**CSC3150 Quiz#1 04/11/2024 Student Name: Student ID:**

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| **Section 1** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
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| **9** | **10** | **11** | **12** | **13** | **14** | **15** | **Total** |
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| **Section 2** | **1** | **2** | **3** | **4** | **5** | **Total** |
|  |  |  |  |  |
| **6** | **7** | **8** | **9** | **10** |
|  |  |  |  |  |

**Please put your answers of section I and II in the above tables.**

**Section I (45 points): Select one best answer**

1. **The process of bringing a page from secondary storage into main memory is known as:**

B

a) Swapping

b) Paging

c) Thrashing

d) Fragmentation

1. **Which page replacement algorithm is considered the upper bound of all replacement algorithms?**

A

* 1. Belady’s MIN algorithm
  2. First-In, First-Out (FIFO)
  3. Least Recently Used (LRU)
  4. Random Replacement

1. **What is the term for the condition where the system spends an excessive amount of time swapping pages in and out of memory?**

C

a) Deadlock

b) Demand paging

c) Thrashing

d) Context Switching

1. **The 'valid-invalid' bit associated with a Page Table Entry (PTE) indicates:**

a) If the page has been modified since being loaded.

B

b) If the page is currently in main memory.

c) If the page is part of a shared memory segment.

d) If the page has been referenced recently

1. **The x86 instruction addsd [rax], [rbx], fetches data from memory locations addressed by RAX and RBX, adds those values, and places the result back into the memory location indicated by RAX. What is the maximum number of page faults may be generated in the worst case by executing this instruction?**

D

* 1. 3
  2. 8
  3. 4
  4. 6

B

1. **What is the primary role of the Translation Lookaside Buffer (TLB)?**

a) To store recently accessed pages for faster retrieval.

b) To speed up the translation of virtual addresses to physical addresses.

c) To manage the replacement of pages in main memory.

d) To resolve conflicts between multiple processes accessing the same location.

1. **When a TLB miss occurs, the operating system must:**

B

a) Signal a segmentation fault and terminate the process.

b) Check the page table to find the corresponding physical page mapping.

c) Immediately swap out a page to make space for the new one.

d) None of the above.

1. **A high TLB miss rate could indicate:**

D

a) The TLB is too small.

b) The working set of the process is larger than the TLB can accommodate.

c) The program's memory access patterns are very scattered.

d) All of the above.

1. **Which of the following is NOT a direct consequence of a page fault?**

D

a) Increased memory access time

b) Potential disk I/O operation

c) Process context switch

d) Guaranteed page replacement

1. **In assignment#3, which one of the following page alignment implementations is correct when you want to locate the page of the fault address and extract the mapped pages according to the size of the mapped region?**
2. PGROUNDUP the possibly unaligned virtual address, PGROUNDOWN the possibly unaligned size.

C

1. PGROUNDUP the possibly unaligned virtual address, PGROUNDOWN the possibly unaligned virtual address.
2. PGROUNDUP the possibly unaligned size, PGROUNDOWN the possibly unaligned virtual address.
3. PGROUNDUP the possibly unaligned size, PGROUNDOWN the possibly unaligned size.
4. **Which one of the following descriptions accurately explains the concept of Virtual Memory Area (VMA)?**

**a)** VMA is a dedicated area in physical memory used for storing virtual machines.

B

b) VMA is a data structure in the operating system used for managing process virtual address spaces, including memory mapped files.

c) VMA is a virtual network device used for running multiple operating systems in a virtual machine.

d) VMA is a special hardware used for speed up virtual address translation.

1. **A process has a virtual address space of 2GB. The page size is 4KB. If the page table entry (PTE) size is 4 bytes, what is the total size of the page table (assuming one level page table).**

A

* 1. 2MB
  2. 4MB
  3. 1MB
  4. 512KB

1. **What is the *advantage* if we increase the page size from 4KB to 16KB?**
   1. TLB misses will increase

B

* 1. Page table size can be reduced and TLB can reach a greater range
  2. Faster process starts up
  3. TLB miss handling becomes less expensive

1. **What is the *disadvantage* if we increase the page size from 4KB to 16KB?**

B

* 1. Page fault handling cost will be significantly increased
  2. Due to the increased fragmentations, more page faults may be generated
  3. It decreases TLB misses
  4. It decreases TLB miss handling time

1. **In the enhanced second chance page replacement algorithm, what are the pair of bits used?**
   1. a reference bit, a valid bit

B

* 1. a reference bit, a dirty bit
  2. a valid bit, a dirty bit
  3. a victim bit, a dirty bit

**Section II (40 points): Multiple Choices (zero, one, or more correct answers)**

1. In Assignment 2, you used the Pthread API. Which of the following statements accurately describe the parameters of the pthread\_create() API? The routine parameters are as follows: **pthread\_create (thread, attr, start\_routine, arg)**
2. The “thread” parameter is a pointer to a pthread\_t

A,B,C

1. The “attr” parameter is used to set thread attributes. NULL indicates the default attributes are used.
2. The data type of the “start\_routine” is a void pointer.
3. The “arg” parameter can be any data type
4. Which of the following statements about the Pthread API are **correct**?
5. The pthread\_t variable must be initialized using pthread\_init() and freed using pthread\_destroy().
6. The pthread\_mutex\_t variable must be initialized using pthread\_mutex\_init() and freed using pthread\_mutex\_destroy().

