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1.

consider a CPU with a 5 stage instruction pipeline

how many instructions per second can this CPU execute

      if the stages are executed sequentially?

      each instruction takes 3ns+6ns+1ns+10ns+5ns = 25ns

      on average the CPU executes 1s/25ns = 40,000,000 instructions/s

if the stages are executed in parallel?

      first instruction will take 3ns+6ns+1ns+10ns+5ns = 25ns

      but over long run the CPU will execute 1s/10ns = 100,000,000 instructions/s

      the pipeline is as slow as its slowest stage

2.

from a company's perspective:

(1) VMs can potentially save lot of money.

(2) If there are many groups in the same company and sharing the same server, but they are required to run their works on difference OSes or versions, they can just use the VMs because this is no way to install all the systems simultaneously.

from a programmer's perspective:

(1) When the programmers receive an unknown program and if they must run it, they can run it on VMs which can protect the host computers and it is much easier to delete the VM after they are done running, and do anything without leaving their seats.

(2) The programmer can run multiple programs which are required to run on OS in different versions because VMs are isolated and safe from each other.

(3) VMs are easy to boot up.

from a regular user's perspective:

(1) VMs are a good tool for users to learn operating system.

(2) VMs are also a perfect vehicle for OS research and development because normal System operation seldom needs to be disrupted from system development

(3) The users can also run different applications on VMs to prevent their host computer from getting computer virus.

(4) VMs are easy to boot up.

from a system administrator's perspective:

(1) If the system administrators don't know how many applications they need to run, they can just simply implement VMs in a big server instead of buying so many smaller servers and if the usages are increasing, the administrators can enlarge the capability and do the migration between the busy servers and free servers easily.

3.

Define interrupts.

When the I/O device finishes the operation, it generates an interrupt, letting the CPU know it's done or if there was an error. At a low-level, interrupt is a mechanism to let the CPU know something 'important' happened.

Define traps:

Traps are basically a type of software interrupts. Trap occurs as result of executing a special instruction and the purpose is to execute predefined routing in kernel mode. Traps can also be implemented system calls.

What are some key differences between hardware interrupts and traps?

Hardware Interrupts is an external event delivered to the CPU and it's origins are I/O, timer, user input, etc. In addition, Hardware Interrupts asynchronous with the current activity of the CPU and the time of the event is not known and is not predictable.

Software Interrupts(traps) is an internal events, eg. system calls , error conditions (div by zero and it synchronous with the current activity of the CPU and occurs as a result of execution of a machine instruction.

Why are interrupts handled in kernel mode instead of user mode?

When the CPU executes a predefined routine, the routing must execute in kernel mode because in the routine, we are going to ask for some information from the devices and we need to talk to the devices and if you run it on user mode you cannot respond to interrupts yourself.

4.

what are the output of the time commands ?

wc:

real   0m0.017s

user   0m0.015s

sys   0m0.002s

simple_wc:

real   0m0.671s

user   0m0.151s

sys   0m0.518s

how much time did the C++ program and wc spend in the kernel mode and user mode?

C++ program spends 0.151s in user mode and 0.518 in kernel mode

Wc spends 0.015 in user mode and 0.002 in kernel mode

Why is the wc program faster than the C++ program?

C++ program read only 1 character once time and involves too many system calls.

Wc program read a chunk of characters once time so it a lot more efficient.

6.

is your program from Q5 faster than simple_wc.cpp? why?

Yes. Because I made an array to store the characters from reading and I avoid my program involving too many system calls.

Is your program faster or slower than wc and why?

My program faster than wc because wc has more system calls than me.