# CS634 Mobile Computing

*Endsem Examination*

09-10-II — Time: 120 minutes

Full Marks: 100 — Date: 3-5-2010

Answer all questions.

1. Consider an audio communication with signal bandwidth 5000Hz. Suppose the carrier wave is modulated at 200MHz. Find the factor by which the height of the antenna is reduced by using modulated carrier? [10]

   **Answer**: We know $\lambda = \frac{c}{f} = \frac{3\times10^8}{5\times10^3} = 6\times10^4$. So the antenna height requirement $= \lambda/4 = 15$Km

   Since carrier wave is modulated at 200MHz, the effective wave length is $\frac{3\times10^8}{2\times10^8} =$ 1.5m, So antenna height = 37.5cm. So, the antenna height can be reduced by a factor of 40000.

2. In the movement based location update (MLU) scheme, a local counter is maintained at each MT to keeps track of its movements. Update is done if counter exceeds a threshold of $d$. To locate an MT, it is paged as follows:

```
Send polling signal to target cell and wait until timeout.
If (reply received before timeout) found.
Else not found.
```

   The process is known as a polling cycle. Let $\eta$ be maximum allowable polling cycles. An MT can always be found within distance $d-1$ from its last registration area. When $\eta > 1$ selective paging is done. A shortest-distance-first (SDF) partitioning scheme is used to partition residing area of an MT between its last registration cell and current position into $\ell = \min(\eta, d)$ sub-areas. Denote a sub-area $j$, $0 \leq j < \ell$, by $A_j$. Each $A_j$ contains one or more rings around last registration cell. Let $s_j$ to $e_j$ be the first and the last ring indices of rings which define $A_j$.

   (a) With $d = 5$, and $\eta = 3$, calculate the values of $s_j$, $e_j$, for $j = 0, 1, 2$. [10]

   (b) Assuming 7-cell reuse find the number of cells in $A_0$, $A_1$ and $A_2$. Also find the number of cells that must be probed before MT can be reached if paging becomes successful after the second polling cycles. [4]

   (c) What will be the maximum number of cells to be paged? [3]

   (d) What is the major drawback of MLU scheme? [3]

**Answer (a)**: First we need to obtain an expression for $s_j$ and $e_j$. Since location update occurs after every $d$ moves, we need to partition the area consisting of cells up to a radial distance $d$ from the mobile's last registration cell. Since, this area should be partitioned into $\eta$ sub-areas, the beginning and the end ring indices a sub-area of $A_j$ are given by the following expressions.

$$s_j = \begin{cases} 0, & \text{for } j = 0 \\ \lfloor \frac{d \times j}{\eta} \rfloor, & \text{otherwise} \end{cases}$$

$$e_j = \lfloor \frac{d \times (j+1)}{\eta} \rfloor - 1$$

Note that threshold $d$ may not be evenly divisible by number of subareas $\ell$. Now plugging the values $d = 5$ and $\eta = 3$,

$s_0 = 0$, $e_0 = \lfloor \frac{5\times1}{3} \rfloor - 1 = 0$

$s_1 = \lfloor \frac{5\times1}{3} \rfloor = 1$, $e_1 = \lfloor \frac{5\times2}{3} \rfloor - 1 = 2$

$s_2 = \lfloor \frac{5\times2}{3} \rfloor = 3$, $e_2 = \lfloor \frac{5\times3}{3} \rfloor - 1 = 4$

**Answer (b)**:

$A_0$ has only ring 0 (the cell of last registration)

$A_1$ consists of rings 1 and 2, and

$A_2$ consists of rings 3 and 4.

With 7-cell frequency reuse scheme, ring $i$, for $i = 0, 1, 2, \ldots$, will have $6i$ cells. If the MT is found after second polling cycle it is in sub-area $A_1$. The number of cells to be probed is, thus: 1+6+12 = 19.

**Answer (c)**: Maximum number of cells are probed when MT in $A_2$. The number of cells to be probed in this case is: 1+6+12+(18+24) = 61 cells.

**Answer (d)**: The major drawback in MLU is: when MT has oscillatory movements between two adjacent cells. The location update occurs frequently even though MT does not move far from its last updated registration cell.

3. Explain how AODV ensures loop-free paths between a source and destination pairs. [10]

   **Answer:** See lecture notes.

4. Consider a simplified version of bakery algorithm for mutual exclusion (code for process $i$) given below:

```
entry(i) {
   1: num[i] = max( num[0], num[1], ... , num[N-1] ) + 1 ;
         // line 1 is atomic
```

```
        for p = 0 to N-1 do  {      // p is local to process i
   2:       while (num[p] != 0 and num[p] < num[i])
                do no-op ;
        }
}

/* Code of critical section */

exit(i) {
   3: num[i] = 0 ;
}
```

Assume that each mobile node has access to registers of other machine, and the above bakery algorithm is executed on mobile nodes. What will be the cost of executing line 1? [4]

**Answer**: When a MH tries to choose its number for entry into critical section, it has to access the register values held by all other mobile nodes. Every such access will incur a search cost. The communication occurs in the following way:

