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Doing the homework will be of help in preparing for exams, and can effect grades, particularly at borderlines. You will not always be asked to hand in your written work for these assignments. Hand-in completed homework by wednesday of the week following the assignment-at recitation or in class.

A record will be maintained of which of the homeworks requiring hand-in have been received.

NOTE Understanding the Notes, the Homework, and old Exams (to be supplied later) will generally be sufficient to do well in the Course. The book can be used to clarify subjects considered in the notes. The exams allow a cheat sheet. Of course an even greater understanding will result if one does all the reading assigned (with understanding).

**HW 1 Assigned 09/05**

Read: CHAPTER 1. Sections 1.3 and 1.4 are Hardware review—most of which should be familiar from 198:211 or equivalent. Skim material on Threads and section 1.7.

Hand In Answers to Questions 8 and 12

Be able to answer questions 1-12 at the end of Chapter 1.

TAs have answers

**HW 2 Review  Notes 1 On Chapt 1-and Notes 2a Chapt 2.**

Assigned 09/12

Read CHAPTER 2 Read to Section 2.5 (Read 2.21 and Skim the rest of Section 2.2 on Threads—we will do these more thoroughly later in the semester.)

Review Second set of NOTES 2a on Chapter 2—look at NOTES 2b also.

Be able to answer Problems 1 (in the NOTES we have given the 3 states the names Wait, Active Ready the book calls them Blocked, Running, Ready), 3, 18, 20, 22

Hand In Answers to: 1, 22, at the end of Chapt 2 also to the following question—1:

TAs have answers

1) Suppose, two processes, P1, and P2 are in Memory (shown below). Suppose P1 is active and enters its Critical Region successfully but before reaching the end of that region it does a test (if(cond)...), when cond is true P1 must block (go into busy waiting) until P2 runs again. Explain or show how this can be done if

a) The critical regions are kept mutually exclusive by use of alternation (top of page 5 of NOTES 2a)
b) The critical regions are kept mutually exclusive by use of tsl atomic instruction (page 6 of NOTES 2a)

Answers on page 15 Notes 2a
HW 3 AssIGNED 09/19 WORK ON YOUR PROGRAMING ASSIGNMENT.

Read CHAPTER 2 to the end (Scheduling) Look at NOTES 2c and 2d.  
Review NOTES 2a and 2b on Chpt 2. (Pages covered in class)  
Be able to answer Problems 22, 24, 28, 24). See Notes pg 10  
Hand In Answers to: 1, 2, and 3 below  

1) Define Mutual Exclusion, and Synchronization-Which one is used in Multiple Alternators?  
   Mutual Exclusion of R1 and R2 once one is started the other will not be started 
   until the first completes.  
   Synchronization is used by Multiple Alternators: R1 is blocked because it cannot 
   use a resource, only action of a related R2 can unblock R1 i  

2) Consider page 11 of Notes 2b  
   A Producer, and Consumer Process are shown. The location of entries into array item(N) 
   is not indicated. Suppose we wish to specify where in item(N) entries and removals are 
   to be made by giving the index at which these occur. The first entry and removal 
   is to be at item[1], the next at item[2], etc. Assume that each entry and removal is from 
   a single, correct value of location, item(i) of item(N). Rewrite the pseudo code to include 
   the values of i, and where in item(i) entries and removals are to be made. 

   see page 16  

3) Again referring to page 11 of Notes 2b, where two Processes are sketched, one for a 
   Producer, and one for a Consumer. Rewrite these processes using the tsl command, 
   and no semaphors.  
   See NOTES 2a labelled page 10 and/or 11  

HW 4 Assigned 09/26 Due by Next Wed-toTA, or in class. WORK ON YOUR PROGRAMING 
ASSIGNMENT. Address programming Questions to TAs. They have office hours.  
Read CHAPTER 2 Scheduling and NOTES 2c and 2d.  
Review CHAPTER 2 NOTES 2b (Particularly Pages covered in class) 
Be able to Answer Problem Problem 22, 29 end of Chapt 2, and 1-and 2 below, 
Hand An Answer to: Question 1, 2 below  

