ICS 233 – Computer Architecture & Assembly Language

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