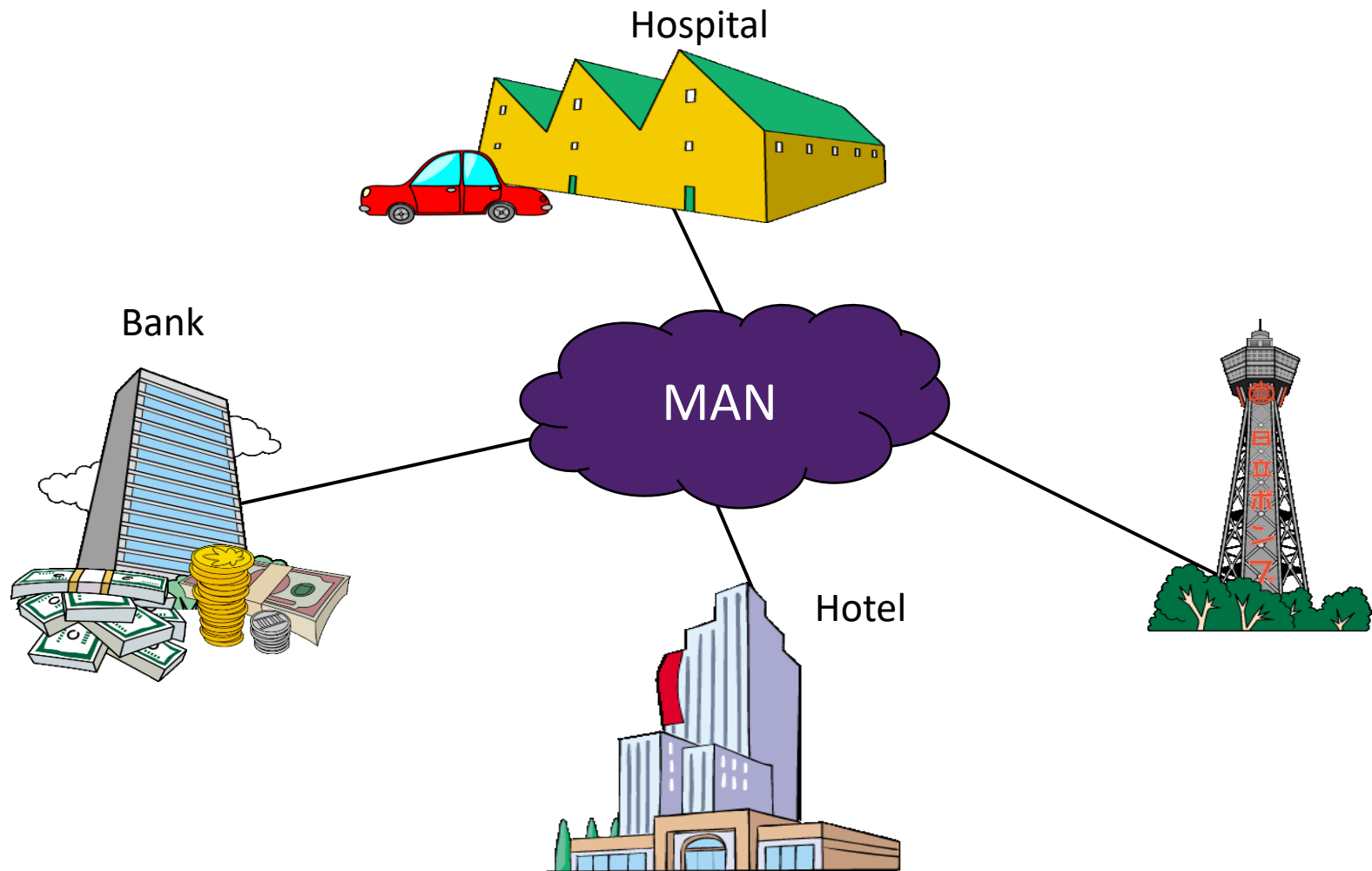
LAN in your home

- How do you access the Internet?
- Can you use the same Internet connection for multiple devices?
 - How are connected to access the Internet?
 - Does the setup look like a LAN?
 - Draw a digram depciting how devices are connected to the LAN