1) Refer to the Producer-Consumer Problem Solution, pg 112 in text,( Also pg 11 of Notes 
   2b). Assume there are 3 Producers, all doing the same thing and 3 
   Consumers, all doing the same thing, we wish to see if that Solution insures 
   appropriate pseudo parallel operation? Suppose there is a blockage on “bempty”=0 
   of a Producer, then blockage of another Producer, etc. until 3 Producers are blocked. 
   Now a Consumer runs and consumes 2 items and is made inactive. 
   2a) What is the value of “bempty” now? What are the states of the 3 Producers now? 
   bempty=0, 2 of the producers are ready to run  
   2) In Multiple Alternators program, Notes 2a pg 7, when the table is full and Producer 
   is activated it goes into a Busy Waiting loop until Consumer puts 1 or more entries in 
   the table and advances its pointer. It is proposed to use a semaphor instead of a 
   Busy Waiting for blocking when the table is full. Show how this can be done.
HW 5 Assigned 10/03 Due by Next Wed-toTA, or in Class.
Read To end of Chapt 2 Scheduling. Notes 2d
Review Notes 2b and 2c
1) Consider the changes in semaphors as the two Processes P1 and P2 are run in multi-
programming mode. P1 runs from a to b and since cond1 is true to c. Then P2 runs from d to e,
finds cond2 is true and continues on to f. The vertical bars represent code without an system calls
a) Record how the semaphors x and z change and the effect as control passes from a to f.
b) After f control may be given to P1. What would happen then.
c) If after f, control continues in P2 until up(x) there is reached. Who can run next? Why?

\[ \begin{align*}
\text{P1} & \quad \text{initially semaphor } z=0, x=1 \\
\text{a) down(x)} \\
\text{b) if(cond1) up(x); down(z); } \\
\text{c) up(x)} \\
\text{P2} & \\
\text{d) down(x)} \\
\text{e) if(cond2) up(z); } \\
\text{f) up(x)}
\end{align*} \]

- [a] x->0, [b] x->1, [c] z=0 P1 blocks
- b) P1 will block on down(x)
- c) P1 or P2 because x = 1.

2) In the Dining Philosopher Monitor solution pg 8 Notes 2c
   a) Why is the state variable q[i] set to H in procedure getchopsticks?
      So that if it is unable to eat (goes into wait) it will remain Hungry and eligi-
      ble for being put in the Eat state when a neighbor calls put chopsticks
   b) In the procedure putchopsticks q[i] = T is the first instruction. If instead it were
      the last instruction how would the solution be affected?

   If either signal was executed the procedure would be deserted before the
   Philosophers state was made T-was still E and a neighbor would also be
   E--a violation.

3) Consider 5 jobs requiring times with run times 2, 5, 1, 1, 2, their respectively arrival times
   are 0,0,3,3,4. In what order should the jobs be run to minimize average turnaround time:
   a) without preemption and
   b) with preemption. In each case give the average turnaround time.

   Try different orderings:
   a) Add as though all start at 0 then subtract for late start.
      \[ \begin{align*}
      \text{abcde} & \quad 2+7+8+9+11=37-(3+3+4)=27 \\
      \text{bacde} & \quad 5+7+8+9+11=40-(3+3+4)=30 \\
      \end{align*} \]
   b) Always do smallest available first add as though all start at 0 then subtract for late
      start. a[b1]cde 4 2+4+5+7+11-(3+3+4) =19
      [b4]acde 3 4+5+7+9+11-(3+3+4) =26

4) Now consider all 5 jobs were available at the time 0 and they were to run round robin with
   a quantum of 1. What is the average turnaround time if they are run in an optimal order.
   \[ \begin{array}{ccccc}
   1 & 1 & 1 & 1 & 1 \\
   1 & 1 & 1 & 1 & 1 \\
   1 & 1 & 1 & 1 & 1 \\
   \end{array} \]

   \[ 1+ 2 + 6 + 7 + 11 = 27 \]
HW 6 Assigned 10/10 Due by Next Wed-toTA, or in class.
Read Chapt 3, Notes 3 Deadlock
Review NOTES 2d,
Be able to Answer problems 1-4 below
Hand In Answers to the following problems below: 1,2, 3,4

1) An average process runs for time T before blocking. if processes are run Round-Robin
with quantum Q and a process switch time S. In each case give the utilization.
a) Q=∞
b) Q>T
c) S<Q<T
d) Q=S [≤T ]
e) Q nearly 0

