IBDP
COMPUTER SCIENCE

Revision & Notes

Erin Mauricio

LESSON 1

SYSTEM FUNDAMENTALS

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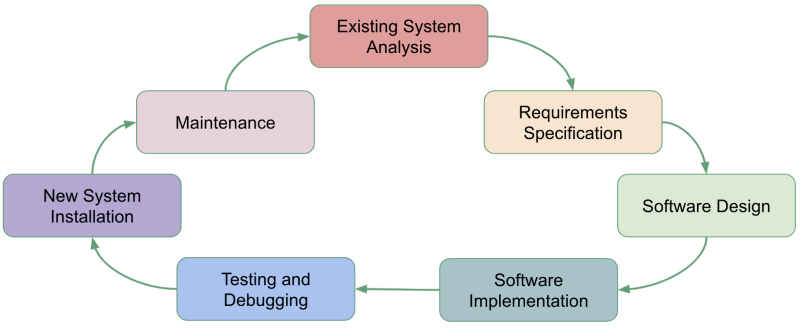
system life cycle

- ➢ refers to the stages through which the development of a new system passes through.
- ➢ it may be necessary to backtrack and return to previous stages at certain points.



1.1 systems in organizations

planning and system installation

1.1.1 the context for which a new system is planned

reasons for a new system:

- old system is inefficient
- old system is no longer suitable for its original purpose or outdated
- to increase productivity and quality of output
- to increase efficiency and minimize costs

a **computer system includes** hardware, software, the people working with it, and its immediate environment. all these factors must be taken to account in creating a new system.

planning refers to the process of thinking about various details and organizing the activities required to achieve the goals. it should consider potential organizational issues such as...

- lack of guiding organizational & business strategies
- lack of stakeholder and end-user participation
- lack of end-user ownership
- lack of attention to required training
- lack of attention to organizational issues
- lack of attention to the overall usability and design of the system

a **feasibility study** should be conducted to evaluate and analyze the potential of the project. it is based on the following criteria:

- **technical** feasibility: is the existing technology sufficient to implement the system?

- **economic** feasibility: is the new system cost effective?
- **legal** feasibility: is the new system in conflict with any regulatory laws?
- **operational** feasibility: are the existing organizational practices enough to sustain the new system?
- **schedule** feasibility: is the project capable of being implemented within the given time frame?

1.1.2 the need for change management

change management refers to the process of shifting individuals, teams, departments, and organizations from the present state to the desired state to maximize benefits and minimize negative impact.

- successful change management guarantees that all stakeholders accept and embrace the changes.

1.1.3 compatibility issues resulting from situations

legacy systems refer to old technologies, hardwares, computer systems, or applications.

- these systems are still in use because data cannot be converted to new formats, applications cannot be upgraded, or they still satisfy user needs.
- however, keeping such systems results in various maintenance challenges such as costs, components, etc.

business mergers occur when two or more business entities combine most often to reduce costs. **software incompatibility** is when different software entities cannot operate satisfactorily together, whether on the same computer or when linked by a LAN or WAN.

language differences refer to communication issues and different interpretations.

strategies for merging include:

- keeping and developing both systems to have the same functionality
- replacing both systems with a new one
- combining the best systems from both companies
- only using one system and abandoning the other

1.1.4. different systems implementation

locally hosted systems have the software installed on the client's own hardware.

pros	cons
• best for large and complex systems • one-time pay (excluding maintenance) • data is controllable and is less vulnerable to external attacks	• higher initial cost • harder to predict cost in the long run (possible maintenance issues) • needs to be maintained alone • needs personal hardware

remotely hosted systems — software-as-a-service (saas), also known as on-demand software, is a contemporary delivery method that allows software and data to be hosted and managed centrally elsewhere. accessible by paying subscription fees.

pros	cons

• lower initial cost
• no need to personally maintain
• easily accessible (only needs a web browser and an internet connection)
• fewer investments needed to upkeep
• scalable and adaptable— supported by a variety of gadgets
• data is secure in the data center
	• reliant on a third party:
	  ○ no control over such data loss
	  ○ legislation differences
	  ○ lower per- formance compared to onsite software
	  ○ dependent on wi-fi
	  ○ time zone differences
	  ○ language differences

1.1.5 alternative installation process

one critical aspect of implementing a new system is the choice of implementation method.

changeover is the process of putting the new system online then retiring the old one.

- **parallel** changeovers entail both systems to work in parallel for a short period of time.
  - pros: less risky, ensures that new system works fine
  - cons: higher initial cost, possible inefficiencies
- **big bang** changeovers, also known as direct or immediate, is when the company unplugs the old system then plugs in the new one at the same time.
  - pros: less costly
  - cons: higher risk of data loss if new system doesn't work
- **pilot** changeovers are used in organizations with multiple sites. the new system is introduced in one of the sites and is extended to the others over time.
  - pros: less risky, helps ensure that software truly works
  - cons: lengthier implementation period, necessity of worker training
- **phased** changeovers occur when one module of the system is converted at a time.
  - pros: less risk, ensures functionality of each individual module
  - cons: lengthier implementation and training period.

1.1.6 problems that may arise as a part of data migration

data migration refers to the transfer of data between different formats, storage types, and computer systems. it comes in three stages: plan, migrate, and validate. several problems can arise during this process, such as...