Metropolitan Area Network - MAN

- Metropolitan Area Network covers a city
 - Connect LANs together
 - Multiple offices of a business within a city
 - Internet access to individual LANs
- Technology
 - Metro Ethernet

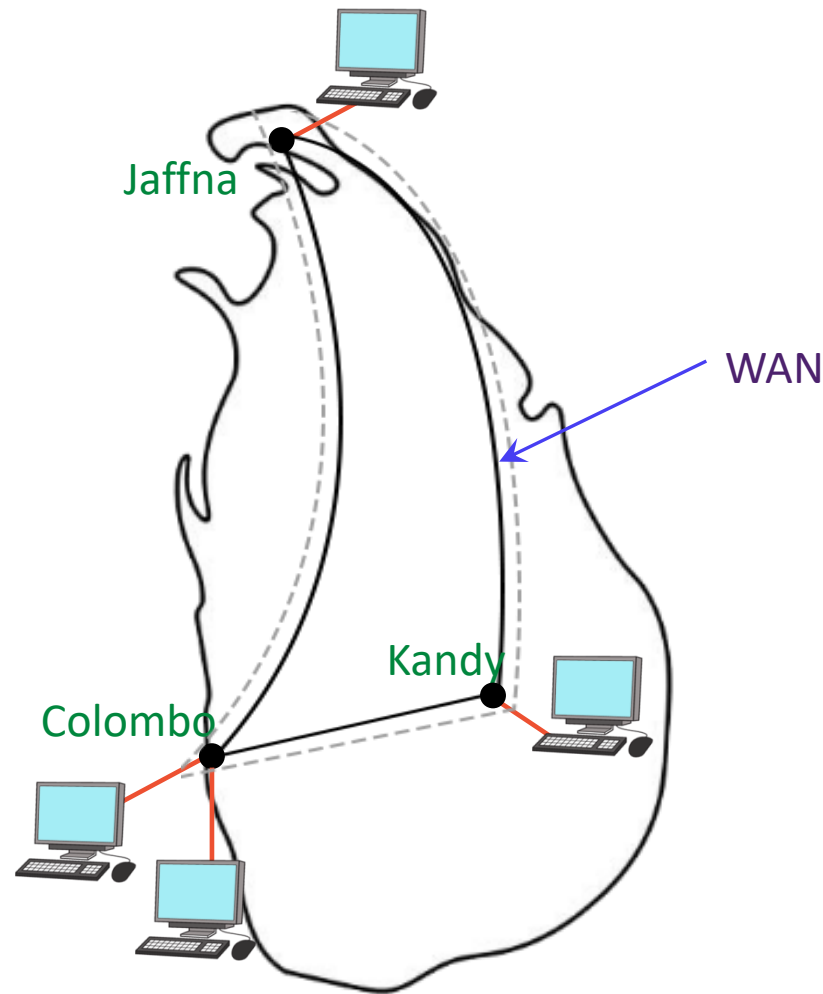
MAN



Wide Area Network

- Wide Area Network spans a large geographical area
 - Country
 - Continent
- The WAN in the following figure connects the offices in Colombo, Kandy and Jafna
 - In a simple configuration each office has a single LAN
 - The communication links of the WAN interconnects these LANs
 - Switches, Gateways, and Routers are required to connect them
 - We will discuss these devices in more detail later

