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CA169
Networks & Internet

Week 1: Introduction

Outline

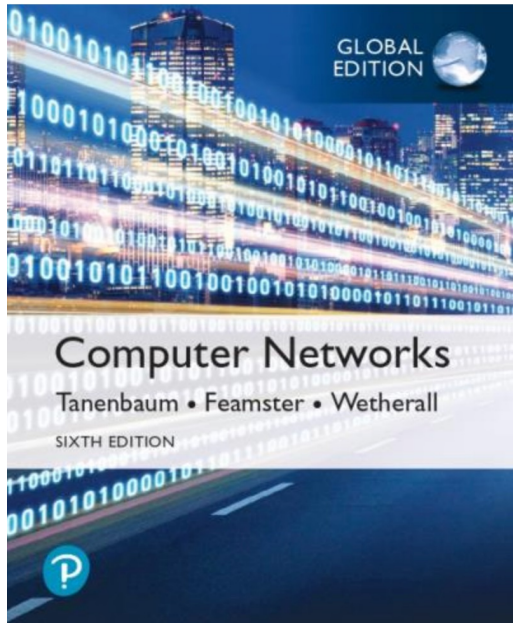
- Structure of the Module
- Why Study Computer Networks
- Basic Concepts
  - What is a Computer Network?
  - Types of Computer Networks
  - Hardware in Computer Networks
  - Software in Computer Networks

Take home message:

Computer Networks consist of a set of ***Hardware*** and ***Software*** components

Course Description

- Based on sections of the book
  - Computer Networks, 6th Edition
  - By:
    - Andrew S. Tanenbaum, rije University, Amsterdam, The Netherlands
    - Nick Feamster, University of Chicago
    - David J. Wetherall, University of Washington
  - ISBN-10 : 0135408008
  - ISBN-13 : 978-0135408001



Lectures and Assessments

- Lecturer: SABER Takfarinas (takfarinas.saber@dcu.ie)

  Call me: **Tak**, or **Dr SABER**
- **Lectures** run from Week 1 to Week 12
- **Assessment** is split between
  - 50% Final Exam at end of term
  - 50% Continuous Assessment work during semester
    - Assignment 1, 15%
    - Assignment 2, 15%
    - Assignment 3, 20%
- Repeats for both assignments and exam

Interactions

- I will also create a **Forum** on Loop where you can ask questions directly to me.
  - Any questions related to the lecture or practical must be asked in the forum, if you think that all the class would like to know the answer.

- For one to one interaction with me:
  - The best way to contact me is by email: takfarinas.saber@dcu.ie. However, don't expect immediate responses, I will endeavour to respond within 48 hours.
  - If you would like to send me an email, use you **DCU account** and state in the email: name (as it appears on Moodle), Module ID CA169, **DCU** student number.
  - I will also put in place a time period to discuss directly with you when necessary.

Computation Over Time

Abacus

Calculator

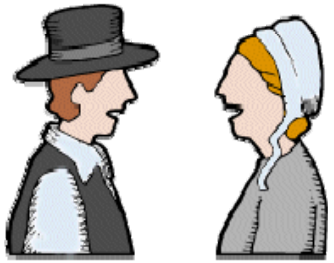
Computer

Before → After

Adding Machine

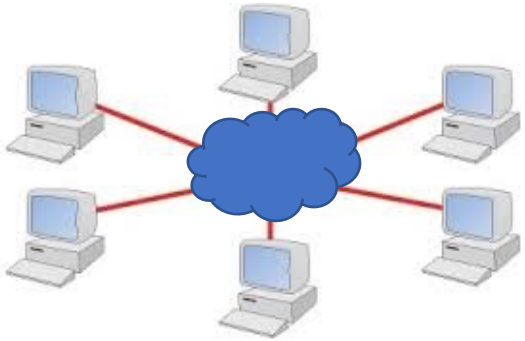
Mainframe

Communication Over Time



Conversation

Telephone



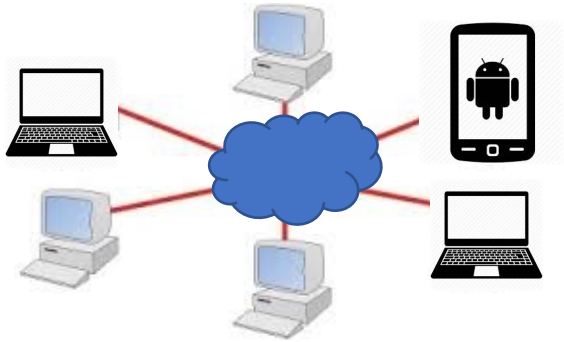
Computer Networks

Before → **After**

Mail

Data Transfer

Communication & Computing Over Time



Mainframe

Personal Computers

Computer Networks

Before → **After**

What is a Computer Network?

Computer Networks have many definitions.

