Information Technology Essentials — Lecture 02

Dr. Karim Lounis

Fall 2023

Computer Systems

What is a system?

Systems

Definition

System. Is a set of components that work together to achieve specific objectives or functions (i.e., provide a service).

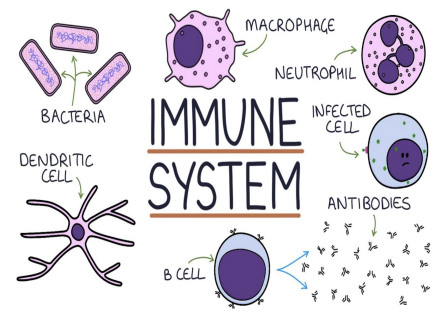
Systems

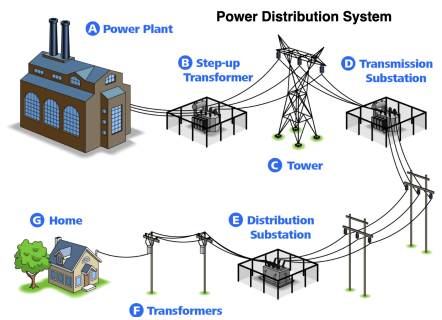
Could you think of real examples of systems?

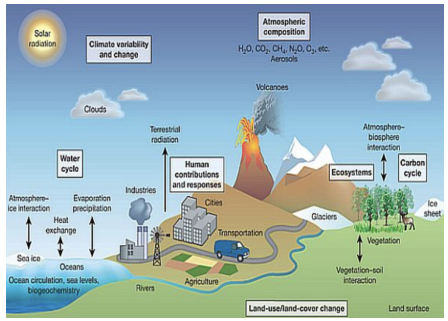
Systems

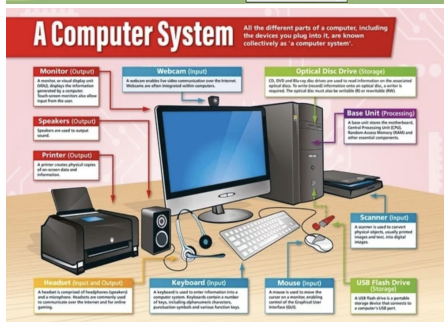
Definition

System. Is a set of components that work together to achieve specific objectives or functions (i.e., provide a service).









What is a computer system?

Computers

Computers

What is a Computer?

Computers

Look at these images and tell what do they have in common.







Computers

Look at these images and tell what do they have in common.





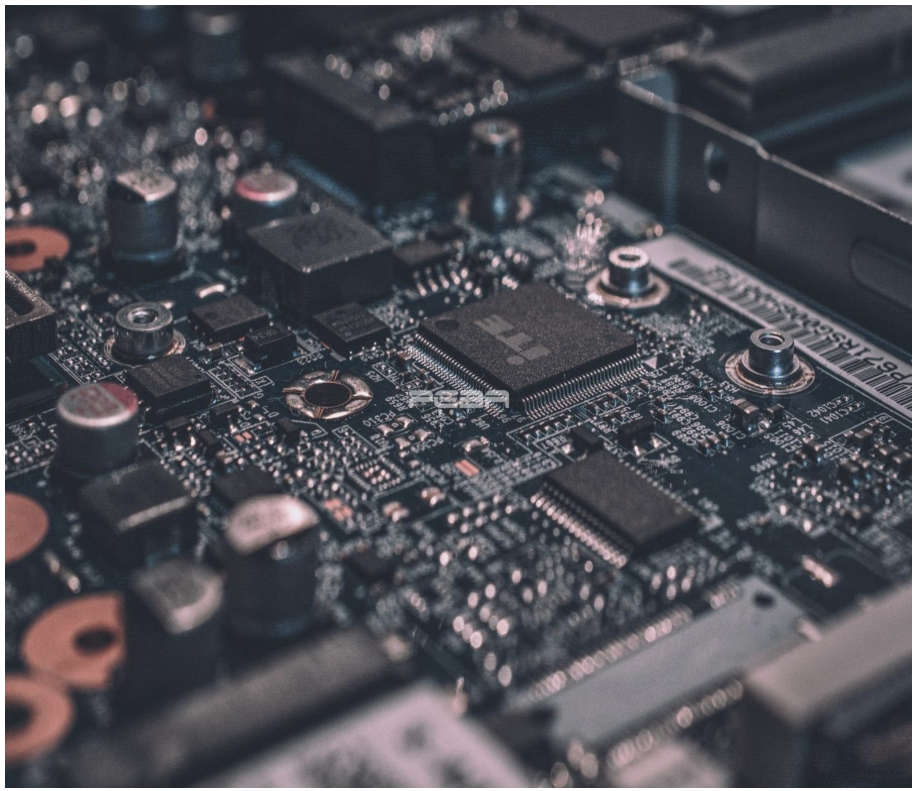


In fact, all these are computers . . . computers are not just laptops and desktops

Computers

Definition

Computer. It is an electronic machine that is designed to automatically compute problems at a very high velocity.



