ENS1161 Computer Fundamentals

Module 1
Introduction

Unit Learning Outcomes

On completion of this unit, students should be able to:

- Describe the fundamental architecture and operating principles of a computer system.
- Interpret computer system specifications and standards and how they relate to system function.
- Compare different types of components and subsystems and their relative impacts on system function and perf
- Make recommendations on the suitability of computer systems and components for a given function.
- Explain the interconnection between the software and hardware components of computer systems, and the processes involved in making them work together.

Module Objectives

On completion of this module, students should be able to:

- Describe the basic components of a computer system
- Give an overview of the evolution of computers
- Discuss current trends in computer technology
- Explain what this unit covers and why it is relevant to their future careers

Introduction

- **Topics Covered**
  - The components of a basic computer system
  - Overview of how a computer works
  - Brief history of computers
  - Unit structure and assessments

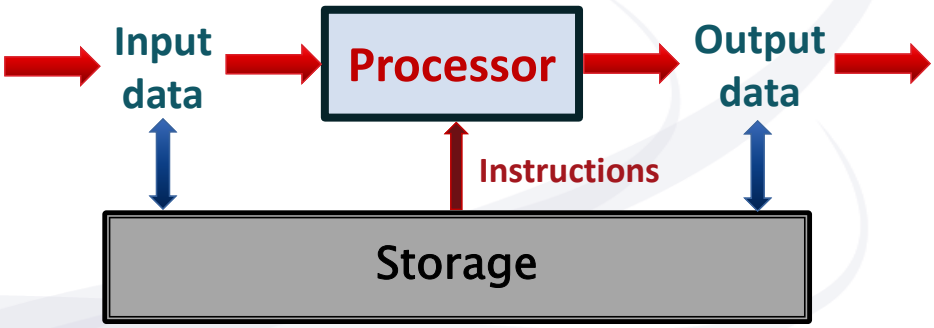
What is a system?

- **System:** a set of things working together as parts of a complex whole
  - Normally to perform some function(s)
  - May be composed of many sub-systems



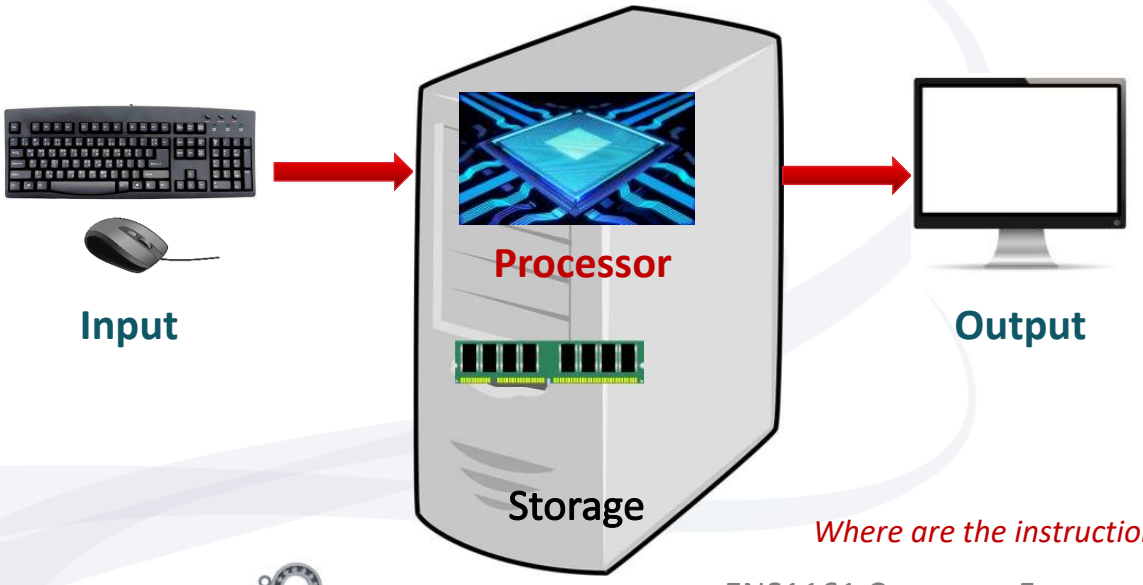
Basic Computer System

- A computer is essentially a system that takes input data and processes it to produce output data



- Storage is used to hold the data and instructions for the processor

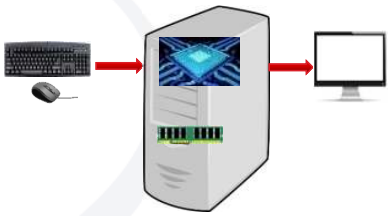
Basic Computer System



Where are the instructions?