One valid definition is:

- "A connected collection of hardware and software that allows **information** exchange and **resource** sharing"

- *information = data, text, audio, video, images, ...*
- *resources = printers, memory, bandwidth, ...*

Advantage of Computer Networks

- **Sharing Resource:** such as equipment, programs, and data
- **Increasing Reliability:** having backups and alternative data supply
- **Improving Efficiency:** with parallelization and distribution of tasks
- **Reducing Cost:** many small computers cost less than one big one

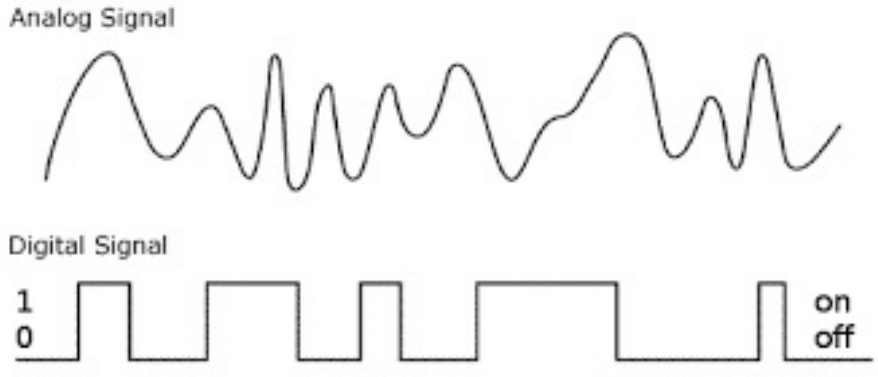
Variety in Computer Networks

- Computer networks vary in:
  - **Type:** Ethernet, Cable TV, Internet, Cellular, Personal, etc.
  - **Technology:** copper wire, coaxial cable, wireless, fibre optics, etc.
  - **Size:** from a few computers close together, to a world-wide network of networks containing millions or billions of computers
  - **Technical issues:** what services are offered?, what rules for communications?, how users are charged for the network use?

Variety in Computer Networks (Cont'd.)

- These variations are due to a combination of factors:
  - **Target Applications:** selecting the network that fits with the intended utilisation
  - **Operating Environments:** for example, if devices are moving, then it better to create a wireless network
  - **Historical Reasons:** for example, many of the Internet connections use the phone cables as it is costly to install new cables
  - **No "Best" Computer Networks:** there is no computer networks that is the best in every situation. Each computer networks is better on some aspect and worse on others.

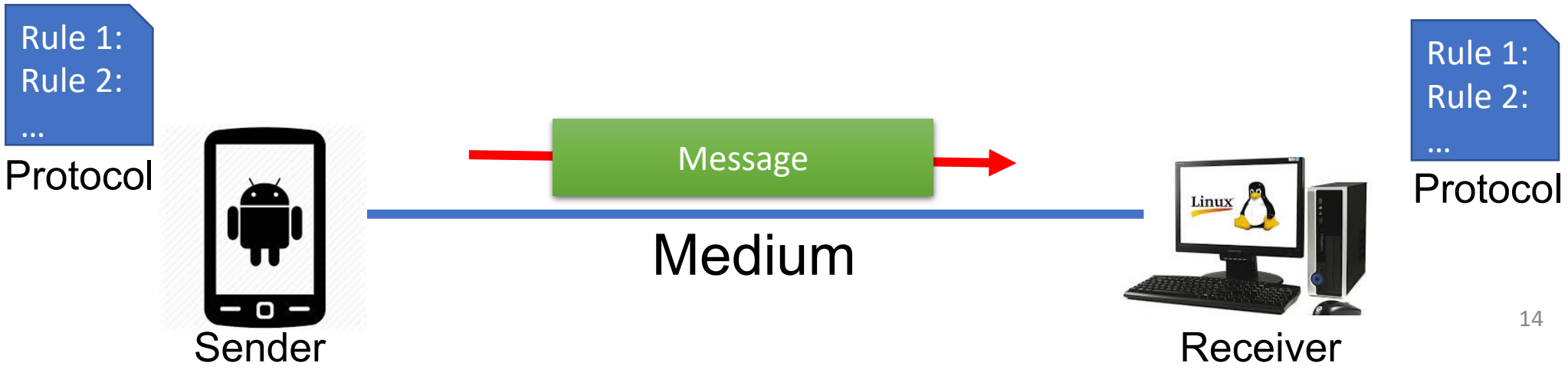
Digital Transmission



- In computer networks, all information is represented by *bits* (only values are 0 and 1)
  - This information is called: digital
  - This is more resistant to ***noise*** (unpredictably changes transmitted values)
- Basic Idea:
  - Transmit two **very different** signals for 0 and 1
  - even if these signals are slightly corrupted during transmission, they should still be **distinguishable**

Components of a Computer Network

- ***message:*** information to be communicated
- ***sender:*** device that sends the message
- ***receiver:*** device that receives the message
- ***medium:*** physical path from sender to receiver
- ***protocol:*** set of rules that govern data communications



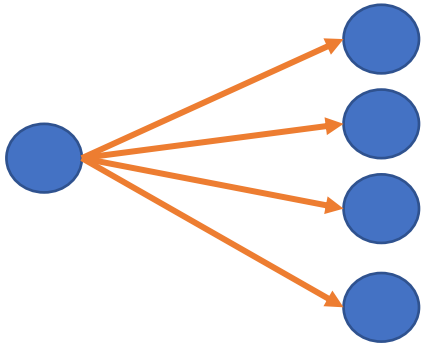
Computer Network Hardware

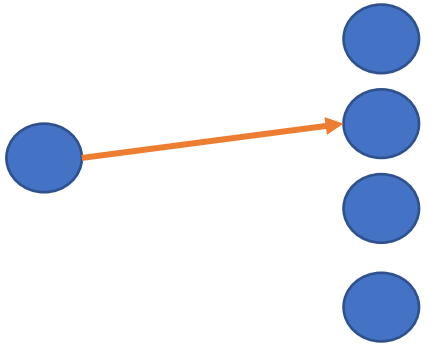
- Computer networks are typically described in two ways
  1. transmission technology
  2. scale of the network

