Sistemas de Operação / Fundamentos de Sistemas Operativos

Processes

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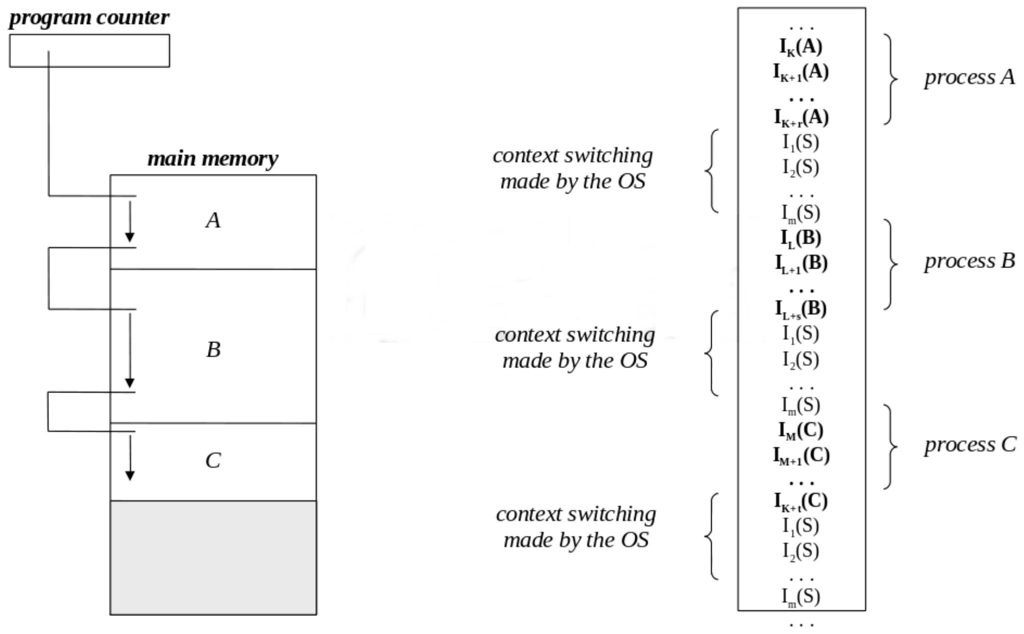
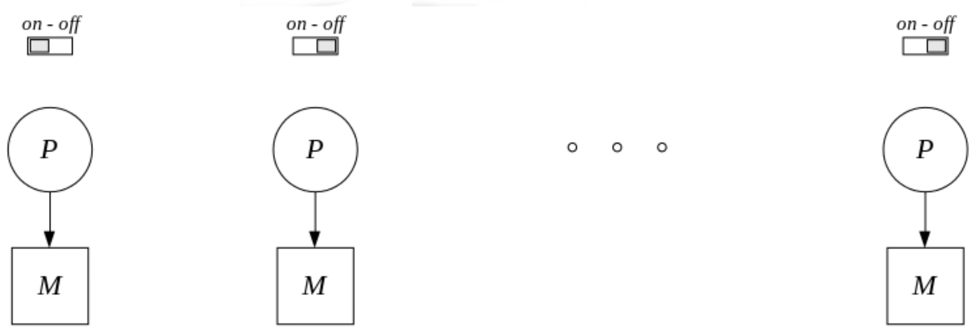
Outline