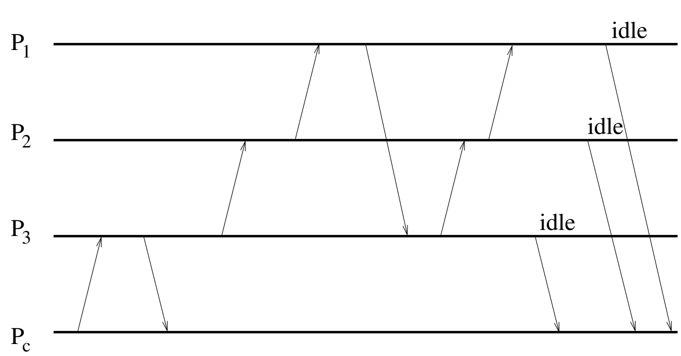
1. MH sends $(N_{MH} - 1)$ request messages: $(N_{MH} - 1)C_w$
2. Local BS deliver message to all requested nodes: $(N_{MH} - 1)(C_s + C_w)$
3. Every other mobile responds to request of MH: $(N_{MH} - 1)(C_s + 2C_w)$

So total cost for line 1 of entry code is: $2(N_{MH} - 1)(2C_w + C_s)$

5. (a) How *idle* and *active* states of a distributed computation are defined? [3]

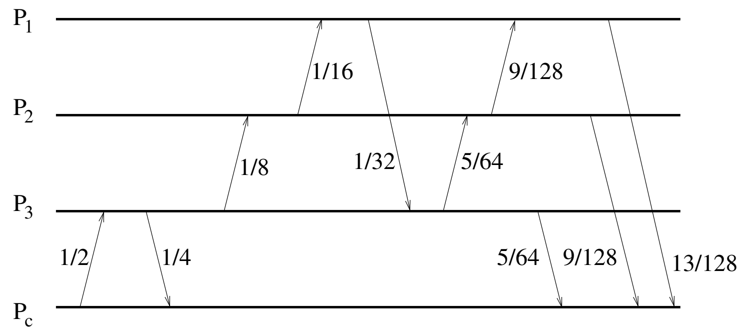
   (b) When does a distributed computation reaches termination state? [3]

   (c) Let the message exchanges involving 4 processes in the WTS based termination detection algorithm be as shown in the figure below. $P_c$ in the figure represents the weight collector process. Find the weights carried by each message, and appropriately label message flows in the figure. [4]



**Answer (a) & (b)**: See lecture notes.

**Answer (c)**: The labels are as shown below.




6. Consider the multi-disk data dissemination scheme with a 4-disk program in which

   The disk frequencies are: $f_1 = 4,\ f_2 = 3,\ f_3 = 2,\ f_4 = 6$.

   The number of pages in disks are: 3, 8, 12, 6

   Now answer the following with proper explanation:

   (a) Find the chunks carried in the 5th minor cycle? [7]

   (b) Find the size of a major cycle in number of pages? [6]

   (*No credit without explanation.*)

   **Answer (a)**: LCM(4, 3, 2, 6)=12. So, the disks are partitioned into chunks as follows:

   $D_1$: 3 chunks $C_{1,0}$, $C_{1,1}$ and $C_{1,2}$

   $D_2$: 4 chunks $C_{2,0}, \ldots, C_{2,3}$

   $D_3$: 6 chunks $C_{3,0}, \ldots, C_{3,5}$

   $D_4$: 2 chunks $C_{4,0}$ and $C_{4,1}$.

   A minor cycle contains 1 chunk from each disk. So it has 4 chunks of the form: $C_{1,j_1}, C_{2,j_2}, C_{3,j_3}, C_{4,j_4}$. For the 5th minor cycle: $j_1 = 1$, $j_2 = 0$, $j_3 = 4$ and $j_4 = 0$. Therefore, the chunks carried by 5th minor cycle are: $C_{1,1}, C_{2,0}, C_{3,4}, C_{4,0}$.

   **Answer (b)**: A major cycle will consist of 12 chunks from each disk. The size of disk chunks are: 1, 2, 2, 3 pages respectively. Thus, the size of major cycle = 12+24+24+36 = 96 pages.

7. (a) Consider LIX page replacement technique for client's cache in the multi-disk data dissemination scheme. Suppose we have 3 disks $D_1$, $D_2$, $D_3$, and the client's cache can hold 12 pages. At some point of time, let the cache hold:

6 pages of $D_1$,

2 pages of $D_2$, and

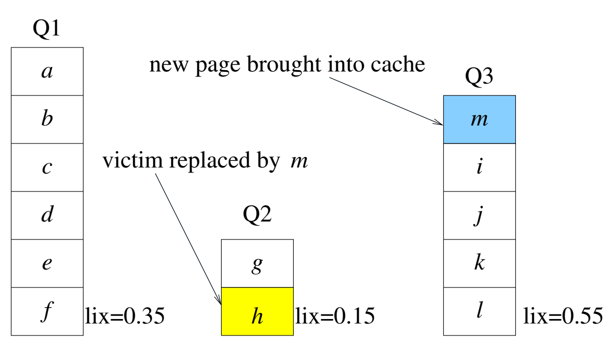
4 pages of $D_3$.