E=T / [T+S]=1/[1+S/T]
d) if S=Q then E=T / T+[T/Q]Q-->1/[1+S/Q] if T is a multiple of Q
E=T / T+[T/Q]S-->1/[1+S/Q] if T is a multiple of Q

e) if Q is small = E=T / T+[T/Q]S =T / T+[∞]S = 0

2) On page 2 of the DEADLOCK NOTES 4 examples of Deadlock are shown. For the bottom two
Show the NEEDS-HOLDS graph for the one labelled “SEMAPHOR ...” and the one
labelled “MODIFIED DINING PHILOSOPHER....” Notes 4 pg 2 Now

3) The Deadlock situation at the top of the page labelled “MEMORY FULL cannot be represented
by a simple Needs-Holds graph. Why?
Because it consists of a set of equivalent resources not individually identified. A
graph is shown now but arrows are not between individual Processes and individual
resources.

4) Suppose Resources are each assigned a distinct integer. By always requesting multiple
resources, all of which must be acquired before any are released, in an order in which the
lowest numbered one is requested first, then the next highest one is requested, next etc.
Deadlock will be prevented. Suppose this is done by all of a set of concurrently running
Processes except one which requests with just 1 Process out of order out of order.
a) Is Deadlock possible in that case? Explain.
Yes: one request Ra then Rb, the other Rb then Ra

b) Suppose two of the Resources were given the same number because nobody will ever Request
both before releasing either.
Is Deadlock possible in that case? Explain.
No, because actual requests will always be in numerical order

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HW 7  Assigned 11/01/07  Due by Next Wed-toTA, or in class.

Read  CHAPT 4 Memory Management Holes and Processes-Paging

Review NOTES 3, and NOTES 4a. Read Notes 4b, 4c

Be able to Answer problems 1-4 below

Hand In Answers to the following problems below:

Given:
1-On average there are $\infty > W > 0$ Processes Waiting for IO.
2-On average the length of time a Process spends in the Waiting for IO state is $T$.

a) Give a the formula for the average rate, $R_{out}$, at which Processes leave the Waiting for IO state.

$$R_{out} = \frac{W}{T} - \text{Littles Law}$$

b) $R_{in}$, the average rate at which Processes enter the Waiting for IO state must equal the Waiting for IO state. Why?

If $R_{in} > R_{out}$ then the number of Processes in Waiting for IO state would keep growing and if $R_{out} > R_{in}$ then number of Processes in Waiting for IO state would keep decreasing-in either case there could be no $\infty > W > 0$.

1) There are 3 processes in MM (Main Memory) Looking at the CPU 64 times chosen randomly) one finds the CPU is occupied with a Process $t$ of those times. Now repeating this experiment many times it is found that the average value of $t$ is 37. What is the fraction of the time (on average) that a process is doing IO?

$$\frac{37}{64} = 1 - p^3$$

$$\frac{27}{64} = p^3$$

$$3 = p$$

2) It takes 10nsecs to write a word (32 = 4bytes) in MM. How long does it take to compact 128MB. Assume that word 0 is part of a hole, and the highest word in MM contains valid data? (book-3)

**Answer:** $2^7 \times 2^{20} \text{bytes} \times (10 \times 10^{-9} \text{sec}/2^2 \text{bytes}) = 2^{25} \times (10 \times 10^{-9} \text{sec})$

3) An address to a byte of MM requires $m$ bits. There are $b$ bits per blocks, the average process is size $N$ bits, and on average 1/2 the memory is devoted to Processes.

a) A bitmap is used to keep track of Holes and Processes. Give an expression for

i) the size of the bitmap in bits.

