CPSC 545 Computing Systems

Quizz #2

Name: _____________________________________

Make your answers concise yet complete! 26 points in total.

1. Give one advantage and one disadvantage of contiguous memory allocation.

   Advantage (2 points): Simple, less hardware support (e.g., relocation and limit registers)

   Disadvantage (2 points): Produces external fragmentation

2. What is thrashing? What will thrashing lead to? (4 points)

   CPU spends more time on page I/O activities than computation (or high page I/O activities) -- 2 pts

   Thrashing will lead to low CPU utilization – 2 pts

3. Explain the difference of wait operations between a semaphore and a condition variable (6 points).

   Semaphore’s wait operation (pthread semaphore wait operation is slightly different):
   - It decreases the semaphore’s value by one (1 pt); If the value is less than zero, it will block the process/thread (1 pt); Otherwise, the process/thread continues (1 pt)

   Conditional variable’s wait operation:
   - It is associated with a lock (lock must be acquired before this operation) (1 pt)
   - This operation always puts the calling process/thread in waiting state and the associated lock is released automatically (1 pt)
   - When the operation returns, the associated lock is acquired automatically (1 pt)
4. **Two-Level Page-based Virtual Addressing.** Consider a 32-bit machine with a multi-level virtual memory system with 32-bit pointers and 4096 byte pages that supports two-levels of page tables. All Page Table Entries (PTEs) are 4 bytes.

a. (3 points) Show the *complete* format of a virtual address (i.e., outer page table bits, inner page table bits, and page offset bits).

<table>
<thead>
<tr>
<th>Outer page table bits</th>
<th>inner page table bits</th>
<th>page offset bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10</td>
<td>12</td>
</tr>
</tbody>
</table>

b. (3 points) Explain the steps the hardware takes in translating a virtual address to a physical address for this scheme.

Given a logical address \((p_1, p_2, d)\), it first uses \(p_1\) to look up the inner page table frame; then it uses \(p_2\) to look up in the inner page table and gets the frame \(f\). Combining \(f\) and \(d\), we get the physical address.

TLB may improve this translation process.

c. (3 points) How many memory operations are required to read or write a single 32-bit word?

Without TLB, it takes 3 memory operations.

d. (3 points) How much physical memory is needed for a process with one page of virtual memory?

3 frames, one for outer page table, one for inner page table and one for the page!