Wide Area Network - WAN



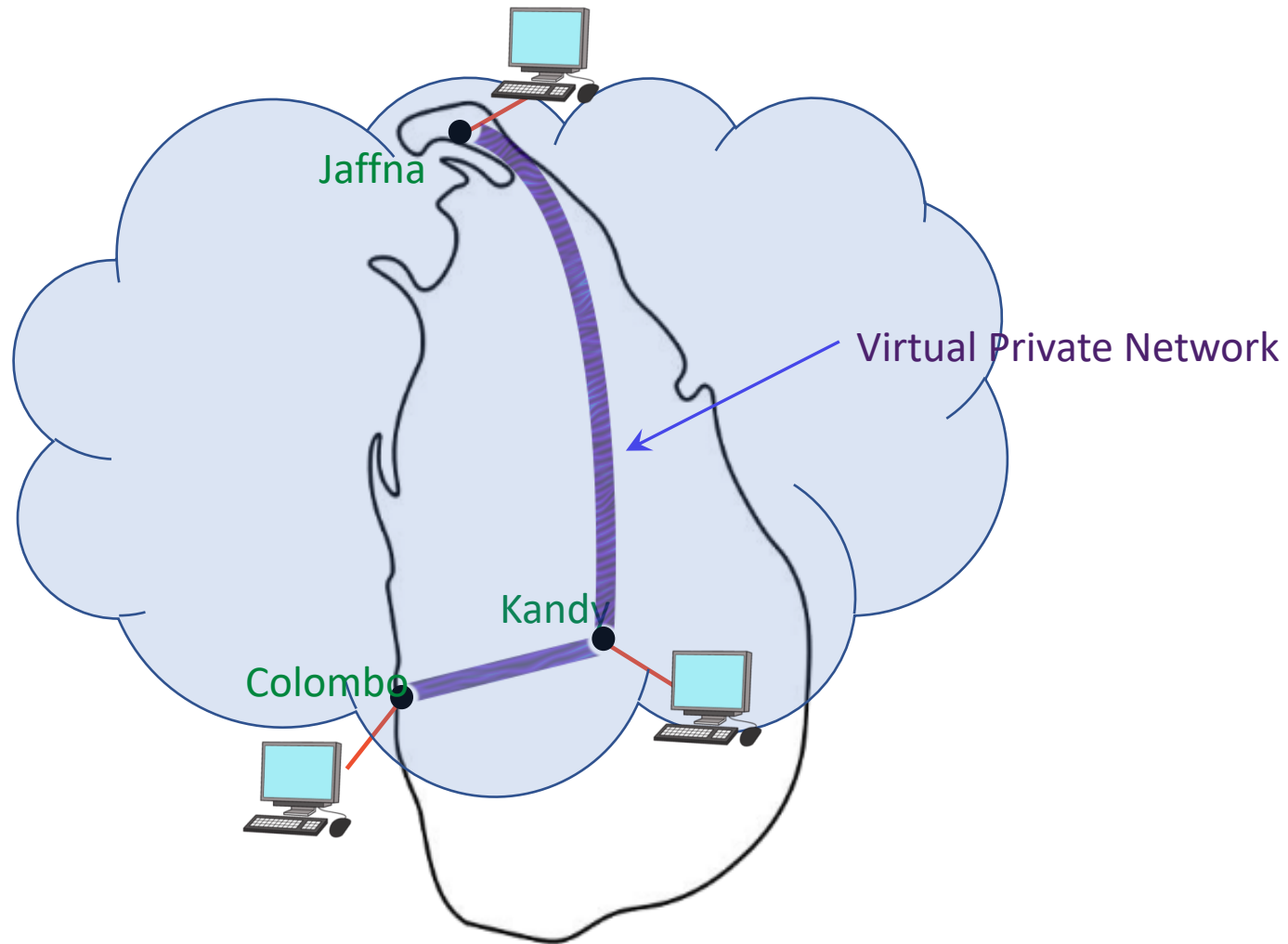
WAN

- Businesses cannot lay their own wires over such long distances
 - Telecommunication providers already have such wires (or other type of links)
 - Businesses can lease these links – leased lines
- WANs can internetwork networks – an internet
 - Note the lower case “i” and “an”
- The Internet can be considered as such a WAN that uses a particular set of protocols to communicate
 - A protocol is an agreement between communicating parties
 - Can be implemented in either hardware and software

Virtual Private Network - VPN

- Scenario
 - Offices in Colombo and Jaffna are connected to the Internet through an Internet Service Provider
- Opportunity
 - Colombo office and the Jaffna office can establish a virtual link over between them over the Internet
 - It is possible to encrypt data between these two sites
- Virtual Private Network - VPN