$$2^m \text{bytes/MM} \times 2^3 \text{bits/byte} = 2^{m+3} \text{ bits/MM},$$

$$\# \text{ of blocks} = \frac{2^{m+3} \text{bits/MM}}{b \text{ bits per block}} = \frac{2^{m+3}}{b} \text{ blocks/MM} = \frac{2^{m+3}}{b \text{ bits per bitmap}}$$

b) $2^{m+3} \text{ bits in/MM} \times 2^{-1} \text{ MM/} \text{in Processes} = 2^{m+2} \text{ bits in Processes,} \quad [2^{m+2} \text{ bits in Processes}] / [N \text{ bits/Processes}] = \frac{2^{m+2}}{N} \text{ Processes}$

$$2^{m+2} / N \text{ Processes} = \frac{2^{m+2}}{N} \text{ end_blocks in MM so b x 2^{m+2} / 2N \text{ bits lost on average}}$$
4) If an instruction takes 10 nsecs and a page fault takes an additional n nsecs, give a formula for the effective (average) instruction time if page faults occur every k instructions. (book-11)

\[ \tau = 10^{10 \left[ \frac{k-1}{k} \right]} + n10^{10 \left[ \frac{1}{k} \right]} \]

b) A link list is used to keep track of Holes and Processes. Assuming Holes and Processes alternate, give an expression for the number of bits needed for the link-list of the type in the notes.

If you need any quantities beside those specified or expressible from what is given indicate that

2 pointer addresses = \(2m\) bits, size = \(m\) bits, address = \(m\) bits, Hole or Process = 1 bit

Total = \(4m\) \([+1]\) bits/cell

\[ 2^{m+2} / N \text{ Processes} = 1/2 \text{ number of cells} \]

There are \(2^{m+3} / N\) cells

Total bits = \(4m\) bits/cell \(2^{m+3} / N\) cells = \(4m^2^{m+3} / N\) bits

5) Referring to Page 7 of Notes 4b. An example of Hashing used in a 2 pass compiler is shown. A modified program is given below, using the same Hash function given on there show the contents of the Hash Table that will result from the first pass through the modified program.

A modified program is given below, using the same Hash function given on there show the contents of the Hash Table that will result from the first pass through the modified program.

<table>
<thead>
<tr>
<th>PROGRAM</th>
<th>HASH TABLE</th>
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<tbody>
<tr>
<td>pass1</td>
<td></td>
</tr>
<tr>
<td>pass2</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Z3: ___</td>
</tr>
<tr>
<td>7</td>
<td>G2: ________</td>
</tr>
<tr>
<td></td>
<td>(_F0 + C3)</td>
</tr>
<tr>
<td>18</td>
<td>G6: ________</td>
</tr>
<tr>
<td>20: G10: <em>L8</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Z1: ________</td>
</tr>
<tr>
<td>actual addr</td>
<td>92</td>
</tr>
<tr>
<td>symbolic addr</td>
<td></td>
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</tbody>
</table>

Hash1(XY) = X/2

Hash2(XY) = Y/2

Hashj(XY) = \([Y/2 + j]\) mod 14 : j = 1, 2, . . . , 13, 0, 1...13,

\( \lfloor \cdot \rfloor \) = floor
HW 8 Assigned 11/07/07 Due by Next Wed-toTA, or in class.

Read CHAPT 4 Processes-Paging,
Review Notes 4b. Read 4c

Be able to Answer Book page 265 problems 22, Hand In Answers to problems 22, and to problems 1 and 2 and 3 below:

1. Memory has 4 page frames, initially empty. The sequence of page requests is 0172327103. What is the hit ratio
   a) for FIFO,
   b) for LRU
   d) What is the highest hit ratio possible?

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<td>0 1 7 2 3 3 3 3 0 0.</td>
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<td>0 1 7 2 2 2 2 2 3 3</td>
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<td>0 1 1 1 1 7 7</td>
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   2 Is there any information one could include as the output of a compiler that would be useful in design of a replacement algorithm?

   if the most probable next page were known when a new page is accessed it would help.

3. The table giving the result for a simulation using the LRU for MMs having 1 through 6 page frames is shown below. Complete the Distance string, the listing of Hits and Misses and givr the Hit Ratio for all MMs of size 1 through 6.

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</table>

   Distance String = M H M H M H H H

   Hits & Misses = size 1 2 3 4 5 6
   Hit Ratios .1 .2 .4 .5 .5 .5
1) An I-node contains 10 direct addresses of 4 bytes, and one single indirect address and all disk blocks are 1KB. What is the largest file possible.

\[10 + \frac{1024 \text{ Bytes}}{4 \text{ Bytes/entries}} = 10 + \frac{2^{10} \times 2^{10}}{2^2} = 10 + 2^{18}\]

2) Disk addresses require D bits. For a Disk with B blocks, F of which are free,

(a) state the condition under which the free list uses less space than the bitmap?