- incompatibility with the file formats in the new system
- non-recognizable data structures and formats
- data lost or not transferred due to errors
- misinterpreted data due to differences in conventions

1.1.7 various types of testing

testing is important because it identifies problems to be fixed, areas for improvement and determines whether a system/ software fulfills requirements.

functional testing tests individual commands, text inputs, menu functions, etc. to confirm that they perform and function correctly according to design specifications.

data testing tests what would occur when normal, abnormal, and extreme data is input into the system. this can be tested with...

- normal data, which is data within the limits of acceptability.
- data at the limits, which is data which are close to the limits of acceptability
- extreme data, which is data beyond the limits of acceptability.
- abnormal data, which is the data that is unexpected.

alpha testing is done before the software is made available to the general public and occurs within the company's laboratory.

beta testing includes comments and suggestions of the users who were sought outside of the company.

dry run testing is conducted using pen and paper in which the programmer mentally runs the algorithm and determines the intended results of execution.

unit testing is when individual parts of the system are tested separately.

integration testing is when the entire system is tested at the same time to verify that all components work together.

user acceptance testing is used to determine if the system satisfies the customer needs.

debugging is the systematic process of finding and correcting the number of bugs in a computer program.

validation and verification of data input

- **validation** is the process of evaluating whether data input follows appropriate specifications and is within reasonable limits. *is the data acceptable for the program?*
- **verification**, on the other hand, is the process of ensuring that data input is the same as the original source of data. *is the data correct?*

validation and verification in software testing

- **validation** is the confirmation that a computer product meets its design function and is appropriate for intended use. *is this the correct system?*
- **verification** is the confirmation that a computer product meets identified specifications. *is this system being developed correctly?*

user focus

1.1.8 importance of user documentation

user documentation is created so users can understand and maximize any given system.

internal documentation refers to the code comprehension features and details as provided by the source code itself. this includes

- appropriate file titles and labels

- appropriate names for variables, classes, modules, functions, methods
- appropriate structure and formatting

external documentation refers to the document separate from the program itself that will be used for user support.

1.1.9. different methods of providing user documentation

user support in the form of **external documentation** can be provided in several ways:

- **manuals,** provided online or offline with multimedia features
- **email support,** which users can contact
- **frequently asked questions (faq)**
- **integrated user assistance / embedded assistance** which is a feature that provides instructions within the application
- **live chat sessions**, providing real time solutions
- **online/web portals**
- **remote desktop connections**, where the developers/trained individuals connect to the

1.1.10 different methods of delivering user training

- self instruction/self study
- formal classes
- remote/distance learning

system backup

1.1.11 causes of data loss

data loss refers to the error condition where data is lost or destroyed due to system failure, storage negligence, or even transmission or processing errors.

- accidental deletion, administrative errors, poor data storage organization system, building fires, closing the program without saving, computer viruses, continued use after signs of failure, data corruption, firmware corruption, natural disasters, outsiders wanting to delete/alter/steal information, physical damage of the storage device, power failure

1.1.12 consequences of data loss

- costly recovery and/or retrieval
- loss of valuable data (i.e. patient information)

1.1.13 range of methods that can be used to prevent data loss

some methods include regular back ups, firewall installation, data storage in several locations, removed hard copies, installation of antivirus program, human error, autosave

redundancy is the duplication of storage devices and stored data with the intention of security.

failover systems are computer systems which are on standby and are capable of switching automatically to a spare computer system when encountering failure.

switchover systems are systems in which the primary and secondary servers switch roles.

software deployment

1.1.14 strategies for managing releases and updates

users can install updates because otherwise they might not have fixes for bugs and errors or be able to benefit from added features/ improvements leading to performance issues.

- **patches** are used to update applications by fixing bugs and vulnerabilities.
- **updates** improve a product in a minor way by adding new functionalities or fixing bugs.
- **upgrades** always contain novel functionalities or characteristics, as well as cumulative bug fixes which are normally bought.
- **releases** are final, working versions of software applications and have been tested.

1.2 system design basics

components of a computer system

1.2.1 hardware, software, peripheral, network, human resources

- **hardware** refers to the physical, tangible elements of a computer system e.g. CPU, HDD
- **software** refers to the set of instructions for the CPU to perform specific operations, can be programs or data
- a **peripheral device** is any auxiliary device that can connect to, communicate and work with the computer.
- a **computer network** is a set of computer systems that are interconnected and share resources
- **human resources** refers to the set of individuals who make up the workforce of an organization, business sector or economy.

1.2.2. the roles of a computer in a networked environment

computers can assume several roles and can function primarily as a client or server.

- a **client** receives data via a network. a **server** is the storage of data which it offers to clients.
- a **dumb terminal** is a device that consists of a keyboard, monitor, and network card and is connected to a server or computer that they are entirely dependent on for data processing and management.
- a **thin client** is a low performance terminal dependent on the server it's connected to.
- an **email server** manages the flow of emails in a network.
- a **router** is a device that accepts incoming quanta of information, reads their address, and then distributes them across the networks.
- a **domain name system server** attributes names to network addresses. the **domain name system** is a TCP/IP protocol that manages public names of websites.
- a **firewall** is a hardware or software infrastructure that controls data flow access to offer protection and limit access to a network

- a **client server** refers to a software network system where clients request information and servers perform tasks to deliver the information.