Some Terminology

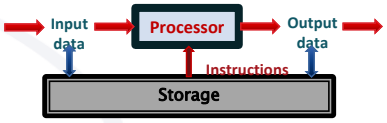
- **Hardware**
  - The physical components of a computer system
    - E.g. processor, keyboard, screen, RAM, hard drive
    - Things you can touch – hence 'hard'



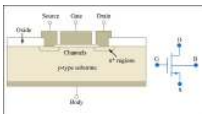
- **Software**
  - The instructions that tell the processor what to do (programs)
    - Logical, not physical – hence 'soft'
    - Reside in storage devices

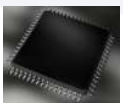
- **Firmware**
  - Special software that is 'fixed' in hardware
    - E.g. BIOS (*software*) in ROM (*hardware*)

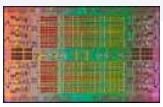
What is a processor?



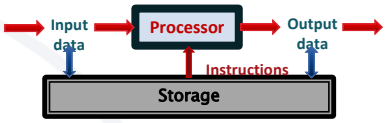
- Also called Central Processing Unit (CPU)
- The 'brains' of the computer
- Fundamentally: a programmable logic device
  - At simplest level - can turn electrical signals on or off according to pre-specified conditions (like a switch)
  - Made up of lots of tiny electronic switches (transistors) connected together
- Used as a data processor
- Or applied to process control or system automation tasks
  - *How they work covered in more detail in Modules 2, 3 and 4*



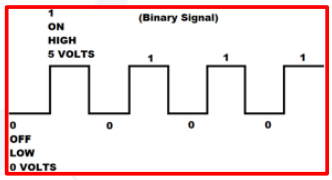




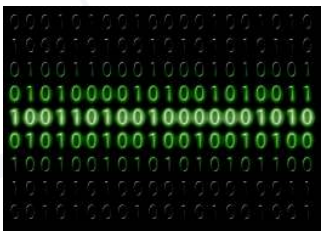
Data & Instructions



- Computer systems are digital systems
  - All **data** and **instructions** are in the form of binary signals
    - signals that have only two possible values
      - **1** or **0**
      - HIGH or LOW
      - ON or OFF

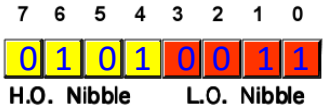


- These digital signals may be used to represent:
  - one bit of a binary number
  - one bit of a binary code
    - ASCII,BCD, instruction code, …
  - a control signal state, etc.



Computer Data

- ***Bit*** : **Bi**nary digi**t**
  - a 0 or a 1
  - most basic signal in a computer system
- ***Byte*** : a group of 8 bits
  - Basic unit of data / memory space
- ***Word*** (or word length) : number of bits the processor is able to recognise and process at a time
  - a 16-bit processor has a word length of 2 bytes
- ***Nibble*** : refers to a group of 4 bits
  - 1 byte = 2 nibbles



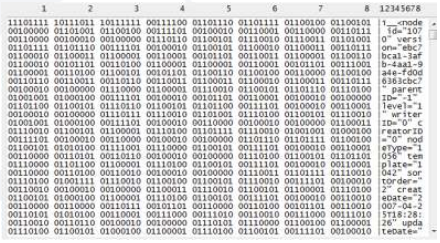
Data & Instructions

- Bytes stored in the memory unit of a computer can represent a number of different things:
  - Binary numerical data
  - Coded data (text, images, sound, video, etc)
  - Instruction codes
  - Operand or program branching addresses

Primarily input and output data

Related to program instructions

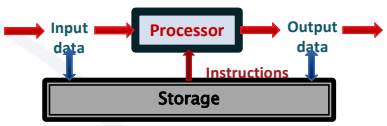
- Difference lies only in context
  - How it is used / interpreted
- Else they cannot be differentiated
  - Just a bunch of bits