VPN



Protocols

- Protocol is an agreement between two (or more) parties who want to communicate with each other
- Scenario: You want to send a letter to your friend in USA
 - Two of you must agree on the language – this can be implicit
 - Let's say you agree on English
 - This agreement is a protocol
 - There is a standard format to write the address
 - This is an agreement between the postal systems of the two countries – a protocol
 - There are other agreements between the postal systems charging etc. - protocols
 - Postal system must hand it and bunch of other letters to the same destination country over to an airline
 - Airlines have agreements on how to route these packages – more protocols

Protocols (Contd)

- When you write the letter you do not worry about how the postal system works or the operation of the air lines.
 - However, you must write the address as expected by the postal system and hand it over to the post office
 - This is the interface between you and the post office
 - Rest of the details are hidden from you (and you don't want to know them either)
 - Information hiding
- Siilarly postal system is not worried about or aware of how packages are routed in the airline system

Protocols (Contd)

- This air mail system can be thought of as having three layers
 - You and your friend
 - Protocol is between you and your friend – you are peers
 - Post offices in Sri Lanka and USA
 - Protcols are between the post offices – they are peers
 - Airline system
 - Protocols between different airlines – they are peers
- In this example airline system is the lowest layer and you and your friend are in the highest layer
- It is also possibe to break this into even finer details and layers. How far you want to go depends on the purpose
- In summary
 - There are interfaces between immediate layers
 - There are protocols between peers

Protocols (Contd)

- Protocol layers are stacked – one on top of the other
 - Protocol Stack
- We can use the same idea to understand and analyze how a network operates
 - A set of layers and protocols is called a Network Architecture

Layers – Design Issues

Error Detection and Correction

- Consider our example again
- Assume that the letter is destroyed due to an accident after you hand it over the post office
 - This is an error. Obviously postal system cannot recreate the letter
 - This layer cannot handle this error
 - It can detect that error and let you know
 - You can rewrite the letter and send it again
 - Top layer (you) can handle the error

Layers – Design Issues

Routing

- A package containing your letter is handed over to the airline
 - There are no direct flights to USA
 - Airline must forward the package through some other city (Singapore)
 - Possibly through more than one city
 - This is called routing – finding a suitable path to the destination

Layers – Design Issues

Addressing and Naming

- There is a particular format to write the address
 - This is how you identify the recipient
 - Addressing and naming
- SL post office does not hand over your letter by itself to the airline
 - A package containing your letter and other destined to USA is handed over to the airline
 - This package is not addressed to your friend
 - It is sent to a central postal office in USA
 - There is a different addressing format in this layer

Layers – Design Issues

Quality of Service

- The post office offers express, regular, registered mail services
 - Quality of service
- Airlines also have similar service levels

1.3 Network Reference Models

Reference Models

- There are standard reference models to describe/design network architectures
 - Open System Interconnection (OSI) model
 - 7 layers
 - TCP/IP model
 - 4 layers
 - The model used in the textbook
 - 5 layers

