# COE 301 – Computer Organization

## Assignment 1 Solution: Computer Abstractions and Technology

**1.** (5 pts) Find the word or phrase from the list below that best matches the description in the following questions. Each answer should be used only once.

| | |
|---|---|
| **Control** | **Transistor** |
| **Wafer** | **Assembler** |
| **Embedded system** | **Cache** |
| **Digital Video Disk (DVD)** | **DRAM** |
| **Instruction set architecture** | **Abstraction** |
| **Server** | **Yield** |
| **Datapath** | **Defect** |

**a)** Approach to the design of hardware or software. The system consists of layers, with each lower layer hiding details from the level above.

**b)** Computer inside another device used for running one predetermined application or collection of software.

**c)** Interface that the hardware provides to the low-level software.

**d)** Integrated circuit commonly used to construct main memory.

**e)** Microscopic flaw in a wafer.

**f)** Percentage of good dies from the total number of dies on the wafer.

**g)** Small, fast memory that acts as a buffer for the main memory.

**h)** Thin disk sliced from a silicon crystal ingot, which will be later divided into dies.

**i)** Component of the processor that performs arithmetic operations.

**j)** Component of the processor that tells the datapath what to do according to the instructions of the program.

**k)** On/Off switch controlled by electricity.

**l)** Computer used for running large programs for multiple users often simultaneously and typically accessed only by a network.

**m)** Optical storage medium with a storage capacity of more than 4.7 GB.

**n)** Program that converts symbolic versions of instructions into their binary formats.

**Solution:**

| | |
|---|---|
| **a) Abstraction** | **b) Embedded system** |
| **c) Instruction set architecture** | **d) DRAM** |
| **e) Defect** | **f) Yield** |
| **g) Cache** | **h) Wafer** |
| **i) Datapath** | **j) Control** |
| **k) Transistor** | **l) Server** |
| **m) Digital Video Disk (DVD)** | **n) Assembler** |

**2.** (2 pts) Given a magnetic disk with the following properties: Rotation speed = 7200 RPM (rotations per minute), Average seek = 8 ms, Sector = 512 bytes, Track = 200 sectors. Calculate the following:

**a)** Time of one rotation (in milliseconds).

**b)** Average time to access a block of 32 consecutive sectors.

**Solution:**

**a)** **Time of one rotation (7200 rpm) = 1 min / 7200 rotations = 60000 msec / 7200**
**Time of one rotation = 8.33 msec**

**b)** **Time to access a block of 32 consecutive sectors = 8 ms (average seek) +**
**8.33 ms / 2 (average rotation latency) + 32/200 * 8.33 (transfer time) =**
**8 + 4.17 + 1.33 = 13.5 msec**

**3.** (4 pts) The cost of an integrated circuit can be expressed in three simple equations:

$$\text{Cost per die} = \frac{\text{Cost per wafer}}{\text{Dies per wafer} \times \text{yield}}$$

$$\text{Dies per wafter} = \frac{\text{Wafer area}}{\text{Die area}}$$

$$\text{Yield} = \frac{1}{(1 + (\text{Defects per area} \times \text{Die area}/2))^2}$$

The following figure shows key statistics for DRAM production over 12 years:

| Year | Capacity | Die area | Wafer diameter | Yield |
|---|---|---|---|---|
| 1980 | 64K bits | 0.16 $cm^2$ | 5 inches | 48% |
| 1983 | 256K bits | 0.24 $cm^2$ | 5 inches | 46% |
| 1985 | 1024K bits | 0.42 $cm^2$ | 6 inches | 45% |
| 1989 | 4096K bits | 0.65 $cm^2$ | 6 inches | 43% |
| 1992 | 16384K bits | 0.97 $cm^2$ | 8 inches | 48% |

**a)** (1 pt) Given the increase in die area of DRAMs, what parameter must improve to maintain yield?

**b)** (2 pts) Derive a formula for the improving parameter found in **(a)** from the other parameters.

**c)** (1 pts) Using the formula in the answer to **(b)**, what is the calculated improvement in that parameter between 1980 and 1992?