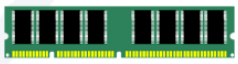
Instruction set and programs

- Instruction: binary code interpreted by the CPU to perform an action
- Every processor has its own set of instructions (its instruction set)
- A program is a series of instructions in binary that the processor can read and interpret
- Difficult for humans to write programs in 1s and 0s, so programs are written in more 'human-like' programming languages
  - E.g. assembler, C, Java, Python
- These programs are translated to binary using other programs
  - Assemblers, compilers
  - *More on this in Module 5*

Storage

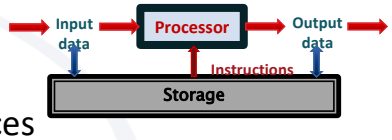


- Components used to 'hold' the binary data
  - The hardware used to store the software
- **Primary memory/storage**
  - Memory directly accessible by the processor
    - E.g. RAM, ROM, cache memory
    - Fast access, but normally *volatile*
      - Data disappears when power goes off



- **Secondary storage**
  - Devices that can store data more permanently (even when power off)
  - E.g. hard disk, flash drive, CD/DVD, etc.
  - *Storage devices are covered in more detail in Module 6*

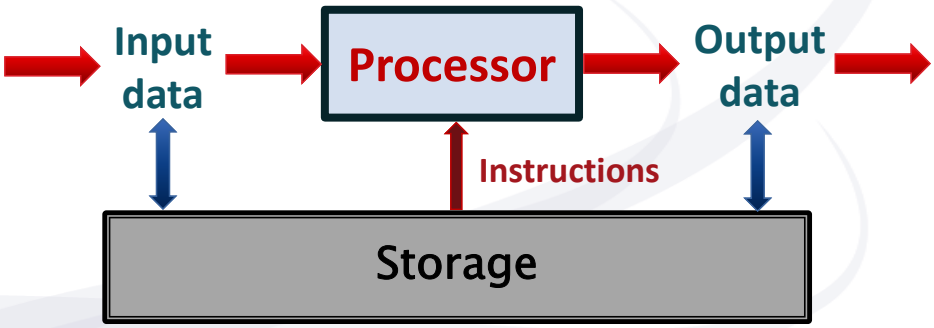
Input/Output devices



- Input/output (I/O) devices are the (hardware) devices that transfer data to and from the main processor
  - E.g. keyboard, mouse, screen, printer, secondary storage, etc.
- Need some method of transferring data to/from processor and to coordinate such transfers
- There are different standards and protocols to allow this to happen seamlessly
  - physical connections, signal voltages and timing, data formats, handshaking protocols
- *Covered in more detail in Modules 7 & 8*

Basic Computer System

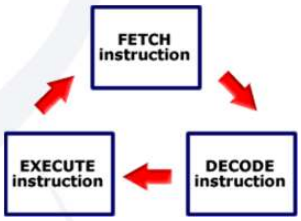
- A computer is essentially a system that takes input data and processes it to produce output data



- Storage is used to hold the data and instructions for the processor

How a Processor works

- A processor needs a set of instructions
  - tells it what operations to perform on what data
- Instructions (programs) are stored in memory
- The microprocessor:
  - *fetches* an instruction from memory
  - *decodes* it, and
  - *executes* the specified operation



- Sequence of *fetch*, *decode* and *execute* continues indefinitely
  - Until reach an instruction to stop or powered off
  - *Covered in more detail in Modules 2 and 3*

Types of software

- 2 broad categories:
  - **Operating system**
    - Main function is to control the hardware and enable other software to interface with the hardware
    - Also acts as 'control program' for other applications
      - e.g. Windows, macOS, Android
  - **Application software**
    - Designed to perform a certain type of function
      - E.g. wordprocessor, browser, spreadsheet, etc.
  - *Operating systems covered in more detail in Module 9*

Networks and the Internet

- Networks are communication channels that allow computers to share information
  - *Local Area Networks* (LANs) connect computers in relatively close proximity (within a building or site)
  - *Wide Area Networks* (WANs) cover greater geographical distance
- Today almost all computers connect to a global network of networks – the **Internet**
- *Covered in more detail in Module 10*

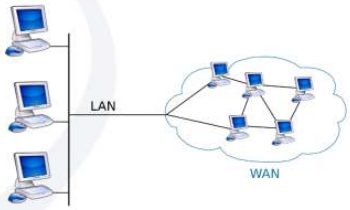


Image: Harald Mühlböck, 2011
https://commons.wikimedia.org/wiki/File:LAN_WAN_scheme.svg