Transmission Technology

There are two widespread transmission technologies:

- **Broadcast links:** the communication channel is shared by all the machines on the network
  - The message is “heard” (received) by every machine on the network
  - E.g.: WiFi and other wireless communications, wired local networks
- **Point-to-point links (also know as Unicast):** connects individual pairs of machines:
  - The message will hop from computer to computer to get to its destination





Network Scale

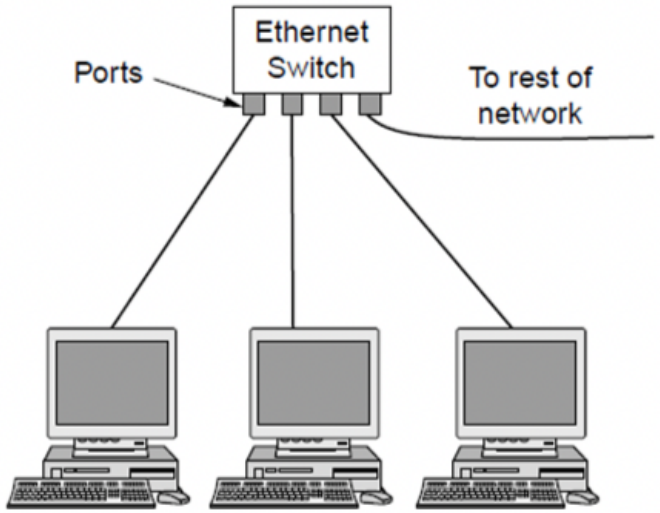
Distance	Located	
10 m	Room	Personal Area Network (PAN)
100 m	Building	Local Area Network (LAN)
1 km	Campus	
10 km	City	Metropolitan Area Network (MAN)
100 km	Country	Wide Area Network (WAN)
1,000 km	Continent	
10,000 km	Planet	The Internet

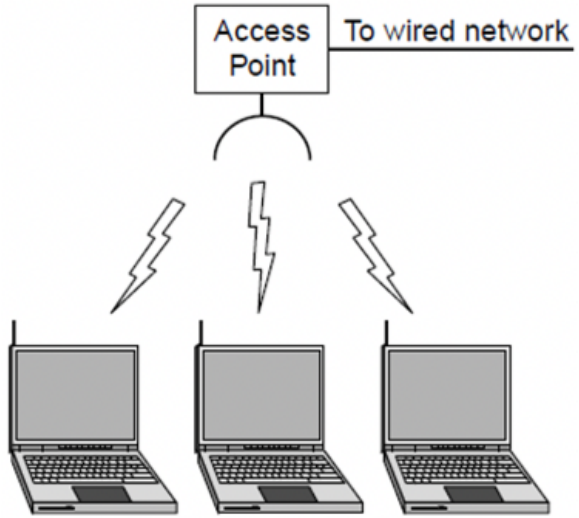
Personal Area Network (PAN)

- Personal area networks let devices communicate in **very short distances**
  - Excellent examples would be wireless keyboards, headphones and wearable technology
- Typically these networks are powered by **Bluetooth** or a very similar technology

Local Area Network (LAN)

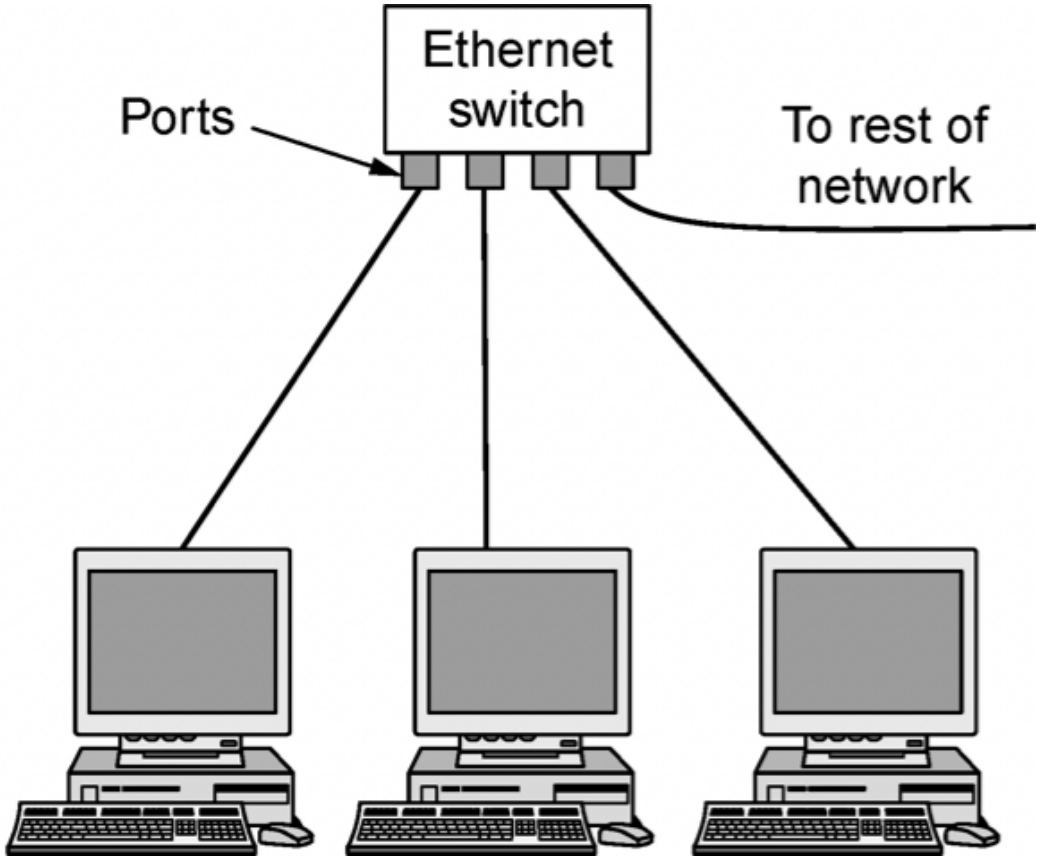
- Local Area Networks usually connect devices **within a single building**
- They are generally used to connect a number of devices to **share resources** (mostly share access to a printer or the Internet)
- They can be wired LAN or wireless LAN



