Introduction to Computer Science

Midterm Review

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Before it is too late, let’s do a review…

Sample Questions

True/False: mark T for True and F for False. *If False, rewrite the statement so that it is True.*

(F) The Internet is a service of the World Wide Web (WWW).

If false:

(F) Wi-Fi and Bluetooth devices allow users to receive files wirelessly and have similar transmission ranges.

If false: different

Sample Questions

Matching: match the terms with their definitions

A. Digital certificate B. Two-step verification

	1. A notice that guarantees a user or a website is legitimate
	2. The use of two different methods (one after another) to verify the user's identity

Open Questions:

Use the following terms to explain the whole processes of searching a keyword on Google: *website*, *webpage*, *web browser*, *search engine*, *search server*

Week 2
Computer Hardware

Week2
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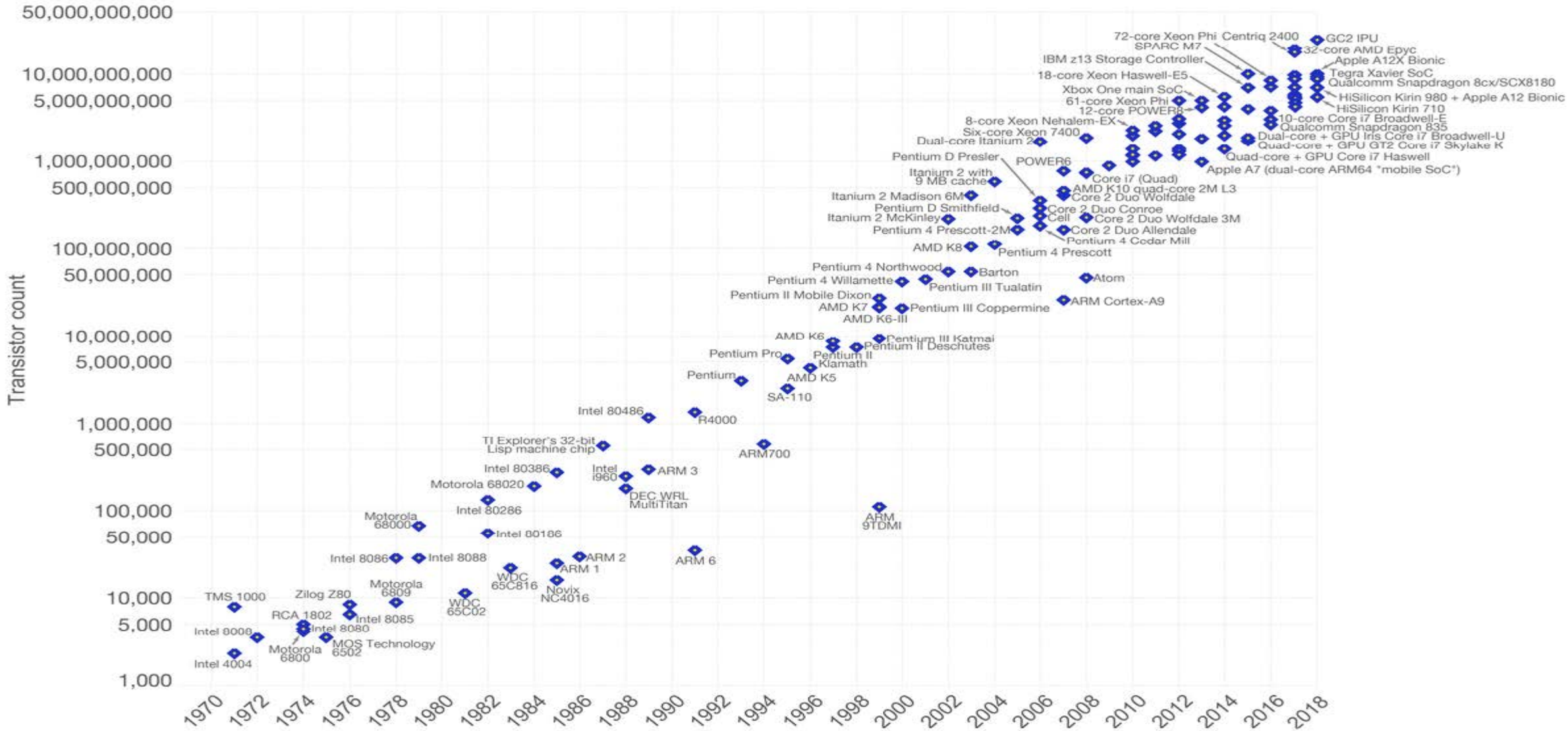
Moore's Law – The number of transistors on integrated circuit chips (1971-2018)

Our World in Data

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important as other aspects of technological progress – such as processing speed or the price of electronic products – are linked to Moore's law.



Data source: Wikipedia (https://en.wikipedia.org/wiki/Transistor_count)
The data visualization is available at OurWorldinData.org. There you find more visualizations and research on this topic.

Transistor 電晶體

Information is kept and manipulated in the binary formats (0 vs. 1)

- Transistor switches are used to manipulate binary numbers
  - Open transistor (i.e., there is no current) represents a **0**
  - Closed transistor (there is a current) represents a **1**
- Operations can be completed by connecting multiple transistors

Image credit: https://en.wikipedia.org/wiki/Transistor

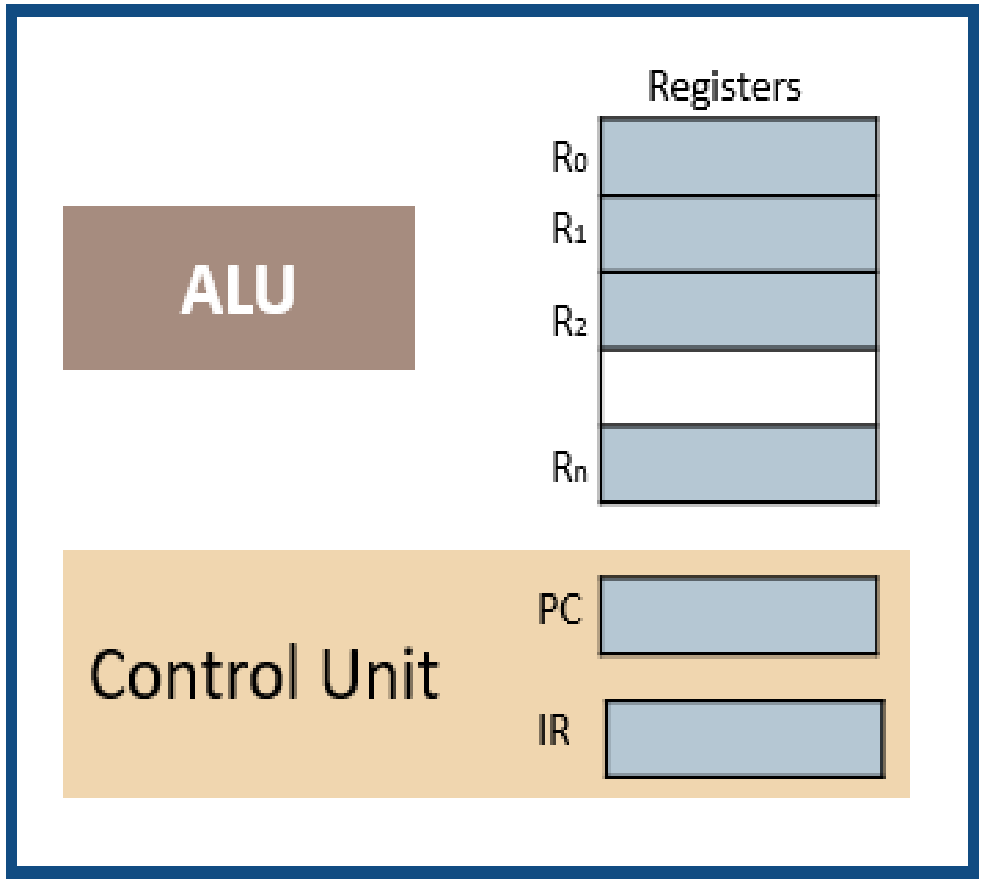
CPU Components- ALU & CU

ALU performs operations

- *Logic* operations
- *Shift* operations
- *Arithmetic* operations

Control Unit tells ALU what operation to perform on that data

- Moves the data between the registers, ALU, and memory
- Controlling is achieved through signals sent from CU to other subsystems



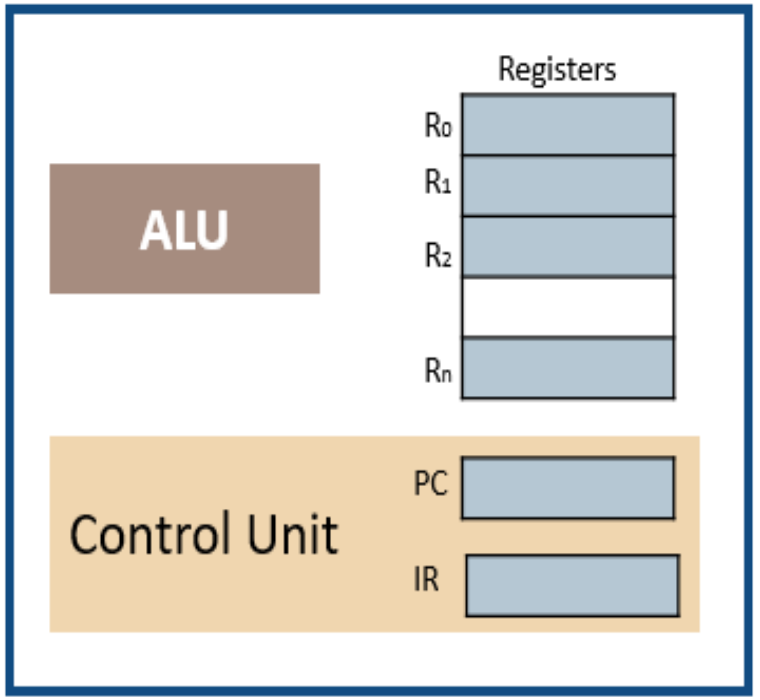
Central Processing Unit

CPU Components- Register

Register is a storage available as part of CPU, which can hold data temporarily

Multiple registers are needed to facilitate CPU operation

- *Data* register: keep the input data and the (intermediate) result of operations
  - Numerous registers may be used to speed up the operation
- *Instruction* register: keep the instructions (one by one from memory)
- Program counter: keep track of the instruction that is being executed
  - Fetch the instruction whose address is indicated by PC from the memory and load the data into instruction register



Central Processing Unit (CPU)

Machine Cycle

For each instruction, the processor repeats a set of four basic operations

- **Fetch**: Control unit fetches instructions or data from memory
- **Decoding**: Control unit decodes instructions and send data and instructions to ALU
- **Execute**: ALU executes command (perform calculation)
- **Storage**: The results are stored in memory

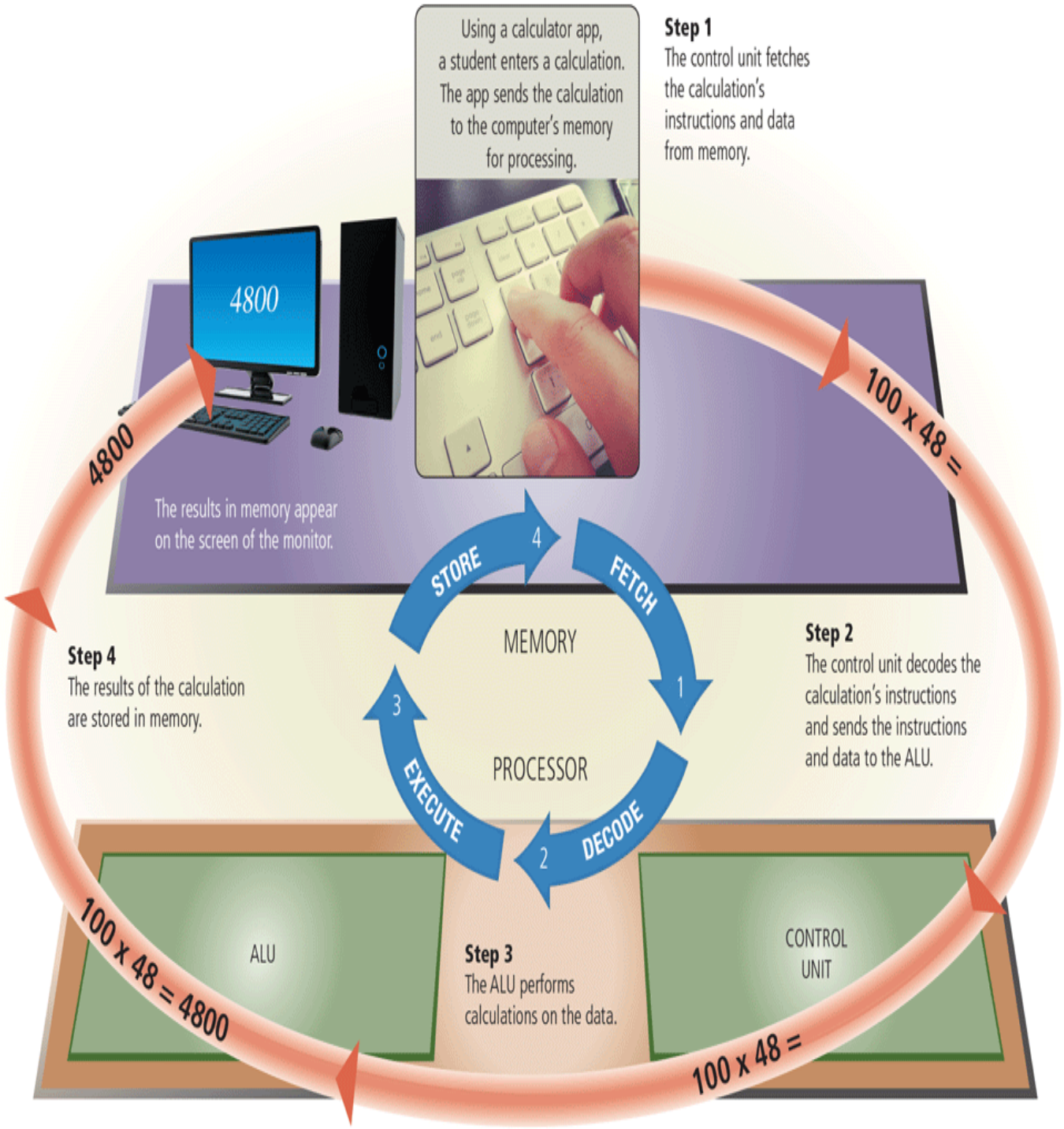
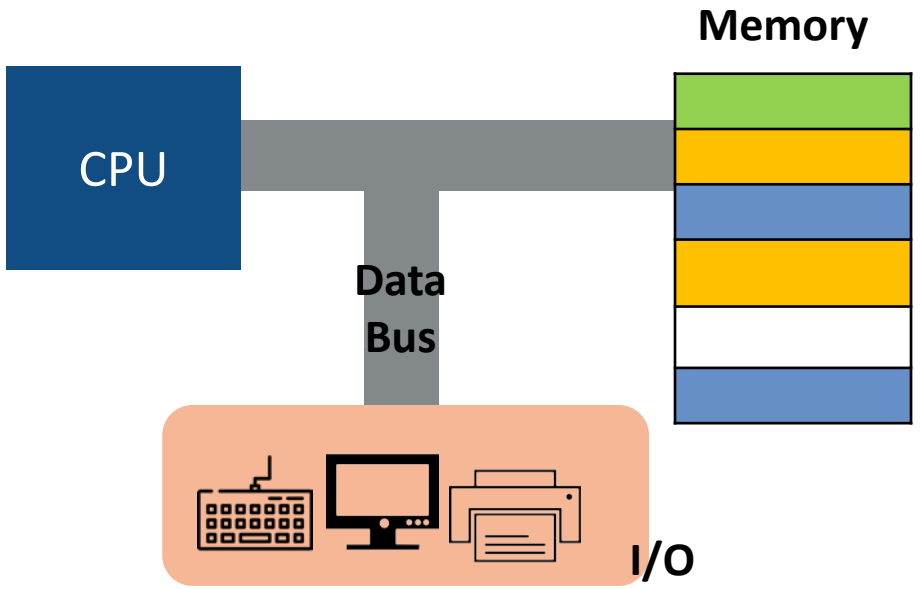


Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

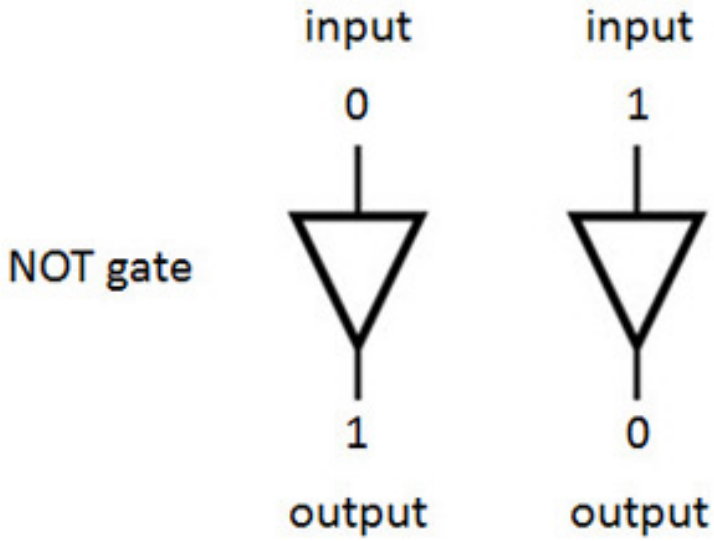
How CPU Executes Instructions?

1. Input instructions (x= i*j and z= x*y)
2. Store the instructions in instruction register
3. CU fetches instructions from instruction register
4. Decode the instructions (machine language)
5. Check cache, ram, external memory
6. Once all the required data ready, send it to ALU
7. CU informs ALU about the required operations
8. Once finished, send the result to data register
    - Task: x= i*j and z= x*y
    1. Fetch i and j from memory and store the values in data register
    2. Compute (i*j) and store x in data register
    3. Fetch y from memory and store the value in data register
    4. Compute (x*y) and store z in data register or output the result

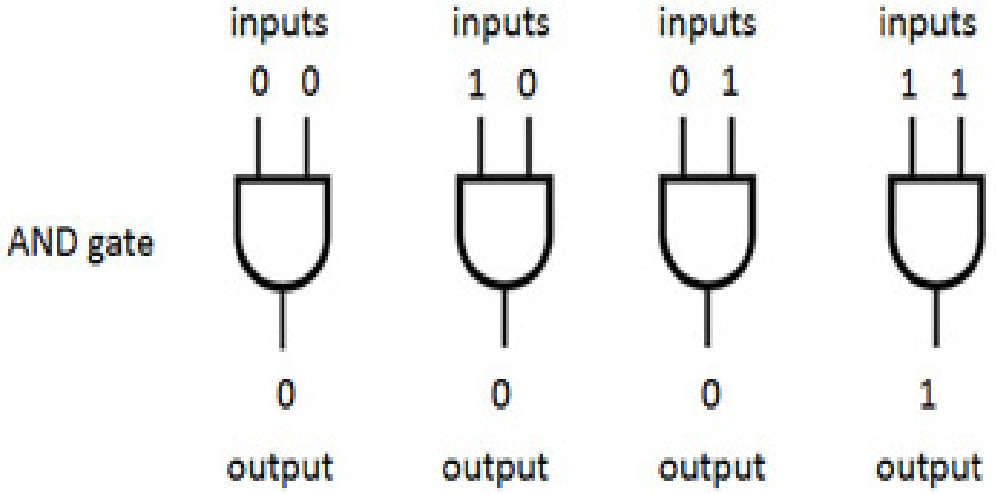


Logic Operations at Bit Level- NOT & AND

NOT operator uses a single input and produces a single output The output bit is always the opposite of the input



AND operator uses two inputs; the output bit is 1 if both the first and second input are 1s