B,D

1. When calling pthread\_mutex\_lock(), if the mutex is already locked by another thread, this call will return immediately with a "busy" error code.
2. When the pthread\_exit(NULL) is called in main(), the main thread terminates, but other threads created in main() can continue to execute.
3. Which of the statements about the implementation of Assignment 2 are **correct**?
4. We can compile our assignment code, test.cpp, with “g++ test.cpp -lpthread”.

A,B,C

1. We may use “\033” to control the cursor in the terminal. For example, printf(“\033[2J”).
2. The srand() call is used to initialize the seed for the rand() function. Without it, the rand() would give you the same random number sequence.
3. The kbhit() function provided in Assignment 2 will return the char value of the keyboard input.
4. Which of the following are the primary benefits of using virtual memory?

a) More programs run at the same time, higher multiprogramming degree

A,C

b) Faster execution for a single program

c) Allows programs to exceed the size of physical RAM

d) Improved the performance of caches

1. In Assignment 3, you have implemented the `mmap` function. Which of the following statements accurately describe the parameters of the `mmap`? Here are the routine parameters: **mmap(addr, length, prot, flags, fd, offset)**
2. The “addr” parameter is a pointer to the starting address of the mapped region. In this assignment, it is 0, letting the kernel to decide.

A,C,D

1. The “prot” parameter is used to determine whether updates to the mapping are carried through to the underlying file, for example, MAP\_PRIVATE and MAP\_SHARED.
2. The “fd” parameter is an integer representing a reference to a file.
3. If the “offset” parameter equals to 0, it means the mmaped region should start at the beginning of the file.

6. What are the memory allocation algorithms commonly used in the OS kernel?

A,C

a) Buddy system

b) Body system

c) Slab allocation

d) Slot allocation

7. What is a hardware page table walker?

a) It is a hardware component automates the process of "walking" a page table

A,B,C

b) It is used to resolve TLB misses

c) It is most frequently used in OSes that run on x86, where page tables are well defined.

d) It is mostly used in RISC machines to avoid executing too many instructions.

A,B,D

8. What is TSW used in the Solaris OS? (This should be TSB, not TSW)

a) It is a soft cache that capture most recently used page table entries

**generous**

**grading**

b) It is located between TLB and Page table

c) It is managed by the hardware page table walker

d) It is used to speed up TLB miss handling

9. Which of the following can take advantages of COW (Copy-On-Write) techniques?

a) forking a child process

A,B,C,D

b) cloning a Virtual Machine

c) Dedup (deduplication) two big files

d) Creating a branch in a version controlling system

C,D

or

D

10. Which of the following page replacement algorithms may run into Belady;s anomaly?

a) MIN algorithm

b) LRU algorithm

c) FCFS algorithm (This spelling is wrong! It should be FIFO)

d) Second Chance algorithm

**Section III (40 points): Short and brief answers**

1. **Virtual Memory** (8 points)

*“Virtual memory was invented in a time of scarcity. Is it still a good idea?” – Charles Thacker, Turing Award Lecture.*

Charles Thacker was the chief designer of the Xerox Alto, considered the first true personal computer. He questioned that currently PC often have 8-32GB of main memory, with such a large main memory, do we still need the feature of virtual memory?

What do you think?

VM has a lot more to offer than just a larger address space

* Demand paging allows more jobs running in a multi-programmed environment
* Memory sharing with multiple process: mmap
* Memory mapped files
* COW
* Any good things from VM

1. **Cache miss, TLB miss, and Page fault** (8 point)

Discuss which of the following cases will not exist when you execute a Load instruction.

1. TLB hit, Cache hit, Page table hit OK
2. TLB hit, Cache hit, Page fault NO
3. TLB hit, Cache miss, Page table hit OK
4. TLB hit, Cache miss, Page fault NO
5. TLB miss, Cache hit, Page table hit NO
6. TLB miss, Cache hit, Page fault NO
7. TLB miss, Cache miss, Page table hit OK
8. TLB miss, Cache miss, Page fault OK
9. **Fast Start-up time** (8 points)

When a job is scheduled to run, it will initially encounter multiple page faults. Handling such page faults is slow, and could delay the responses to users. In order to get a fast start-up, what can we do to significantly reduce the page fault handling overhead?

Place functions used in the start-up phase together in a few pages, so that one or a few page faults could bring in most functions required at the start-up and save multiple page faults. This can be guided with a profile.

Prepaging (guided by working set or ML)

1. **Page Tables** (8 points)
2. What are the differences between multi-level page tables and inverted page tables?
3. What are the advantages and disadvantages of each?

Inverted table size is fixed depending on the size of physical memory. Virtual page numbers are stored as tags in the table.

PTE in multiple level PT stores physical page number

Multi-level table is better for memory sharing among processes

1. **DMA and IOMMU** (8 points)
   * 1. What is DMA?
     2. What is IOMMU?
     3. With IOMMU, can DMA take virtual addresses instead of real addresses?
     4. If ( c ) happens, what may happen to the kernel memory allocation requirements.

DMA: Direct Memory Access

DMA is a hardware mechanism that allows I/O devices (like hard drives, network cards, graphics cards, etc.) to transfer data directly to or from the system's main memory without requiring the CPU's involvement.

IOMMU: The IOMMU acts as an intermediary between DMA-capable devices (like hard drives, graphics cards, network cards, etc.) and the computer's main memory.

Yes

Memory allocation in kernel no longer need to be contiguous for DMA.