1.2.3. social and ethical issues associated with a networked world

- **reliability** refers to how an IT system functions
- **integrity** refers to the completeness and accuracy of data
- **inconsistency** refers to variations in information leading to several issues
- **security** refers to the protection of devices from unauthorized access
- **authenticity** refers to the confirmation of the identity of a user to gain access
- **privacy** refers to the ability to control to what extent data can be used
- **anonymity** refers to the use of technology to conceal one's identity to do illegal things
- **intellectual property** refers to personal works that are protected by copyright laws
- **the digital divide and equality of access** refers to the unequal development of technology and IT across countries and social classes.
- **surveillance** refers to the use of IT to monitor individuals with or without their consent.
- **globalization and cultural diversity** refers to the capability of IT to diminish boundaries across people from different nations.
- **it policies** are procedures and measures enforced to ensure the appropriate use of technology
- **standards and protocols** are predefined technical rules and conventions that developers must follow to ensure compatibility and facilitate communication between different systems/networks.
- **people and machines** refers to the impact of technology on the interactions between IT and people.
- **digital citizenship** covers appropriate behavior in a digital world, particularly using IT ethically.

system and design analysis

1.2.4 relevant stakeholders when planning a new system

stakeholders are the parties who have an interest in the realization of a project. they are directly connected to and will be affected by the outcome of a project.

- **end-users** refer to the people who will use the product. they are **stakeholders** capable of providing necessary feedback, proposing improvements, and identifying flaws of a product.

1.2.5. methods of obtaining requirements from stakeholders

- **interviewing stakeholders** entails a face-to-face conversational procedure to gather information, make necessary clarifications, and observe behaviors. they can be **structured or unstructured**.
- **questionnaires** are carefully constructed sets of written questions. they can be **closed or restricted** (strictly yes or no, box-checking, and short responses) or **open or unrestricted** (free response questions for deep responses)
- **direct observation of current procedures** entails spending time in different departments to collect various forms of necessary information.

1.2.6. appropriate techniques for gathering information needed to arrive at a solution

- **examining current systems** entails the detailed examination of the workings of a current system to determine the aspects that need to be changed.
- **literature search** is the process of gathering information from other sources.
- examining **competing products** will help the product in development be more competitive in the market.

1.2.7. suitable representations to illustrate system requirements

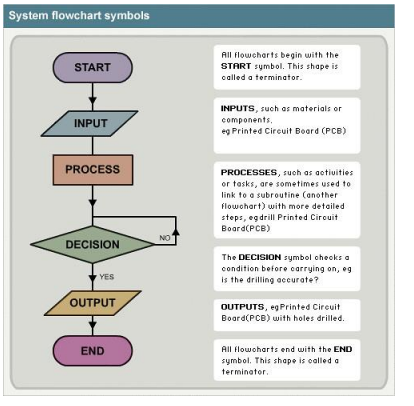
requirements are specified through the **requirements specification document**, which defines customer needs and wants.

there are three **types of processing**:

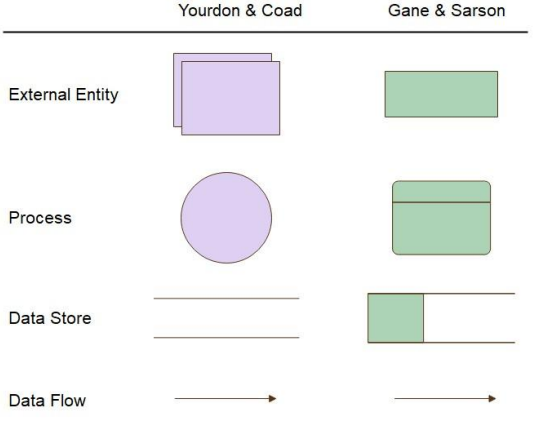
- **online processing (interactive)** refers to processing performed by a single processor through the equipment it controls.
- **real time processing** is performed on-the-fly where generated data influences the actual process taking place.
- **batch processing** is performed on data condensed into a single unit.

system flowcharts are illustrations of the processes of a single program, including data flow, conditions, etc.

common symbols used in flowcharts are indicated to the right.



data flow diagrams are used to describe the problem to be solved and shows how data moves through the system.



structure charts describe functions and subfunctions of a system, as well as the relationships between modules of a program.

modular design refers to the process of designing system modules separately then combining them to form a solution.

- **top-down design** or "stepwise refinement" is the process of partitioning a problem into subproblems that are then attacked with code.
- **pseudocode** refers to the artificial language used to describe algorithms
- a **module** is a complete and independent part of a program.
- **modular programming** is the process of sub-program development versus working on it as a whole.
- **modular language** is a language used in modular programming.

1.2.8. purpose of prototypes to demonstrate the proposed system

a **prototype** is a preliminary version (either working or non-working) of the final product.

- it provides enough to attract stakeholders and give them a grasp of the software, allowing them to provide feedback and/or comments early on.

1.2.9. the importance of iteration during the design process

iteration is the repetition of a set of instructions until the operations yield a desired result. It allows the steady improvement of the design through adding and/or removing features in every round of repetition.

1.2.10. possible consequences of failing to involve the end user in the design process

the failure to include stakeholders in the design process could result in discordances between the client's needs and the resulting software.

1.2.11. social and ethical issues associated with introduction of new IT systems

social disturbances such as job displacement, dissociation with reality, addiction, pressure, rapid change, can all affect the introduction of a new system and call to mind the ethics of the situation.

human interaction with the system

1.2.12. usability

accessibility refers to the potential of a product to serve and meet the needs of as many people as possible. **usability,** on the other hand, refers to the potential of a product to accomplish user goals. **ergonomics** refers to the design of safe and comfortable products specifically for people.