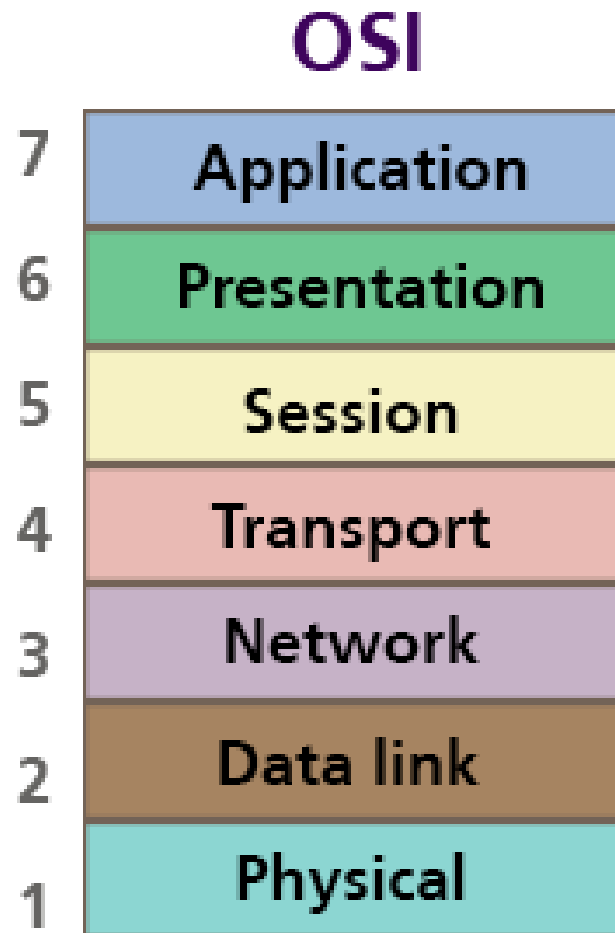
OSI Model

- Physical Layer
 - Concerned with transmitting raw bits over the physical channel
- Data Link Layer
 - Transforms a raw transmission facility into a line that appears free of undetected transmission errors
 - Frames
- Network Layer
 - controls the operation of the subnet and determines how packets are routed from source to destination.
- Transport Layer
 - accepts data from the layer above, splits it up into smaller units if need be, passes these to the network layer, and ensures that the pieces all arrive correctly at the other end.

OSI Model

- Session Layer
 - establishes sessions between communicating parties
 - Dialog control
 - Synchronization
- Presentation Layer
 - concerned with the syntax and semantics of the information transmitted
 - Data representation
 - Data structures
- Application Layer
 - contains a variety of protocols that are commonly needed by users
 - Example - HTTP