**It takes D bits for each Free Block.**

So a total of FD bits in the Freelist. There is 1 bit in the Bitmap for each lock or a total of B bits. So if FD < B or F < B/D the bitmap uses less space than the bitmap.

(b) For D= 16 bits express your answer as a percentage of the disk space that must be free.

(pg 450 prob21)

If the number of freeblocks are < 1/16 of total number of blocks

3) What is the purpose of the File Descriptor in language which requires open\(ing\) a File and can a language dispense with the opening of Files- allow reading and writing etc. of a File without a preceding open command.

The file descriptor gives an index into a table in the Process table which points ultimately to the in-core I-Node of the file

4) Consider the 3 implementations of the File Name-Disk Block association:

a) Give one advantage and one disadvantage that the UNIX I-node implementation has compared to the other two (MS-DOS, CP/M)

b) Give one advantage and one disadvantage that the MS-DOS implementation has compared to the other two (UNIX, CP/M)

a) advantage; Indirection allows hard linking disadvantage extra references to get to file.

b) advantage; Data structure convenient for implementing freelist + every freeblock on DISK is useable disadvantage: Extra space required in MM.

5) What would happen if the bitmap or Free List were completely lost in a crash? Is there any way to recover from this. Give your answer for UNIX and for MS-DOS.(pg 451 prob23)

All blocks in use are pointed to by Inodes other blocks are free

All blocks in use are recorded in the MS-DOS disk record in MM

6) After the UNIX system has been brought up from a crash there are consistency checks. It is found that the same disk block is pointed to by the I-nodes for 3 different files, and also it appears to be free in the bit map. What is to be done?

Make two copies of the block in free blocks remove them from free list have 2 of the 3 which were pointing to the original block each point to one of the new blocks.

7) What problem can arise when hard linking is allowed from a directory file to any other file?
2) RAID level 2 uses Hamming encodings, and thus generally more than 1 parity disk (the more data disks the more parity disks are necessary) for correcting a single error. RAID level 3 just uses one parity disk, all others (of any number) have data, and it too can correct a single error. Why would one ever use RAID level 2? [16] The Hamming can identify a single error even without having the failed disk being identified by crashing. The other requires knowing which has the error in order to correct it.

3) A disk with 8 sectors is doubly interleaved. How many rotations (include fractions) are necessary before all 8 sectors are read if it starts by immediately reading the first sector?

4) $T_{s-b}$ is the time to read a sector to a buffer from a rotating disk. $T_{b-MM}$ is the time to empty a sectors of data from the buffer into MM. (The average rate into the buffer must equal the average rate out of the buffer.)

What is the maximum rate of data into the MM, given as the number of sectors read into the MM in time $T_{s-b}$ in each of the following cases. Also give the degree of interleaving in each case.

a) If $T_{b-MM} = T_{s-b}$ and single buffering is used
b) If $T_{b-MM} = 2T_{s-b}$ and double buffering is used
c) If $T_{b-MM} = 2T_{s-b}$ and single buffering is used
d) If $T_{b-MM} = 2T_{s-b}$ and double buffering is used

Answer 2+6/8
5) a) Name 2 examples of the need for watchdog timing.
   Waiting for the disk, tape, or CD-ROM to reach full speed.
   Waiting for the printer to come up to temperature.

b) What is the relation between the size of the Disk Cache and Power Consumption.
   The bigger the cache the longer a disk, which has been stopped to save power,
   can remain stopped.

6) Suppose that a single CPU user is typing at 1 char/sec, but the CPU requires only 100msec
   to process that character when running at full voltage, V. The voltage can be decreased to V/n
   so that the handling can be done optimally (minimum power with out loosing characters). What
   is the value of n, and what is the corresponding saving in percent of power used with such a
   voltage decrease?

   \[
   \text{Speed} = kV \quad \text{V' = V/n} \\
   \text{Power} = mV^2 \quad \text{Power} = m(V/n)^2 = m(V^2/n^2)
   \]

   Speed is reduced by 100msec/1000msec = 1/10 so n = 10
   \[
   m(V^2/n^2)/m(V^2) = m(V^2)(1/n^2)/m(V^2) = 1/n^2 = 1/(10)^2 = 1/100 \text{ or } 1%
   \]