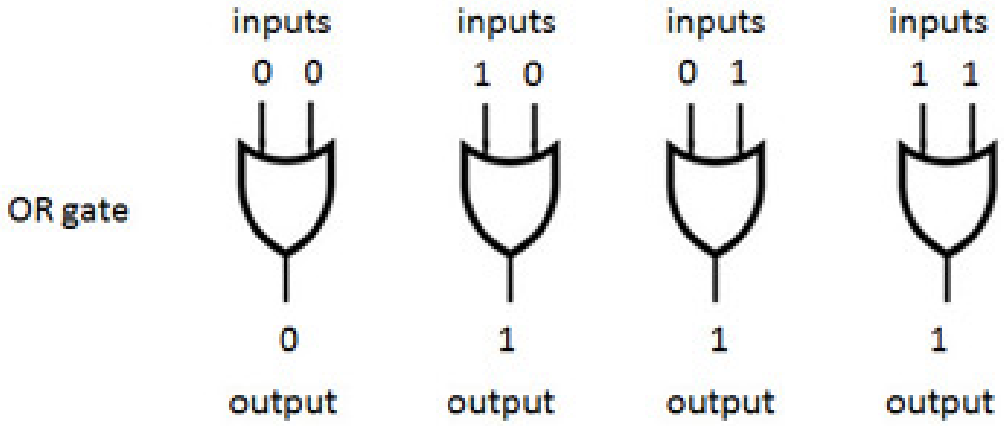


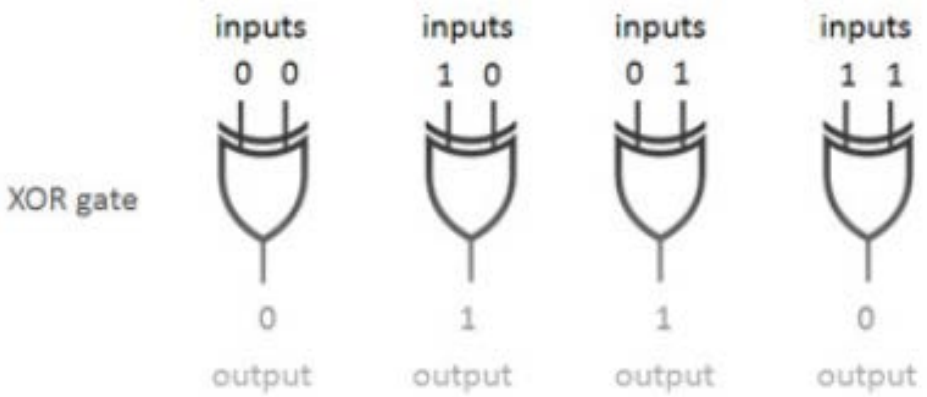
Source: https://study.com/academy/lesson/arithmetic-logic-unit-alu-definition-design-function.html#:~:text=An%20arithmetic%20logic%20unit%20(ALU)%20is%20a%20digital%20circuit%20used,(CPU)%20of%20a%20computer.&text=Most%20of%20the%20operations%20of,load%20data%20from%20input%20registers

Logic Operations at Bit Level- OR & XOR

OR operator uses two inputs; the output bit is 1 if either the first or the second input is a 1 (the output bit is 0 if both inputs are 0)

XOR operator uses two inputs; the output bit is 0 if both the inputs are 0 or if both are 1 (otherwise, the result is a 1)





Source: https://study.com/academy/lesson/arithmetic-logic-unit-alu-definition-design-function.html#:~:text=An%20arithmetic%20logic%20unit%20(ALU)%20is%20a%20digital%20circuit%20used,(CPU)%20of%20a%20computer.&text=Most%20of%20the%20operations%20of,load%20data%20from%20input%20registers

Storage

- A storage medium is the physical material on which a computer stores data, information, programs, and applications
- Cloud storage keeps information on servers on the Internet, and the actual media on which the files are kept are transparent to the user

Internal hard drive for a laptop

Photo by Vincent Botta on Unsplash

USB flash drive

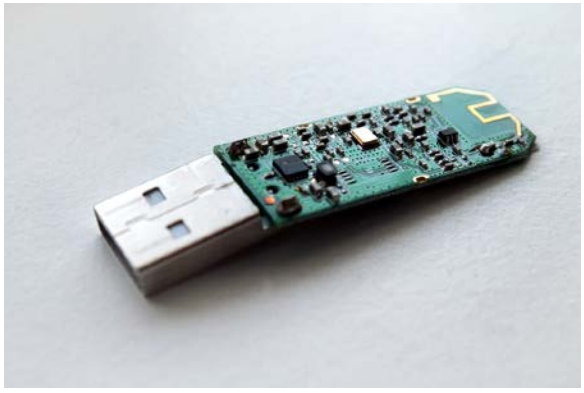


Image by FlitsArt from Pixabay

Memory cards

Image by Photo Mix from Pixabay

External hard drive

Photo by：Jessica Lewis，from：Pexels

Types of Memory

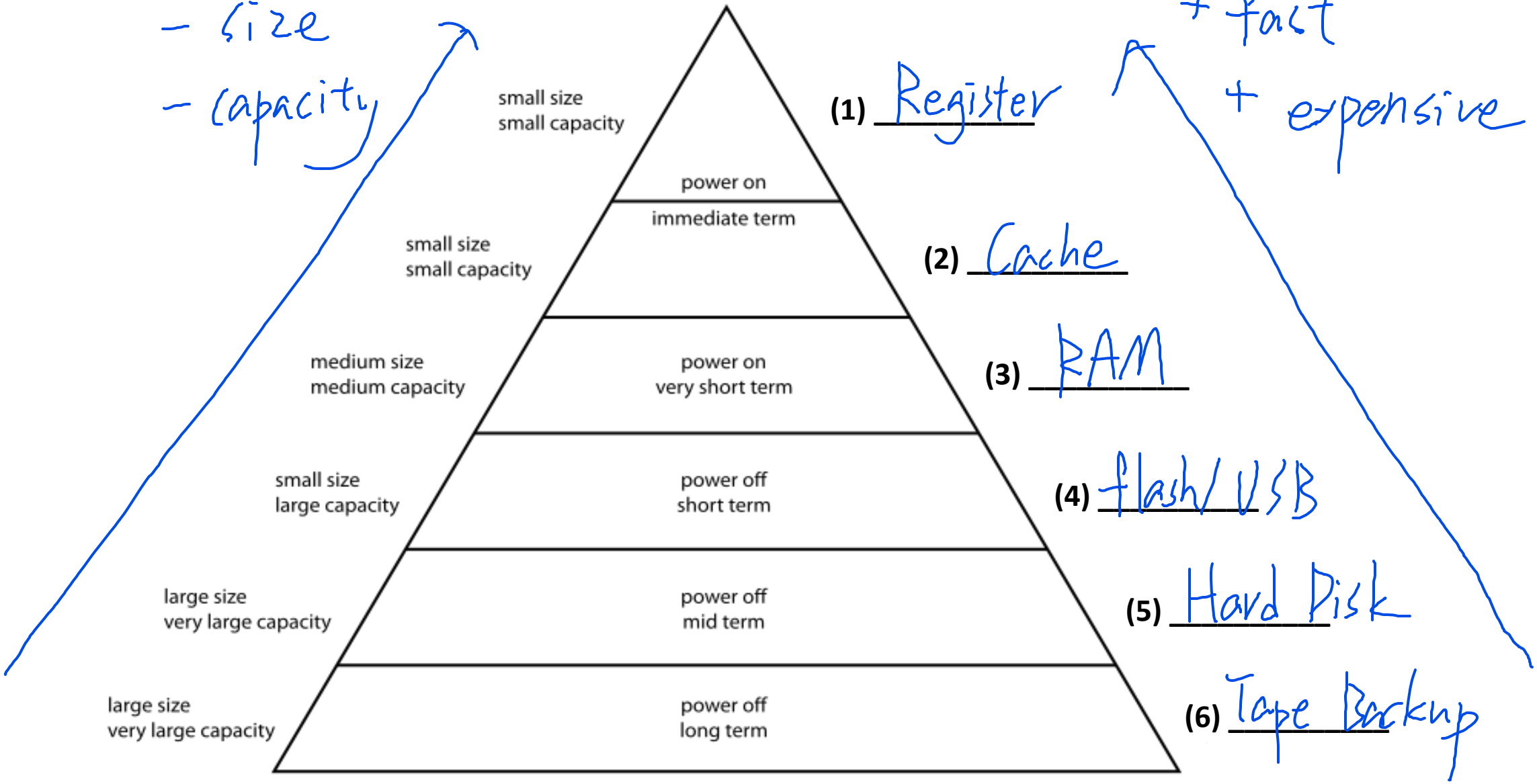
RAM (random access memory)

- Contents of RAM are lost when power is off (volatile)
- Temporarily store data required by the operating system and applications
- When the application is launched, the instructions of the application are transferred from the hard drive to the RAM

ROM (read-only memory)

- Contents of ROM are NOT lost when power is removed (nonvolatile)
- The ROM chip contains the BIOS (instructions to start a computer)
  - Power-on self test: Test whether all computer components are ready
- ROM provides means to communicate b/t operating system and hardware devices
  - Firmware: low-level control for a device's specific hardware
  - Updated firmware version allows you to fine-tune the communication with other devices
    - Programmable ROM is used in smartphones and other mobile devices

Computer Memory Hierarchy



Virtual Memory

Running more applications at the same time will require more RAM

- Exchange the content b/t RAM and hard drive
- **Virtual memory** is a *part of a storage medium that acts as additional RAM*
- The area of the hard drive used for virtual memory is called a swap file
  - **Swap** (exchange) data b/t memory and storage
- Page is the **amount of data** that can be exchanged at a given time
  - Swapping items b/t memory and storage is called paging
- Thrashing operating system spends lots of time paging instead of executing the application

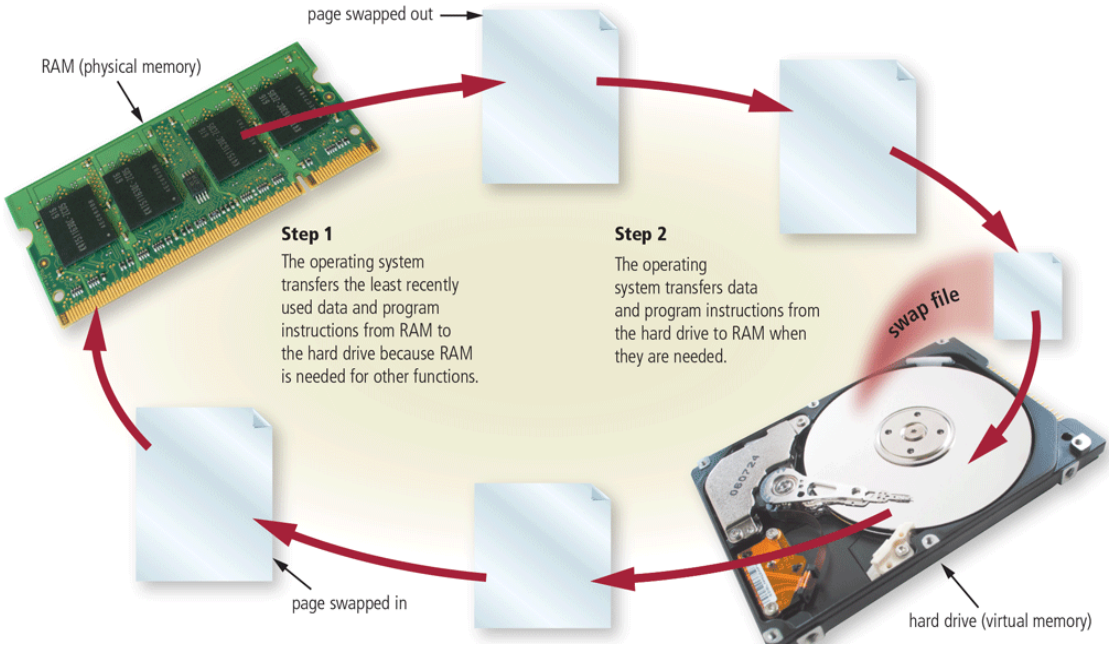
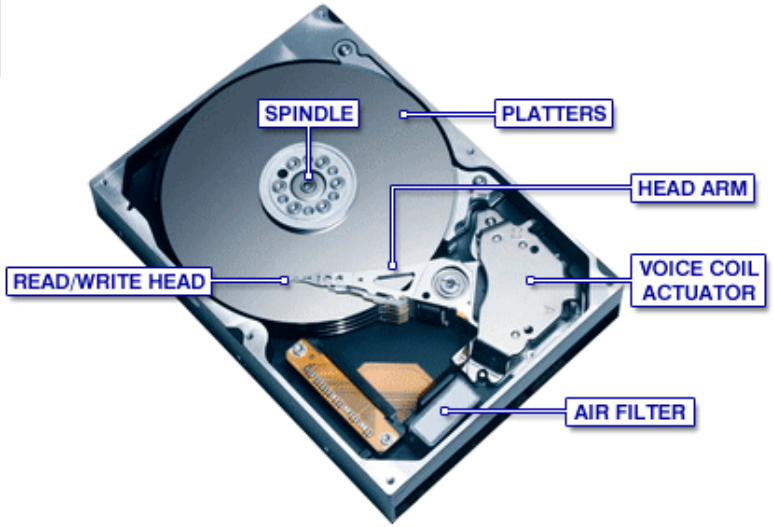


Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

Characteristics of Hard Disk

- Before reading from or writing on a hard disk, the disk must be formatted
  - Formatting: the process that dividing the disk into tracks and sectors
- **Track** is a narrow recording band that forms a full circle on the surface of a disk
  - **Cylinder**: tracks that line up on each platter from top to bottom and can be read at the same time
- Breaking the tracks into small arcs called sector
  - A sector stores up to 512 bytes of data
  - Several sectors (n>1) form a **cluster**
- When a computer is running, the platters in the HD rotate at high speed; this rotational speed is called **revolutions per minute** (RPM)
  - 5400 rpm to 15000 rpm



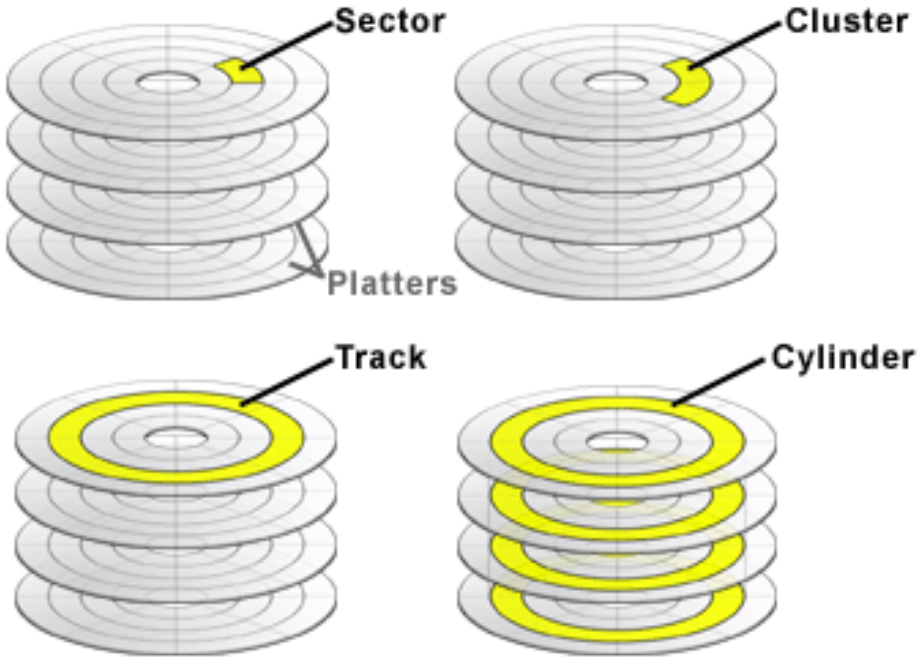


Photo credit: https://goo.gl/images/3vyj6n
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Solid State Drive (SSD)

SSD (**solid state drive**) is a flash memory storage device that contains its own processor to manage its storage

- An SSD has several advantages over traditional (magnetic) hard disks:
  - Faster access times
  - Faster transfer rates
  - Quieter operation
  - More durable
  - Lighter weight
  - Less power consumption
  - Less heat generation
  - Longer life
  - Defragmentation not required

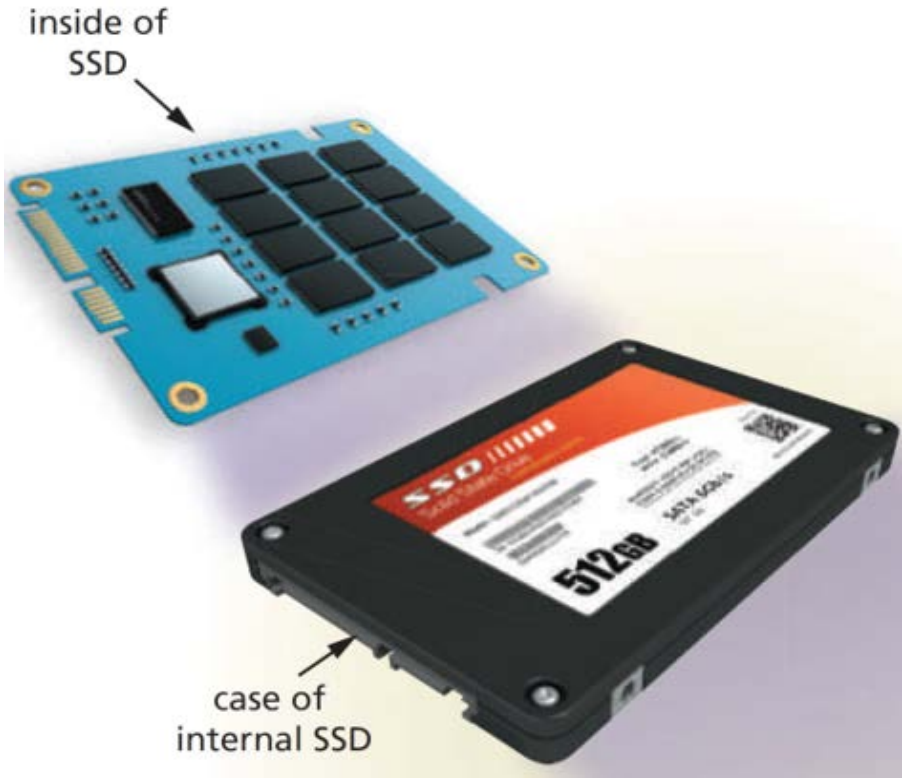

Image credit: Discovering Computers 2018: Digital Technology, Data, and Devices

Cloud Storage

Cloud storage : An Internet service that provides storage to computer or mobile device users

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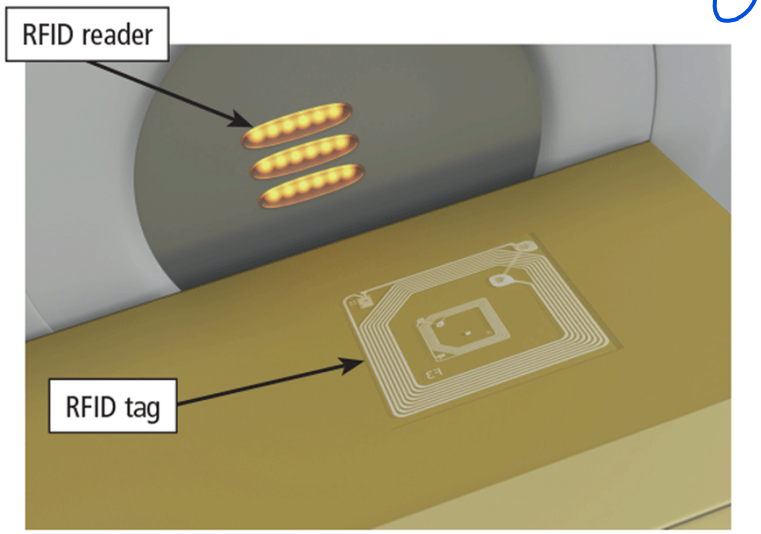
RFID 單向. 遠距

- **RFID tag** : consists of an antenna and a memory chip that contains the information to be transmitted via radio waves
- RFID reader reads radio signals and transmits the information to a computer or computing device

eg eTag



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NFC

雙向

receiver sender

An NFC-enabled device contains an NFC chip

- An NFC tag contains a chip and an antenna that contains information to be transmitted

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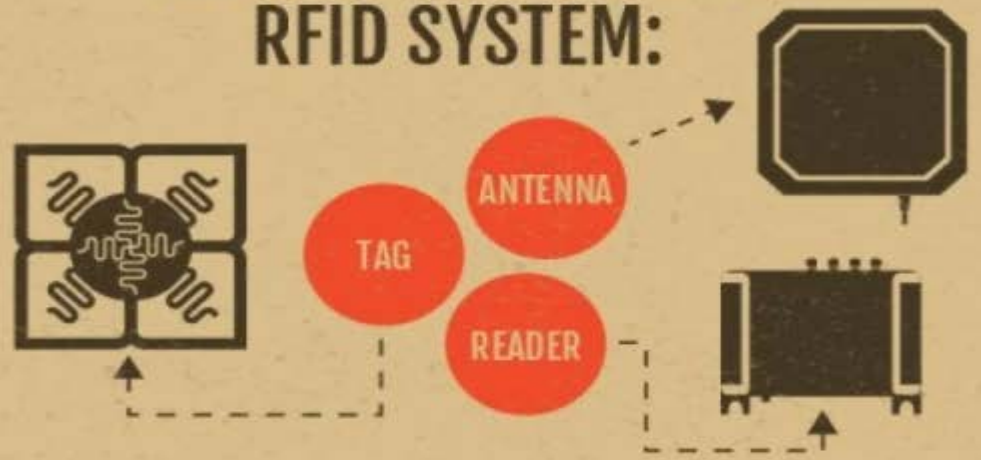
WHAT'S THE DIFFERENCE BETWEEN ... RFID & NFC?