OSI Model



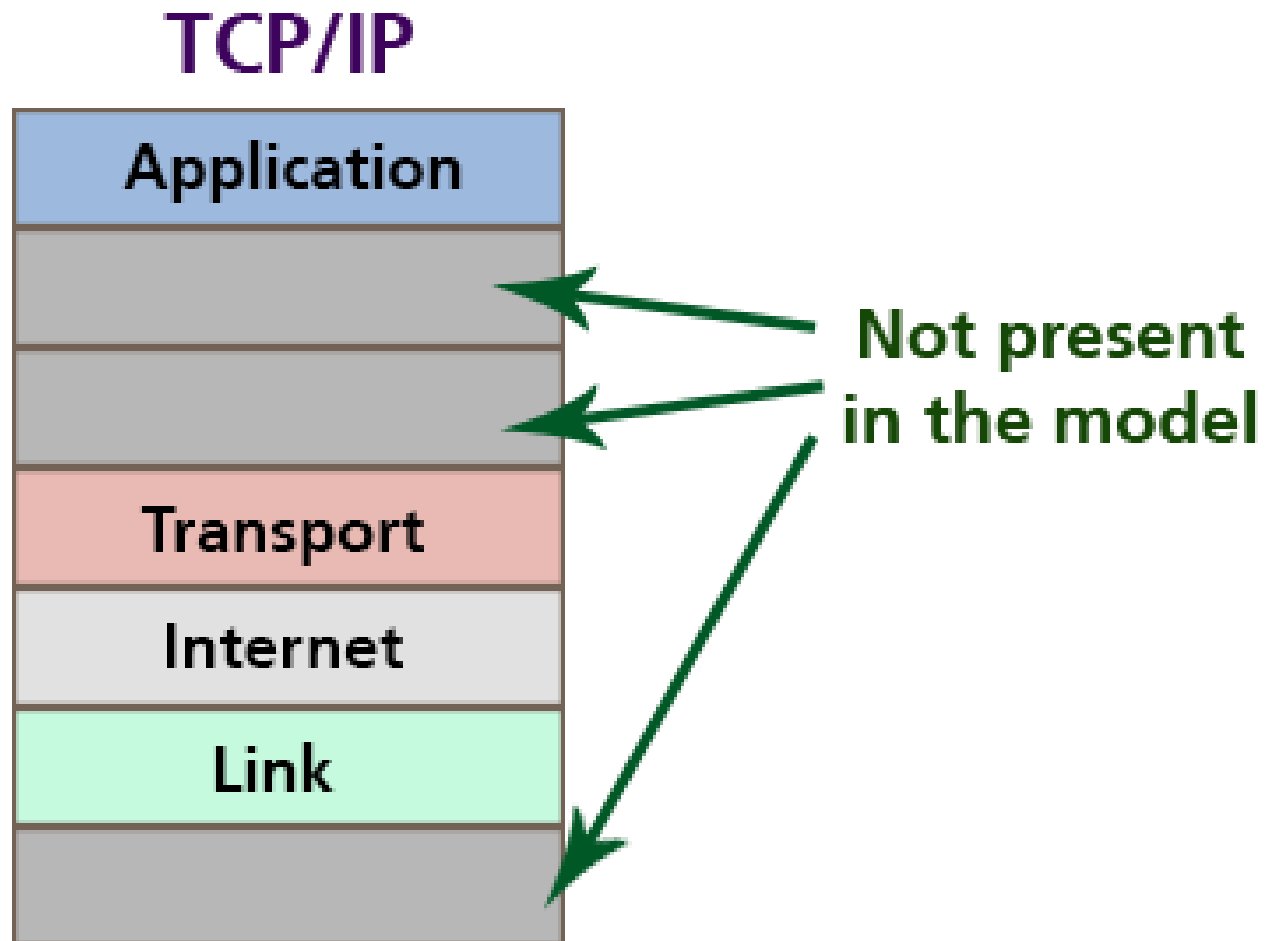
TCP/IP Model

- Link Layer
 - Not really a layer
 - It does not define a protocol between peer entities
 - Defines an interface to the upper layer – Internet Layer
- Internet Layer
 - Corrosponds (approximately) to the Network Layer in the OSI model
 - Packet routing
 - Packets are moved towards the detination independent of each other
 - They may arrive out of order
 - They may not arrive at all

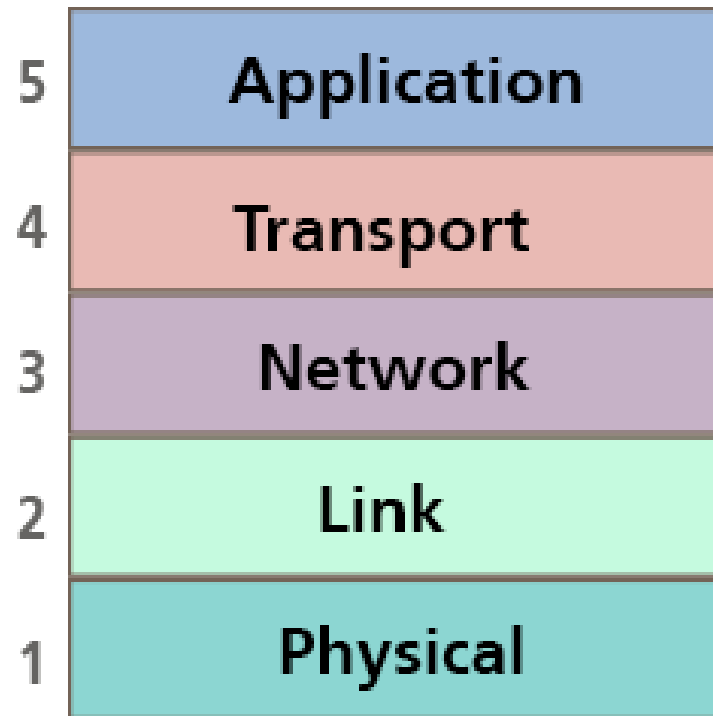
TCP/IP Model

- Transport Layer
 - allows peer entities on the source and destination hosts to carry on a conversation
 - Similar to OSI transport layer
 - Transmission Control Protocol – TCP
 - User Datagram Protocol – UDP
- Application Layer
 - This includes session and presentation functions of the OSI model in addition to application protocols

TCP/IP Model



Reference Model Used in the Textbook



Activity

- Compare and contrast TCP/IP and OSI reference models

1.4 Metric Units

Units

- Networks
 - Units are based on power of 10
 - 10^3 – killo
 - 10^6 – Mega
- Storage – Hard disks etc
 - Units are based on power of 2
 - 2^{10} – Kilo
 - 2^{20} – Mega
- B – Bytes
- b - bits