Image: Bastenbas, 2014
https://commons.wikimedia.org/wiki/File:R%C3%A9pr%C3%A9sentation_d%27internet.jpg

Categories of computers

- **Embedded computers**
  - Integrated into a larger device or system to monitor and control
  - Used for a specific purpose rather than general processing
    - E.g. in appliances, phones, cars, etc.
- **Personal computers**
  - General purpose computers for a single user
    - E.g. Desktop, laptop, notebook computers
- **Servers and Enterprise Systems**
  - Larger computers meant to be shared by many users
    - E.g. application servers, database servers
- **Supercomputers and Grid Computers**
  - Highest performance, used for highly demanding computation
    - E.g. weather forecasting, complex design simulations

(Hamacher et al, 2012)

General purpose vs embedded systems

- **General purpose computers**
  - Designed to be used for a variety of applications
    - E.g. word processing, presentation, simulation, entertainment
  - Based on general purpose processor chips
  - 'Normal' computer

- **Embedded systems**
  - Integrated into a larger device or system to perform a specific function
  - Generally use single chip integrated microcontroller devices
  - Used to provide the 'smarts' in a range of appliances and products
    - E.g. microwaves, air-conditioners, TVs, cars, phones, routers
  - General purpose computers use these special purpose processors for subsystems
    - E.g. graphics coprocessor, DMA controller, keyboard controller

- Both have same general architecture and principles of operation

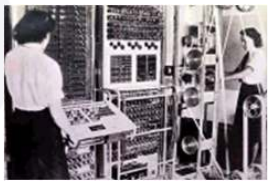
More in Module 11

Brief History of Computers

- **Pioneers**
  - **1642** – Blaise Pascal invents the first operational calculating machine
    - Capable of performing basic addition and subtraction
  - **1832** – Charles Babbage invents the first "computer": the analytical engine
    - never built, but his precursor invention, the difference engine, has been
  - **1945** – John Von Neumann defines the basic elements of the stored program computer
    - A memory containing both data and instructions
    - A calculating unit (arithmetic and logical operations)
    - A control unit (to interpret program instructions)

Brief History of Computers

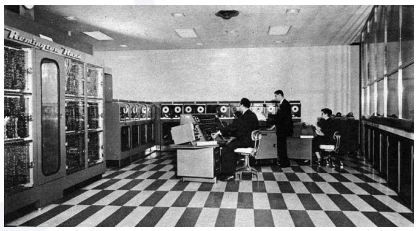
- **First Electronic Computers**
  - **1943** – Colossus installed at Bletchley Park
    - Used to help decipher messages encrypted using the Lorenz cipher machine
    - The first totally electronic computing device



  - **1945** – ENIAC (Electronic Numerical Integrator and Computer)
    - The first electronic general purpose computer, 30 tonnes, 60 kW, 80 bytes of memory
    - Used vacuum tubes
    - Led to Von Neumann's development of a computer design where programs and working data are both stored in a single unified store

Brief History of Computers

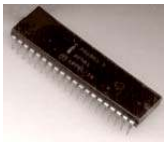
- **Early commercial computers**
  - **1951** – Univac 1
    - First unit delivered to United States Census Bureau
    - Used 5,200 vacuum tubes, weighed 7.6 tonnes, consumed 125 kW
    - Process 11-digit numbers, half a second to do one addition
    - Eventually 46 Univac 1s sold at more than $1 million each



  - **1961** – PDP-1
    - 2,700 transistors and 3,000 diodes, made into 'blocks' of 19-inch racks
    - Weighed about 730 kg
    - Cathode ray tube graphic display, paper tape input/output
    - Needed no air conditioning and required only one operator
    - Used to write the first computerized video game, *SpaceWar!*

Brief History of Computers

- **Microprocessor Genesis**
  - **1971** - Intel 4004
    - first general-purpose microprocessor
      - A microprocessor integrates the whole function of a CPU into 1 (or a few) integrated circuit (IC) chips
    - The 4004 housed 2300 transistors on a 3mm × 4mm die
    - First used in the manufacture of calculators
  - **1974** - Intel 8080
    - An 8-bit microprocessor 20 times faster than the 4004
    - contained twice as many transistors (5000)
    - a technological milestone, used in a wide variety of products
    - most notable as the processor in the first kit computer, the Altair
      - ignited the personal (micro) computing phenomenon