Computers

What Do We Need Computers?

Computers

Why do we need computers?

- Data Processing and Analysis: Computers can analyze large volumes of data quickly and accurately (good for decision-making).
- Automation and Efficiency: Computers automate tasks that would be time-consuming and error-prone if done manually.
- Communication and Connectivity: Computers enable global communicaiton using various tools.
- Innovation and Creativity: Computers provide tools for creative activities, e.g., creating multimedia content.
- Research and Exploration: Computers allow access to a large amount of various information.
- Education and Learning: Computers have revolutionized education by providing access to online learning resources (e.g., virtual classrooms).

And more: entertainment, healthcare, finance, e-commerce, weather prediction, space exploration, agriculture, social-interaction, etc.

Computers

Definition

Computer. It is an electronic machine that is designed to automatically compute problems at a very high velocity.

Let us take a moment and analyze the above definition:

- Eletronic machines: Following the the development of electronics.

  Moore's Law. It is an observation that the number of transistors in an integrated circuit (IC) doubles about every two years.
- Automatic: Reducing human intervention.
- Compute: means, solve problems.
- Problem: A situation or question that requires a solution.

Computers

Definition

Computer. It is an electronic machine that is designed to automatically compute problems at a very high velocity.

- Eletronic machines: Following the the development of electronics.
- Automatic: Reducing human intervention.
- Compute: solve problems.
- Problem: A question that requires a solution.

Also, we may say that a computer decides a problem (decidability).

Computers

Definition

Computer. It is an electronic machine that is designed to automatically compute problems at a very high velocity.

- Eletronic machines: Following the the development of electronics.
- Automatic: Reducing human intervention.
- Compute: solve problems.
- Problem: A question that requires a solution.

Also, we may say that a computer decides a problem (decidability).

Of course, some problems cannot be solved. They are called: undecidable problems.

Computers

Definition

Computer. It is an electronic machine that is designed to automatically compute problems at a very high velocity.

- Eletronic machines: Following the the development of electronics.
- Automatic: Reducing human intervention.
- Compute: solve problems.
- Problem: A question that requires a solution.

How do computers try to solve problems?

Also, we may say that a computer decides a problem (decidability).

Of course, some problems cannot be solved. They are called: undecidable problems.

Computers

To solve a problem using a computer, the following steps are performed:

1. We analyze and understand the problem.
2. We propose a solution to the problem.
3. We write the solution as a set of finite steps, called algorithm.
4. We translate the algorithm into a program by rewriting all the steps using a programming language.
5. Feed the computer with the written program with any required intput.
6. The computer, may use another program to translate the written program into a sequence of instructions — known as machine code.
7. The computer automatically executes the produced machine code and rapidly solves the problem.
8. The computer outputs the results (output).

Computers

To solve a problem using a computer, the following steps are performed:

1. We analyze
2. We propose
3. We write th
4. We translat steps using a pro
5. Feed the cc tput.
6. The compu pro-gram into a
7. The compu e and rapidly solves the problem.
8. The computer outputs the results (output).

Algorithm

خوارزمية

It is a finite sequence of steps to solve a problem.

Muḥammad ibn Musa al-Khwarizmi (780-850)

Computers

To solve a problem using a computer, the following steps are performed:

1. We analyze
2. We propose
3. We write th
4. We translat steps using a pro
5. Feed the cc tput.
6. The compu pro-gram into a
7. The compu e and rapidly solv
8. The computer outputs the results (output).

Algorithm

خوارزمية

Algorithms have characteristiques:

- Finite set of steps.
- Steps are unambiguous.
- Inputs and outputs.
- Termination.
- Feasability.
- Expressed in natural language.

Computers

To solve a problem using a computer, the following steps are performed:

1. We
2. We
3. We
4. We usi

Algorithm Let us solve a problem.

Problem statement 1. Given a list of random natural numbers, we would like to compute their product.

Let us write an algorithm that solves the problem.

5. Feed the computer with the written program with any required intput.
6. The computer, may use another program to translate the written program into a sequence of instructions — known as machine code.
7. The computer automatically executes the produced machine code and rapidly solves the problem.
8. The computer outputs the results (output).

Computers

To solve a problem using a computer, the following steps are performed:

1. We
2. We
3. We
4. We
   usi
5. Fee
6. Th
   gra
7. Th
   rap
8. The computer outputs the results (output).

Algorithm Let us solve a problem:

Algorithm 1

1. Obtain the complete list of those numbers.
2. Take the first number and multiply it with the second number then write down the result.
3. Take the next number on the list and multiply it with the result you wrote down in Step 2.
4. Repeat Step 3 until numbers run out.
5. Announce the final result.