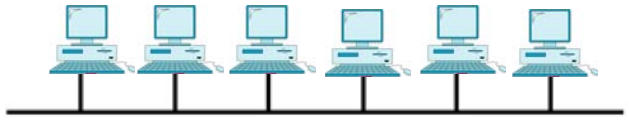


Example of Wired LAN

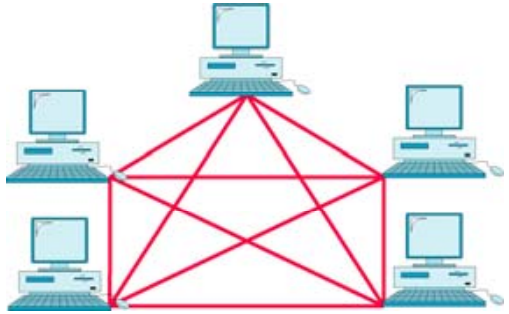
- Switch Ethernet is the most common type of wired LANs
- In Switched Ethernet:
  - each computer connects to an Ethernet **switch** through a **port**
  - a switch has multiple ports, each can connect to a single computer
  - switch relays messages to the correct computer using the address in the packet



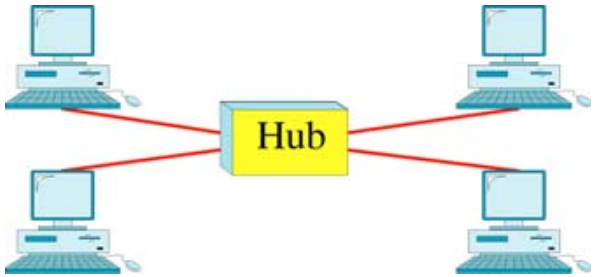
Other Examples of LAN Topologies



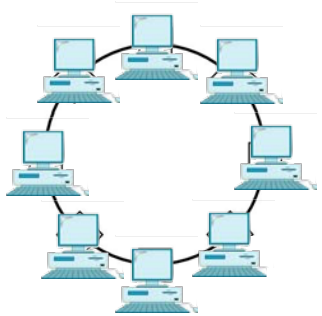
Bus



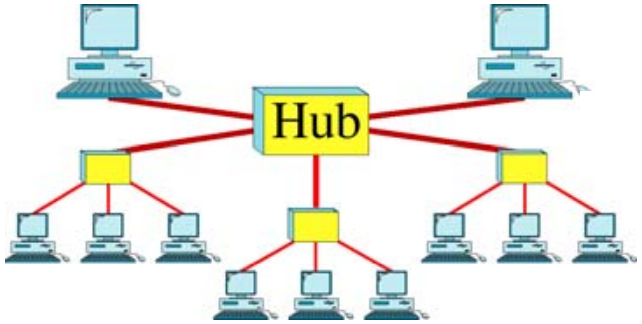
Mesh



Star



Ring



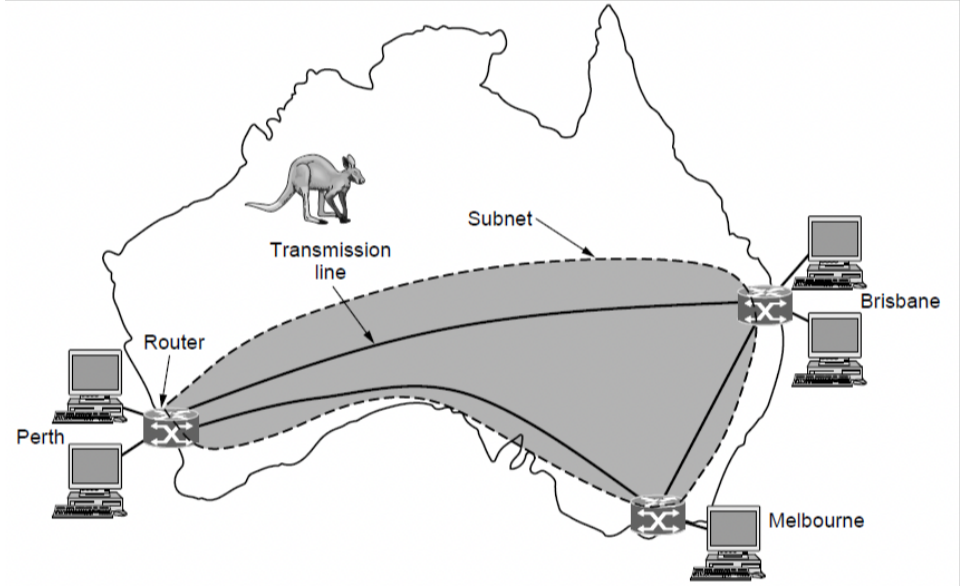
Tree

Metropolitan Area Network (MAN)