RADIO FREQUENCY IDENTIFICATION

NEAR FIELD COMMUNICATION

3 PARTS OF A TYPICAL RFID SYSTEM:



- Operate at the same frequency (13.56 MHz) as HF RFID readers and tags
- May act as both a reader and a tag
- Devices must be in close proximity due to the short read range limitations of its radio frequency (usually no more than a few centimeters)

Operating System

Graphical User Interface (GUI)

Command Line

```
C:\Windows>dir
 磁碟區 C 中的磁碟沒有標籤。
 磁碟區序號:  E032-1298

 C:\Windows 的目錄

2020/10/14  上午 03:14    <DIR>          .
2020/10/14  上午 03:14    <DIR>          ..
2018/04/12  上午 07:38    <DIR>          addins
2018/10/17  下午 07:19    <DIR>          appcompat
2020/07/07  下午 02:53    <DIR>          apppatch
2020/10/14  上午 03:15    <DIR>          AppReadiness
2020/10/15  上午 03:17    <DIR>          assembly
2020/10/14  上午 03:14    <DIR>          bcastdvr
2020/09/30  下午 04:59            67,072 bfsvc.exe
2018/04/12  上午 07:38    <DIR>          Boot
2018/04/12  上午 07:38    <DIR>          Branding
2020/10/14  上午 02:50    <DIR>          CbsTemp
2019/08/29  下午 05:32             2,052 comsetup.log
2018/10/09  下午 05:08    <DIR>          Containers
2018/10/09  下午 04:13    <DIR>          CSC
2018/04/12  上午 07:38    <DIR>          Cursors
2018/10/09  下午 04:32    <DIR>          debug
2019/08/29  下午 04:34            17,148 diagerr.xml
2018/04/12  上午 07:38    <DIR>          diagnostics
2019/08/29  下午 04:34            17,148 diagwrn.xml
2018/04/12  下午 11:52    <DIR>          DigitalLocker
2020/04/06  下午 02:55    <DIR>          Downloaded Installations
2019/08/29  下午 04:34             2,139 DtcInstall.log
2018/04/12  上午 07:33            36,540 Education.xml
2018/10/26  下午 06:11    <DIR>          en-US
2018/04/12  上午 07:33            36,580 Enterprise.xml
```

What is OS?

Operating system (OS) : A program which manages the complete operation of your computer or mobile device and let you interact with it

- a general manager supervises the activities of each component in the system
- a program (or a set of programs) that helps to execute other programs
- Interface between computer computer and user
- Coordinate tasks and configure devices
- Monitor performance and provide file management

Goals : Easy to use resources and efficient to use hardware

Bootstrap process

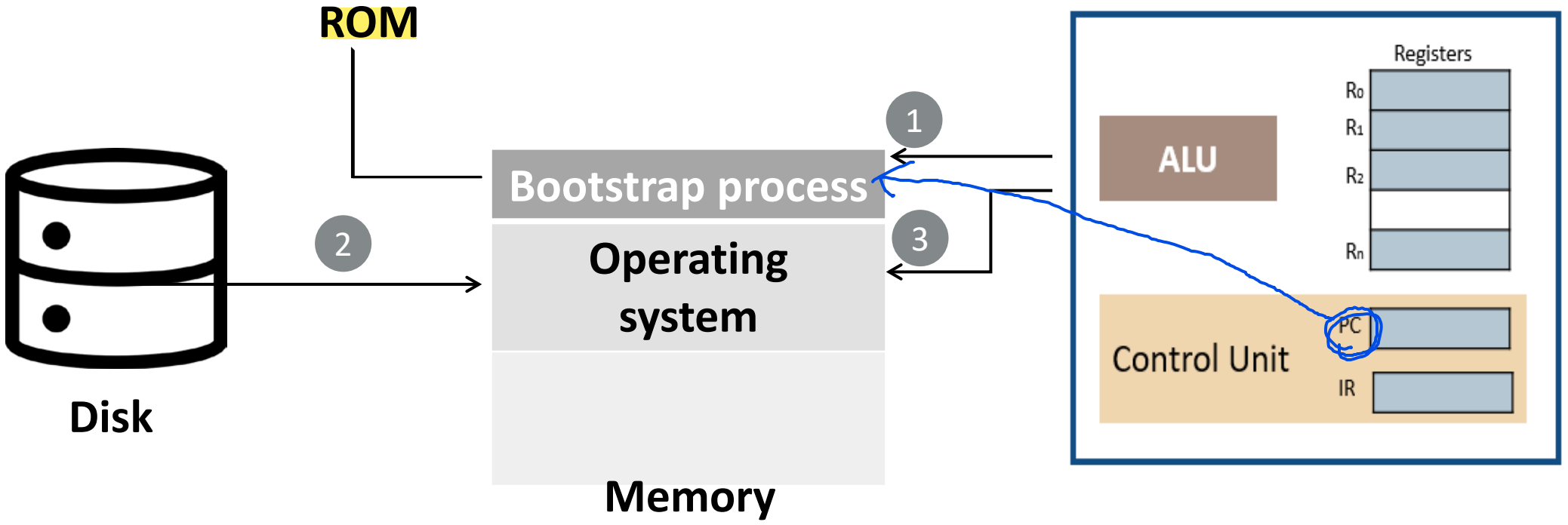
The OS itself needs to be loaded into the memory and run to load other programs into memory for execution

ROM holds a small program called the bootstrap program

- When the computer is turned on, the CPU counter is set to the first instruction of this bootstrap program and executes the instructions in this program
- Once finished, the program counter is set to the first instruction of the operating system in RAM

Bootstrap Process

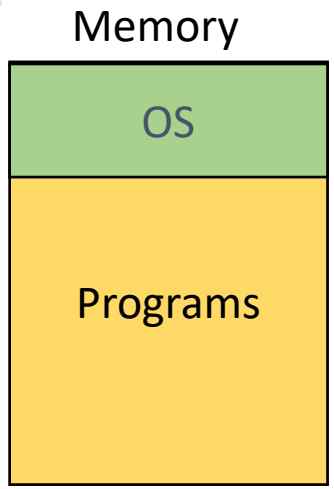
1. Bootstrap program runs
2. Operating system is loaded
3. Operating system runs



Memory Management

Monoprogramming (belongs to the past)

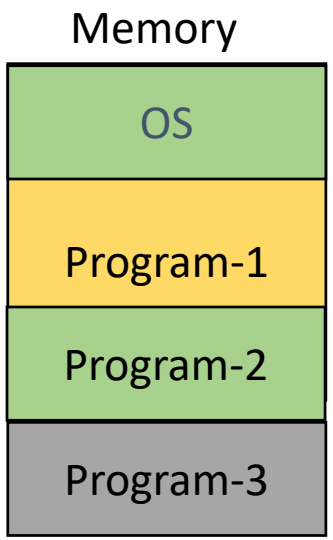
- Memory capacity is dedicated to a single program
  - Only little part is needed to hold the operating system
- When one program is running, no other program be executed
  - Speed: CPU >> Input & Output
  - CPU is idle when receiving data from or sending data to devices
- If size of program > size of memory: cannot be run



Multiprogramming (current approach)

Multiple programs are stored in memory and executed concurrently

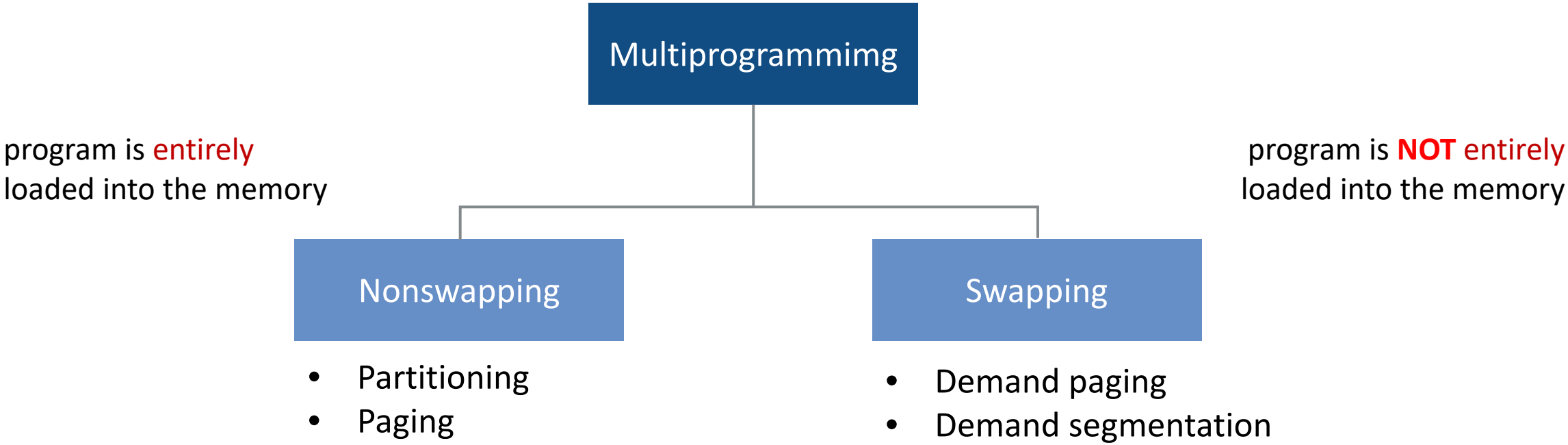
- CPU switch rapidly between programs



Memory Management- Multiprogramming

Nonswapping: program keeps in memory for the duration of execution

Swapping: programs can be swapped between memory and disk



Nonswapping- Partitioning

Memory is divided into variable-length sections

- Each partition holds one program
- CPU switches between programs
  - Execute instructions of the program, until an I/O operation is encountered or the time allocated for the program expires
- Each program is entirely loaded into the memory, requiring **contiguous** locations
  - Small partition size: programs cannot be loaded into memory
  - Large partition size: holes (unused locations) in memory
    - Memory manager can compact the partitions to remove holes and create new partitions, but it takes extra costs

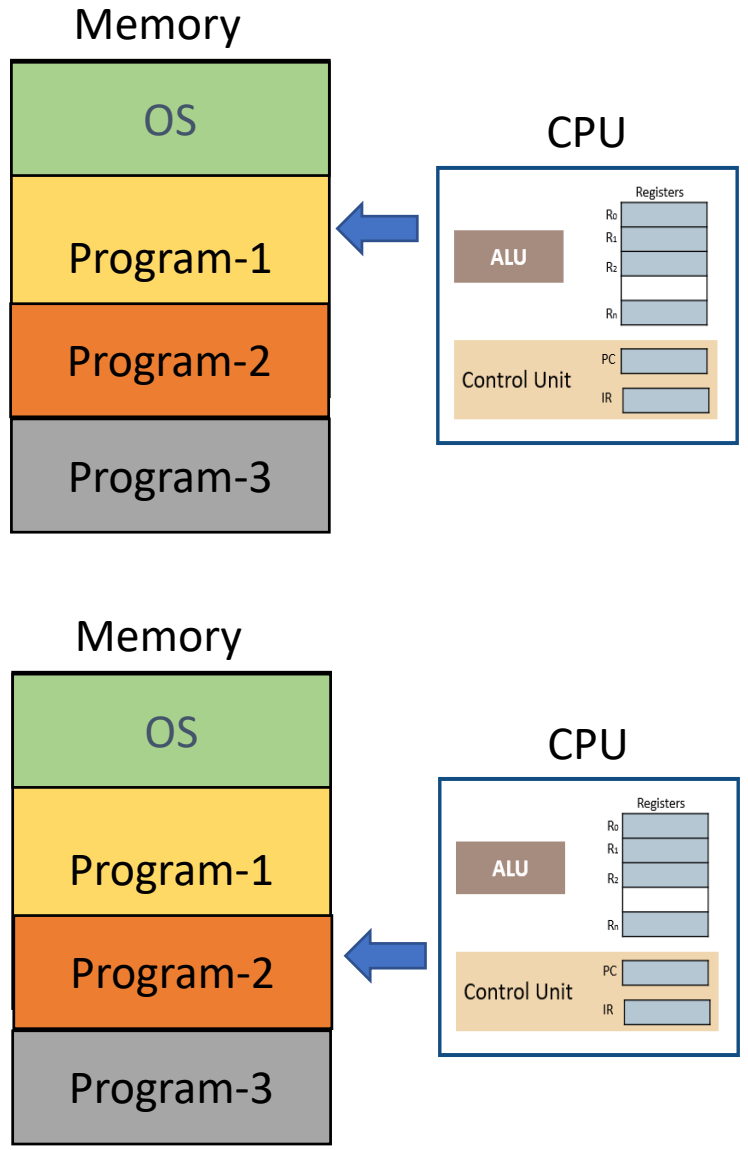


Image credit: Foundations Of Computer Science 4th edition, Behrouz Forouzan, (ISBN:1473751047)

Nonswapping- Paging

Programs are divided into equally sized sections: pages

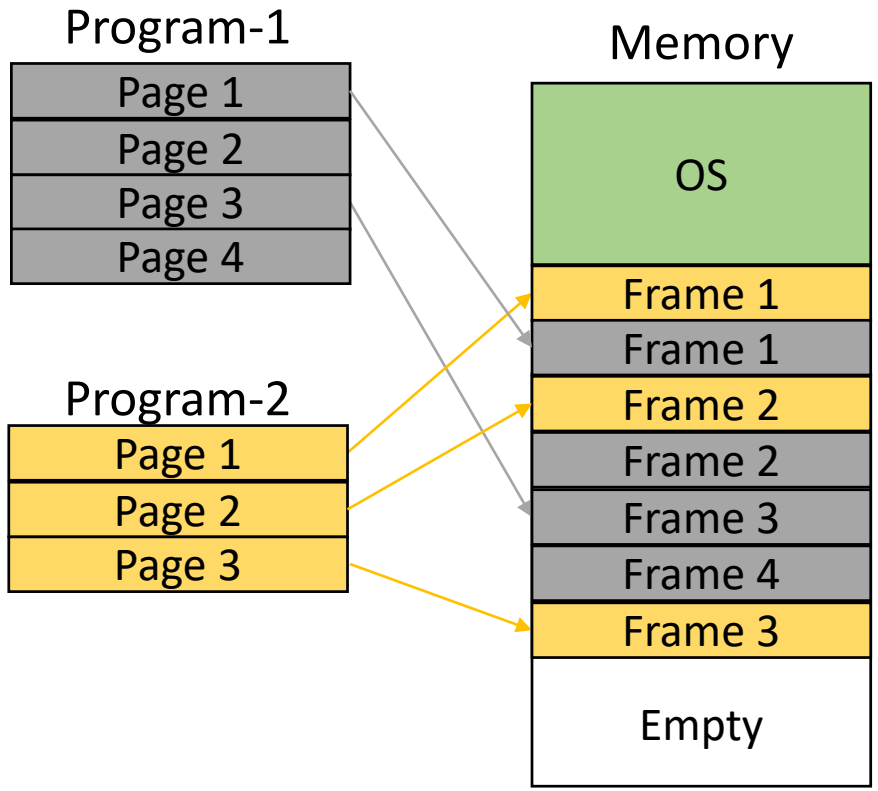
Memory is divided into equally sized sections: frames

- The size of a page/frame is the same and equal to the size of the block used by the system

Programs do not have to be contiguous in memory

- Two consecutive pages can occupy **noncontiguous** frames in memory

Paging can improve efficiency, but the entire program needs to be loaded into memory before execution

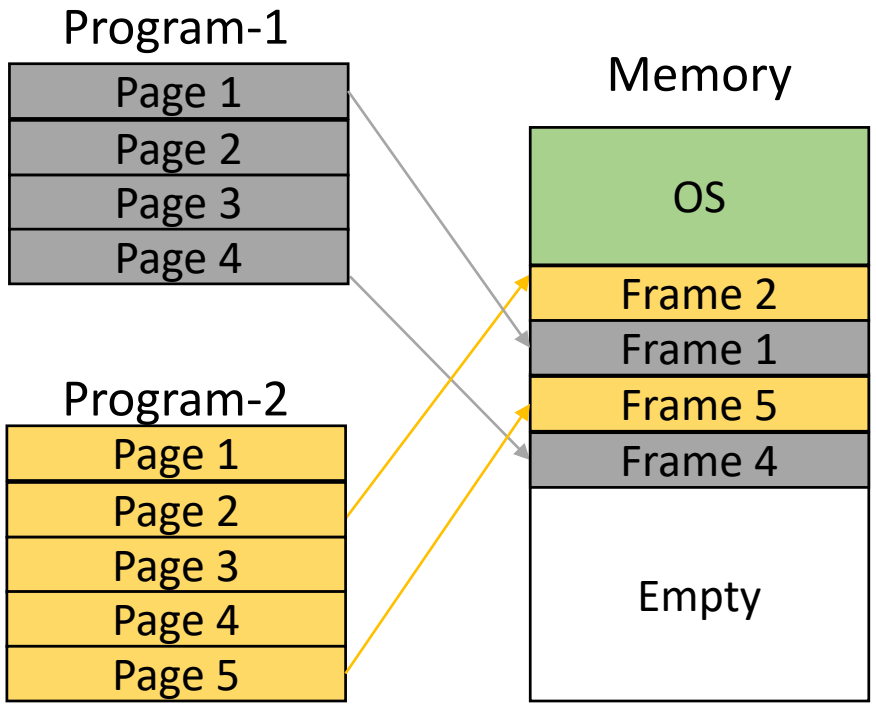


Swapping- Demand Paging

A program is divided into pages, and these pages can be loaded into memory one by one (not entirely), and can be executed and replaced by another page

Memory can hold pages from multiple programs at the same time

- Pages can be loaded into any free frame

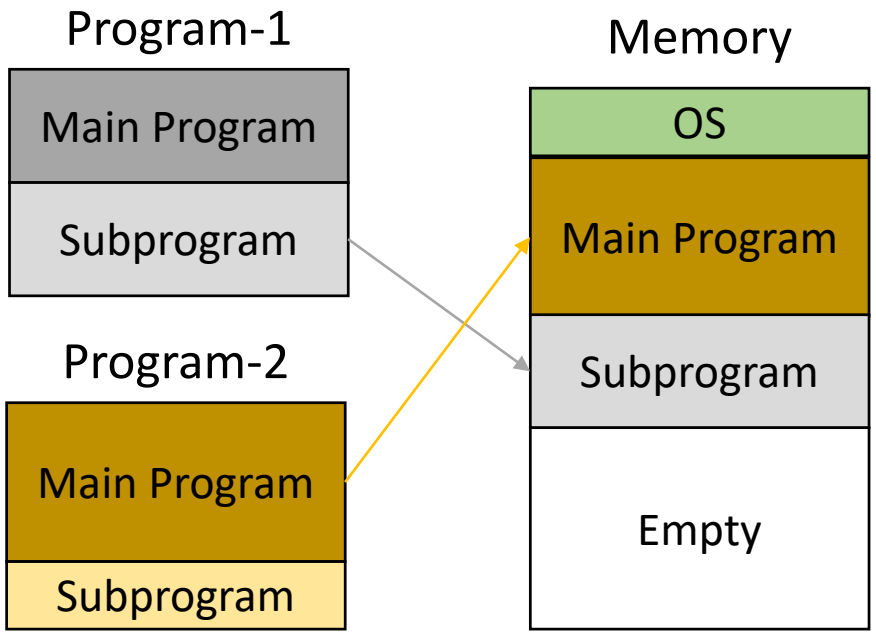


Swapping- Demand Segmentation

A program is usually made up of a main program and subprograms

A program is divided into multiple segments, and the segments are loaded into memory, executed and replaced by another module in the same or different program

- While segments in memory are of equal size, part of a segment may remain empty




```
Main() {
  …
  …}

Add() {
  …}

Times() {
  … }
```

OS uses three terms that refer to a set of instructions

Program: a nonactive set of instructions stored on disk

- A program may or may not become a job

Job: a program becomes a job when it is selected for execution until it has finished and becomes a program again

- A job may or may not be executed
  - Located on disk waiting to be loaded to memory; loaded into memory waiting for execution by CPU; on disk or in memory waiting for input/output events
- When finished executing, a job becomes a program again
- Every job is a program, but not every program is a job

Process: a program in execution (has started but has not finished)