Process
Execution in a multiprogrammed environment



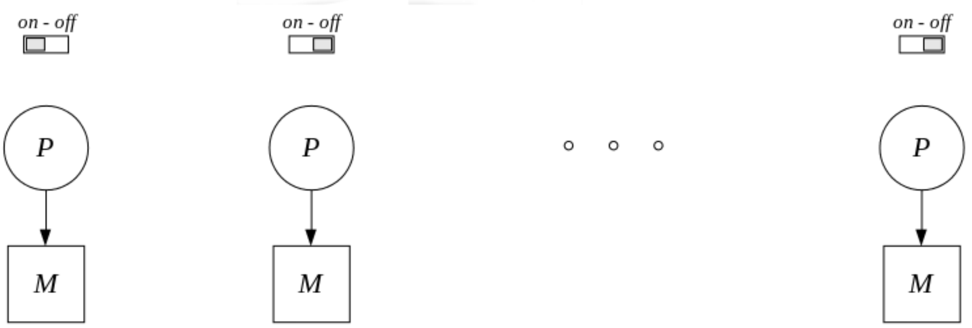
Processes
Process model

- In multiprogramming the activity of the processor, because it is switching back and forth from process to process, is hard to perceive
- Thus, it is better to assume the existence of a number of virtual processors, one per existing process
  - Turning off one virtual processor and on another, corresponds to a process switching
  - number of active virtual processors $\leq$ number of real processors



Processes
Process model (2)

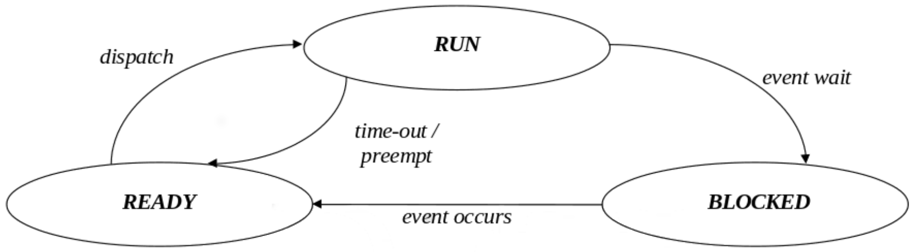
- The switching between processes, and thus the switching between virtual processors, can occur for different reasons, possible not controlled by the running program
- Thus, to be viable, this process model requires that
  - the execution of any process is not affected by the instant in time or the location in the code where the switching takes place
  - no restrictions are imposed on the total or partial execution times of any process



Processes
(Short-term) Process states

- A process can be not running for different reasons
  - so, one should identify the possible process states
- The most important are:
  - RUN – the process is in possession of a processor, and thus running
  - BLOCKED – the process is waiting for the occurrence of an external event (access to a resource, end of an input/output operation, etc.)
  - READY – the process is ready to run, but waiting for the availability of a processor to start/resume its execution
- Transitions between states usually result from external intervention, but, in some cases, can be triggered by the process itself
- The part of the operating system that handles these transitions is called the (processor) scheduler, and is an integral part of its kernel
  - Different policies exist to control the firing of these transitions
  - They will be covered later

Processes
Short-term state diagram

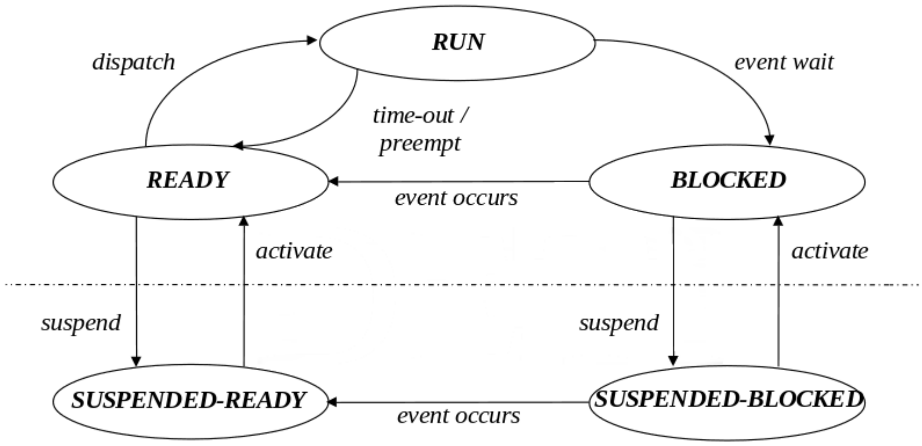


- event wait – the running process is prevented to proceed, awaiting the occurrence of an external event
- dispatch – one of the processes ready to run is selected and is given the processor
- event occurs – an external event occurred and the process waiting for it is now ready to be given de processor
- preempt – a higher priority process get ready to run, so the running process is removed from the processor
- time-out – the time quantum assigned to the running process get to the end, so the process is removed from the processor