- A Metropolitan Area Network covers a city
  - The best-known examples of MANs are the cable television networks available in many cities.
- Usually these were built just for TV signals, but operators quickly realized the networks could also provide internet access

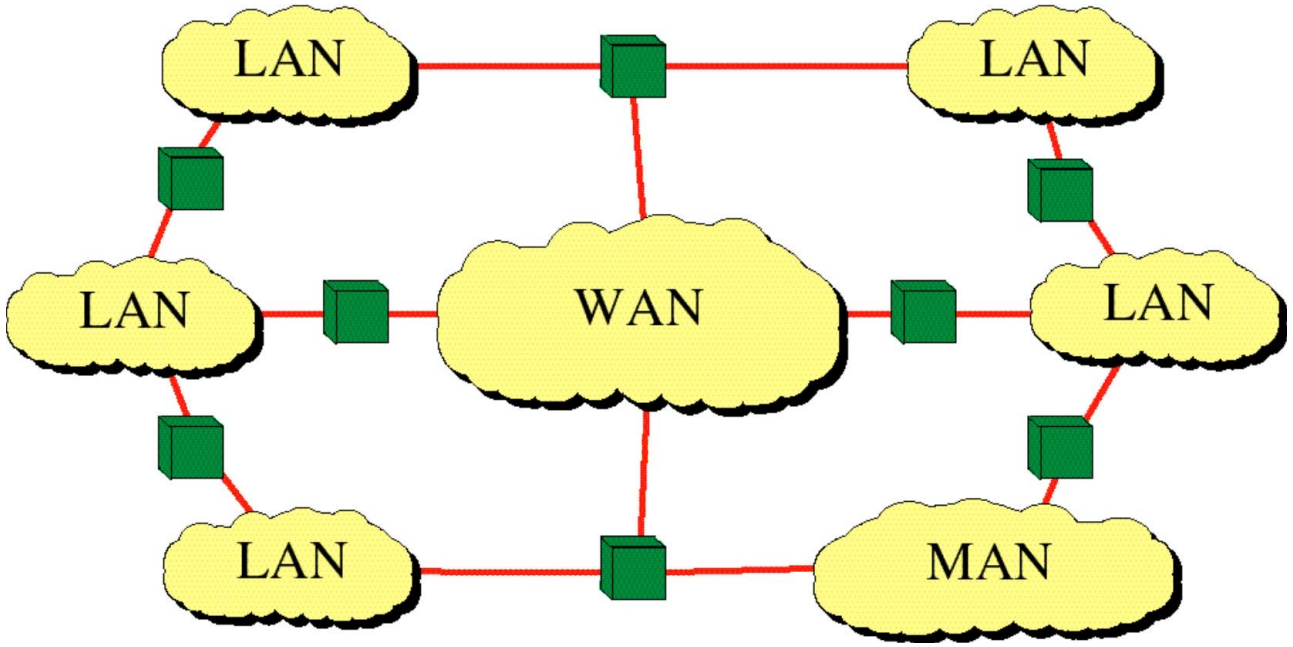
Wide Area Networks

- A WAN (Wide Area Network) spans a large geographical area, often a country or continent.
- A WAN connects several subnets:
  - The most common subnet type in WAN is: **point-to-point subnet**
- An ISP (Internet Service Provider) network is also a WAN.
  - E.g., Eir, Virgin, Vodafone, Sky, Etc.
- Most people buy connectivity from the ISP to access it.



Internetwork (or internet)

- It is a collection of two or more connected networks



When we say the **Internet**, we are talking about one specific internet.

- Notice the capital I for the Internet

What About Computer Network Software?

- Hosts 1 and 2 have different types of:
  - Applications
  - Operating Systems
  - Networks

