CSCI 516 - Fundamental Concepts in Computing and Machine Organization
Homework Assignment 1 Solutions

Questions

1. What are the 6 different classes of computers and what are their characteristics

- Personal computers
  - They are designed for individual users for general purposes.
  - They execute variety of software.
  - They usually cost less than other classes of computers.
- Servers
  - Servers are usually network-based, and multiple users can use it simultaneously.
  - They can be used for running large programs or complex applications.
  - They provide greater computing, storage, and input/output capacity.
  - They have higher reliability and dependability.
- Supercomputers
  - They may consist of tens of thousands of processors and many terabytes of memory.
  - They are usually used for high-end scientific and engineering calculations.
  - They represent a tiny fraction of overall computer market in terms of total revenue.
- Embedded computers
  - They are computers inside other devices, hidden as components of the systems.
  - They run one or one set of predetermined application which are integrated with the hardware.
- Personal mobile devices (PMD)
  - PMDs are battery operated with wireless connectivity to the Internet.
  - They no longer have a keyboard and mouse but rely on a touch-sensitive screen.
- Cloud Computing
  - It relies upon Warehouse Scale Computers (WSCs).
  - It provide services over the Internet, then a portion of software run on personal devices and a portion run on the Cloud.

2. What is system software? Also, give the definition of two types of system software.

System software is the software that provides services that are commonly useful, including operating systems, compilers, loaders, and assemblers. Two types of the systems software are central to every computer system today:

- Operating system: it is a supervising program that manages the resources of a computer for the benefit of the programs that run on that computer.
- Compiler: A program that translates high-level language statements into assembly lanaguage statements.

3. What is High-level programming language? Give one or more examples.

High-level programming language is a portable language that composed of words and algebraic notation that can be translated by a compiler into assembly language. Such as C/C++, Java, Python.

4. What is Assembly language? What is the tool to convert high-level language to assembly language? Please describe the tool.

Assembly language is a symbolic representation of machine instructions.The tool to convert high-level language to assembly language is compiler. Compiler is a program that translate high-level language statements into hardware instructions.

5. What is machine language? What is the tool to convert assembly language to machine language? Please describe the tool.

Machine language is a binary representation of machine instructions. The tool ot convert assembly language to machine language is assembler. The assembler translates a symbolic version of an instruction into the binary version.

6. What are the five components of a computer? Describe each of the component. Give at least two examples for each component.

- Input: Provide data and control signals to an information processing system. Such as keyboards, mouse, scanners, digital cameras.
- Output: Uses received data and commands to perform a task and then to display, projection, or physical reproduction. Such as speaker, display, printer, projector.
- Memory: Holds instructions and most of the data for currently executing programs. For example, static random-access memory (SRAM) and dynamic random-access memory (DRAM).
- Control: generates control signals that direct the operation of memory and the datapath. Such as CPU, GPU, APU.
- Datapath: manipulates the data coming through the processor. It also provides a small amount of temporary data storage. Such as buses, registers.

7. Assume a 15 cm diameter wafer has a cost of 12, contains 84 dies, and has 0.020 defects/cm2. Assume a 20 cm diameter wafer has a cost of 15, contains 100 dies, and has 0.031 defects/cm2.

1. Find the yield for both wafers.

$$diearea_{15cm} = \frac{wafer}{dies/wafer} = \pi * \frac{7.5^2}{84} = 2.10cm^2 \tag{1}$$

$$\begin{aligned} yiled_{15cm} &= \frac{1}{(1 + (Defects/Area * DieArea/2))^2} \\ &= \frac{1}{(1 + 0.020 * 2.10/2)^2} = 0.9593 \end{aligned} \tag{2}$$

$$diearea_{20cm} = \frac{wafer}{dies/wafer} = \pi * \frac{10^2}{100} = 3.14cm^2 \tag{3}$$

$$\begin{aligned} yiled_{20cm} &= \frac{1}{(1 + (Defects/Area * DieArea/2))^2} \\ &= \frac{1}{(1 + 0.031 * 3.14/2)^2} = 0.9093 \end{aligned} \tag{4}$$

2. Find the cost per die for both wafers.

$$\begin{aligned} CostperDie_A &= \frac{Cost\ per\ wafer}{Dies\ per\ wafer * yield} \\ &= \frac{12}{84 * 0.9593} = 0.1489 \end{aligned} \tag{5}$$

$$\begin{aligned} CostperDie_B &= \frac{Cost\ per\ wafer}{Dies\ per\ wafer * yield} \\ &= \frac{15}{100 * 0.9093} = 0.1650 \end{aligned} \tag{6}$$

3. If the number of dies per wafer is increased by 10% and the defects per area unit increases by 15%, find the die area and yield.

$$die\ area_{15cm} = \frac{wafer\ area}{dies\ per\ wafer} = \frac{\pi * 7.5^2}{84 * 1.1} = 1.91cm^2 \tag{7}$$

$$\begin{aligned} yiled_{15cm} &= \frac{1}{(1 + (Defects/Area * DieArea/2))^2} \\ &= \frac{1}{(1 + 0.020 * 1.15 * 1.91/2)^2} = 0.9575 \end{aligned} \tag{8}$$

$$die\ area_{20cm} = \frac{wafer\ area}{dies\ per\ wafer} = \frac{\pi * 10^2}{100 * 1.1} = 2.86cm^2 \tag{9}$$

$$\begin{aligned} yiled_{20cm} &= \frac{1}{(1 + (Defects/Area * DieArea/2))^2} \\ &= \frac{1}{(1 + 0.031 * 1.15 * 2.86/2)^2} = 0.9082 \end{aligned} \tag{10}$$

4. Assume a fabrication process improves the yield from 0.92 to 0.95. Find the defects per area unit for each version of the technology given a die area of 200 mm^2.

$$\begin{aligned} defects\ per\ area_{0.92} &= \frac{(1 - yield^{0.5})}{(yield^{0.5} * die\_area/2)} \\ &= \frac{(1 - 0.92^{0.5})}{0.92 * 2/2} = 0.043 defects/cm^2 \end{aligned} \tag{11}$$

$$\begin{aligned} defects\ per\ area_{0.95} &= \frac{(1 - yield^{0.5})}{(yield^{0.5} * die\_area/2)} \\ &= \frac{(1 - 0.95^{0.5})}{0.95 * 2/2} = 0.026 defects/cm^2 \end{aligned} \tag{12}$$