PHYSICAL AND DATALINK LAYERS (WEEK 2)

COMPUTER NETWORKS

RECAP?

- What did we see last time?

RECAP…

- Introduction to networking
  - Broadcast/point-to-point
  - All the 7 layers and their specific responsibility
  - ISO/OSI vs TCP/IP
  - The journey of a message

TODAY:

THE PHYSICAL AND DATALINK LAYERS!

LEARNING OUTCOMES

- At the end of today's lesson you will be able to:
  - Describe how digital data stored in our computers are converted into signals before transmission.
  - Describe what transmission impairments may occur and what solutions exist for them
  - Understand how data is formatted and error-checked
  - Design and implement a simple local area network

LAYER 1

THE PHYSICAL LAYER!

PHYSICAL LAYER

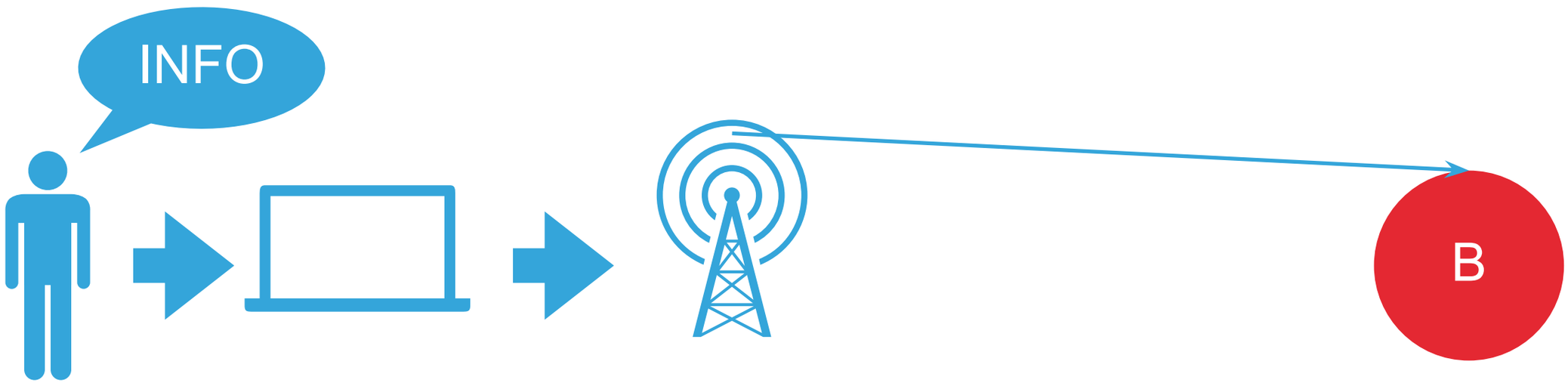
- The information in computers is stored in **digital format**.
- To transmit this information we have to **convert** them into **signals**
- The *Physical layer* is responsible for this conversion.
  - In addition physical layer deals with the mechanical and electrical specifications of the interface and transmission medium

WAVES

- Waves are created when a physical quantity changes in the form of a moving ridge or swell. (such as the surface of a liquid body, as the sea or a lake).

WHAT IS A SIGNAL?

- Waves by themselves contain no information.
- Signals are waves with added data.
- Signals can carry information.



TRANSFORMATION INTO SIGNALS

CARRIER WAVE

- A signal is made of a **carrier** and the **data** added to it.
- The carrier is generally a simple sine wave

DATA MODULATION

- **Adding data** to a carrier is called **modulation**.
- Data can be added to a carrier by either changing its…
  - Height - **amplitude**
  - Rate of changes per second - **frequency**
  - Shift - **phase**

MODULATION BY CHANGING AMPLITUDE:

MODULATION BY CHANGING FREQUENCY:

MODULATION BY CHANGING PHASE:

ANALOG VS DIGITAL

DATA

- **Analog** data are **continuous** and take continuous values.
- **Digital** data have **discrete** states and take discrete values.

SIGNALS

- Analog signals can have an **infinite** number of values in a range
- Digital signals can have only a **limited** number of values.

ANALOG VS DIGITAL

TRANSMISSION IMPAIRMENTS

- The signal may face some problems during transmission.
- These problems are called *transmission impairments*.
- The most important transmission impairments are:
  - Loss of energy - **attenuation**
  - Change of shape - **distortion**
  - **Noise** effect

ATTENUATION

SOLUTION TO ATTENUATION

- Divide the communication line into short segments and use **amplifiers between segments**

DISTORTION

SOLUTION TO DISTORTION

- **Using lower bit rate** will make bit duration longer and therefore, less susceptible to distortion

NOISE

SOLUTION TO NOISE

- **Using stronger signal** power compared to the estimated average noise power will reduce the impact of noise.
- This is referred to as **signal to noise ratio** (**SNR**)

TRANSMISSION MEDIA

- A transmission medium can be broadly defined as anything that can carry information from a source to a destination.
- The transmission medium is usually free space, metallic cable, or fiber-optic cable.
- Transmission media can be divided into two broad categories:
  - guided
  - unguided

GUIDED MEDIA

- Guided media, which are those that provide a conduit from one device to another, include twisted-pair cable, coaxial cable, and fibre optic cable.