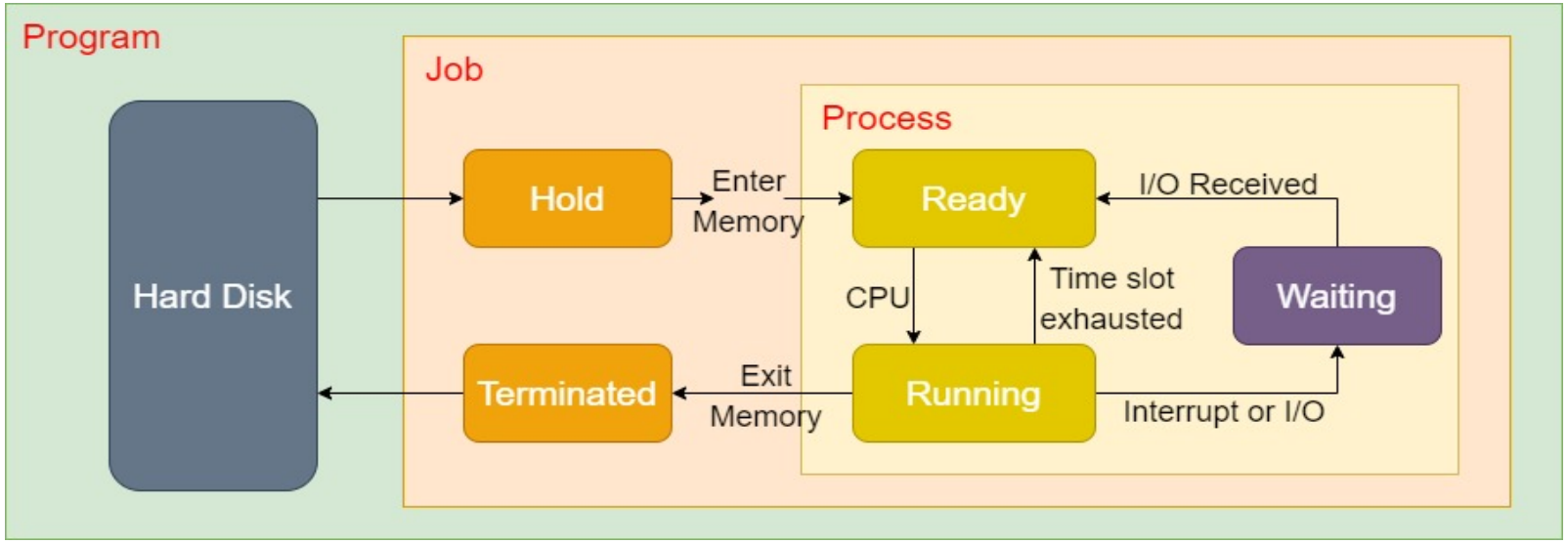
- As long as a job is in memory, it is a process (executing or waiting for CPU time)
- Selected among other waiting jobs and loaded into memory
- Every process is a job, but not every job is a process

Process Manager

1. Program becomes Job when selected by OS and bring to Hold state
2. Once being loaded to memory, the Job moves to Ready state and becomes Process
3. When the CPU can execute the Job, it moves to Running state

In Running state, three things can happen:

- Process execution until I/O are needed→ move to Waiting state until I/O is finished
- Process exhausts its allocated time slot → move to Ready state
- Process terminates → move to Terminated state
- Process can move b/t the Running, Waiting and Ready states many times



Schedulers

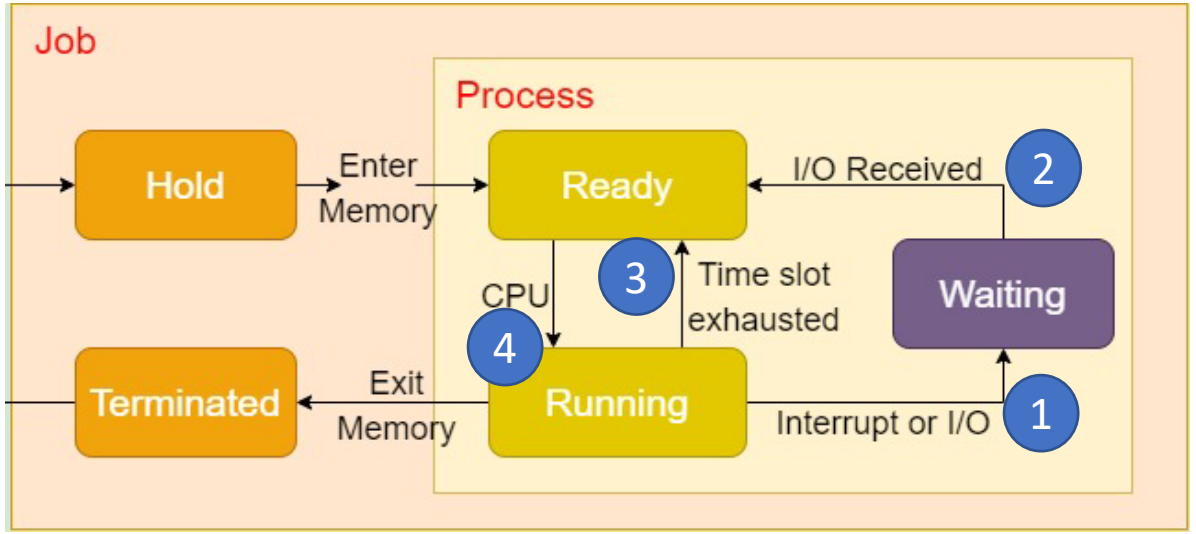
Move a Job or Process from one state to another

Job scheduler

- Create Process from Job: move Job from Hold to Ready state
- Terminate a process: move Job from Running to Terminated state

Process scheduler

1. Move a process from Running to Waiting state
   - When the process is waiting for some (I/O) events
2. Move a process from Waiting to Ready state
   - When the event is satisfied
3. Move a process from Running to Ready state
   - When the process' time allotment has expired
4. Move a process from Ready to Running state
   - When the CPU is ready to run the process



Queuing

Process manager uses queues (waiting lists) to store information

- A block of memory that stores information about jobs or processes
- Process manager stores the job or process control block instead of the job or the process itself (representing the job or process that is waiting) in the queue

An OS can have several queues

- Job queue: hold jobs that are waiting for memory
- Ready queue: hold processes (in memory, ready to be run, waiting for CPU)
- I/O queue: hold processes waiting for I/O device(s)

How to select the next job

- FIFO (first in first out)
- LIFO (last in first out)
- Shortest length first
- Highest priority first

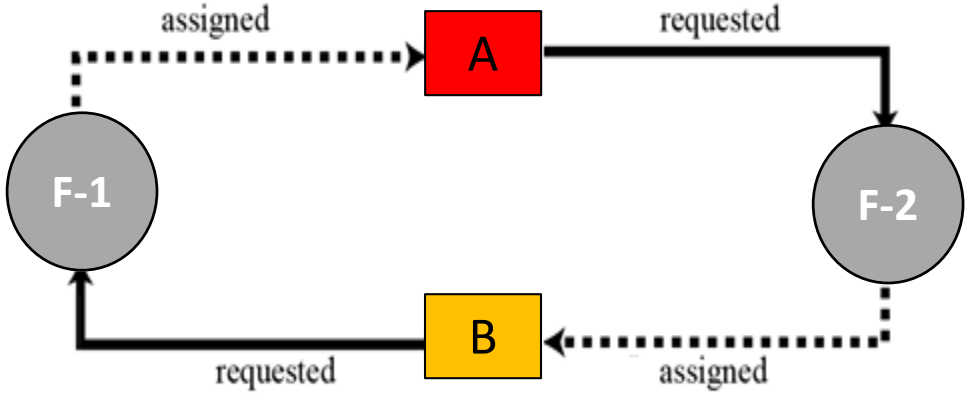
Deadlock

Deadlock occurs when the OS fails to put resource restrictions on processes

- If the OS allows the process to start running without first checking whether the required resources are ready
  - To avoid: cannot start running until the required resources are free
- If the OS allows the process to reserve resources as needed without restrictions
  - To avoid: limit the time a process can hold a resource

When resources are accessed by multiple users

- File-1 is assigned to process-A and cannot release until it acquires File-2
- File-2 is assigned to process-B and cannot release until it acquires File-1



Starvation

Starvation is the opposite of deadlock

- When OS puts too many resource restrictions on a process

Process-A needs file-1 & file-2

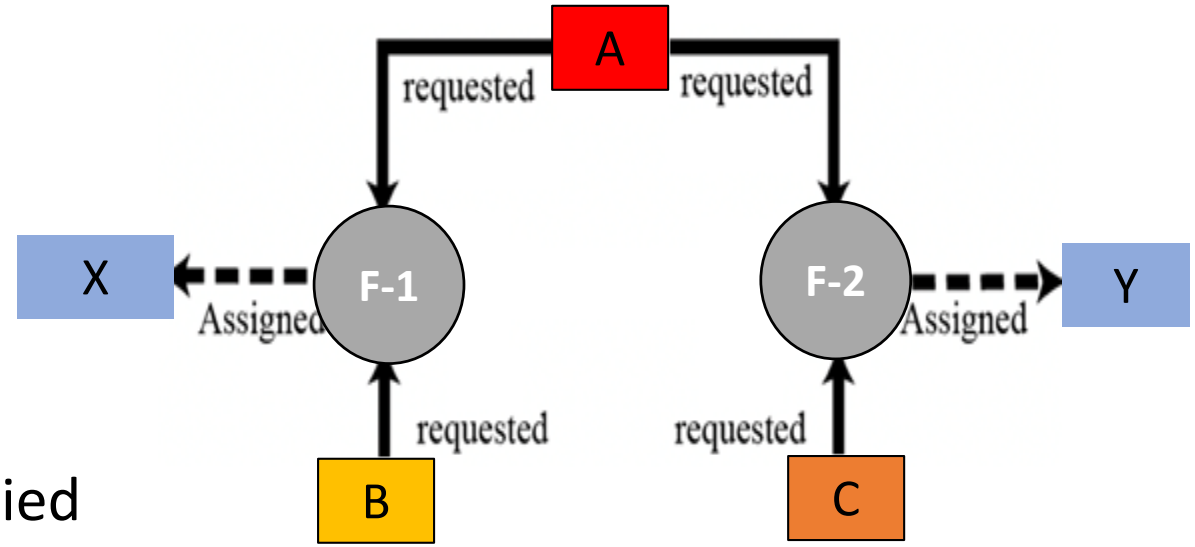
File-1 is being used by process-X

File-2 is being used by process-Y

Process-X terminates and release File-1

- Process-A cannot start as File-2 is still occupied

Process-Y needs only File-1 and is allowed to run



Components of OS

Shell is a user interface for access to an OS's services

介面

- User give shell a command
- Command-line interface or graphical user interface
- OS can have several different shells

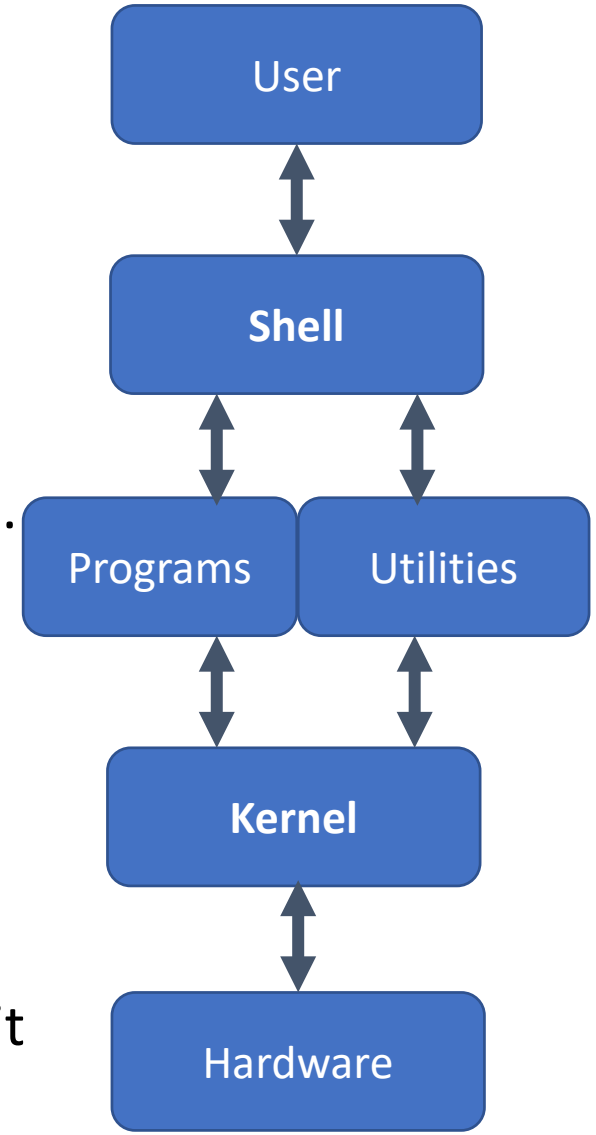
Utilities provide a support process for users

- Common utilities: text editors, search programs, sort programs, etc.

Kernel is the heart of an OS with complete control over everything in the system

跟硬體溝通

- Contain the most basic parts of OS
  - Memory management, process management, device/file management
- Other components of the system call on the kernel to perform services
- If the command requires an application, the shell requests kernel to run it



Arithmetic operations

All arithmetic operations such as addition, subtraction, multiplication, and division can be applied to integers

A + B

A − B → A + ($\overline{B}$ + 1)

5 – 3 → 5 + (-3)

(a) 3: 0011

(b) Transfer to two's complement: 1100 → 1101

(c) 5: 0101

-3: 1101

2: 0010

Example A+B

A=17, B=22; A+B= ?

A = $(00010001)_2$ **B = $(00010110)_2$**

	0	0	0	1	0	0	0	1	A
+	0	0	0	1	0	1	1	0	B
	0	0	1	0	0	1	1	1	

Example A+(-B)

A=24, B=-17; A+(-B)= ?

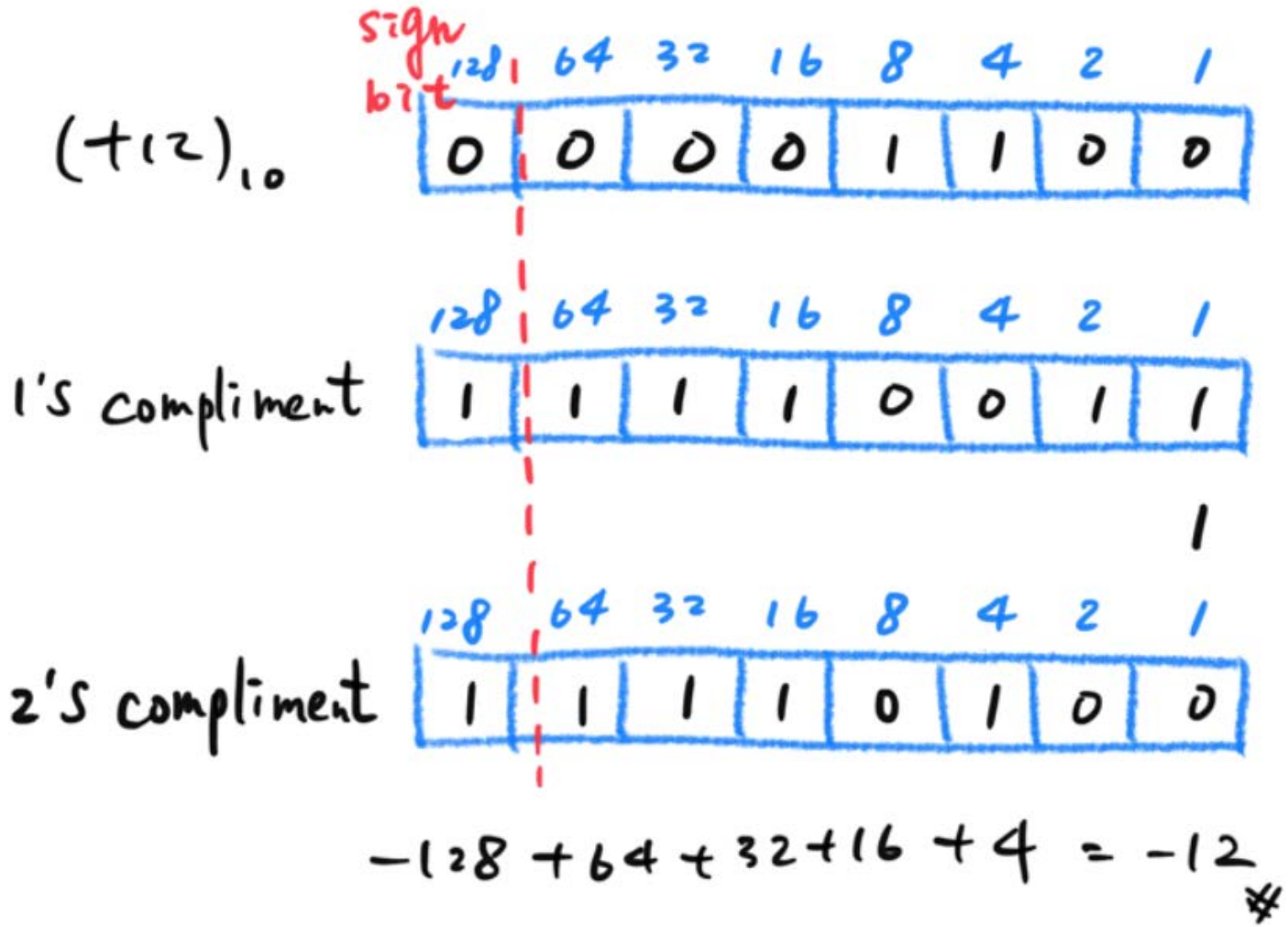
A = $(00011000)_2$ **B = $(11101111)_2$**

17= $(00010001)_2$

	0	0	0	1	1	0	0	0	A
+	1	1	1	0	1	1	1	1	B
	0	0	0	0	0	1	1	1	

2's complement

$(-12)_{10}$: ?



12 - 7

$(12)_{10}$ 0 0 0 0 1 1 0 0

$-(7)_{10}$ $-$ 0 0 0 0 0 1 1 1

$(5)_{10}$ 0 0 0 0 0 1 0 1

(+7) 0 0 0 0 0 1 1 1

↓

(-7) 1 1 1 1 1 0 0 1

$-128+64+32+16+8+1=-7$

$(12)_{10}$ 0 0 0 0 1 1 0 0

$+(-7)_{10}$ $+$ 1 1 1 1 1 0 0 1

$(5)_{10}$ (1) 0 0 0 0 0 1 0 1

ignore overflow value

7 - 12

8 4 2 1

$(7)_{10}$ 0 0 0 0 0 1 1 1

$-(12)_{10}$ $-$ 0 0 0 0 1 1 0 0

$(-5)_{10}$ (1) 0 1 1

$-8+2+1=-5$

$(12)_{10}$ 0 0 0 0 1 1 0 0

↓

1 1 1 1 0 0 1 1

+1

$(-12)_{10}$ 1 1 1 1 0 1 0 0

128 64 32 16 8 4 2 1

$(7)_{10}$ 0 0 0 0 0 1 1 1

$+(-12)_{10}$ $+$ 1 1 1 1 0 1 0 0

$(-5)_{10}$ 1 1 1 1 1 0 1 1

$-128+64+32+16+8+2+1=-5$

Eight-bit two's complement

Binary value	Two's complement interpretation	Unsigned interpretation
00000000	0	0
00000001	1	1
⋮	⋮	⋮
01111110	126	126
01111111	127	127
10000000	−128	128
10000001	−127	129
10000010	−126	130
⋮	⋮	⋮
11111110	−2	254
11111111	−1	255