Processes
Medium-term states

- The main memory is finite, which limits the number of coexisting processes
- A way to overcome this limitation is to use an area in secondary memory to extend the main memory
  - This is called *swap area* (can be a disk partition or a file)
  - A non running process, or part of it, can be swapped out, in order to free main memory for other processes
  - That process will be later on swapped in, after main memory becomes available
- Two new states should be added to the process state diagram to incorporate these situations:
  - suspended-ready – the process is ready but swapped out
  - suspended-blocked – the process is blocked and swapped out

Processes
State diagram, including short- and medium-term states

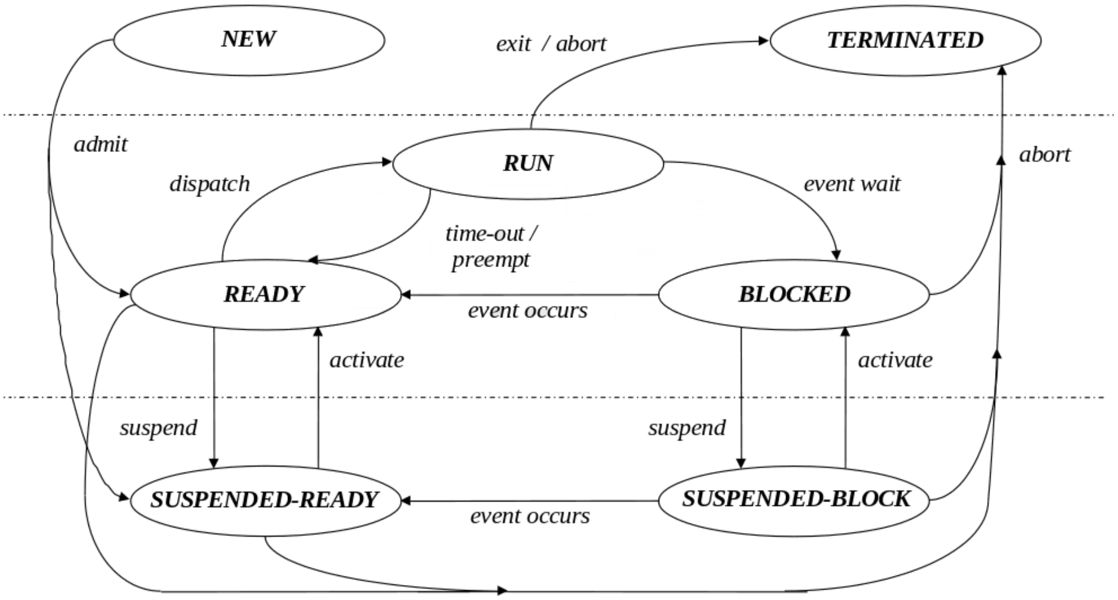


- Two new transitions appear:
  - suspend – the process is *swapped out*
  - activate – the process is *swapped in*