Therefore, they need a set of rules (**protocols**) to be able to communicate

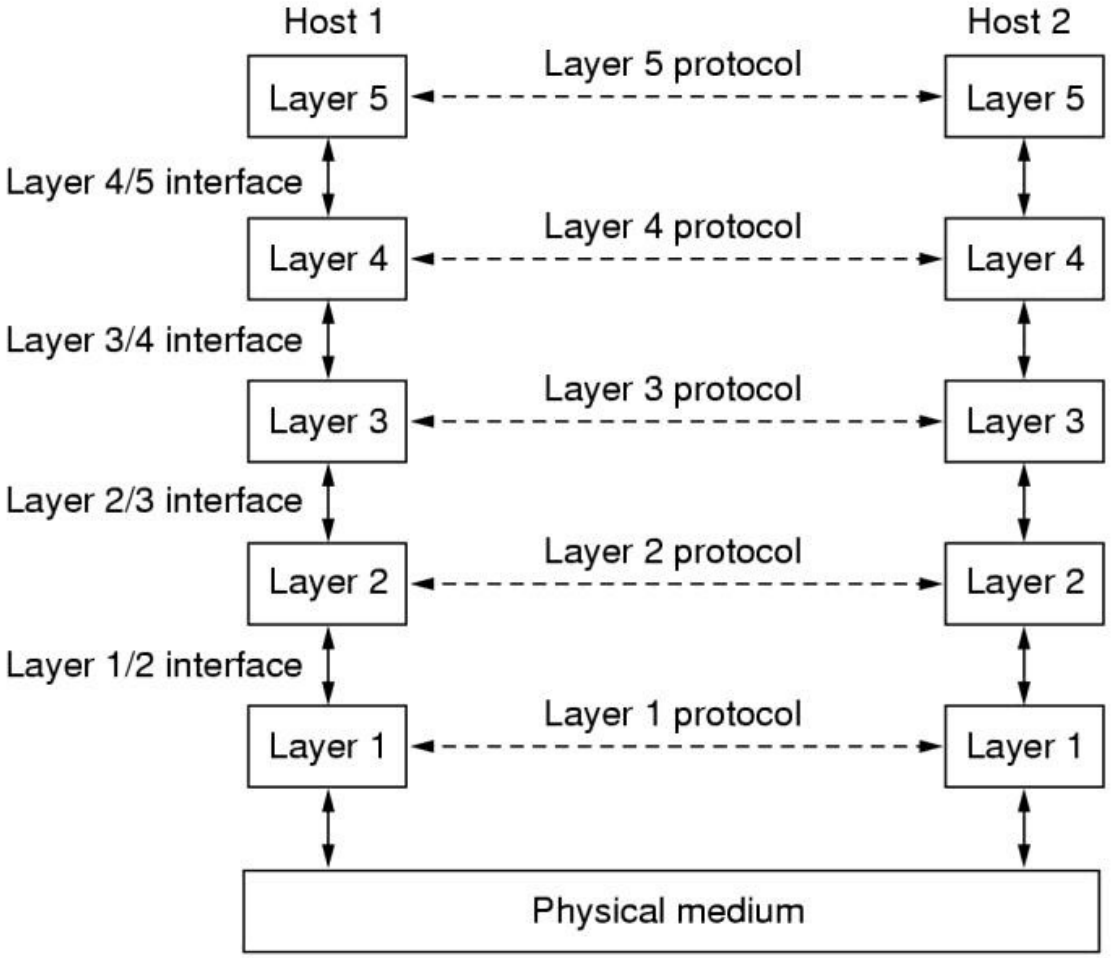
Communication Protocols

- **Protocol:** is an agreement about the format and meaning of exchanged messages

- In order to reduce the design complexity, most networks are organized as a stack of **layered structures**
  - Each layer:
    - Is built upon the one below it
    - Provides a set of **services** to the layer above
    - **Hides the details** of how the offered services are actually implemented upper layers (called *hierarchical modularity*)
    - Has a **protocol** on how the communication happens