https://en.wikipedia.org/wiki/Signed_number_representations

Software

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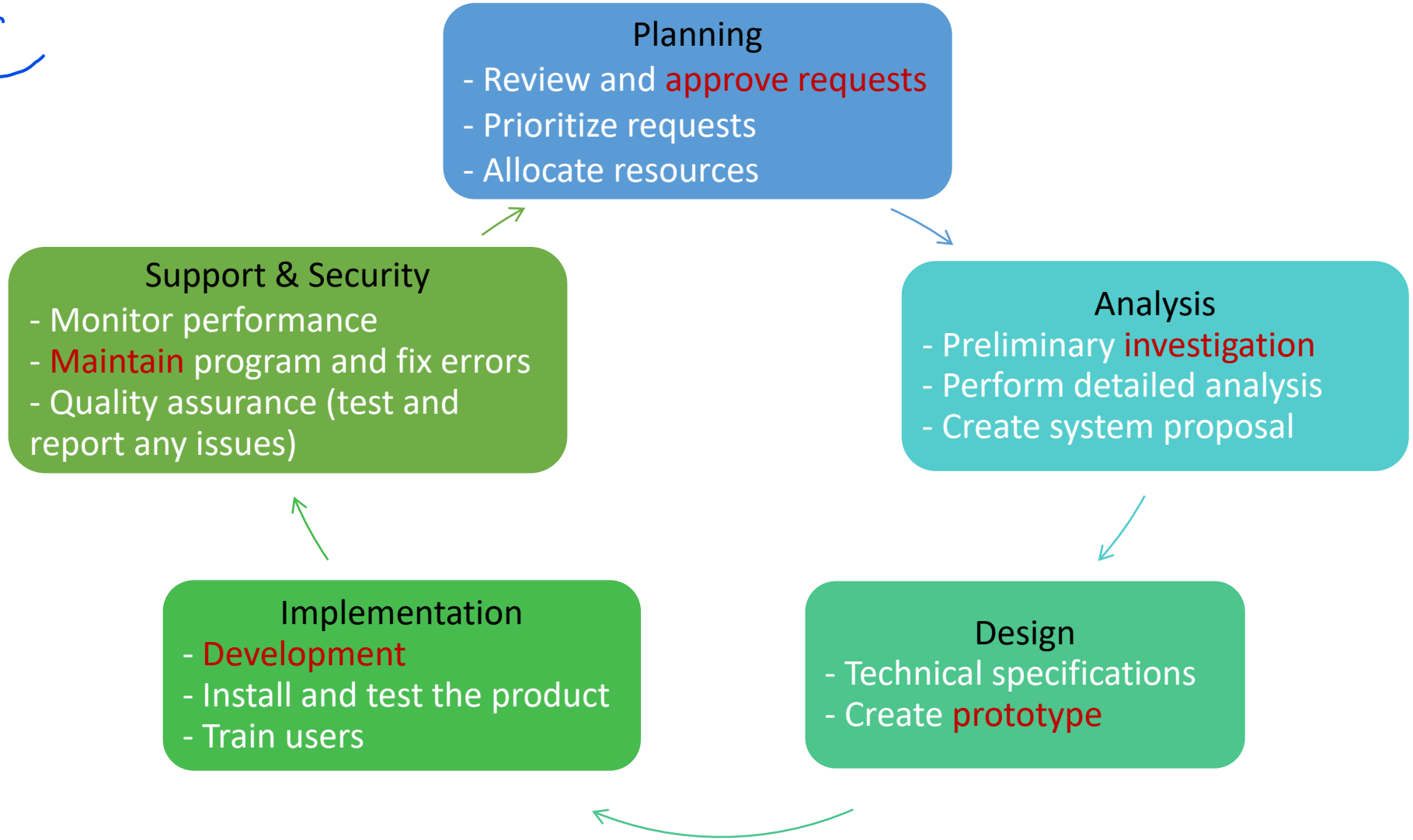
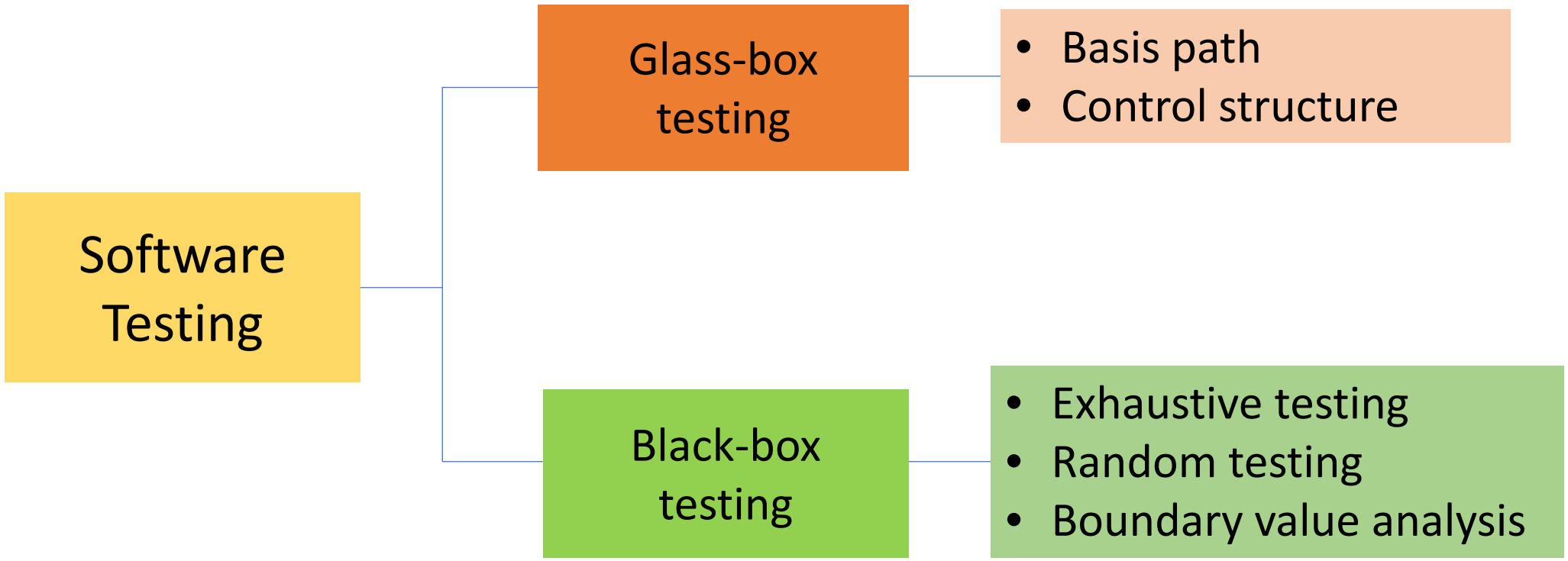
Software Development Life Cycle (SLDC)

SLDC produces the fastest, least expensive, and highest quality products



Testing Phase

Develop and test the product, and convert it to the new system

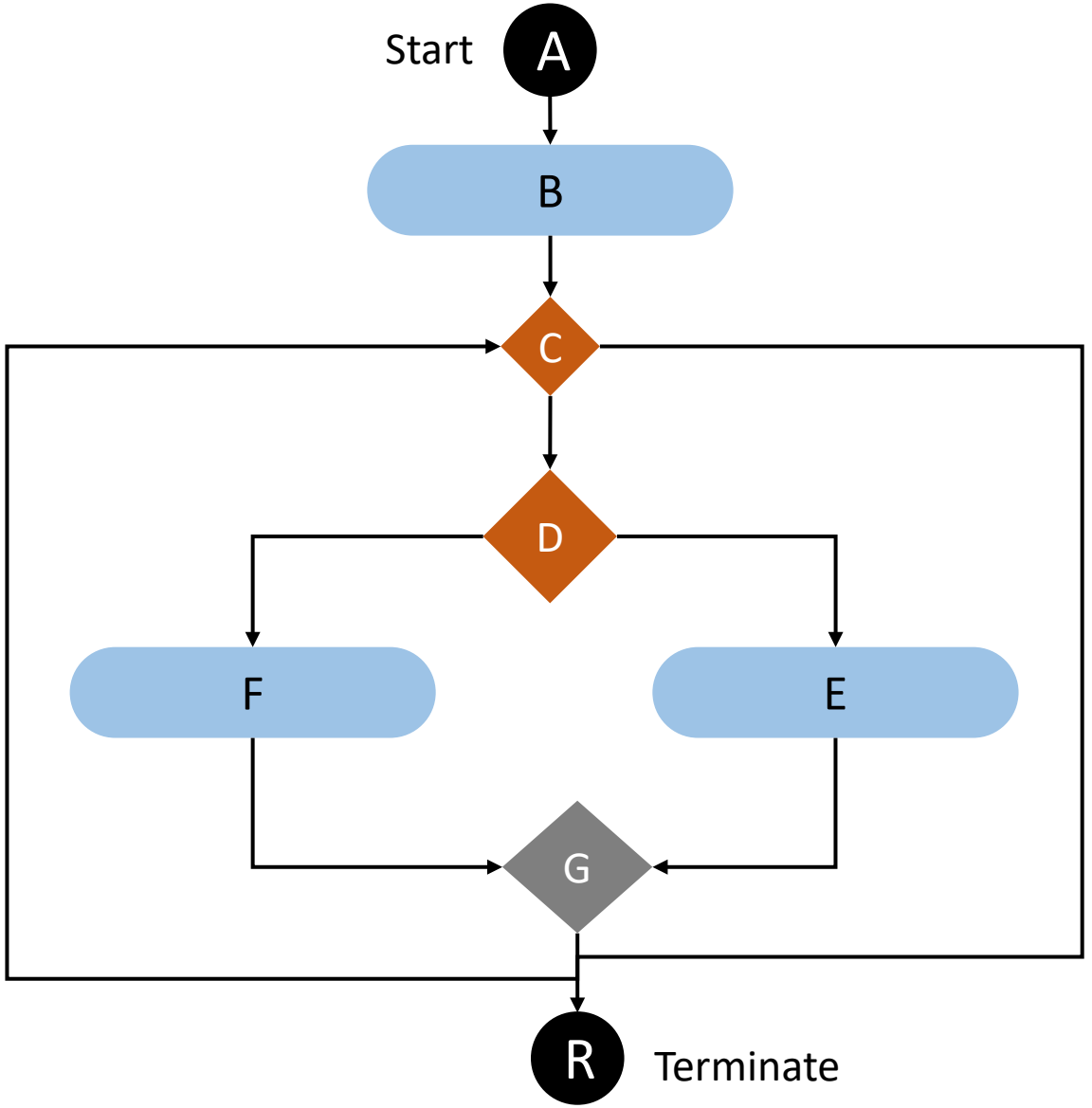


Glass-box testing (white-box testing)

- Goal: determine whether all components of the software work according to their design purpose
- Assumes that the tester knows everything about the software
  - Software is like a glass box in which everything inside the box is visible
  - Testing is done by the software engineer
- All independent paths in each module are tested at least once
- All the decision constructs (two-way and multiway) are tested on each branch
- Every loop construct is tested
- All data structures are tested

Basis Path Testing

- Create a set of test cases that each statement in the software is executed at least once



Independent paths:
Path-1: (A, B, C, R)
Path-2: (A, B, C, D, E, G, R)
Path-3: (A, B, C, D, F, G, R)

Control Structure Testing

- More comprehensive than basis path testing
- Use different types of tests
- Condition testing
  - Apply any condition expression in the module
  - Simple condition vs. Compound condition
- Loop testing
  - All types of loops (while, do, for)

Black Box Testing

- Test without knowing the internal functions of the software and how the software works
- Test the functionality of the software
  - Functions that the software should complete (e.g., input and output)

Predictive Development

Waterfall model takes each step separately and completes it before continuing to the next stage

- Pro: each stage knows exactly what to do because they have the complete results of the previous phases
- Con: difficult to locate a problem, the entire process must be checked

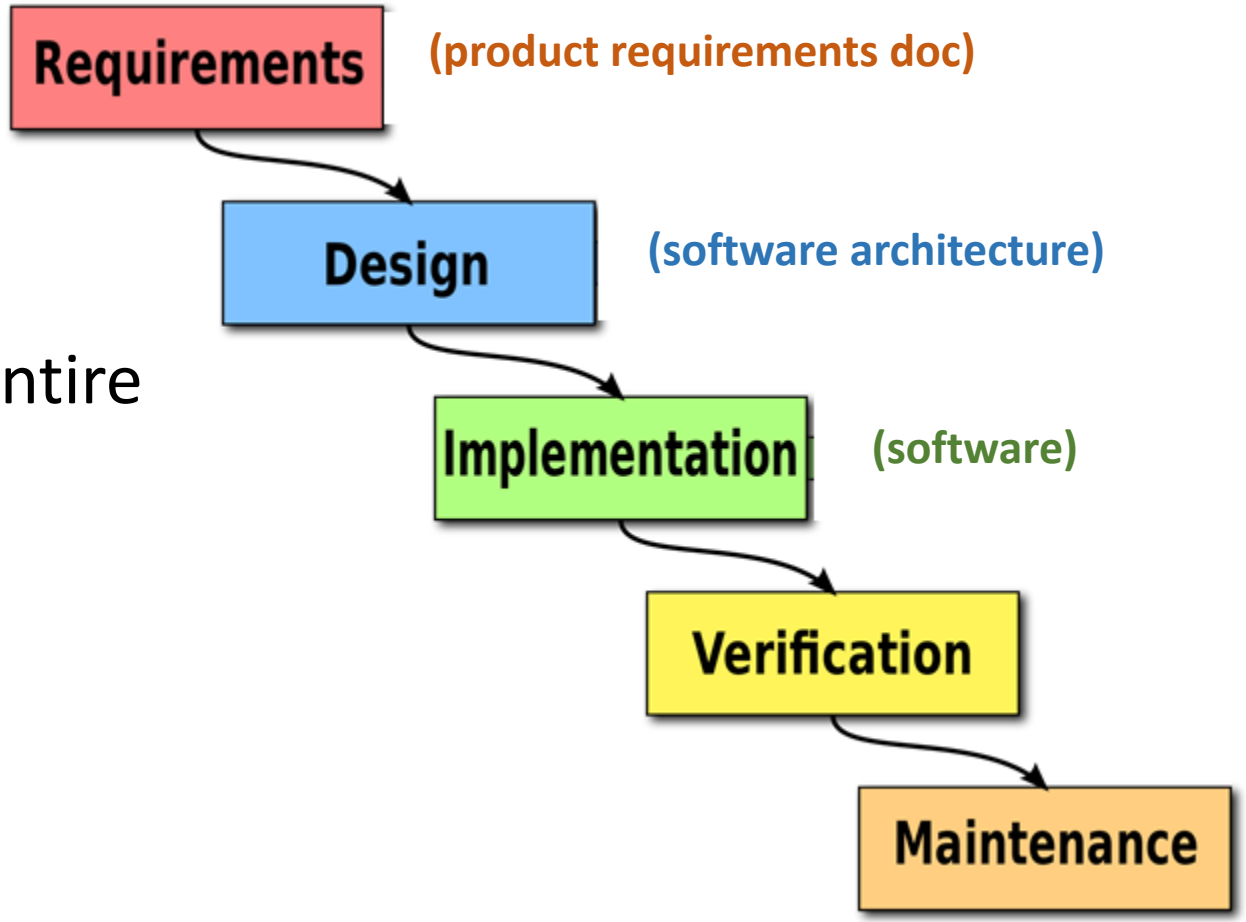


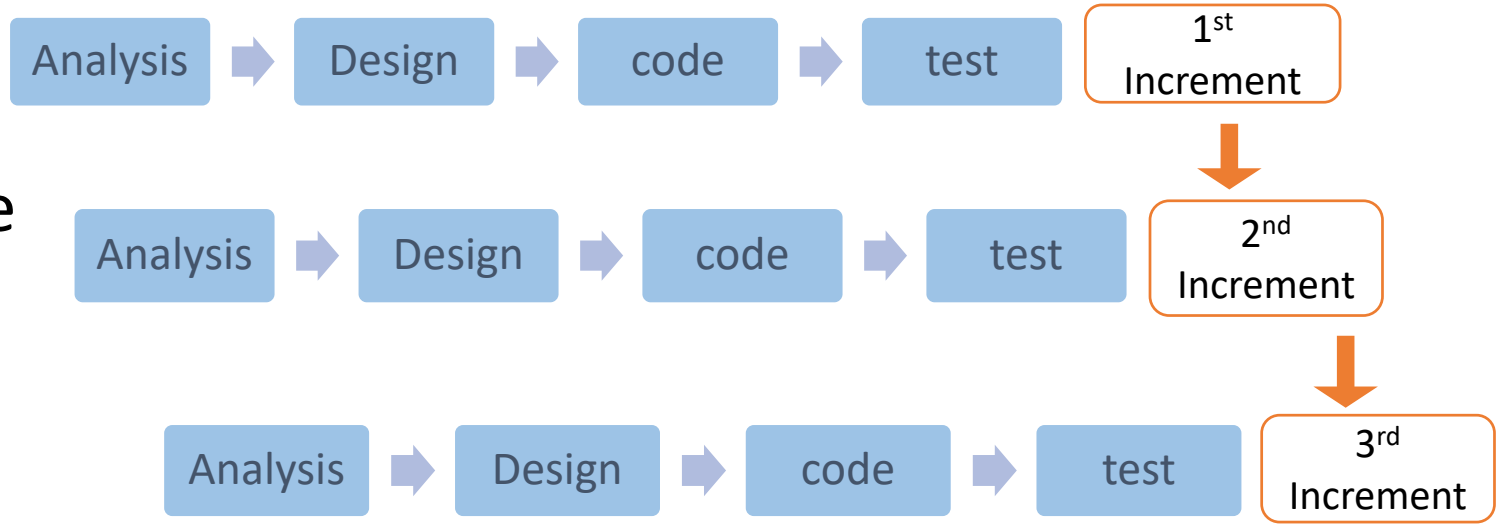
image credit: https://en.wikipedia.org/wiki/Waterfall_model#/media/File:Waterfall_model.svg

Incremental model

Software is developed in a series of steps

- First: a simplified version of the system
  - Represent the entire system by little details
- Second: Include more details
- Pro: easy to find problems
- Con: problems might cause due to system architecture fails to accommodate all requirements for the entire software lifecycle

(need good planning and designing)

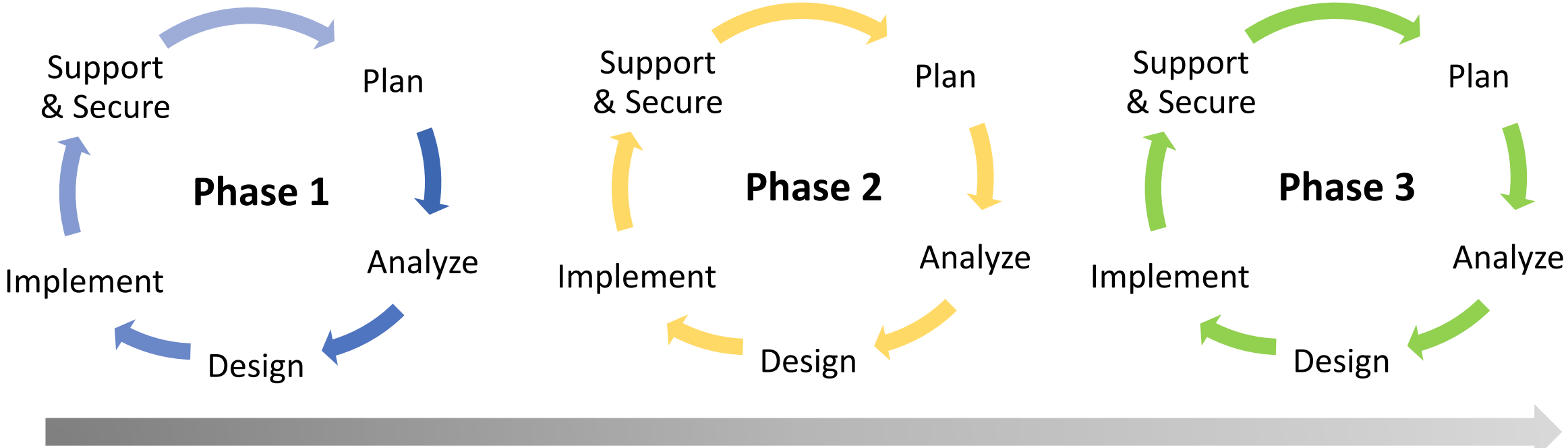


Agile Development (Adaptive Development)

Incorporate the iterative and incremental software development

Increase flexibility to the project goals and scope

- Evolving in phases
- Adding components according to user needs or requirements
- Incorporate testing and feedback from users at all processes and phases
  - Change rapidly to adapt to the market



Network

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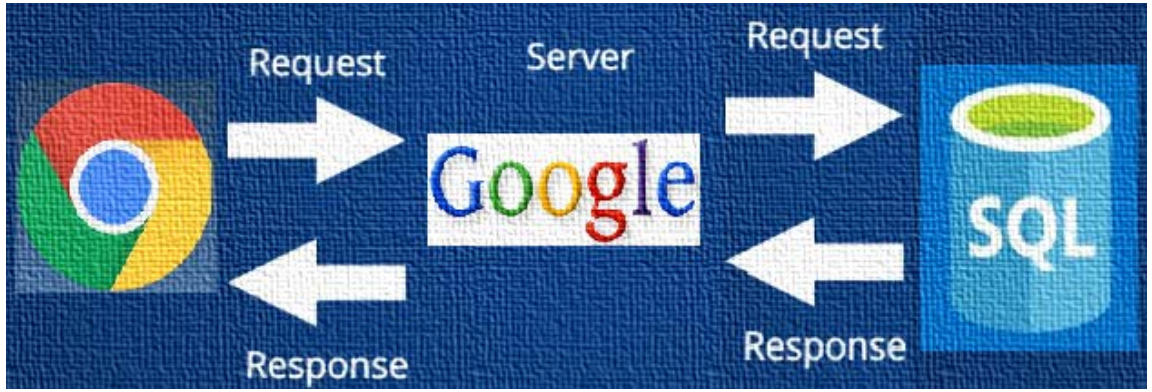
How does internet work?

