Question 1 (6 points)

Explain how it is that both the virtual-machine and the microkernel approaches protect various portions of the operating system from one another?

Question 2 (8 points)
In Fig. 1, a multithreaded Web server is shown. If the only way to read from a file is the normal blocking read system call, do you think user-level threads or kernel-level threads are being used for the Web server? Why?

**Fig. 1**

In Fig. 1, a multithreaded Web server is shown. If the only way to read from a file is the normal blocking read system call, do you think user-level threads or kernel-level threads are being used for the Web server? Why?

**Question 3** (5 points)

Which of the following instructions should be allowed only in kernel mode?
Question 4 (6 points)

What is the purpose of a system call in an operating system?

Question 5 (10 points)

Assume that at time 5 no system resources are being used except for the processor and memory. Now consider the following events:

At time 5: P1 executes a command to read from disk unit 3.

At time 15: P5's time slice expires.

At time 18: P7 executes a command to write to disk unit 3.

At time 20: P3 executes a command to read from disk unit 2.

At time 24: P5 executes a command to write to disk unit 3.

At time 28: P5 is swapped out.

At time 33: An interrupt occurs from disk unit 2: P3's read is complete.
At time 36: An interrupt occurs from disk unit 3: P1's read is complete.

At time 38: P8 terminates.

At time 40: An interrupt occurs from disk unit 3: P5's write is complete.

At time 44: P5 is swapped back in.

At time 48: An interrupt occurs from disk unit 3: P7's write is complete.

For time 37, identify which state each process is in. If a process is blocked, further identify the event on which it is blocked.

**Question 6 (15 points)**

1. Consider the following set of processes:

<table>
<thead>
<tr>
<th>Process Name</th>
<th>Arrival Time</th>
<th>Processing Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>E</td>
<td>12</td>
<td>5</td>
</tr>
</tbody>
</table>

a. Perform the same analysis as depicted in Figure 9.5 (textbook p. 409) for this set and fill in the blanks in the table below. Each square represents one time unit; the number in the square refers to the currently-running process.
b. Perform the same analysis as depicted in Table 9.5 (textbook p. 409) for this set and fill in the blank parentheses in the table below.

<table>
<thead>
<tr>
<th>Process</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>9</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>FCFS</td>
<td>3</td>
<td>11</td>
<td>10</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>3.00</td>
<td>7.00</td>
<td>13</td>
<td>6.00</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>1.40</td>
<td>3.50</td>
<td>1.20</td>
<td>1.60</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.74</td>
</tr>
</tbody>
</table>
1. A
2. B
3. C
4. D
5. E
6. 1
7. 2
8. 3
9. 5
10. 6
11. 7
12. 8
13. 9
14. 10
15. 15
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