1.2.13. usability problems with commonly used digital devices

- **complexity/simplicity** is the amount of effort required to get a result
- **effectiveness** is the comparison of user performance against a baseline
- **efficiency** is the amount of time it takes to complete a task
- **error** is the mistakes in the program

- **learnability** is the time used to accomplish tasks on the first use
- **memorability** is the amount of steps taken upon return to the device
- **readability** is the comprehensibility of the text (reading speed)
- **satisfaction** refers to the user attitude after interaction with the software

1.2.14. methods that can be used to improve the accessibility of systems

disability	**input methods**	**output methods**
visual impairment	braille inputs, speech recognition	text-to-speech, screen readers, color changes, magnifiers
hearing and speech	n/a	subtitles, visual effects
cognitive problems	multi-sensory experiences, strong interactions, personalized instructions, visual processors	n/a
mobility impairments	specialized hardware (handed keyboards, pointing devices, track balls, SNP)	n/a

1.2.15. range of usability problems that can occur in a system

it is of value that a website and/or system states everything clearly, offers proper usability, quality interfaces, is readable, simple to navigate, etc.

1.2.16. moral, ethical, social, economic, and environmental implications of the interactions between humans and machines.

- advances in AI could lead to unpredictable situations where there is no human control
- manipulation of digital information that leads to fake news and/or fooled senses
- I.T. has increased the amount of printed paper due to manuals
- the digital divide still exists across nations, resulting in inequality and reduced opportunities.

LESSON 2

COMPUTER ORGANIZATION

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computer architecture

2.1.1.-2.1.3. the central processing unit and its elements, RAM and ROM, caches

computer systems follow the concept of input, process, output, and storage model. a computer system accepts data or instructions as input from an input device, processes the instructions, then outputs it through information and saves it to the storage.

data is processed by the **central processing unit (CPU),** which is a hardware component that can perform basic arithmetic, logical, and input/output operations. it is the "brain" of the computer system, and is comprised of the…

- **control unit (CU)**, which is responsible for the operation of the CPU and controls the retrieval of instructions and sequence of their execution from the primary memory. to do this, it is comprised of **registers.**
    - these **registers** are small storage locations that hold data. the basic registers in the CU are the MAR and MDR.
        - the **mar** or **memory address register** holds the address of the data to be used by the ALU and the location of the storage of the output. this register is connected to the RAM through the **memory address bus**.
        - the **mdr** or **memory data register** holds the data to be used by the ALU, which is loaded from the information in the mar. this register is connected to the RAM through the **data bus**.
            - the **memory address bus** and **data bus** serve as the transportation of data from the RAM in the primary memory to the CU in the CPU.
- **arithmetic logic unit (ALU)**, which performs the aforementioned arithmetic, logical, and input/output operations.

storage outside of the CPU is made of the **random access memory (ram)** and the **read only memory (rom)**.

- the **random access memory (RAM)** stores the instructions and any immediate data. each piece of information is attributed to a specific address which the MAR uses to retrieve the information and the content. RAM is easily rewritten and is volatile, which means that the contents are lost when the power is lost. it has two forms:
    - **dynamic RAM (DRAM)**
    - **static RAM (SRAM)** is faster but more expensive than DRAM, so the latter is preferred for computers. however, a smaller set of SRAM called the **cache** is placed in between the CPU and the primary memory. it holds the information that is most frequently used so that the slower main memory can be accessed less. there are two caches: **L1** (on the CPU) and **L2** (on primary memory).

- the **read only memory (ROM)** also holds instructions and data, but unlike the RAM, they cannot be rewritten. data in the ROM is full of permanent instructions that are used to boot the computer.

2.1.4. the machine instruction cycle

step	explanation	component
fetch instructions from primary memory to control unit	CPU is responsible for knowing which instructions are needed to process a certain piece of data	the MAR and MDR is sent through the Memory Address Bus and Data Bus
decode instructions in the control unit	data from the MDR is read and broken down.	CU
execute instructions	instructions are executed by the CU once all necessary data has been retrieved	ALU / CPU
store of result of execution and next instruction	the result is forwarded as an output and is stored in the primary memory.	CPU

secondary memory

2.1.5. persistent storage and secondary memory

secondary memory, also called secondary or auxiliary storage, is a slow memory that can be written to (like RAM) but is non-volatile. it also has a relatively high capacity to hold data compared to the primary memory, and serves as the persistent storage.

operating and application systems

2.1.6. functions of an operating system

an operating system (OS) is a set of software programs controls the computer's hardware resources and provides services for computer programs. it serves as the intermediary between the software and the hardware.

the **roles of an operating system** include:

- **peripheral communication**, which is the communication of the OS with hardware devices outside of the CPU like mouses, keyboards, printers.
- **memory management**, which is the assignment of the transfer and storage of memory used by applications to ensure that there is no overlap.
- **resource monitoring and multitasking,** which is the efficient allocation of resources to ensure that applications run effectively.
- **networking**, which refers to how the OS manages connections to and interactions with networks of other computer systems to share resources. it also serves as the intermediary between applications and networks in a straightforward manner.
- **disk access and management** is the ability to access and store data in disks.
- **security** is the protection offered by the OS through authentication.

2.1.7. software applications

application softwares are programs designed for the end-user to be able to complete various tasks efficiently and effectively. these include...

- **word processors** applications used for the production of any document.
- **spreadsheets** are used to organize and analyze as data through cells
- **database management systems** provides users with an interface to interact with a ***database***, which is an organized collection of data.
- **web browsers** are applications used to access, retrieve, and present content on the world wide web.
- **email** allows users to exchange digital messages with other parties.
- **computer aided design (CAD)** is used by engineers to create, analyze, and modify a design and increase its quality.
- **graphic processing software** allows the user to manipulate visual images on a computer.

