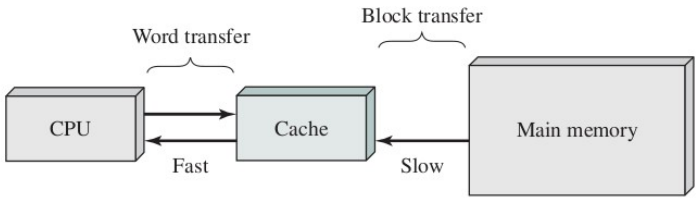
UNIVERSITY OF BIRMINGHAM

M.Sc. CS/AI & CS
Computer Systems
Operating Systems and Architecture

Exercise #1: Assuming that a CPU is operating at 1 MHz, and is able to execute one instruction / clock cycle by taking benefit of pipelining. The DMA module on the same system is transferring characters (one byte at a time) to the main memory from an external device transmitting at 9600 bits per second. By approximately how much the processor will be slowed down due to the DMA activity?

Exercise #2: Suppose that the processor has access to two levels of memory. Level 1 contains 1000 bytes and has an access time of 0.1µs; level 2 contains 100,000 bytes and has an access time of 1µs. Assume that if a byte to be accessed is in level 1, then the processor accesses it directly. If it is in level 2, then the byte is first transferred to level 1 and then accessed by the processor. For simplicity, we ignore the time required for the processor to determine whether the byte is in level 1 or level 2. Such a two level memory can be shown as in figure below:



(a) Single cache

We can define hit-ratio H, as the fraction of all memory accesses that are found in the faster memory e.g. the cache memory. T1 is the access time to level 1 (cache) and T2 is the access time to level 2 (main memory). Now suppose 95% of the memory accesses are found in the cache (H=0.95). Then what would be the average time to access a byte from such a two-level memory sub-system? Hint, the graph below shows the average access time to a two-level memory as a function of the hit-ratio H.

The following figure shows the average access time to a two-level memory as a function of the hit-ratio H.

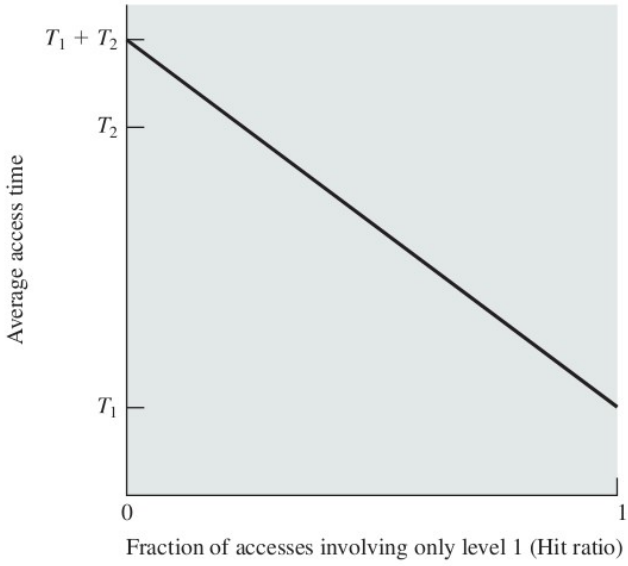


Figure 1.15 **Performance of a Simple Two-Level Memory**

Exercise #3: A computer system has a cache, main memory, and a disk used for virtual memory. If a referenced word is in the cache, 20ns are required to access it. If it is in the main memory but not in cache, 60ns are needed to load it into cache (this includes the time to originally check the cache), and then the reference is started again. If the word is not in main memory, 12ms are required to fetch the word from disk, followed by 60ns to copy it to the cache, and then the reference is started again. The cache hit-ratio is 0.9 and the main memory hit-ratio is 0.6. What is the average time in ns required to access a referenced word on this system?

Exercise #4: What is a program? and what is a process? Discuss as many differences between them as you can imagine.

Exercise #5: List down three reasons for a process to move from running state to blocked state?

Exercise #6: Multi-programming (or multi-tasking) enables more than a single process to apparently execute simultaneously. How is this achieved on a uniprocoessor where we have only one CPU?

Exercise #7: Calculate number of times hello is printed:

```
int main() {
      fork();
      fork();
      fork();
      printf("hello\n");
      return 0;
}
```

Exercise #8: Predict the Output of the following program:

```
int main() {
    int x = 1;
    if (fork() == 0)
        printf("Child has x = %d\n", ++x);
    else
        printf("Parent has x = %d\n", --x);
    return 0;
}
```