**Solution:**

**a)** ***Yield* = 1/(1 + *Defects per area* × *Die area* / 2)$^2$**
**If *die area* is increased then to keep the *yield* constant, we must improve (reduce) the *defects per area*.**

**b)** ***Yield* = 1/(1 + *Defects per area* × *Die area* / 2)$^2$**

**(1+ *Defects per area* × *Die area* / 2)$^2$ = 1/*Yield***

$$(1 + Defects\ per\ area\ \times\ Die\ area\ /\ 2) = \frac{1}{\sqrt{Yield}}$$

$$Defects\ per\ area\ = \left(\frac{2}{Die\ area}\right)\times\left(\frac{1}{\sqrt{Yield}} - 1\right)$$

**c)** **In 1980, *Yield* = 48%, *Die Area* = 0.16 cm$^2$.**

$$Defects\ per\ area\ = \left(\frac{2}{0.16}\right)\times\left(\frac{1}{\sqrt{0.48}} - 1\right) = 5.54 \text{ defects per cm}^2$$

**In 1992, *Yield* = 48%, *Die Area* = 0.97 cm$^2$.**

$$Defects\ per\ area\ = \left(\frac{2}{0.97}\right)\times\left(\frac{1}{\sqrt{0.48}} - 1\right) = 0.91 \text{ defects per cm}^2$$

**4.** (3 pts) Assume you are in a company that will market a certain IC chip. The fixed costs, including R&D, fabrication and equipments, and so on, add up to $500,000. The cost per wafer is $6000, and each wafer can be diced into 1500 dies. The die yield is 50%. Finally, the dies are packaged and tested, with a cost of $10 per chip. The test yield is 90%; only those that pass the test will be sold to customers. If the retail price is 40% more than the cost, at least how many chips have to be sold to break even?

**Solution:**

**Number of good dies per wafer = 1500 × 0.5 = 750**
**Number of chips that are sold to customers per wafer = 750 × 0.9 = 675**

**Cost per wafer = $6000 + $10 × 750 = $13500**
**Retail price per wafer = $13500 × 1.4 = $18900 (40% more than the cost)**
**Retail price per chip = $18900 / 675 = $28**

**Let *W* be the total number of wafers that must be sold:**
**Total cost = $500,000 + $13,500 × *W***
**Total retail price = $18,900 × *W***

**To break even: $500,000 + $13,500 × *W* = $18,900 × *W***
***W* = 92.59 wafers**
**Number of chips that must be sold = 92.59 × 675 = 62,500 chips**

**5.** (2 pts) What are the unsigned and signed decimal values of the following binary and hexadecimal numbers?

**a)** 10110110

**Unsigned Value** = **128 + 32 + 16 + 4 + 2 = 182**

**Signed Value** = **–128 + 32 + 16 + 4 + 2 = –74**

**b)** C1B3

**Uunsigned Value** = $12*16^3 + 16^2 + 11*16 + 3 = 49587$

**Signed Value** = $49587 - 2^{16} = -15949$

**6.** (2 pts) Carry the following additions. Indicate whether there is a carry or overflow?

a)
```
    1111
   11010010 (binary)
 + 10111101 (binary)
   ________
   10001111
 Carry = 1
 Overflow = 0
```

**No overflow because operands and result are negative**

b)
```
   1 11
   A1CF (hexadecimal)
 + B2D3 (hexadecimal)
   ____
   54A2
 Carry = 1
 Overflow = 1
```

**Yes, there is an overflow because operands are negative, but result is > 0**

**7.** (2 pts) Carry the following subtractions. Indicate whether there is borrow or overflow.

a)
```
    1111 1
   11010010 (binary)
 - 10111101 (binary)
   ________
   00010101
 Borrow = 0
 Overflow = 0
```

**No overflow can occur because both operands are of the same sign**

b)
```
   111
   71CF (hexadecimal)
 - B2D3 (hexadecimal)
   ____
   BEFC
 Borrow = 1
 Overflow = 1
```

**There is an overflow because result should be positive, not negative**