1. Input google.com in the browser's address bar 

2. Browser asks DNS server: how to reach google.com (DNS server is maintained by service providers)
3. DNS looks up domain name and its associated IP address
4. DNS replies: go to 172.217.27.142
5. Browser uses the IP address and contact the Google web server to request the content
6. Google server checks with its DB regarding the requested content
7. DB finds the relevant information and responds to Google server
8. Google server sends the requested content to the user's browser (webpages)
9. Browser shows whatever it receives from the Google server on the screen



What is a Network

Network is a system of multi-devices linked by wires, cables, or a telecommunications system

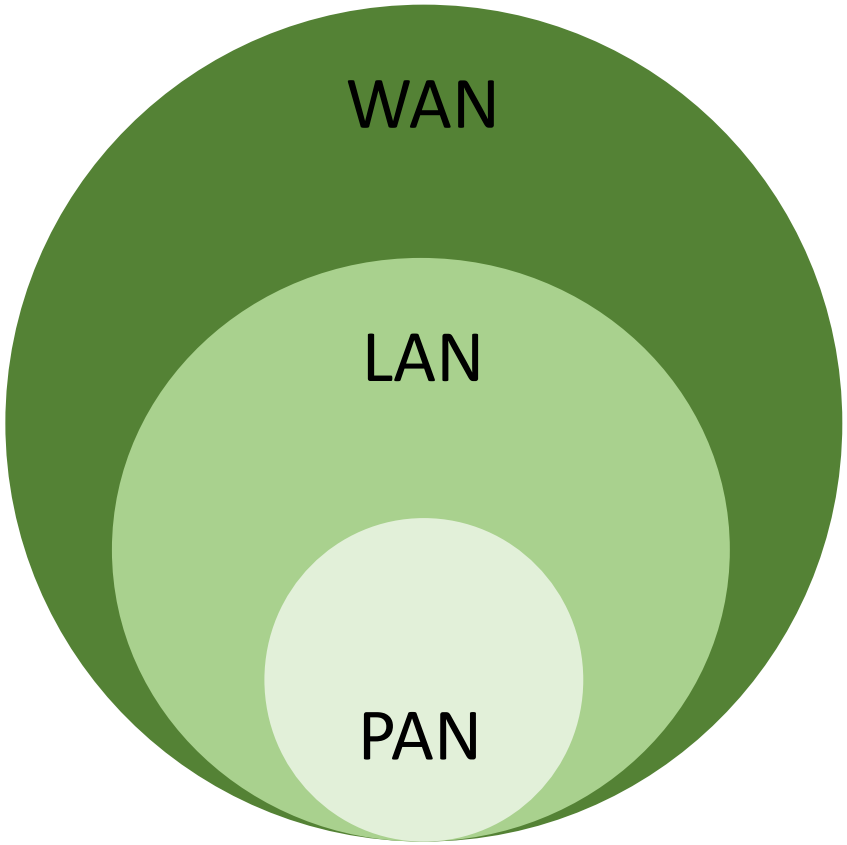
- Combine hardware and software
- Enable a networks to communicate
- Allow computers to share resources
  - Hardware, software, data, and information

Computer network to connect to each other

- Wide area network (WAN)
- Local area network (LAN)
- Personal area network (PAN)

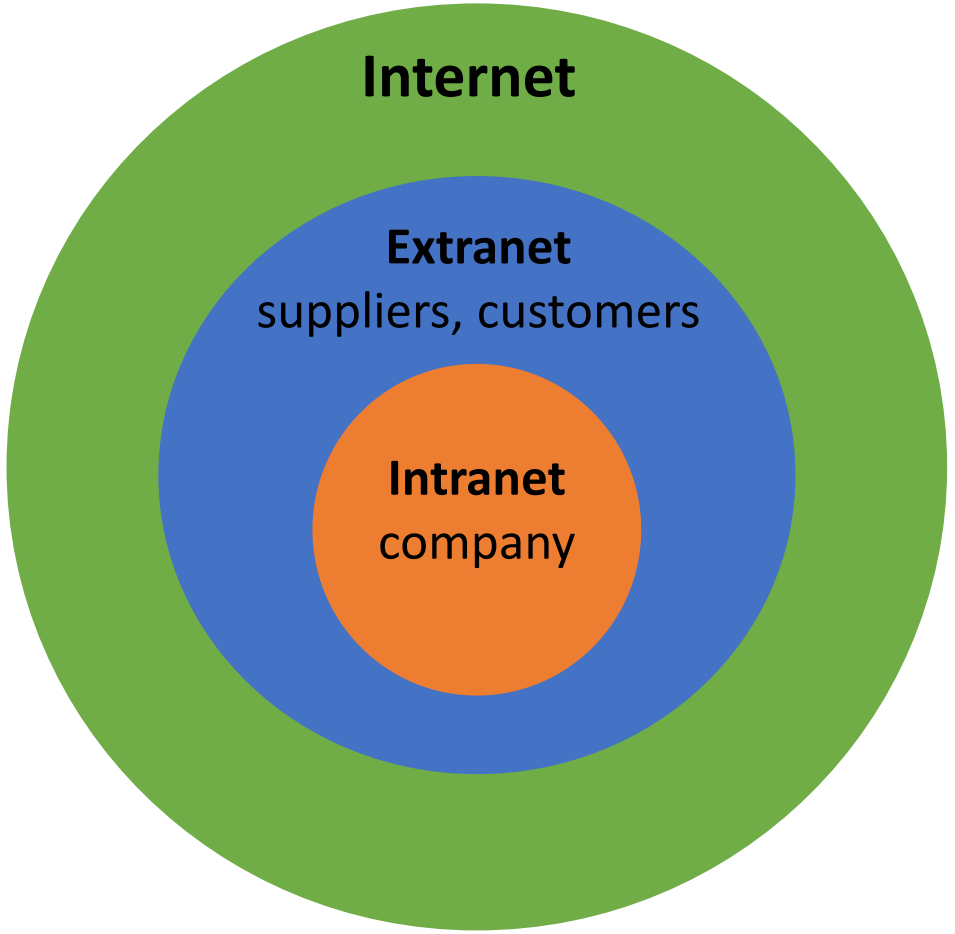
Computer network for sharing information

- Internet, Extranet, Intranet



Computer Network Type

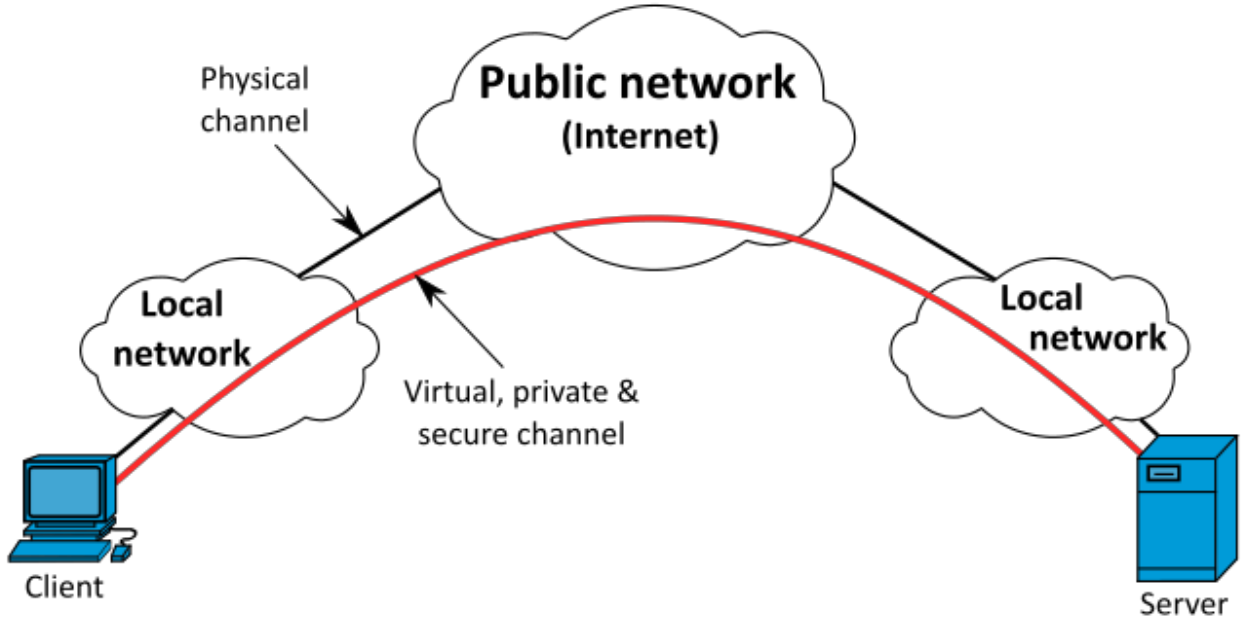
- Extranet
  - Allows outsiders (such as customers and suppliers) to access an organization’s intranet
  - A supplier can check the customer's inventory level before deciding whether to ship other products
- Intranet
  - A private network for authorized individuals
  - Companies use the intranet to communicate internally
  - Intranets are preferable when data being transferred should not necessarily reach the Internet



Parameter	Internet	Extranet	Intranet
Type of Network	Public	Private	Private
Accessibility	Anyone	Authorized people	Authorized people
Size	Large number of connected to the devices	Limited number of connected devices over internet	Limited number of connected devices
Information Sharing	Information can be shared across the world	Information can be shared between employees and external people	Information can be shared securely within an organization
Example	World Wide Web, social media, Email	Network of collaboration between corporations	Internal operations within an organization

Virtual private network (VPN)

- VPN extends a private network to a public network and allows users to send and receive data through networks
- VPN provides a secure path across public networks, allowing authorized users to access the organization's network
- By using encryption technologies, VPN can protect the data transmitted along the path



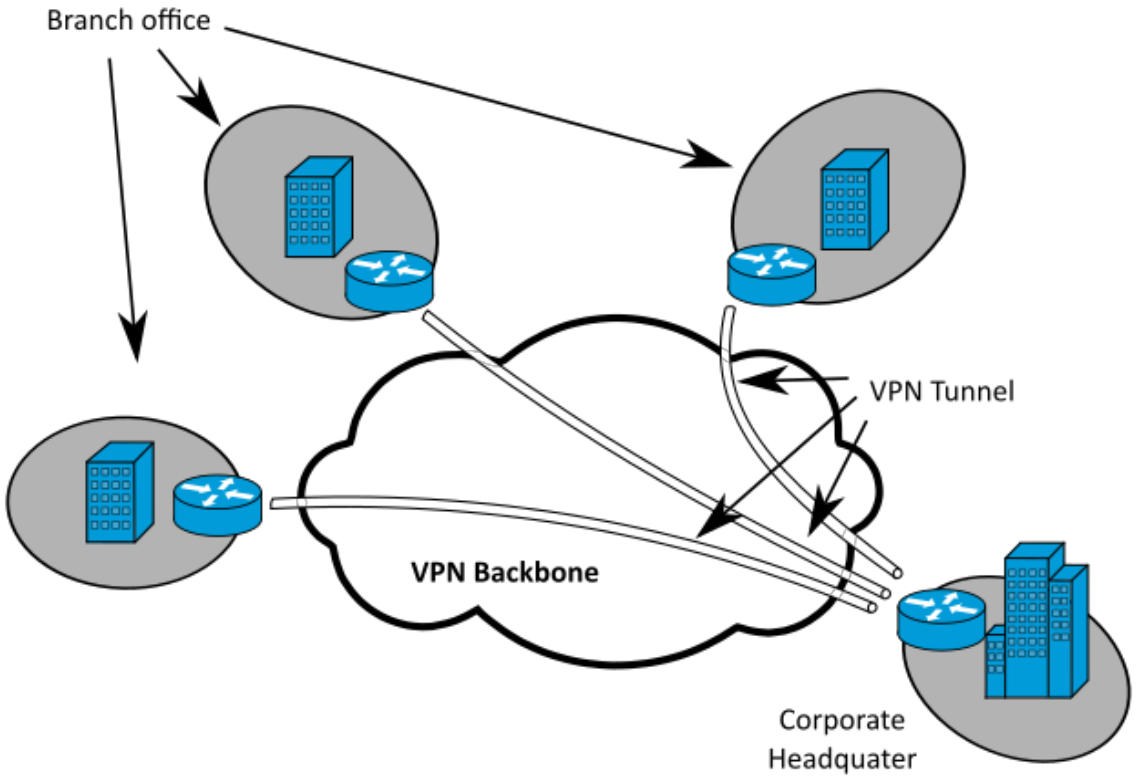


Image credit: https://en.wikipedia.org/wiki/Virtual_private_network

Standard and Protocols

Standard defines guidelines that specify the way computers access the connected media

- Ethernet: guidelines for the physical configuration of a network (1-physical layer)
- Wi-Fi: how two wireless devices communicate with each other

Protocol is the characteristic of two devices communicating on the network

- TCP/IP: how to transmit data from one end of the network to the other
- Bluetooth: how two Bluetooth devices use short-range radio waves to transmit data

Ethernet	Standard
Wi-Fi	Standard
TCP/IP	Protocol
Bluetooth	Protocol
RFID	Protocol
NFC	Protocol

Clip: https://www.youtube.com/watch?v=5u52wbqBgEY
5G: https://www.youtube.com/watch?v=Agw4bnvgLxc

OSI Model

OSI Model: conceptual model that characterizes and standardizes the communication functions of a telecommunication or computing system

7	Application	High-level APIs, including resource sharing, remote file access
6	Presentation	Translation of data between a networking service and an application; including character compression and encryption/decryption
5	Session	Managing communication sessions, i.e. continuous exchange of information in the form c transmissions between two nodes
4	Transport	Reliable transmission of data segments between points on a network, including segmentation, acknowledgement and multiplexing
3	Network	Structuring and managing a multi-node network, including addressing, routing and traffic
2	Data link	Reliable transmission of data frames between two nodes connected by a physical layer
1	Physical	Transmission and reception of raw bit streams over a physical medium

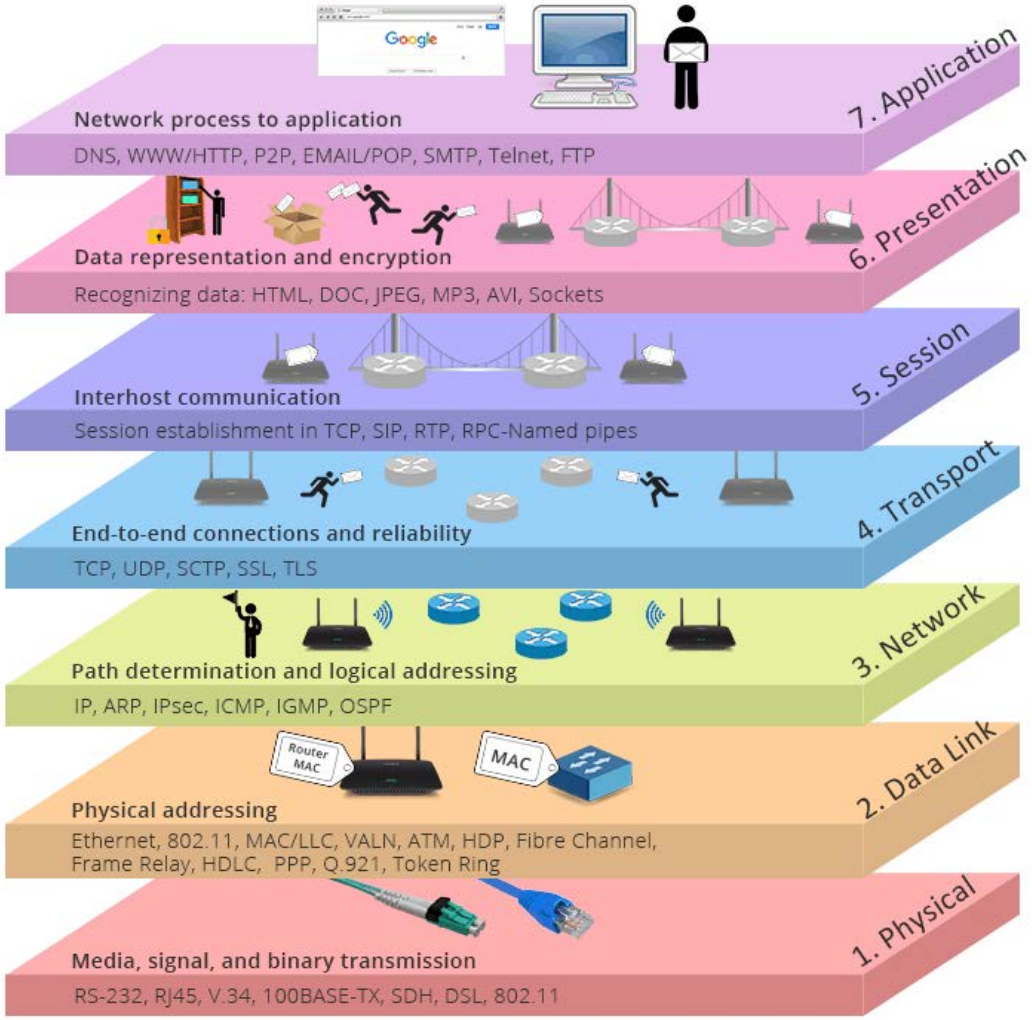


Photo: https://en.wikipedia.org/wiki/OSI_model
https://community.fs.com/blog/tcpip-vs-osi-whats-the-difference-between-the-two-models.html

Connecting to the Internet

Connects the network to the Internet through an Internet Service Provider (ISP)

- ISP is a business that provides Internet access to individuals and organizations for free or for a fee
- ISP is the company that provides Internet connections to users or companies
- ISP may also provide online services, such as e-mail, personal Web site or home page

- **Latency** is the time it takes a signal to travel from one location to another on a network
- **Bandwidth**: the amount of data and information that can be transmitted through the transmission medium
  - The measure of the network's capability to send and receive data
  - Megabyte (MB), Gigabyte (GB)

IP address and Domain Name System

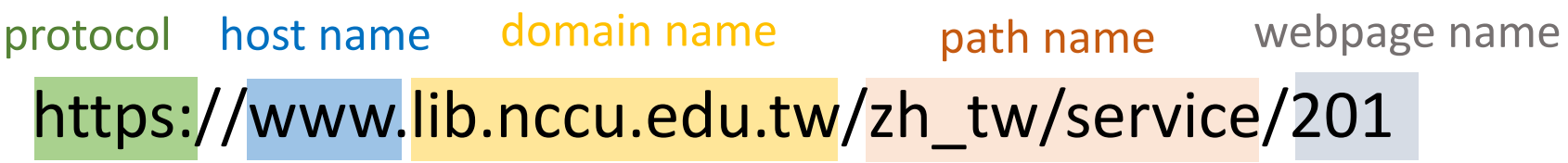
- An IP address is a sequence of numbers that uniquely identifies each computer or device's location to connected to the Internet or any other network
- The domain name is a text-based name which corresponds to the IP address of the server
- The Domain Name System (DNS) server converts the domain name to its associated IP address

IPv4 address: 74.125.22.139
IPv6 address: 2001:4860:4860::8844
Domain name: google.com

	IPv4	IPv6
Full Name	Internet Protocol version 4	Internet Protocol version 6
Format	32-bit Internet addresses	128-bit Internet addresses
Capacity	2^32 IP addresses (4.29 billion)	2^128 IP addresses

Uniform Resource Locator (URL)

Webpage has a unique address, called a **web address** or Uniform Resource Locator (URL)



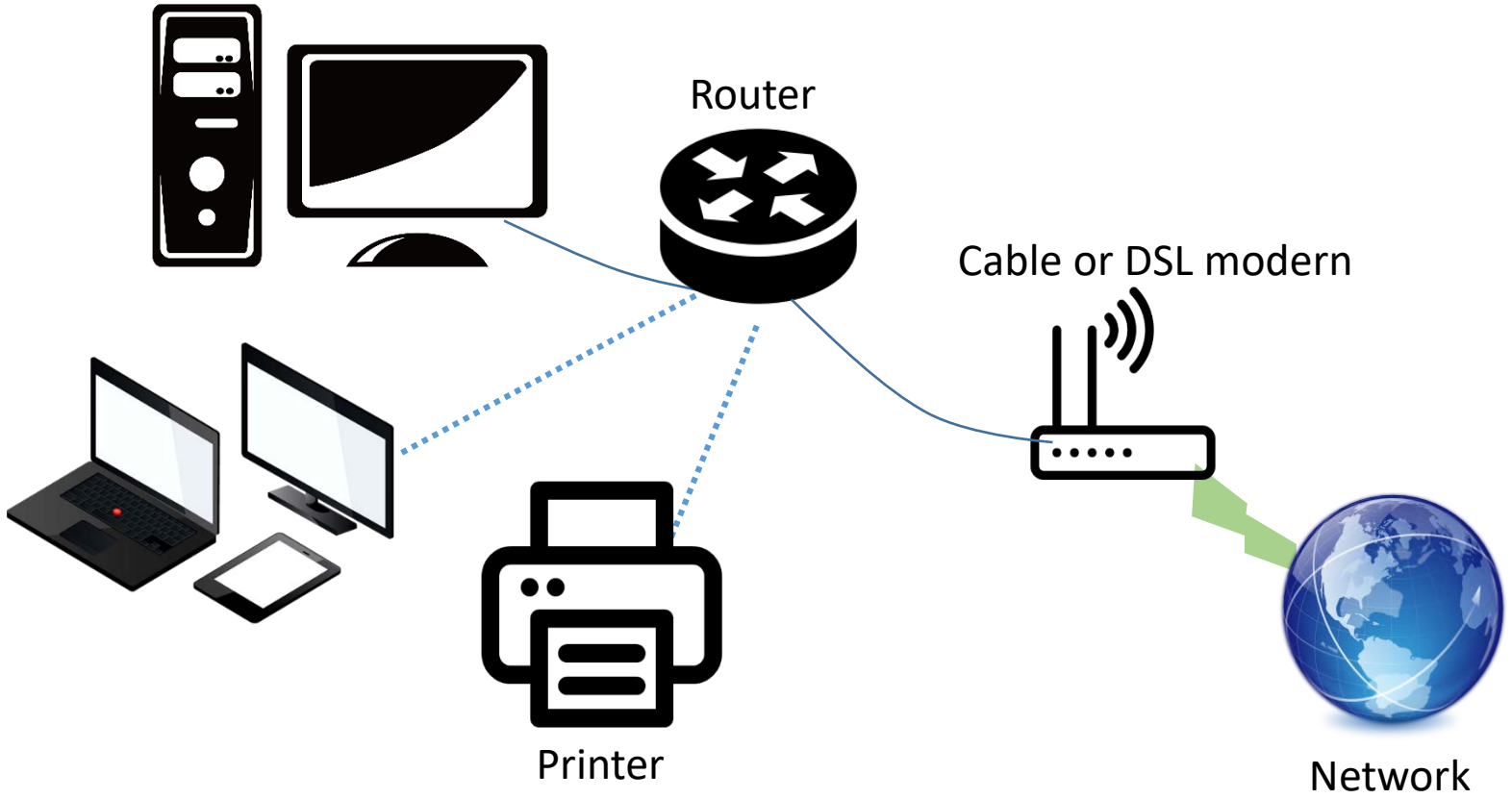
Elements and Devices to Create a Network