2.1.8. common features of applications

apps include a **graphical user interface (GUI)** that allows users to interact with them in a number of ways efficiently versus a **command line processor (CLI)** which requires commands to be typed in. these include:

- **toolbars** contain buttons, icons, menus, and other elements.
- **menus** contain a list of commands that can be chosen from
- **dialogue boxes** communicate information with the user and allow them to respond by choosing an option.

they are described through the acronym **WIMP**: **windows, icons, menus, pointers.**

binary representation

2.1.9. bit, byte, binary, decimal, and hex

bits (b) are binary digits that serve as the basic unit of information in computer systems and can only take the form of either 1 or 0. sequences of **8 bits** form a **byte (B)**.

the **decimal** number system is a positional system that uses 10 digits to represent a number. +/- signs indicate if it is larger or smaller than 0 (Base-10).

the **binary** number system is a positional system that uses 2 digits to represent a number. it is most widely used in computer science (Base-2).

- **two's complement** is used to represent signed binary numbers.

the **hexadecimal** number system is a positional system that uses 16 digits to represent a number (Base-16), from 0-9 then A-F.

2.1.10. data representation

integers are represented by binary numbers (in an 8-bit store) from 0-255 for a total of 256 (2^8) numbers. if the msb (most significant bit) is used in signifying positivity or negativity, only -127 to +127 can be represented (2^7).

characters are typically represented through the American Standard Code for Information Interchange (ASCII), which is a character encoding scheme based on the alphabet, representing each character with 7 bits for a total of 128 representations.

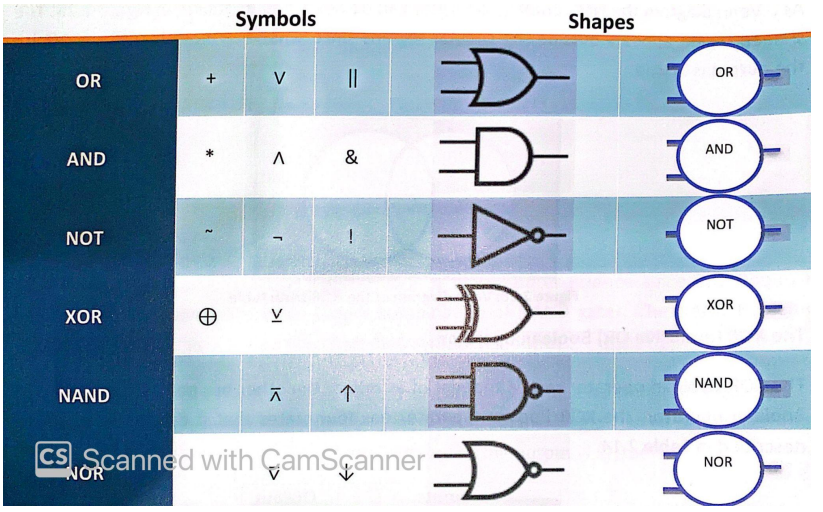
strings are sequences of characters. The UTF-8 (unicode) scheme entails that each character is represented by 8 bits.

colors are used to represent information through pixels, typically through hexadecimal characters 000000 to FFFFFF (for a total of 256 raised to 3 colors).

simple logic gates

2.1.11. boolean operators

operator	condition	
and both conditions are fulfilled as true.	1	1
or at least one condition is true.	1	0
	0	1
	1	1
not	reverses the existing condition.	
nand "not and"— false when both are true.	0	0
	1	0
	0	1
nor "not or"— false when at least one is true	0	0
xor "exclusive or" — one or the other is true	1	0
	0	1



2.1.12. truth tables using boolean operators

symbols of note:

- [•], [Λ], and [*] represent an 'and'
- [+], [V], and [||] represent an 'or'
- a bar over, a [‾], and [!] represent a 'not'
- [⊕] represents 'xor'
- [⊼] and [↑] represent 'nand' (not and)
- [⊽] and [↓] represent 'nor' (not or)

tips to construct truth tables and statements:

1. start with the truth table on every condition
2. extract the conditions where final output is true
3. develop the truth statement based on the conditions that output true.

for example:

an alarm system has 3 inputs: q, w, and r, and one output i. if q is false, r = i. if q is true, w = i.

q	w	r	i
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

therefore: Q’•W’•R + Q’•W•R + Q•W•R’ + Q•W•R

LESSON 3

NETWORKS

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network fundamentals

3.1.1. different types of networks

networks are comprised of two or more computer systems that are interconnected and can communicate and exchange data.

a **server** is a system or an application that provides a service to the other connected systems.
a **client** is a system or an application that requests a service from the server.

a **hub** is the connection point for devices on a single network through ethernet cables attached to the ports. sends data to all connected devices.

a **switch** is a connection point for devices on a single network, however, it is capable of determining which device needs the given data.

a **router** is used to join multiple networks and serves as an intermediary for data to be exchanged efficiently.

types of networks:

- the **local area network (LAN)** connects computer systems within a limited geographical area. characterized by high data transfer rates, sharing of peripheral devices, and exchange of data. connected via hub/switch.
- the **wireless local area network (WLAN)** functions similarly to a LAN except the connections are completely wireless.
- the **virtual local area network (VLAN)** is a LAN segmented into logical separate networks that cannot access one another except through t he main hub/switch and router.
- the **wide area network (WAN)** is a network that covers a large geographical area. it is typically consisted of LANS connected together.
- the **storage area network (SAN)** is a network designed to cater to large storage devices that can be accessible to other networks.
- the **intranet** is a collection of private computer networks that utilizes standards/protocols. essentially a private internet.
- the **internet** is a global WAN that is decentralized and provides various services, one of which being the world wide web (www).
- the **internet of things (IoT)** is the network of individual devices that connect to the internet. these carry hardware and software data and are assigned an IP address.
- the **extranet** is a network that utilizes the internet to control access to a WAN or LAN.
- the **personal area network (PAN)** is the network that connects devices centered around an individual person's workplace. a LAN that supports only one person.