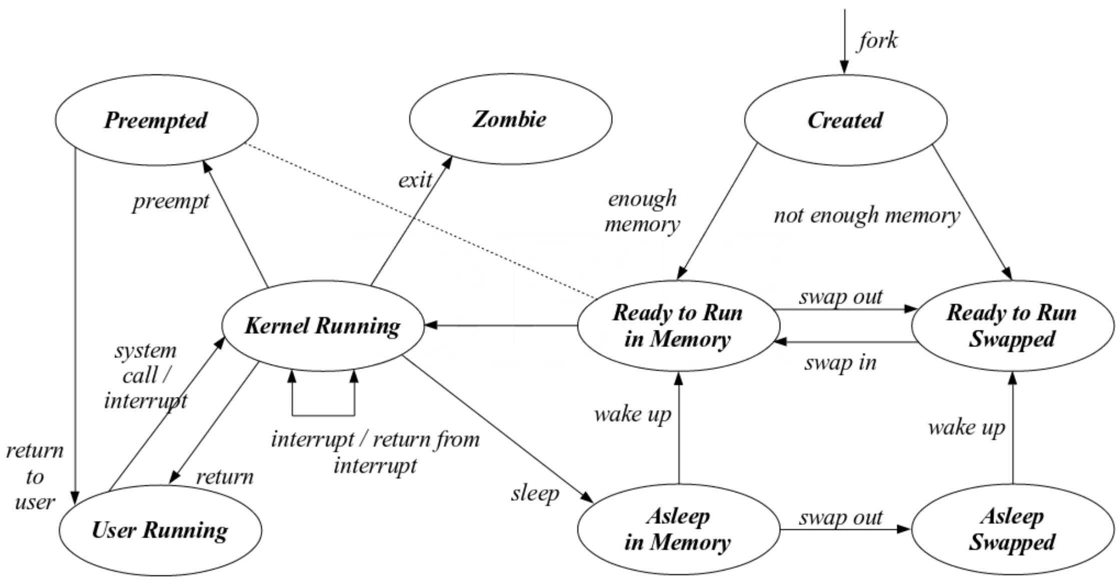
Processes
Long-term states and transitions

- The previous state diagram assumes processes are timeless
  - Apart from some system processes this is not true
  - Processes are created, exist for some time, and eventually terminate
- Two new states are required to represent creation and termination
  - new – the process has been created but not yet admitted to the pool of executable processes (the process data structure is been initialized)
  - terminated – the process has been released from the pool of executable processes, but some actions are still required before the process is discarded
- three new transitions exist
  - admit – the process is admitted (by the OS) to the pool of executable processes
  - exit – the running process indicates the OS it has completed
  - abort – the process is forced to terminate (because of a fatal error or because an authorized process aborts its execution)