Brief History of Computers

- **Personal Computers**
  - **1981** – the first IBM PC
    - Used the 8088 - a budget version of the 8086 16-bit microprocessor
      - 8-bit rather than a full 16-bit external data bus
    - could access up to 256 kb memory (standard:16kb)
    - Ran off floppy drives
  - **1984** – Apple Macintosh
    - first mass-market personal computer that featured a graphical user interface, built-in screen and mouse
    - found success in education and desktop publishing despite being expensive
    - Based on Motorola 68000 processor with 128kb RAM

Brief History of Computers

- **Portable Computers**
  - **1983** – Compaq Portable
    - Single or dual 360kb floppy drives
    - Folded into a luggable case the size of a sewing machine
    - Weighed about 13 kg

  - **1991** – Apple Powerbook 100 series
    - Featured a built-in trackball, internal floppy drive, and palm rests
    - Monochrome screen
    - Set the standard form for laptops for years
    - Weighed about 2.5 kg

Brief History of Computers

- **Computers in phones**
  - **1994** – IBM Simon
    - Handheld touchscreen Personal Digital Assistant (PDA)
    - Cellular phone could also send and receive faxes and emails
    - Applications/features included calendar, appointment scheduler, calculator, electronic notepad and handwritten annotations
    - 'Brick' form that weighed 0.5 kg

  - **2007** – iPhone
    - A combination of web browser, music player and cell phone
    - Could download new functionality in the form of "apps"
    - 128 MB DRAM and 4 / 8 / 16 GB flash memory
    - Weight: 135 g

Brief History of Computers

- **Wearable computers**
  - **2014** – Google Glass
    - smart glasses - an optical head-mounted display designed in the shape of a pair of eyeglasses.
    - Works with voice recognition, and has built in GPS, camera and speakers
    - Has had limited success

Antonio Zugaldia (https://commons.wikimedia.org/wiki/File:Google_Glass_detail.jpg), „Google Glass detail", https://creativecommons.org/licenses/by/2.0/legalcode

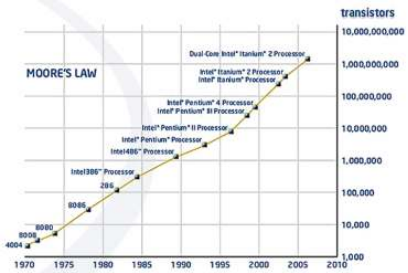
  - **2015** – Apple Watch
    - Functions as watch, health monitor, music playback device
    - Initial versions had to be paired with iPhone for certain functions
    - Newer versions have GPS and cellular (phone) capability

Internet of Things

- A system of computing devices connected together via the Internet
- Consists of sensors, actuators and various other systems
- Enables us to various things such as:
  - Control appliances such as air-conditioners and ovens using our mobile phones
  - Monitor security systems remotely
  - 'Smart' buildings that can adjust lighting, heating and cooling based on internal conditions
  - Find the best route based on current traffic conditions

More in Module 11

General trends



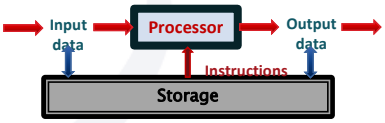
- Computers have been shrinking in physical size
  - Due to advances in electronics
- Computing power has grown exponentially
  - The speed and amount of data that can be processed
- The cost of computers has (generally) dropped
- The number computers / computing devices has grown exponentially
- The amount of data being produced has grown exponentially
- The cost of storage has dropped dramatically
- Connectivity (ability to communicate) between computers is a key factor
- All of the above have made computers disrupt how we work and play

Intel Processor History

- Attached doc

Basic principles

- Computer technology has been evolving at a tremendous rate
- However, the basic principles remain the same
  - with a few exceptions



- This unit will cover these basic principles and concepts that underpin computers and other computing technology

Unit Learning Outcomes

On completion of this unit, students should be able to:

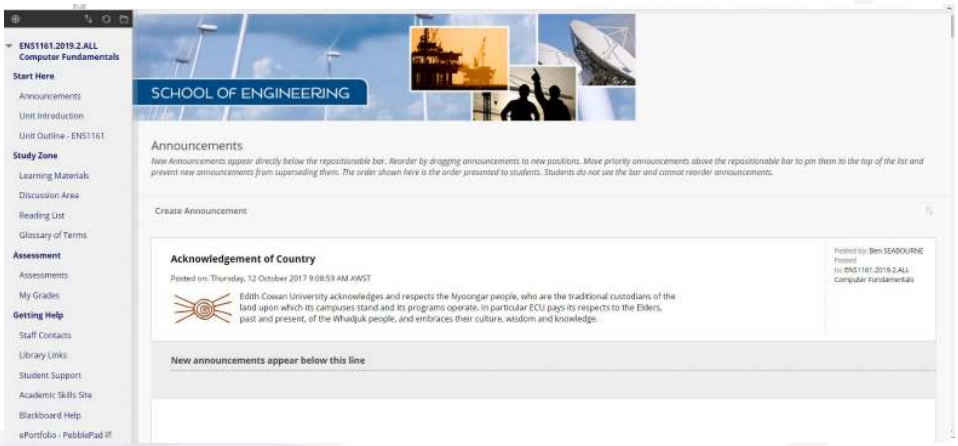
- Describe the fundamental architecture and operating principles of a computer system.
- Interpret computer system specifications and standards and how they relate to system function.
- Compare different types of components and subsystems and their relative impacts on system function and perf
- Make recommendations on the suitability of computer systems and components for a given function.
- Explain the interconnection between the software and hardware components of computer systems, and the processes involved in making them work together.

Unit Topics

Module	Topic
1	Introduction and overview
2	Basic Computer Architecture and Principles of Operation
3	Data and instruction formats
4	Basic computation in computers
5	Programming languages and tools
6	Memory devices and storage systems

Module	Topic
7	I/O devices and interfacing
8	I/O modes and BIOS
9	Operating Systems
10	Networks and the Internet
11	Embedded Systems and Cloud Computing
12	Review & Revision

Unit Blackboard Site



- Learning materials, recordings, assessments, grades, etc.

Assessment

Component	Weighting
Online Quizzes • 10 quizzes : 1% each	10%
Portfolio of Exercises • Exercise 1 : 10% • Exercise 2 : 10%	20%
Assignment	45%
End-of-semester Final Assessment	25%

Assessment

- Quizzes: *10%*
  - On-line multiple-choice tests
  - Made available every week (starting from Module 2) on Blackboard
  - Each test will be available for 1 weeks (no extensions possible)
  - 30-minute time limit and each test can be attempted twice
- Portfolio of Exercises: *20%*
  - 2 exercises based on material covered up to that point
  - Written answers in response to specific questions
  - Exercises build skill and knowledge for next assignment
  - *Due in Weeks 5 and 8*

Assessment

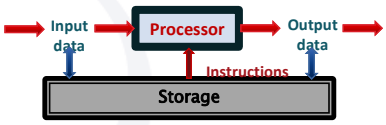
- Scenario based Assignment : *45%*
  - Based on material covered in the first 10 weeks
  - Applying knowledge gained in unit, some critical analysis
  - May require some additional research
  - Due: End of Week 11
- Final Assessment: *25%*
  - Will cover all material

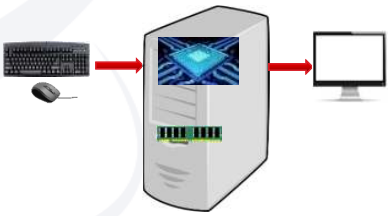
A note on academic misconduct

- Edith Cowan University regards academic misconduct of any form as unacceptable
- It includes conduct in relation to any academic work that is dishonest or unfair, including, but not limited to:
  - plagiarism;
  - unauthorised collaboration;
  - cheating in examinations;
  - theft of other students' work.
- Severe penalties apply

Summary

- A computer is a system that takes input data and processes it to produce output data
- The hardware consists primarily of electronics
- Software is the set of instructions that tell the processor what to do
- All data and instructions are in binary
- Computers have evolved dramatically over the last 80 years but the basic principles of operation remain largely the same





Next Module

- Basic architecture and principles of operation of a computer
  - Components of a computer broken down further
  - Focus on subcomponents of a processor
  - Principles of operation of a processor
    - More detailed look at the fetch, decode and execute cycle
    - The function of the various subcomponents during this process