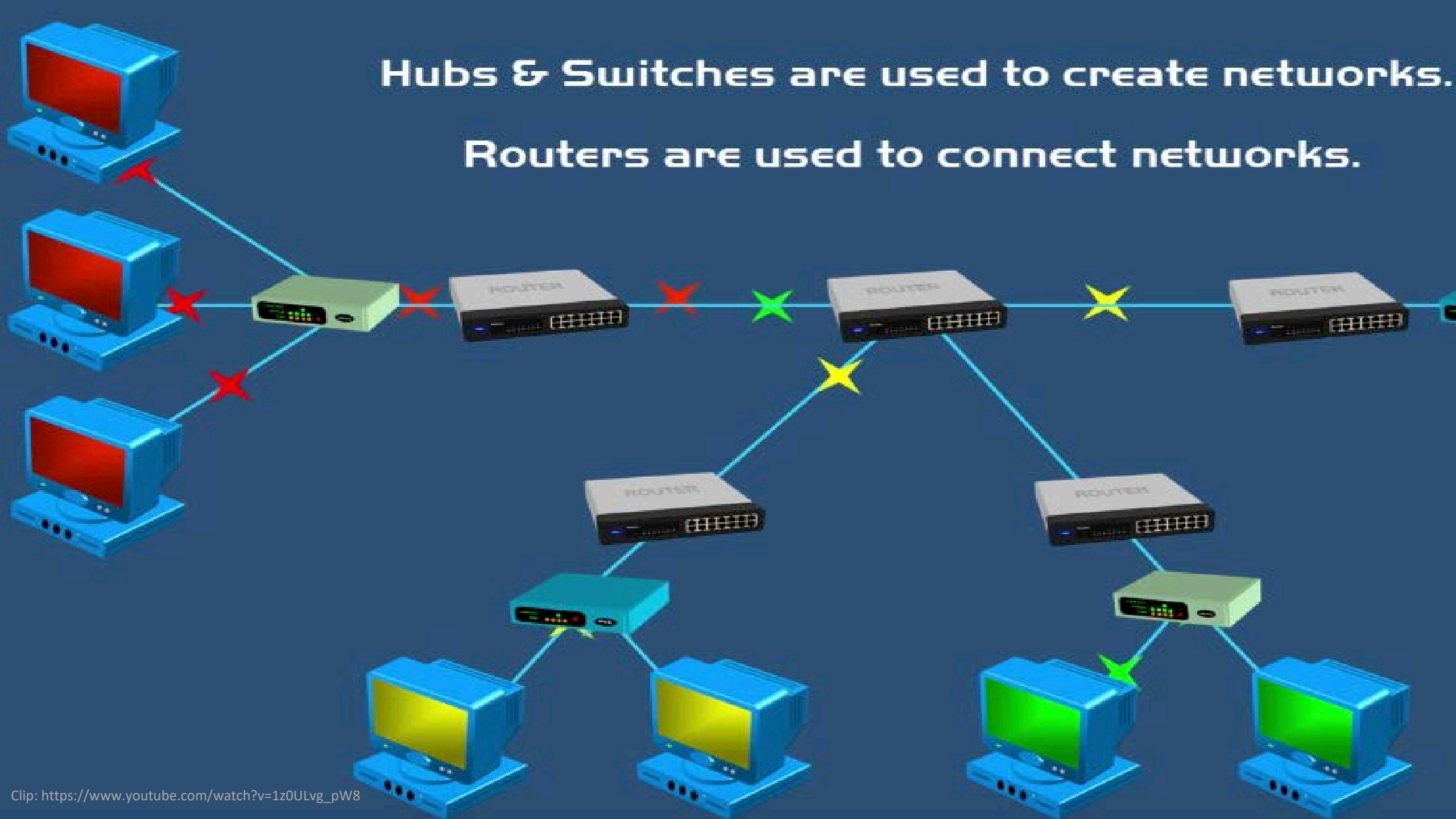
- Hub: a central point in a network; transmit data to all devices
- Switch: a central point in a network; only transmits data to the intended device(s)
- Router: device that connects two or more networks
  - Connect the computer to the Internet (networks)
  - Wireless router: provide wireless network access to the devices
- Modem: the communications device that connects a communications channel to a device

Router

A router connects multiple computers/devices or other routers together and transmits data to the destination on a network

- Through a router, the networks can share access to a broadband Internet connection, such as through a cable or DSL modem



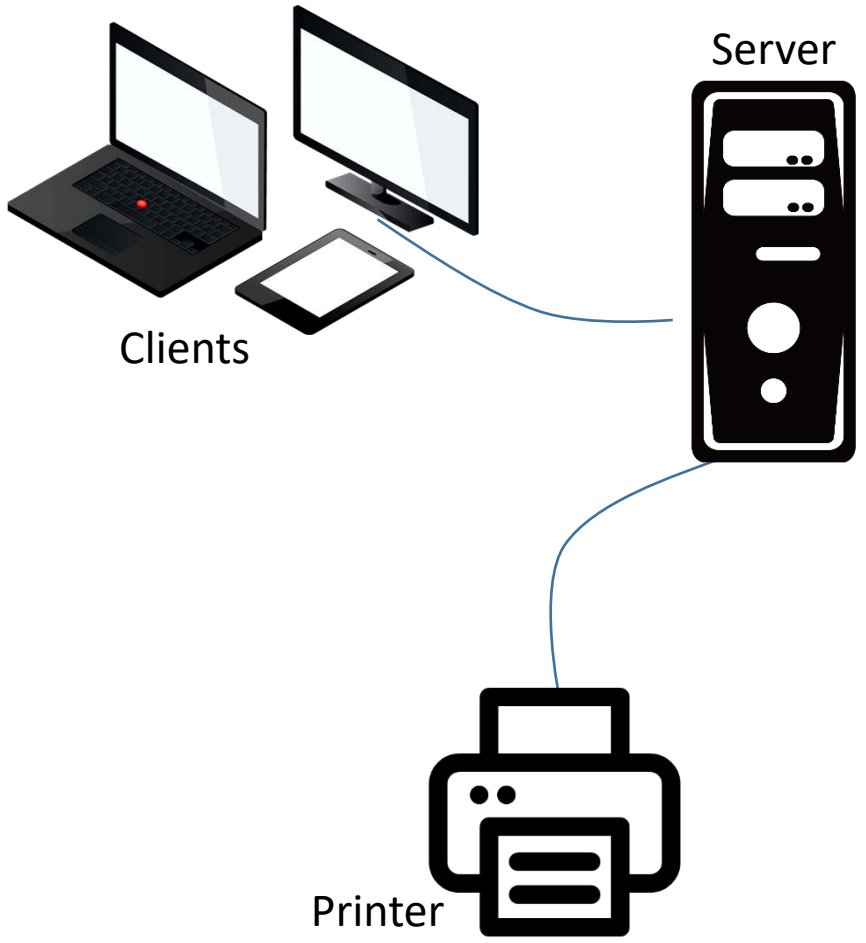


Clip: https://www.youtube.com/watch?v=1z0ULvg_pW8

Network Architecture- Client/Server

Client/server network

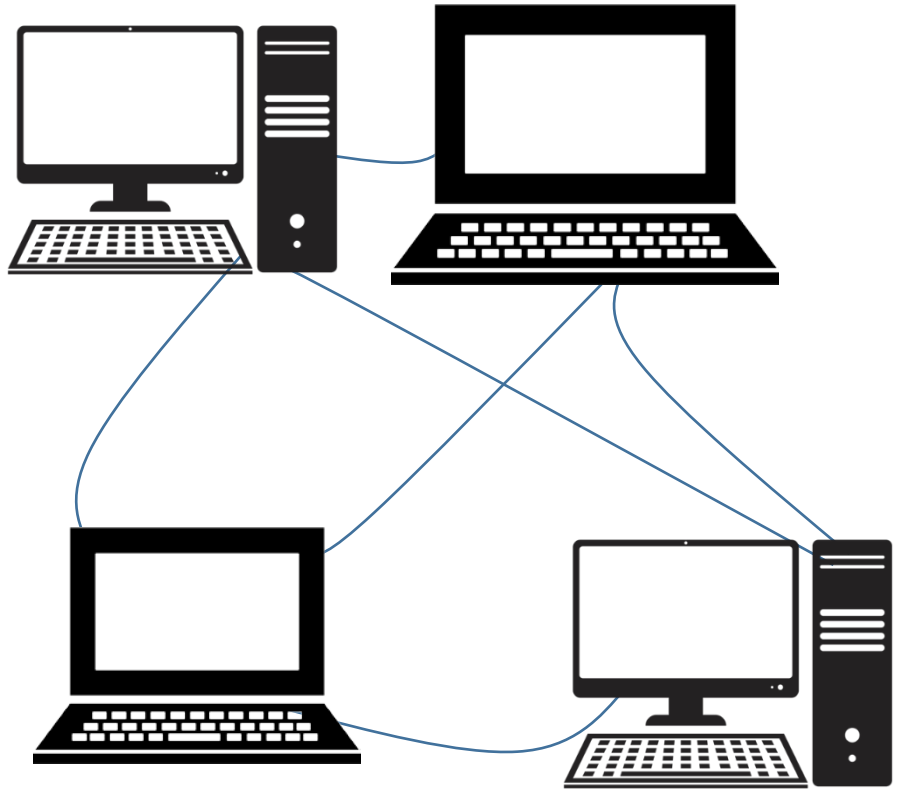
- Server: one or more computers
  - Computer on the network controls access to hardware, software, and other resources
  - Centralized storage location which is accessible to other computers on the network
- Client: other computers on the network request resource from the server
  - Rely on the server for its resources
  - Different clients may have different permissions to access files or resources
- Can connect to one or more servers to sharing files or resources



Network Architecture- P2P

Peer-to-peer (P2P) network

- Computers communicate directly with each other and share each other's resources
  - Computer-A uses a printer connected to Computer-B and revising a file stored on Computer-C
- Administrator is not required since the P2P network treats all computer equally



Network Device

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Servers

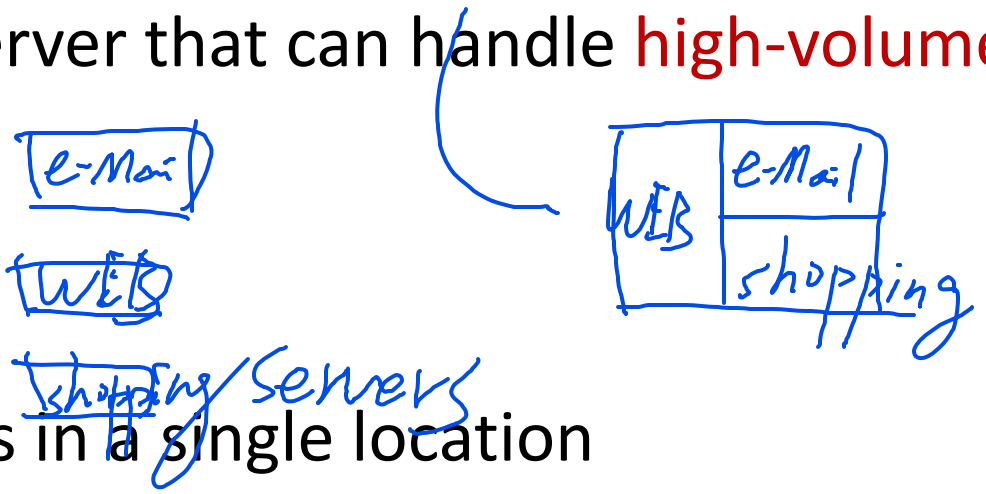
A **server** is a computer dedicated to providing services to other computers or devices on a network

- Tower server
  - Desktop or laptop can be
- Rack server
  - Require more spaces for the machines
  - Better scalability (more memory slots)
    - Might strengthen the computing power
- Blade server
  - Save space but cooling can be an issue
  - Limited spaces for scalability
  - Support hot plugging
- Scalability: memory, network
- Management: power, cooling

Photo credit: https://www.youtube.com/watch?v=bhT1rV5JUQc&ab_channel=ITSimplifiedinHINDI

Servers

- Virtualization is the practice of sharing or pooling computing resources, such as servers and storage devices
  - Server virtualization uses software to enable a physical server to emulate the hardware and computing capabilities of one or more servers, known as virtual servers
- Mainframes are large, expensive, powerful server that can handle high-volume online transaction processing simultaneously
  - Highly reliable, robust backward compatibility
  - Finance and banking industries
  - High learning curve for most administrators
- A **server farm** is a network of multiple servers in a single location
  - Increasingly being used instead of mainframes by large enterprises
  - Server farms do not yet reach the same reliability levels as mainframes
  - Num of computers in large server farms, the failure of an individual machine is common
  - Better scalability, cost-effective, agile and innovative environments
  - Easy to maintain the machines (with universal OS, such as Linux and Windows)

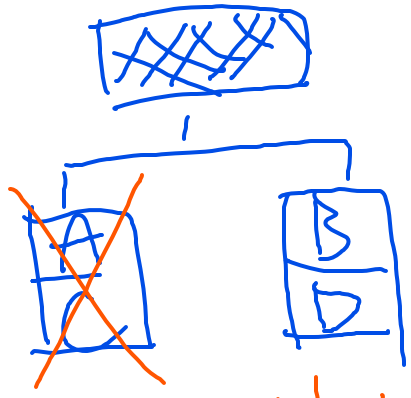


Clip: https://www.youtube.com/watch?v=V9AiN7oJaIM

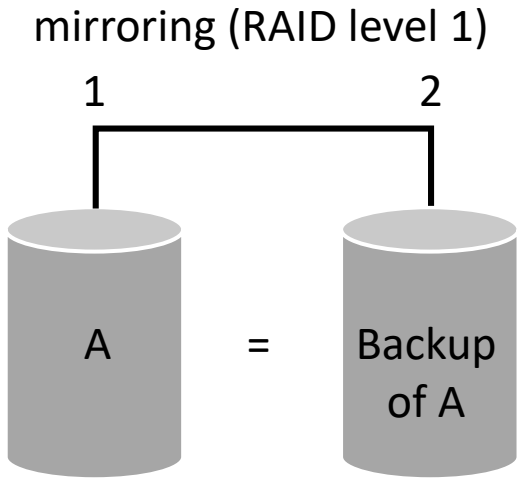
Enterprise Storage - RAID

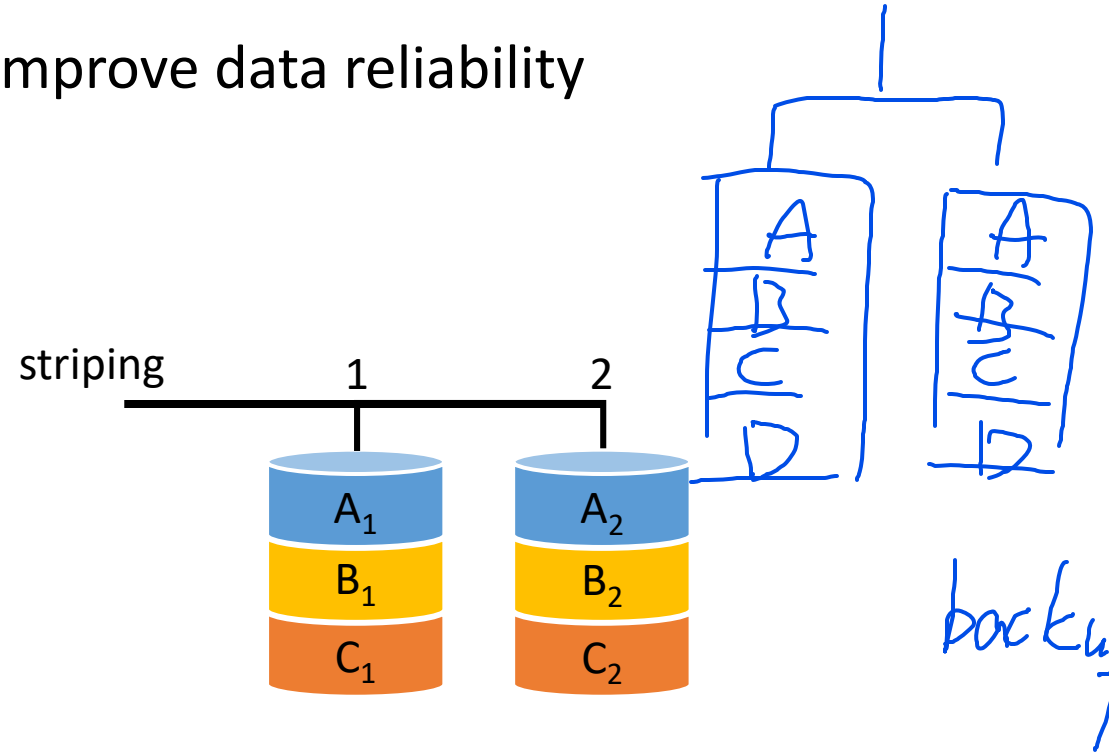
- Enterprise hardware allows large organizations to manage and store data and information with equipment designed for heavy use, maximum efficiency, and maximum availability
- **RAID** (redundant array of independent disks) is a group of two or more integrated hard drives
  - RAID duplicates data, instruction, and info to improve data reliability
  - RAID 0, 1, 5, and 10

