Homework 2 solution

1) Consider the operation of a machine with the data path of figure 2-2. Suppose that loading the ALU input registers takes 5 nsec, running the ALU takes 10 nsec, and storing the result back in the register scratchpad takes 5 nsec. What is the maximum number of MIPS this machine is capable of in the absence of pipelining?

Solution: The cycle time = 5+10+5 = 20 nsec. Since there is no pipelining, the best the machine can do is 1/20nsec = 50 * 10^6 instructions. So the maximum number of instructions is 50 MIPS.

3) On computer 1, all instructions take 10 nsec to execute. On computer 2, they all take 5 nsec to execute. Can you say for certain that computer is faster? Discuss.

Solution: You cannot say anything for sure. Different factors such as pipelining can change the execution time significantly. For example, if computer 1 has a five-stage pipeline, it can issue up to 500 MIPS where if computer 2 is not pipelined it cannot do any better than 200 MIPS. Thus without more information, we cannot say which is faster.

12) Devise a 7 bit even parity Hamming code for the digits 0 to 9.

Solution:

Number	Binary value	Code (1234567)
0	0000	0000000
1	0001	1101001
2	0010	0101010
3	0011	1000011
4	0100	1001100
5	0101	0100101
6	0110	1100110
7	0111	0001111
8	1000	1110000
9	1001	0011001

14) In a hamming code, some bits are wasted in the sense that they are used for checking and not information. What is the percentage of wasted bits for messages whose total length (data + check bits) is 2^n -1? Evaluate this expression numerically for values of n from 3 to 10?

Solution: For a total length of (2^n – 1) bits, there are n check bits. Consequently, the percentage of wasted bits is n/(2^n − 1) × 100%. Numerically for n from 3 to 10 we get: 42.9%, 26.7%, 16.1%, 9.5%, 5.5%, 3.1%, 1.8%, and 1.0%.

17) The disk illustrated in Figure 2-19 has 1024 sectors/track and a rotation rate of 7200 RPM. What is the sustained transfer rate of the disk over one track?

Solution:

RPM =7200, that means, it can read 7200 tracks per minute or 7200/60 = 120 tracks per second.

A track has 1024 sectors.

So 120 tracks have 120 * 1024 = 122880 sectors. That means in one second it can transfer 122880 sectors of data. Each sector contains 4096 bits of data. So it can transfer 122880*4096 = 503,316,480 bits. So it can read 503,316,480/8 = 62,914,560 bytes/sec.

22) What is the exact data capacity (in bytes) of a mode 2 CD-ROM containing the now standard 80 min media? What is the capacity for user data in mode 1?

Solution: In mode 2, the data streams at 175,200 bytes/sec.

In a 80-min time span, the number of seconds is 80*60 = 5920.

So the size of a 80-min mode 2 CD-ROM is 175200 * 5920 = 840,960,000 bytes or 802 MB.

In mode 2 there is no error correction, which is fine for music but not for data.

In mode 1, only 2048 data bytes can be stored in a total of 2336 bytes (leaving the rest for error code.)

So here, it can store 802MB * 2048/2336 = 703 MB.

23) To burn a CD-R, the laser must pulse on and off at a high speed. When running at 10x speed in mode 1, what is the pulse length, in nanoseconds?

Solution: The mode does not matter, since the laser has to pulse for preamble bits, data bits, ECC bits, and all the overhead bits as well.

The gross data rate at 1x is 75 sectors/sec

Each sector consists of 98 × 588 = 57,624 bits.

Thus 75*57,624 = 4,321,800 bits/sec fly by the head at 1x.

At 10x, this is 43,218,000 bits/sec.

Thus each pulse must last no more than (1/43,218,000) = 23.14 nsec (actually slightly less, since there is a blank interval between pulses).

24) To be able to fit 133 minute worth of video on a single sided single layer DVD, a fair amount of compression is required. Calculate the compression factor required. Assume that 3.5GB of space is available for the video track, that the image resolution is 720*480 pixels with 24-bit color, and images are displayed at 30 frames/sec.

Solution:

A frame size is 720*480 pixels = 345,600 pixels
= 345,600*24/8 bytes
= 1,036,800 bytes

At 30 fps byte rate is 1,036,800 * 30 bytes
= 31,104,000 bytes/sec

In 133 minutes, the amount of data delivered = 31,104,000 * 133 * 60 = 2.482 × 10^(11) bytes.

Disk capacity = 3.5GB = 3.5*2^30 = 3.758 ∗ 10^9 bytes.

So required compression ratio = 2.482 × 10^(11) /3.758 ∗ 10^(9) = 66.

Thus the compression has to be 66x.

32) A digital camera has a resolution of 3000*2000 pixels, with 3 bytes/pixel for RGB color. The manufacturer of the camera wants to be able to write a JPEG image at a 5x compression factor to the flash memory in 2 sec. What data rate is required?

Solution: Each uncompressed image file is 3000*2000*3 bytes = 18 million bytes.
After 5x compression, it is (18/5) = 3.6 million bytes.

Now, data rate = data size/time
= 3.6*10^6/2 = 1.8 MB/sec.

33) A high end digital camera has a sensor with 16 million pixels, each with 3 bytes/pixel. How many pictures can be stored on a 8 GB flash memory card if the compression factor is 5x? Assume that 1 GB means 2^(30) bytes.

Solution:

1 photo has 16 * 10 ^6 pixels = 16*3*10^6 = 48 million bytes.
When compressed the size will be 48/5 = 9.6 million bytes.
Number of such images that can be stored = (8*2^30) / (9.6*10^6) = 894 with a few megabytes left.

(Textbook**)33) A high end digital camera has a sensor with 24 million pixels, each with 6 bytes/pixel. How many pictures can be stored on a 8 GB flash memory card if the compression factor is 5x? Assume that 1 GB means 2^(30) bytes.**

Solution:

1 photo has 24 * 10 ^6 pixels = 24*6*10^6 = 144 million bytes.
When compressed the size will be 144/5 = 28.8 million bytes.
Number of such images that can be stored = (8*2^30) / (28.8*10^6) = 298 with a few megabytes left.