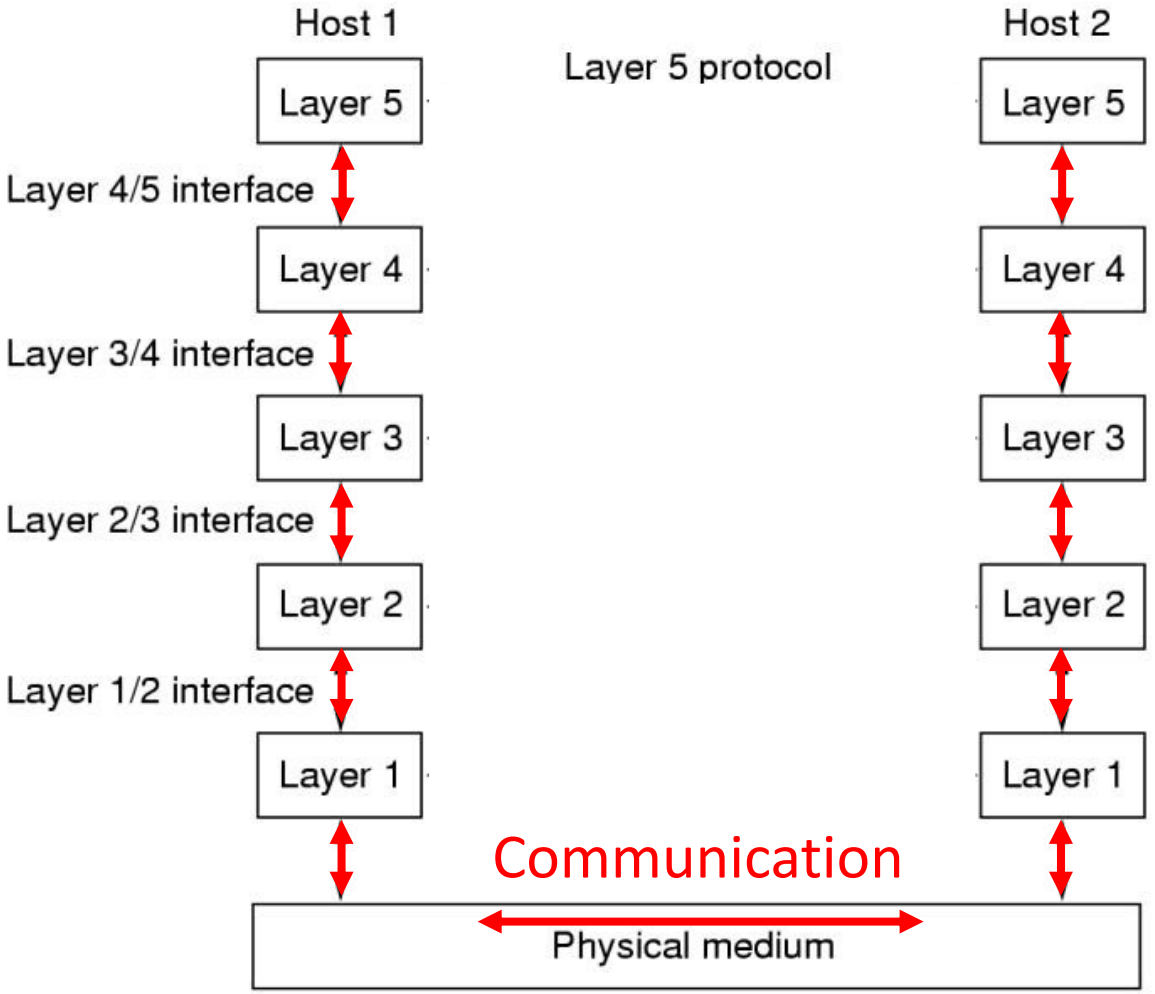
Communication Between Layers

- A particular **layer *n*** in Host 1 communicates **"horizontally"** with the corresponding **layer *n*** in Host 2 from another network
- They also use an agreed **protocol** for that layer *n*



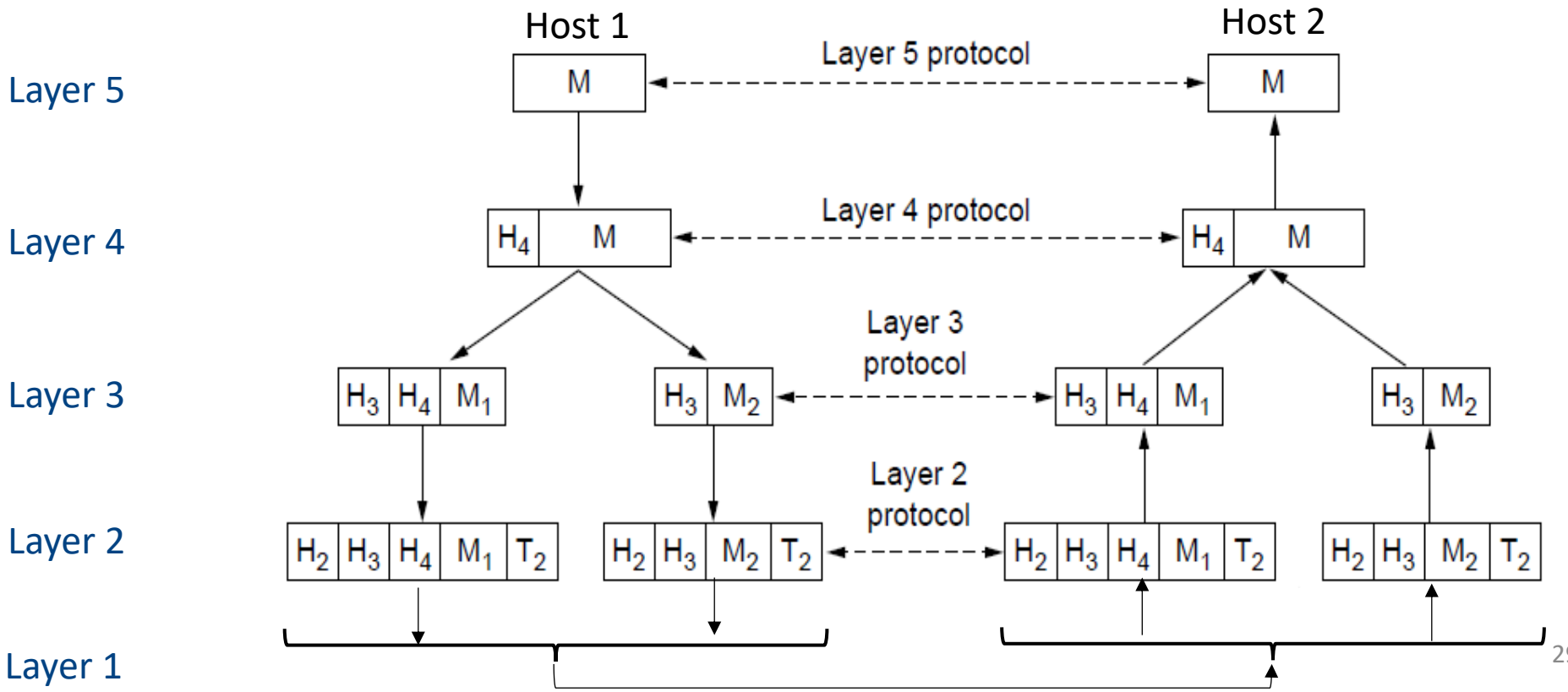
The Reality

- However, in reality:
  - No data is directly transferred from layer *n* on Host 1 to layer *n* on Host 2.
- Each layer passes data to the layer immediately below it, until the lowest layer is reached.
  - Actual communication is **"vertical"** except in the physical medium



The Reality (Cont'd.)