RAID-0



x has fault tolerance

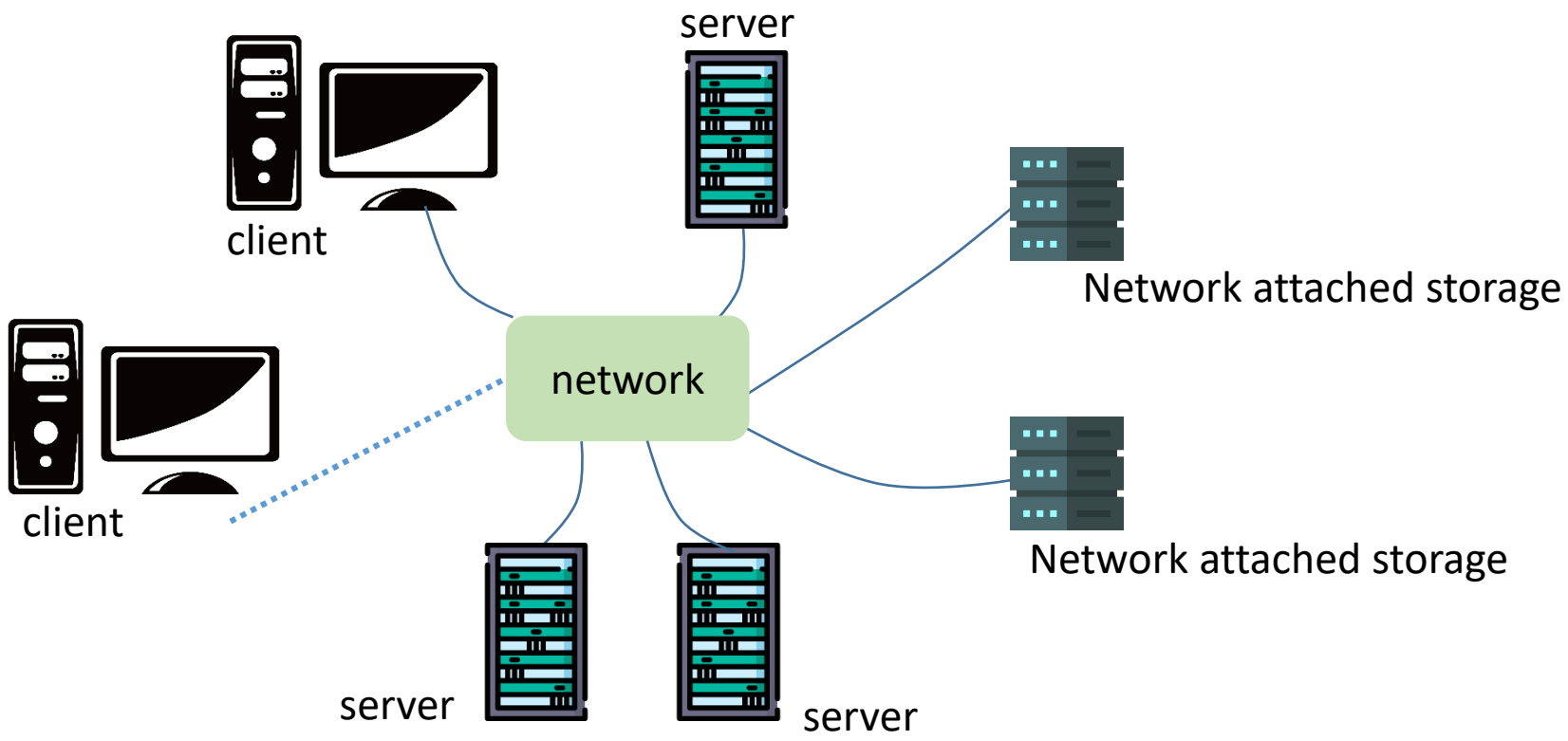




Clip: https://www.youtube.com/watch?v=U-OCdTeZLac

Enterprise Storage – NAS

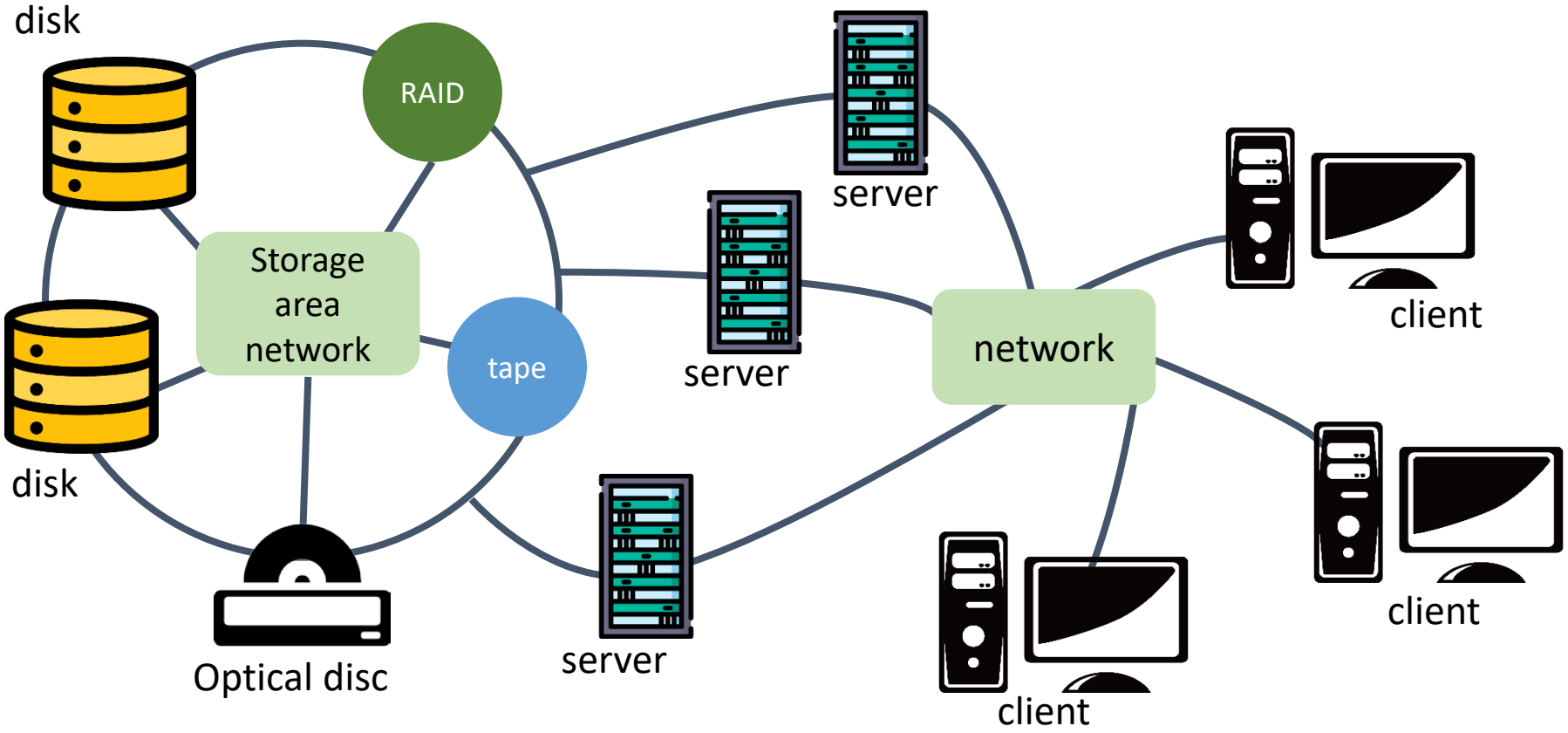
- **Network attached storage** (**NAS**) is a server placed on the network, its sole purpose is to provide storage for users, computers and devices connected to the network



An example of how network attached storage connects on a network

Enterprise Storage - SAN

- A **storage area network** (**SAN**) is a high-speed network with the sole purpose of providing storage to other attached servers



Clip: https://www.youtube.com/watch?v=3yZDDr0JKVc

DAS vs. NAS vs. SAN

- DAS (direct attached storage)
  - Simple, efficient, low cost
- NAS (network attached storage)
  - Remote access, file sharing, affordable, scalability
  - small and medium enterprises
- SAN (storage area network)
  - Top security and huge capacity, higher speed and performance
  - Large company

https://www.youtube.com/watch?v=bpUzGZLO948

Digital Security and Privacy

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Cybercrime

- Cybercrime: crime that involves a computer and a network
  - Unauthorized access and use of computers devices or networks
- Digital security risks are the events that may cause loss or damage of computer hardware, software, data, or information
- Identity theft: someone uses another person's personal identifying information
  - Name, ID card or credit card number, password, fingerprints
  - Without their permission, to access a person's (financial) resources

clip: https://www.youtube.com/watch?v=Pm1Wgd9bbOk&ab_channel=XPRIZE

Internet and Network Attacks

- **Botnet** is a group of compromised (mobile) computers connected to the network
  - A compromised computer or device is called as a **zombie**
  - The owner does not know that the computer is remotely controlled by an outsider
- **Denial of service attack** (**DoS attack**) disrupts computer access to Internet
  - Distributed DoS attack (DDoS attack): utilize **many** computers and networks (zombie army)
- **Back door** is a program that allows users to bypass the security control program and remotely access the computer without the user's knowledge
  - Programmers often install back doors to test programs
- **Spoofing** is a technique used by intruders to make network or Internet transmissions appear legitimate
  - IP, email, caller ID spoofing
- **Phishing** is the fraudulent attempt to obtain sensitive information, such as passwords and credit card details, by disguising oneself as a trustworthy entity
  - Email spoofing, instant message, text message

Clip: https://www.youtube.com/watch?v=c9EjuOQRUdg

Hardware Firewall

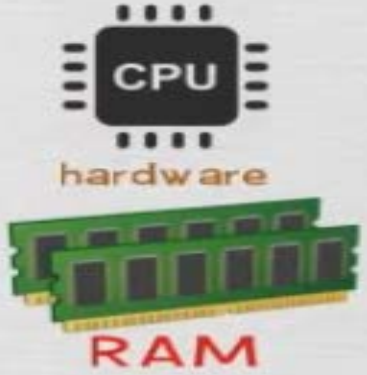
between two networks

VS

Software Firewall

within user's pc

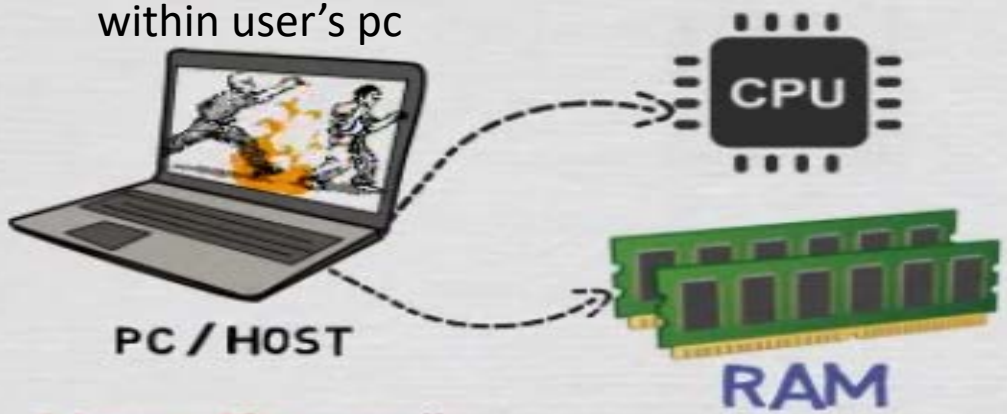
個人設定



Appliance Firewall

擋網域

block



Host Firewall

Based on the predefined rules, hardware firewall protects the entire network from the outside world with a single physical device (before reaching the server). Control how the network is used.

Controls the behavior of specific applications
Block access to certain websites

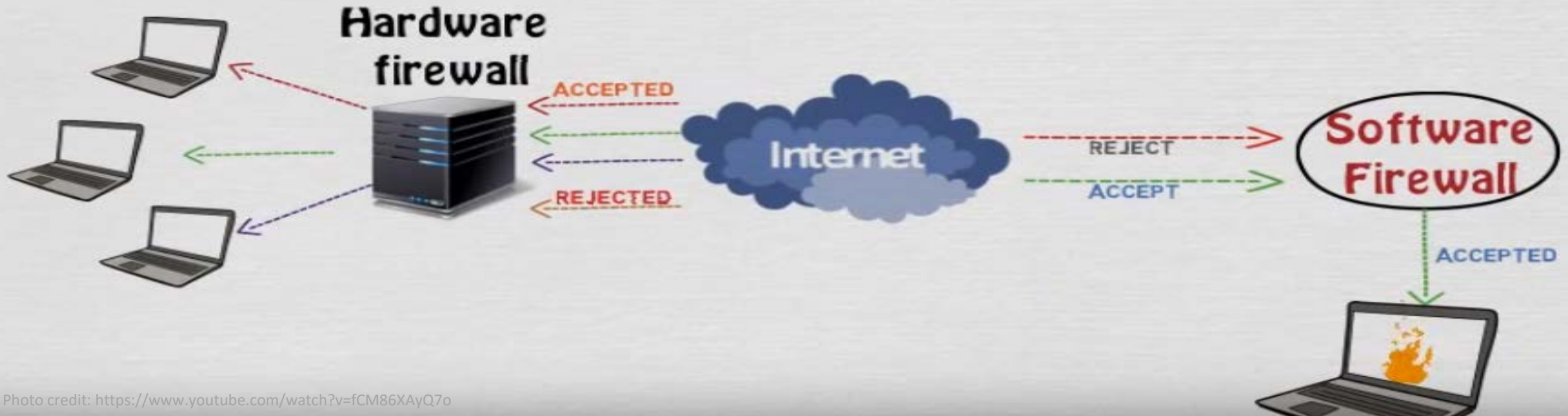


Photo credit: https://www.youtube.com/watch?v=fCM86XAyQ7o

Biometric Device

- **Biometric device** verifies the identity of a person by converting personal characteristics into a digital code
  - Fingerprint reader
  - Face, voice, and signature recognition system
  - Hand geometry system: shape and size
  - Iris recognition system: patterns in the iris of the eye

Two-step Verification

- **Two-step verification** uses two different methods (one after another) to verify the user's identity
  - ATM card, then enter a PIN
  - ID and password, then enter security code (text message)

Signing in to your account will work a little differently

1 You'll enter your password

Whenever you sign in to Google, you'll enter your password as usual.

2 You'll be asked for something else

Then, a code will be sent to your phone via text, voice call, or our mobile app. Or, if you have a Security Key, you can insert it into your computer's USB port.

Image credit: https://www.google.com/landing/2step/#tab=how-it-works

An Example of Public Key Encryption

Step1
The sender creates a document to be sent via email to the receiver.

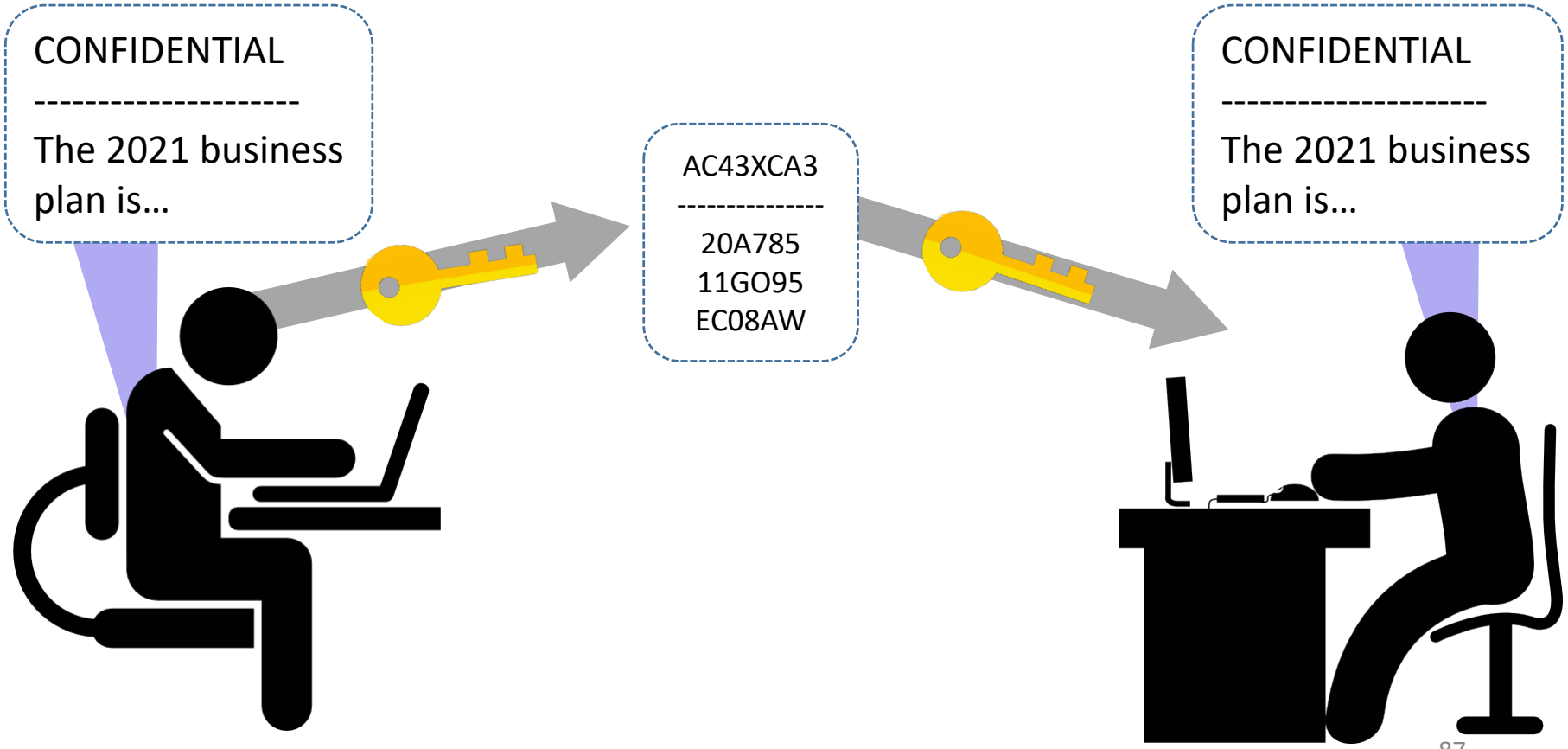
Step2
The sender uses the receiver's public key to encrypt a message.

Step 3
The receiver uses his or her private key to decrypt the message.

Step 4
The receiver can read or print the decrypted message.

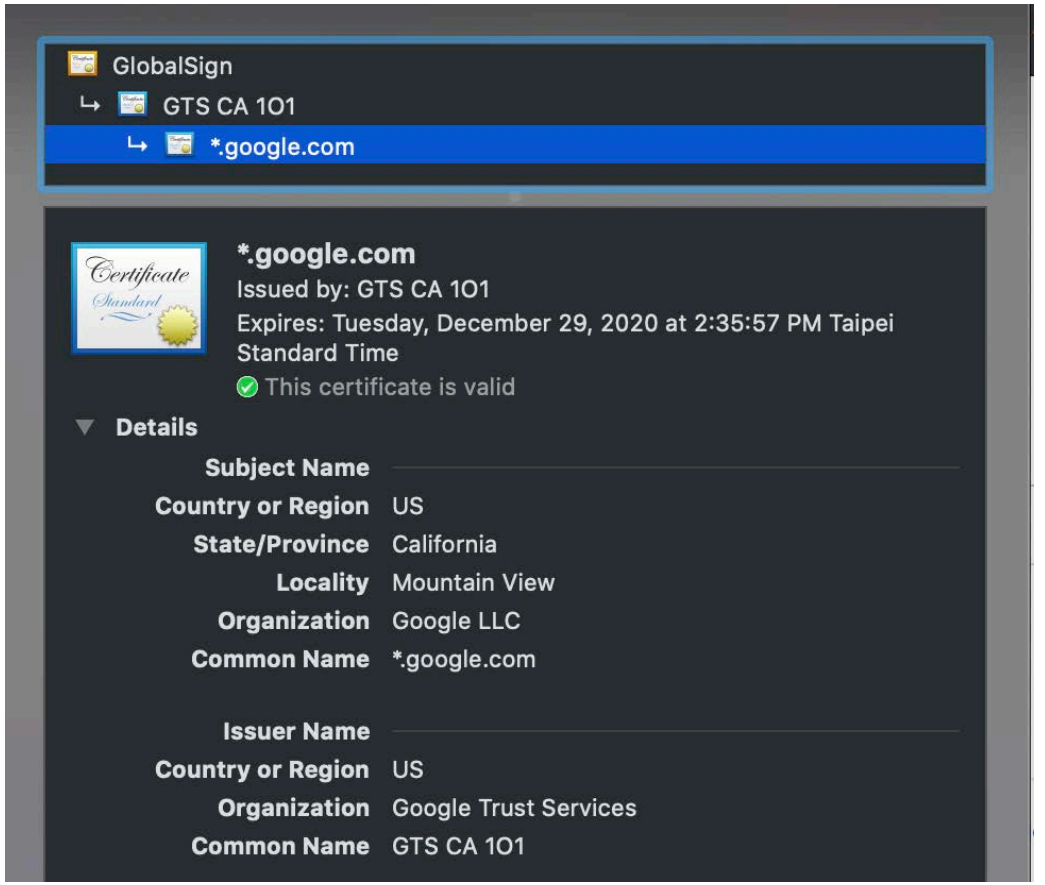
Symmetric key encryption: Originator and recipient use **the same secret key** to encrypt and decrypt data

Asymmetric key encryption
Originator (**public** key)
Recipient (**private** key, must be confidential)



Digital Signature & Certificate

- **Digital signature** is an encrypted code that a person, website, or organization attaches to an electronic message to verify the identity of the sender
  - Internet transaction
- **Digital certificate** is a notice that **guarantees** a user or a website is legitimate
- **Secure site** which uses **encryption techniques** to secure its data
  - HTTPS: Hypertext Transfer Protocol Secure



Types of Backups

- Differential: backup the files changed since last full backup (sun<->mon, sun<->tues)
- Incremental backup: backup the files changed since last incremental backup (sun<->mon, mon<->tues)

Type	Description
Full backup	A full backup is the process of making at least one additional copy of all data files that an organization wishes to protect in a single backup operation. The files that are duplicated during the full backup process are designated beforehand by a backup administrator or other data protection specialist.
Differential backup	A differential backup is a cumulative backup of all changes made since the last full backup, i.e., the differences since the last full backup. The advantage to this is the quicker recovery time, requiring only a full backup and the last differential backup to restore the entire data repository.
Incremental backup	An incremental backup is a backup type that only copies data that has been changed or created since the previous backup activity was conducted. An incremental backup approach is used when the amount of data that has to be protected is too voluminous to do a full backup of that data every day.
Selective backup	Selective backup is a type of data backup process in which only user-specified data, files and folders are backed up. It enables short listing only selected files in a backup process rather than backing up the whole folder, disk or system. Selective backup is also known as partial backup.
Cloud backup	Cloud backup, also known as online backup or remote backup, is a strategy for sending a copy of a physical or virtual file or database to a secondary, off-site location for preservation in case of equipment failure or catastrophe. The secondary server and data storage systems are usually hosted by a third-party service provider, who charges the backup customer a fee based on storage space or capacity used, data transmission bandwidth, number of users, number of servers or number of times data is accessed.