- the **peer-to-peer (P2P)** network is a decentralized network where connected devices are both client and server simultaneously
- a **virtual private network (VPN)** is a network that connects two or more computer systems like a LAN or WLAN, but it also allows clients to connect to the LAN or WLAN from remote locations and appear physically present in the LAN.

3.1.4. technology required to provide a VPN

a vpn makes a tunneled network connection through the public networks and connect directly to a network.

VPN technologies

hardware and software requirements:

- internet access
- VPN software (client/utilities and server)
- VPN routers
- VPN appliances
- VPN concentrator (handles large amounts of VPN tunnels)
- VPN servers

secure VPN

- all traffic is encrypted and authenticated before transported.
- IPSec or internet protocol security protocol functions in both transport and tunnel mode.
- secure sockets layer (SSL) or transport layer security (TLS) employ encryption of information.

trusted VPN

- traffic on the VPN is reliant on the provider's network for security and protection
- layer 2 VPNs and layer 3 VPNS

hybrid VPNs combine trusted and secure VPNs.

common VPN types

- **site-to-site VPNs** connect entire networks and facilitate data change.
- **remote access VPNs** connect individual hosts to the private networks.

3.1.5. use of a VPN

- easier communication / provides secure connections / decreases traditional costs / extends connections / flexibility for remote working / global networking

3.1.3. networks, communication, and layers

an application goes through different layers to send data between systems. data packets go through different layers with different protocols before being reassembled at the other application.

the **open systems interconnection (OSI) model** was established by the international standards organization and aims to facilitate communication across a variety of systems.

1. **physical**- e.g. cabling system components
2. **data link**- e.g. network interface card (nic)
3. **network**- routing
4. **transport**- transmission-error detection
5. **session**- retransmission of data if not received by device
6. **presentation**- encryption and decryption of message for security
7. **application**- the end-receiver application, e.g. e-mail

TCP/IP (transfer control protocol/internet control protocol) is a protocol model that describes all the functions that take place in each layer within the suite. it is a hierarchical model that represents all of the required functionalities to ensure successful communication.

1. application (OSI 5-7)
2. internet (OSI 3)
3. transport (OSI 4)
4. network access (OSI 1-2)

3.1.2. importance of standards in the construction of networks

standards describe the common ground that hardware and software manufacturers must depend on when building systems to ensure that they can communicate with one another. as such, they provide a common international language for users worldwide.

data transmission

3.1.7. the necessity of protocols

protocols are rules of communication across networks, such as:

- having an identified sender and receiver
- having a defined medium of communication
- common language and grammar
- a specific message format
- the presence of intermediary devices
- error detection and correction
- data compression
- recovery and resending.

additionally, protocols provide data integrity, source integrity, flow control, congestion management, deadlock prevention, and error checking and correction.

3.1.6. & 3.1.11 data packets & packet switching

a **data packet** is a unit of data made into a single package that travels along a given network path.

the **datagram** is the basic transfer unit that
packet switching refers to the communication method where data are grouped into packets and transported along a network. there are two methods:

- **datagram packet switching** is when each data packet contains the designated address and their order and is sent individually along the network to the destination, where it is reassembled.
- **virtual circuit packet switching**, also referred to simply as circuit switching, is when a route of transmission of data is predetermined and data is sent together.

3.1.8. speed of data transmission across a network

bits per second (bps) is used to measure data transfer.

bandwidth refers to the theoretical speed of data in a medium. the actual transfer rate is called **throughput**. the measure of the transfer of usable data is **goodput**. a **bottleneck** is the slowest segment of data transfer.

factors affecting the speed of data transmission

- bandwidth, data transfer rate, interferences, malware, capabilities, media differences, network speed and capacity, chosen medium, number users and their demand, file types, authentication and security, packet loss and retransmission, cpu speed, ram catching, overall cpu performance

3.1.9. compression of data

compressed files take up less bandwidth and are faster to send, so files are often compressed. the process of **data compression**, also called bit-rate reduction, reduces the bits of a data packet by encoding the information with fewer bits. there are two forms:

- **lossy compression** is when loss of information is acceptable and unavoidable.
- **lossless compression** is the reduction of bits through eliminating statistical redundancy, therefore eliminating the possibility of data loss.

3.1.10. characteristics of transmission media

wired communication

1. copper cable (metal conductors) for computer networks
2. coaxial cable: consists of 2 copper conductors
3. unshielded twisted pair cable (utp) for LANs between repeaters. also for telephone networks.
4. shielded twisted pair cable
5. fiber optic cable: optical fiber carries a beam of light. it offers high speeds, enhanced security, and requires less repeaters.

wireless communication

1. microwave radio used for telephone networks and LANs.
2. satellites use microwave signals.
3. infrared used for short distances; requires a line of sight.
4. RFID uses radio technology; requires internal power.
5. Bluetooth uses microwave radio to exchange information.
6. free space optics uses lasers for computer communication.