- Each lower layer adds its own **header** (H4, H3, …) to the message it transmits and removes it from the message it receives
- Layers may also split and join messages (M into M1 and M2)



Computer Network Software Layers

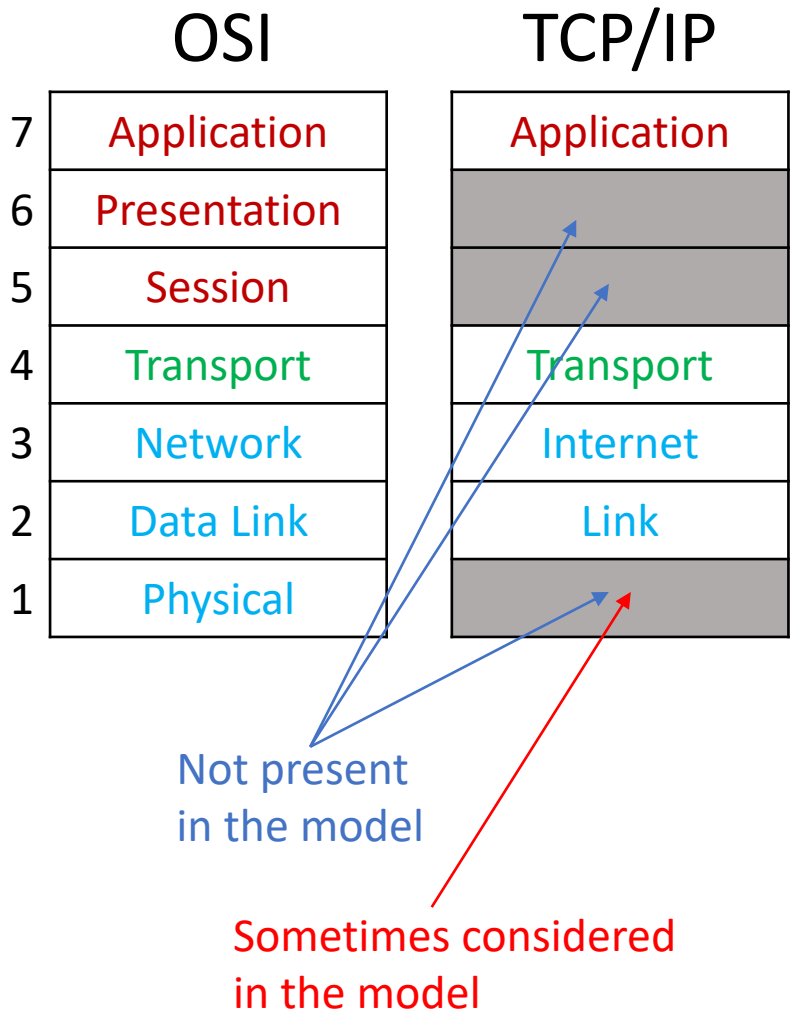
- **Network Architecture** = set of layers & protocols
  - It does not contain implementation details
  - It only says that each layer should perform a specific set of well-defined functions
- How many layers are needed?
  - minimum of 2: one for application issues, and one for network issues
  - But we often have more than 2 to address other general issues

General Issues When Designing the Layers

- **Reliability** is the design issue of making a network that operates correctly
  - Errors can easily happen in transmission.
    - How do we fix/detect them?
  - How do we find a working path through the network?
- **Evolution** of the network
  - Over time, networks grow larger and new designs emerge that need to be connected to the existing network.
- **Resource allocation:** networks provide a service to hosts from their underlying resources, such as the capacity of transmission lines.
- **Security** of the network by defending it against different kinds of threats.
  - Such as eavesdropping on communications
  - Making sure you are communicating with the correct person/business
  - Stopping messages getting altered in transmission

Network Architectures

- Next week, we will discuss two important network architectures:
  - OSI reference model
  - TCP/IP reference model
- They are also known as “reference models”



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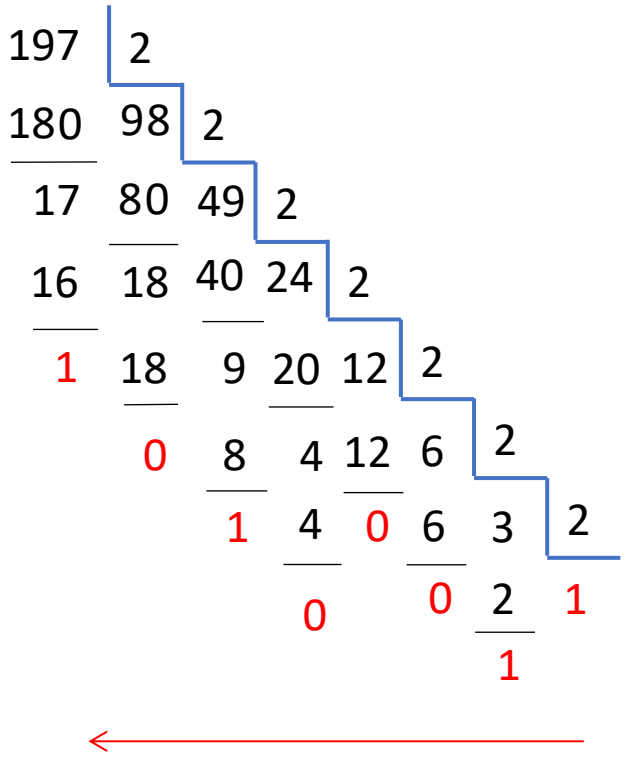
Practical: Numerical Systems & Base Convergence

Numerical Systems

System	Base	Valid Digits	Example
Decimal	10	0,1,2,3,4,5,6,7,8,9	29301
Binary	2	0,1	1000101101
Octal	8	0,1,2,3,4,5,6,7	723104
Hexadecimal	16	0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F	14EF094A

Decimal To/From Binary Conversion



Digits:	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**1**
Position:	7	6	5	4	3	2	1	0
Base and Position:	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
Converted components:	128	64	0	0	0	4	0	1

$197_{10} = 11000101_2$

$11000101_2 = 128_{10} + 64_{10} + 4_{10} + 1_{10}$
$= 197_{10}$