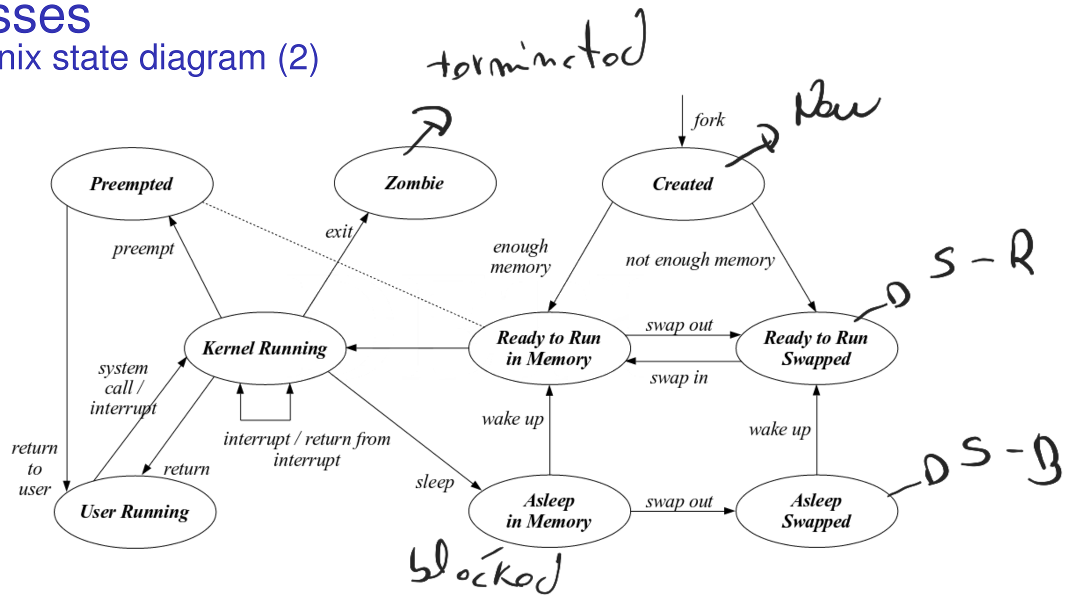
Processes
Global state diagram



Processes
Typical Unix state diagram

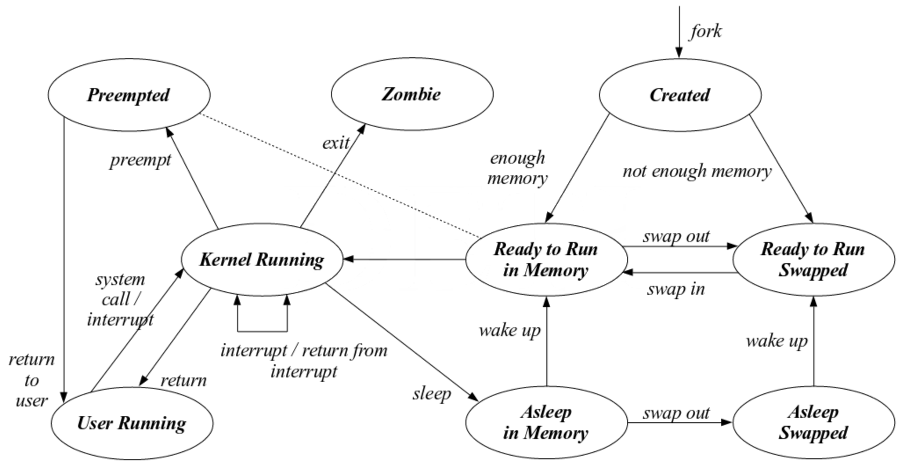


Processes
Typical Unix state diagram (2)



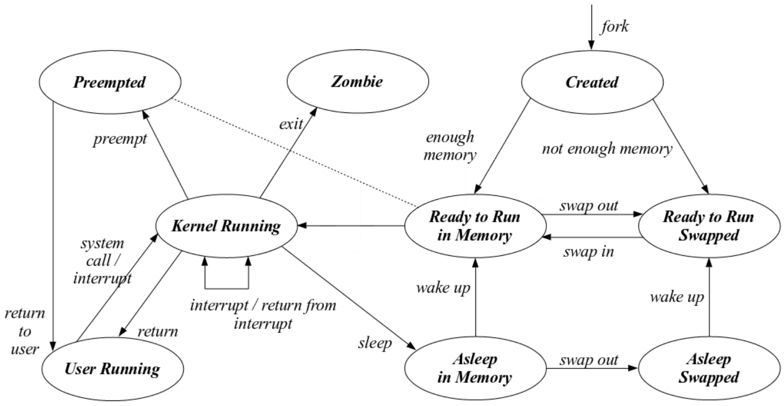
- There are two run states, kernel running and user running, associated to the processor running mode, supervisor and user, respectively
- The ready state is also splitted in two states, ready to run in memory and preempted, but they are equivalent, represented by the dashed line

Processes
Typical Unix state diagram (3)



- When a user process leaves supervisor mode, it can be preempted (because a higher priority process is ready to run)
- In practice, processes in ready to run in memory and preempted shared the same queue, thus are treated as equal
- The time-out transition is covered by the preempt one

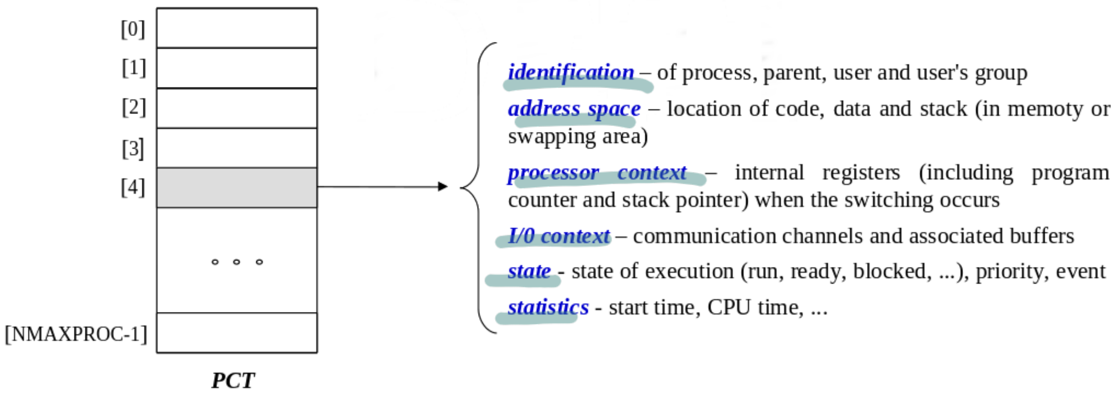
Processes
Typical Unix state diagram (4)