3.1 (additional section) network topologies

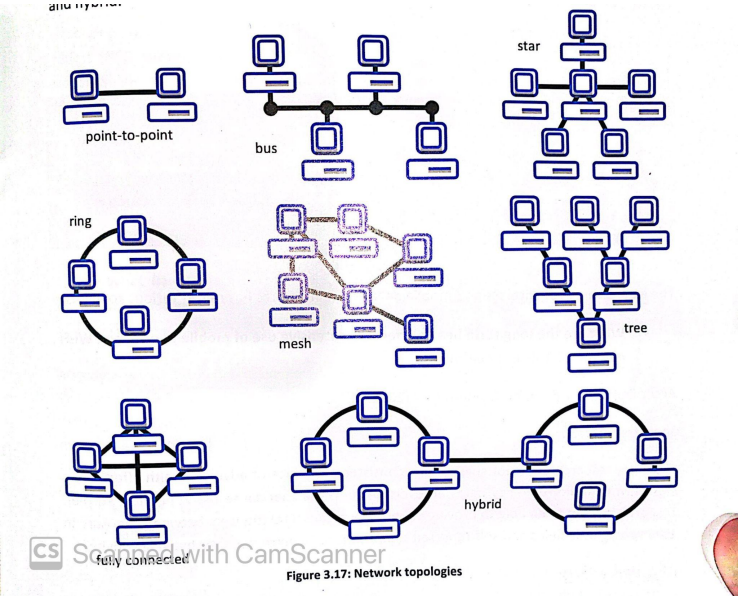


Figure 3.17: Network topologies

wireless networking

3.1.13. hardware and software components

hardware:

- **modems** allow users to connect to the internet.
- **wireless routers** allow wireless connections to an existing network and data transfer between a device and network. also a wireless access point (WAP). typically has jacks for wired devices.
- **wireless network adapters** also known as wiress network interface controller/card (NIC) is required for every device to connect to a network.
- **wireless antennas** that increase the effective communication area of a network.
- **wireless repeaters** boost and/or expand the range of a router.
- **ethernet to WAP / repeater** uses ethernet cables to carry the signal
- **ethernet over power lines** rely on power lines to carry signals.

software:

- **dynamic host configuration protocol (DHCP)** that allows a server to automatically assign an IP address to a client.
- **software firewalls** that determine the data let in and out.
- **name / service set identification (SSID)** that is used to differentiate one WLAN from another.
- the **NIC driver**, which operates the hardware in accordance with the NIC.
- the **operating system (OS)** handles resources and manages all aspects of a CPU that are required for a network
- **security software** to protect data and the network
- **wireless access protocol** is the set of protocols that are designed to specify rules for information access online
- **web browsers** are applications designed to retrieve content from the WWW such as chrome or safari.

3.1.14. characteristics of wireless networks

1G and 2G are the first generation of mobile technology that used analog transmission and digital exchange.

3G is the third generation used widely in telephony, GPS, internet access, and mobile TV.

4G is the fourth generation used for mobile Internet access. it permits high mobility communication through digital telecommunication, with greater capabilities and allowance of multimedia transfers.

LTE or long term evolution is a 4G network that is a standard for high speed wireless data communication for smartphones.

WiMAX or worldwide interoperability for microwave access is a 4G network designed as an alternative to DSL cable. it does not need cables to operate and it can reach across cities and even countries. It allows connectivity even in remote and isolated locations where WiFi cannot reach.

5G is the fifth generation of mobile telecommunications technology that has not been released to the public.

sensor networks are used to measure data and parameters

WiMAX versus LTE	
both 4G technologies	
not compatible with 2G/3G	compatible with 2G/3G
cheaper and more accessible	more expensive
less popular	more widespread; greater speed

3.1.15. methods of network security

encryption is necessary to protect data from unauthorized access; uses complex mathematical algorithms and encryption keys to alter a message into a form that is unreadable for unauthorized individuals.

- **symmetric-key encryption**, also known as single key encryption or secret key encryption, is when the same key is used to encrypt and decrypt the message.
- **public-key encryption** or asymmetric key encryption is when a public key is used for encryption but a private key is used for decryption.

other methods include:

- using passwords and/or two-factot authentication
- installing anti-virus or firewall programs
- disabling SSID broadcast
- blocking specific MAC (medium access control) addresses