Twisted pair **Coaxial cable** **Fibre optics cable**

UNGUIDED MEDIA

- Unguided media transport electromagnetic waves without using a physical conductor.
- This type of communication is often referred to as: **wireless communication.**
- Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them.

ELECTROMAGNET SPECTRUM

For in depth informations: https://xkcd.com/273/

LAYER 2

THE DATA LINK LAYER!

DATA LINK LAYER

- Data link layer makes sure the **correct data is delivered** to **correct destination**.
- Data link transforms the physical layer (a raw transmission facility) into a **reliable** link and makes the physical layer appear **error-free** to the upper layer
- Data link layer **splits the data** into short messages, puts them in specific format, and specifies the sender and the receiver of the messages.

ERROR DETECTION

- Transmission channels are not always error free.
- In case of an error it should be detected and the message should be re-transmitted (if possible!)
- Detecting errors requires specific algorithms:
  - **Parity bit**
  - **CRC**

PARITY BITS (OPTIONAL)

- For every group of bits a single bit named parity bit is added.
- If the number of ‘1’ bits in the group is odd then the parity bit will be one, and zero otherwise. (Even parity)
- If the number of ‘1’ bits in the group is even then the parity bit will be one, and zero otherwise. (Odd parity)
- If any bit (data or parity) changes, then the rule of having Even or Odd number of ‘1’s will not be satisfied. Therefore, 1 bit error can be detected using this method

CYCLIC REDUNDANCY CHECK (CRC) (OPTIONAL)

- A polynomial of degree N, with one or zero coefficients is used as the generating polynomial.
- To calculate the CRC we consider the data as a number, put N zeros in front of it, divide it by the generating polynomial coefficients, and find the remainder.
- The remainder is sent together with the data. The receiver will follow the same procedure. If the computed CRC and the delivered CRC are different then we have error(s)

FRAMING

- The data is split into short segments before transmission. For each segment some extra data (metadata) is used to define:
- Who is the sender
- Who is the receiver
- Length of the segment
- Type of segment (such as normal message, error message, control message. Etc.)
- Error checking codes (such as CRC code)
- Data and metadata are put in a single message called a frame

ETHERNET

- Ethernet is the most commonly used protocol at the datalink layer of wired networks
- Ethernet uses specific hardware addresses to identify hosts in a network. These 6-byte-integer addresses are named Medium Access Control (MAC) addresses
- An Ethernet frame has the following format

WIRELESS NETWORKS

- Wireless networks do not use wire medium for communication and the messages are sent through radio waves.
- Each member of wireless network is called a station
- Wireless networks are implemented in different sizes (ranges)
- Wireless Local Area Networks (WLAN)
- Wireless Metropolitan Area Networks (WMAN)
- Wireless Wide Area Networks (WWAN)

BASIC SERVICE SET (BSS)

- A **BSS** is a network with a specific station called **Access Point**
- All **transmissions** from a station to anther station are **through the Access Point**
- Access Point also connects the network (BSS) to other networks, and hence the Internet

AD-HOC NETWORKS

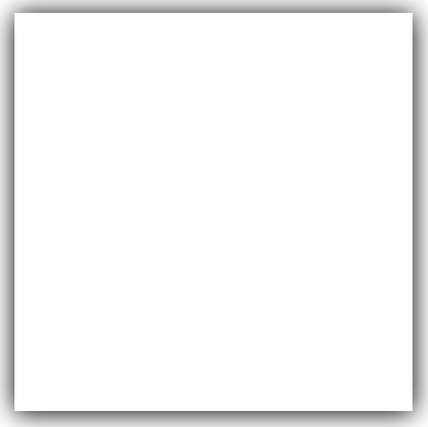
- Ad-hoc networks do not have any central node (access point).
- Every station can send data to every other station directly

SUMMARY

- The main goal is using computer networks is sharing/exchanging data.
- To transmit data from a point to the next we have to create and use signals. This is done by the **physical layer**.
- Data may be subject to impairments during transmission. *Attenuation*, *distortion* and *noise* are the most common impairments.
- To avoid confusions in data transmission, data should be given a format (framing) and error-checked. This is done by the **data-link layer**.

HOW ABOUT SOME FUN WITH …

- Packet Tracer…
  - Open the second week exercise (available on the classroom)
  - Read the descriptions and follow the instructions carefully.
- **What happens when 3 or more switches connect in a loop?**



QUIZ

- Let’s see what we learned this week
- Go to the classroom and open the second week quiz
- We will discuss the questions/solutions after 10 minutes