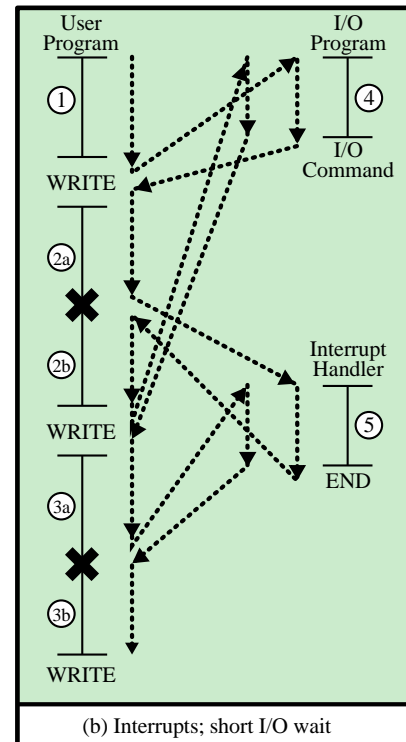


1. Refer to the diagram on the right. What could happen when the I/O operation **takes much more time** than executing the code segment 2 or 3 of the user program, i.e., the **user program reaches the second WRITE call before** the I/O operation called by the first one is **completed**?



- 1
2
4
wait
5
4
3



2. What is **multiprogramming**? How is it different from **multiprocessing**?
3. Consider a memory system with the following parameters:
 Cache access time: **0.1 μs**
 Memory access time (time needed to load a word into the cache): 1 μs
 Suppose we ignore the time required for the processor to determine whether a word is in cache or memory. What is the **hit ratio** in order to have an average time to access a word **no more than 50% greater than the cache access time**?
 (Hit ratio: **fraction** of accesses that are **found in the cache**)

4. The **principle of locality** states that memory references tend to cluster. In the literature, there is a distinction between **spatial locality** and **temporal locality**. **Spatial locality** refers to the tendency of execution to involve a number of memory locations that are clustered while **temporal locality** refers to the tendency for a processor to access memory locations that have been used recently.

- a) Can you figure out strategies for exploiting spatial locality and temporal locality?
 b) Consider the following code:

```
for (i=0; i<20; i++)
    for (j=0; j<10; j++)
        a[i]=a[i]*j;
```

- (i) Give one example of the spatial locality in the code.
 (ii) Give one example of the temporal locality in the code.

Self-test

Choose the best answer.

1. When an external device becomes ready to be serviced by the processor the device sends a(n) _____ signal to the processor.
 - A. access
 - B. halt
 - C. handler
 - D. interrupt

2. Which of the following is the correct sequence of hardware events after the I/O device issues an interrupt signal to the processor?
 - (i) Processor loads new PC value based on interrupt
 - (ii) Processor finishes execution of current instruction
 - (iii) Processor pushes PSW and PC onto control stack
 - A. (iii), (ii), (i)
 - B. (ii), (i), (iii)
 - C. (ii), (iii), (i)
 - D. None of the above

3. In a uniprocessor system, multiprogramming increases processor efficiency by:
 - A. Increasing processor speed
 - B. Taking advantage of time wasted by long wait I/O operations
 - C. Disabling all interrupts except those of highest priority
 - D. All of the above

4. Which of the following are the benefit of multiprogramming?
 - A. Shorter mean response time
 - B. Higher resource utilization
 - C. Higher throughput
 - D. All of the above

5. Which of the following characteristics distinguish the various elements of a memory hierarchy?
 - A. Cost
 - B. Capacity
 - C. Access time
 - D. All of the above

6. The unit of data exchanged between cache and main memory is _____.
 - A. block size
 - B. map size
 - C. word size
 - D. slot size