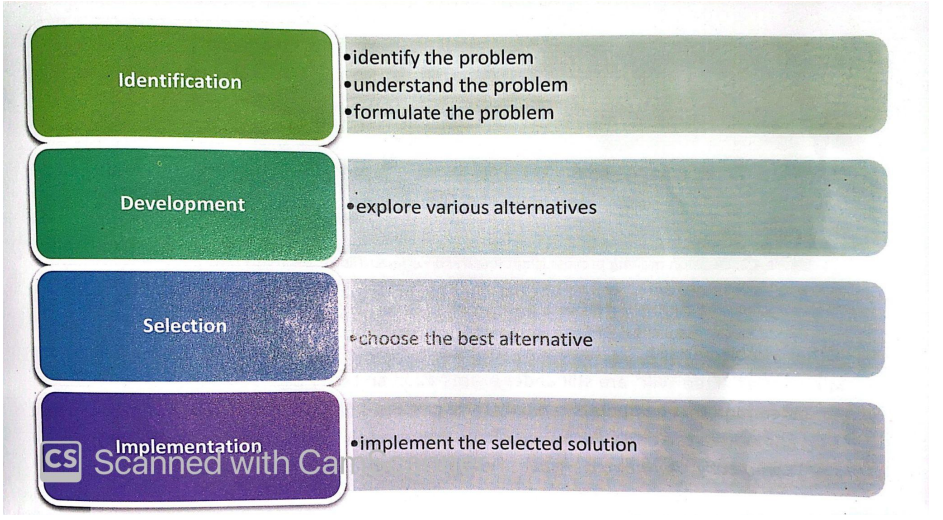
- Wired Equivalent Privacy (WEP) Wireless Security, which is a data encryption technique.
- WPA and WPA2 (WiFi protected access), which are interrim security measures making use of an advanced encryption standard (AES) block cypher which offers stronger encryption.
- Wireless Protected Setup (WPS), also referred to as Quick Security Setup (QSS) is a protocol designed to allow users to securely operate their networks. it requires compatible routers and devices, but it works with legacy systems
    - methods include PIN numbers, push buttons (on the router and client), near field communication (NFC), or usb data transfer methods
- restraining physical access to the hardware that the network operates on, such as a router firewall.

LESSON 4

COMPUTATIONAL THINKING

the concept of a problem

a **problem** is a situation that needs attention to be dealt with or solved. the decision maker framework (seen below) is used to solve problems.



programming refers to the creation of a series of steps to solve a problem.

algorithm

a series of unambiguous instructions designed to solve and achieve a goal in a certain number of steps. it has the following properties:

- **finiteness**; the quality of ending after a reasonable number of of steps.
- **definiteness;** each step is clearly defined
- **input;** where there are initialized quantities
- **output;** the result of the program
- **effectiveness;** its efficiency and simplicity

pseudocode

a language used to help develop programs; it is unspecific to a language and does not follow strict rules of syntax.

4.1. general principles of computational thinking

thinking procedurally

- appropriate when problems are solved through a specific procedure or sequence of steps. there is a specific order of activities that must be followed.
- sometimes, problems can be divided into more digestible sub-problems which result in appropriate sub-procedures. this strategy is also referred to as top-down design or step-wise refinement.

thinking logically

- appropriate when a decision needs to be made to solve a problem. uses logic, truth, and conditions.
- iteration is the process of repeating a series of instructions within an algorithm. it is expressed using "from to loop " and "while loop"

thinking ahead

- identify the inputs and outputs needed in a given solution.
- preplanning refers to the act of considering the problem beforehand to develop a solution.
    - prefetching refers to the act of fetching data before it is needed.
    - a gantt chart is a bar chart named after henry gantt used to plan projects out by blocking certain activities according to the time it takes to complete it.
    - software libraries are libraries of preformed elements that can be incorporated into a solution without hassle.
- pre-conditions and post-conditions are the required states of the systems before and after a given solution for it to be carried out successfully.

thinking concurrently

- the act of considering what aspects of a solution can be implemented at the same time to achieve maximum efficiency.
- requires proper coordination and planning to be successful.

thinking abstractly

- reflecting upon the subject matter from a general point of view removing all unnecessary details to leave only what is essential.

4.2. computational thinking and program design

4.2.1 searching, sorting, and other algorithms

arrays hold multiple data elements of the same type sequentially; they are assigned names and sizes.

- linear arrays are singular arrays.
- parallel arrays are arrays that hold information (with varying data types) about a specific object in the same position.
- arrays of objects are arrays where one element holds references to a specific variable.

sequential search is an array search method where each element is run through sequentially to find a specific element.

binary search is an array search method used for sorted arrays where the elements are divided in half and searched to find a specific element.

bubble sort is an array sorting method that moves through an array repeatedly to swap adjacent elements that are not in order. this process is repeated until the array is in the chosen order.

selection sort is an array sorting method where the array is divided into sorted and unsorted sections. elements in the unsorted section are run through and the smallest/largest element is pushed to the sorted section. the boundary is then adjusted forward, then the process repeats.

4.3. introduction to programming

4.3.1.-2. fundamental and compound operations of a computer

- fundamentally, computers can retrieve, add, store, and compare data.
- any other operations (booleans, complex maths, etc) are considered to be compound.

4.3.3. the essential features of a computer language

- **semantics** refers to the meaning of the constructions in the language. **syntax** refers to the structure of said constructions.
- **grammar** defines the syntax of a language.
- each language (python, java, php) have a unique syntax and language specific vocabulary.

4.3.4. levels of computer languages

- **machine languages** are low-level languages that are computer specific and is the only language that can be understood by a computer.
- **assembly languages** are languages that use mnemonics to provide computers with instructions rather than using binary. an assembler converted mnemonics to machine languages.
- **high level programming languages** are languages that make use of natural language to facilitate programming. it follows abstraction in that non-significant areas to a program are hidden. it allows faster, simpler, and more understandable program development.

4.3.5. translating computer languages

- the source program/code written in a high level language is converted into the object/target program in machine language.
- a **compiler** executes the translation process once and saves the whole source program into the object program. they issue error messages for untranslatable sections.
- an **interpreter** executes the translation process every time a program is run. it interprets the source program line by line.

4.3.6. variable, constant, operator, object

a **variable** is a storage location for a value. they are given names called identifiers, and the data they store can differ.

a **constant** is a specified value in a program that does not change.

an **operator** is used to manipulate variables and constants in accordance with the necessities of the solution.

objects are comprised of data and methods (operations that can be performed).