CpSc-418 **Midterm** Oct. 22, 2002

HINT: Brief answers are good. Show your work for calculations. Sentence form answers should be short and to the point.

1. (3 points) What is your name?

2. (20 points) **Synopsis:** *My Cache or Yours…*

   (a) (5 points) What problem does the paper address?

   (b) (5 points) What are the key observations that lead to the solution presented in the paper?

   (c) (5 points) What is the solution presented in the paper?

   (d) (5 points) How is the solution validated?

3. (20 points) **Compare and Contrast:**
   Compare and contrast the DEMOTE policy described in the "My Cache or Yours…" paper with cache enhancements proposed by Norman Jouppi in "Improving Direct-Mapped Cache Performance by the Addition of Small Fully-Associateve Cache and Prefetch Buffers."

   (a) (10 points) What are two similarities in the approaches proposed? What common factors motivate these similarities?

   (b) (10 points) What are two differences in the approaches proposed? What factors motivate to these differences?

   Hint: When I ask "What factors motivate…?", I'm noting that the two papers address different problems (i.e. disk caching and main memory caching). What do these problems have in common that lead to the similarities of approach? What difference lead to the differences of approach?

4. (30 points) **Slow Down**
The RAID paper included a factor S that reflected the property that when N disks do one operation each in parallel the operation completes when the *last* disk finishes. Accordingly, the average time for all N to finish is greater than the average time for one disk to complete. The factor S is this ratio. This question explores S.

   (a) (10 points) Assume that the time for a disk to complete a read or write is uniformally distributed between 0.2 ms and 10.2 ms. Assume that if N disks perform N reads or writes in parallel, their times to perform these operations are independent random variables.

   Give S as a function of N. What is S for $N = 2$? What is S for $N = 10$?

   (b) (10 points) Now add a cache to the disk controller (in the drive). Assume that 90% of all reads and writes are handled by the cache. When an operation hits in the disk's cache, it takes time 0.2 ms (the transfer time). When an operation misses, it takes time that is uniformally distributed between 0.2 and 10.2 ms. As above, assume that if N disks perform N reads or writes in parallel, their times to perform these operations are independent random variables.

   Give S as a function of N. What is S for $N = 2$? What is S for $N = 10$?

   (c) (10 points) Assume for a "typical" workload, 30% of the time is spent waiting for disk reads and writes of which half is for reads and half is for writes.

   What speed-ups are achieved by adding a disk-cache for a storage array with no redundancy ("just-a-bunch-of-disks" – too bad if one fails), RAID 1, and and RAID 5?

Hint: I've included some handy probability formulas at the end of this exam.

5. (27 points) **Pot Pourri**
For each of the terms below, write one or two sentences describing what problem it addresses (3 points), one or two sentences describing how it solves it (3 points), and name the paper where it is described (3 points). To name the paper, you can just give the first few words of the title, enough to make your reference unambiguous.

   (a) virtual channel

   (b) iSLIP

   (c) ghost caching

6. (5 points) **Extra Credit**
What UBC faculty member is cited twice in the "My Cache or Yours" paper? Given the professor's name, and the reference numbers for the citations.

Handy-Dandy Probability Formulas:

Let X be a random variable. I'll write F_X to denote the distribution function of X:

$$F_X(a) = P\{X \leq a\}$$

If $X \geq 0$, then the expected value of X can be readily calculated from given its distribution:

$$E(X) = \int_{u=0}^{\infty}(1 - F_X(u))du$$

Assume that X and Y are independent random variables, and let $Z = \max(X, Y)$. Then,

$$F_Z(a) = F_X(a)F_Y(a)$$

If X is uniformally distributed in the interval $[u, v]$ with $u < v$, then,

$$F_X(a) = \begin{cases} 0, & \text{if } a < u \\ \frac{a-u}{v-u}, & \text{if } u \leq a < v \\ 1, & \text{if } v \leq a \end{cases}$$