Computers

To solve a problem using a computer, the following steps are performed:

1. We
2. We
3. We
4. We
   usi
5. Fee
6. Th
   gra
7. Th
   rap
8. Th

Algorithm Let us solve a problem:

Algorithm 1

1. Obtain the complete list of those numbers.
2. Take the first number and multiply it with the second number then write down the result.
3. Take the next number on the list and multiply it with the result you wrote down in Step 2.
4. Repeat Step 3 until numbers run out.
5. Announce the final result.

Does this conform to the characteristics of an algorithm?

Computers

To solve a problem using a computer, the following steps are performed:

1. We
2. We
3. We
4. We usi
5. Fee
6. Th gra
7. Th rap
8. The computer outputs the results (output).

Algorithm Let us solve another problem.

Problem statement 2. We want to deliver a parcel (e.g., could be an egg tray) to a customer using a drone.

Let us write an algorithm that solves the problem.

Computers

We do not want this:

Computers

We want something close, or even better than this:

Computers

To solve a problem using a computer, the following steps are performed:

1. We
2. We
3. We
4. We
   usi
5. Fee
6. Th
   gra
7. Th
   rap
8. Th

Algorithm Here is an attempt to solve this (**Algorithm 2**):

1. Obtain the customer location.
2. Check that location is within drone's operational range. Otherwise, cancel delivery and notify customer (go2 Step 9).
3. Load drone with parcel (may need assistance).
4. Take off and fly to customer location.
5. Use drone's sensors to avoid collisions during flight.
6. Inform customer that drone is approaching destination.
7. Gently release the parcel using parachute at a safe spot.
8. Confirm successful delivery with the customer. If successful delivery is confirmed, return to store. Otherwise, ...
9. Announce delivery status to the customer service.

Computers

To solve a problem using a computer, the following steps are performed:

1. We
2. We
3. We
4. We usi
5. Fee
6. Th gra
7. Th rap
8. Th

Algorithm Let us solve another problem.

Problem statement 3. Salim wants to send some confidential documents to Ali in a locked box without sharing the key for his lock with Ali. Also, the postman will not be able to open the box.

Let us write an algorithm that solves the problem.

The box should not be broken or destroyed.

Computers

Algorithm Here is an attempt to solve this (**Algorithm 3**):

1. Put confidential documents in box then lock the box.
2. Send box to Ali.
3. Postman collects the box and transports it to Ali.
4. When Ali receives the box, he locks it again with his lock.
5. Send the box to Salim.
6. Postman collects the box and transports it to Salim.
7. When Salim receives the box, he removes his lock from the box.
8. Send box to Ali.
9. Postman collects the box and transports it to Ali.
10. When Ali receives the box, he removes his lock from the box.
11. Ali opens the box and collects the documents.

Computers

To solve a problem using a computer, the following steps are performed:

1. W
2. W
3. W
4. W
   us
5. Fe
6. Tl
   gr
7. Tl
   ra
8. The computer outputs the results (output).

Algorithms, Decidability, & Undecidability:

In theoritical computer science, **decidability** looks at whether a problem can be solved using an algorithm or not.

I.e., given a problem, if you can find an algorithm that can solve that problem for whatever input (and will always terminate — halt), then the problem is **decidable** — or **computable**.

Undecidable problems are those problems for which we cannot construct an algorithm to solve the problem in finite time.

Example: The halting problem.

Computers

To solve a problem using a computer, the following steps are performed:

1. W
2. W
3. W
4. W
   us
5. Fe
6. Tl
   gr
7. Tl
   rapidly solves the problem.
8. The computer outputs the results (output).

Algorithms & Complexity:

Complexity studies the difficulty of solving comptational problems by looking at their solvability, requirements (space and time), efficiency, and classification.

Space complexity looks at how much memory I need to solve the problem, whereas **time complexity** looks at how much time I need to solve the problem (focusing on wost case scenario).

Big-$\mathcal{O}$ notation: $\mathcal{O}(1)$, $\mathcal{O}(log(n))$, $\mathcal{O}(\sqrt{n})$, $\mathcal{O}(n)$, $\mathcal{O}(n \cdot log(n))$, $\mathcal{O}(n^2)$, $\mathcal{O}(n^3)$, ..., $\mathcal{O}(2^n)$, and $\mathcal{O}(n!)$.

Computers

To solve a problem using a computer, the following steps are performed:

1. We
2. We
3. We
4. We
   usi
5. Fee
6. Th
   gra
7. Th
   rap
8. Th

Algorithm Let us solve another problem.

Problem statement 4. We want to display the numbers from 1 to 100, but for muliples of 3, print "EN" instead of the number, for multiples of 5, print "SIA", and for the numbers that are multiples of both 3 and 5, print "ENSIA".

Let us write an algorithm that solves the problem. For consistency, let us use the following algorithm template:

Input: ...

Body: ...

Output: ...

- End.