Let the computed LIX values of victim pages at this point of time be 0.35, 0.15 and 0.55 respectively. Now explain with a figure how disk queues in cache would change if a new page arrives for disk 3. Use letters starting with $a$ to denote the pages in cache. [9]

(b) Explain why PIX is more preferable client cache replacement policy compared to pure demand driven caching in the case of multi-disk data dissemination. Use the following example to illustrate your points: [9]

| Page No | Probability | Frequency |
|---|---|---|
| 1 | 0.5% | 0.3% |
| 2 | 1% | 2% |

**Answer (a)**: LIX keeps separate chains for each disk in cache. Let the queues for disk 1, disk 2 and disk 3 be known as Q1, Q2 and Q3 respectively. Since LIX value for victim page in Q2 is the least. So Q2's last page will vacate a slot for new page of Q3. Assuming pages are denoted by letters $a, \ldots, m$, ($m$ is the new incoming page). The modified cache queues will be as shown in figure below.




**Answer (b)**: In pure probability of caching, since page 1 has lower probability of access, page 1 will be chosen as more suitable victim. But it is possible that hot page for client is also hot for server. So server may broadcast hot page more often than the cold page. The requirement of cold page in client application could affect its performance. So, it should ideally cache the cold page for better performance.

In PIX strategy, the victim is selected according to "P inverse X" principle, where P is probability of access and X is frequency.

PIX (page 1) $= \frac{0.005}{0.3X} = \frac{1}{120X}$

PIX (page 2) $= \frac{0.01}{2X} = \frac{1}{200X}$

So, page 1's PIX value greater than that of page 2, implying page 2 will be selected as victim over page 1. This clearly shows that page colder for server could be cached even though it is not a hot page for the client compared to the victim.

8. Consider indexing scheme in air having partially replicated multi-level index tree distributed along with the data. Let the index tree be structured as follows:

   Number of levels = 4.

   Upper 2 levels are replicated.

   Fanout for levels 1 and 2 is 3.

   Fanout for level is 3 is 4.

   Each leaf level can hold keys for 4 records.

   Assume the record keys to be represented by natural numbers starting with 1.

   Now answer the following questions:

   (a) Find 4th and 9th tuples in broadcast sequence. [4]

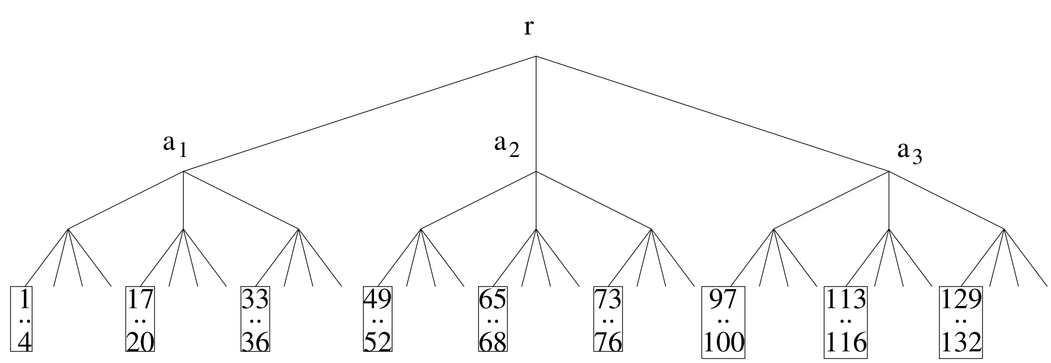
   (b) What is the total number of non-replicated roots? [3]

   (c) Find the size of data component in a broadcast sequence? [3]

   (d) Find the size of the replicated path component in a broadcast sequence? [3]

   (e) Find the total size of a broadcast sequence? [2]

   **Answer (a)**: Let us first draw the index tree:




   From the figure, it is clear that:

   4th tuple: $< r, a_2 >< b_4, c_{13}, c_{14}, c_{15}, c_{16} >< 49 - 64 >$

9th tuple: $< a_3 >< b_9, c_{33}, c_{34}, c_{35}, c_{36} >< 129 - 144 >$

**Answer (b)**: The each of the two replicated levels has a fanout of 3. So, Top 2 levels of the tree are replicated, so number of non-replicated roots is equal to $3^2 = 9$.

**Answer (c)**: The size of the data component in each tuple is 16. Since there are 9 distinct tuples in a single broadcast sequence, the total size of the data part of the full broadcast sequence is 16*9 = 144.

**Answer (d)**: The possible sizes of the replicated levels are 1 and 2. The length of the replicated in tuples 1, 4, 7 is 2 each, and in the rest 6 tuples, it is 1 each. So the total size of the replicated path in a single broadcast sequence is 2*3 + 1*6 = 12.

**Answer (e)**: Adding the totals of replicated, index and the data components in all 9 tuples, we get the size of the broadcast sequence as

| Component | Size |
|---:|---|
| Replicated | 12 |
| Index | 5*9 = 45 |
| Data | 144 |
| Total | 201 |