- Tradicionally, execution in supervisor mode could not be interrupted (thus UNIX does not allow real time processing)
- In current versions, namely from SVR4, the problem was solved by dividing the code into a succession of atomic regions between which the internal data structures are in a safe state and therefore allowing execution to be interrupted
- This corresponds to a transition between the preempted and kernel running states, that could be called return to kernel

Processes
Process control table

- To implement the process model, the operating systems needs a data structure to be used to store the information about each process – process control block
- The process control table (PCT), which can be seen as an array of process control blocks, stores information about all processes



Processes
Context switching

- Current processors have two functioning modes:
  - supervisor mode – all instruction set can be executed
    - is a privileged mode
  - user mode – only part of the instruction set can be executed
    - input/output instructions are excluded as well as those that modify control registers
    - it is the normal mode of operation
- Switching from user mode to supervisor mode is only possible through an exception (for security reasons)

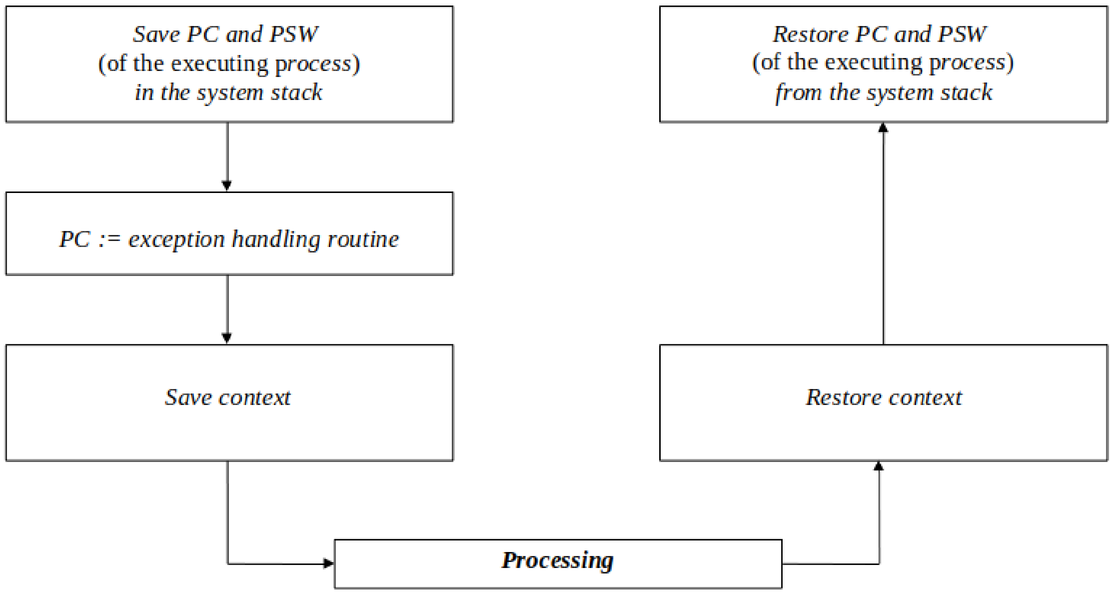
- An exception can be caused by:
  - I/O interrupt
    - external to the execution of the current instruction
  - illegal instruction (division by zero, bus error)
    - associated with the execution of the current instruction, but not intended
  - trap instruction (software interruption)
    - associated with the execution of the current instruction, and intended

Processes
Context switching (2)

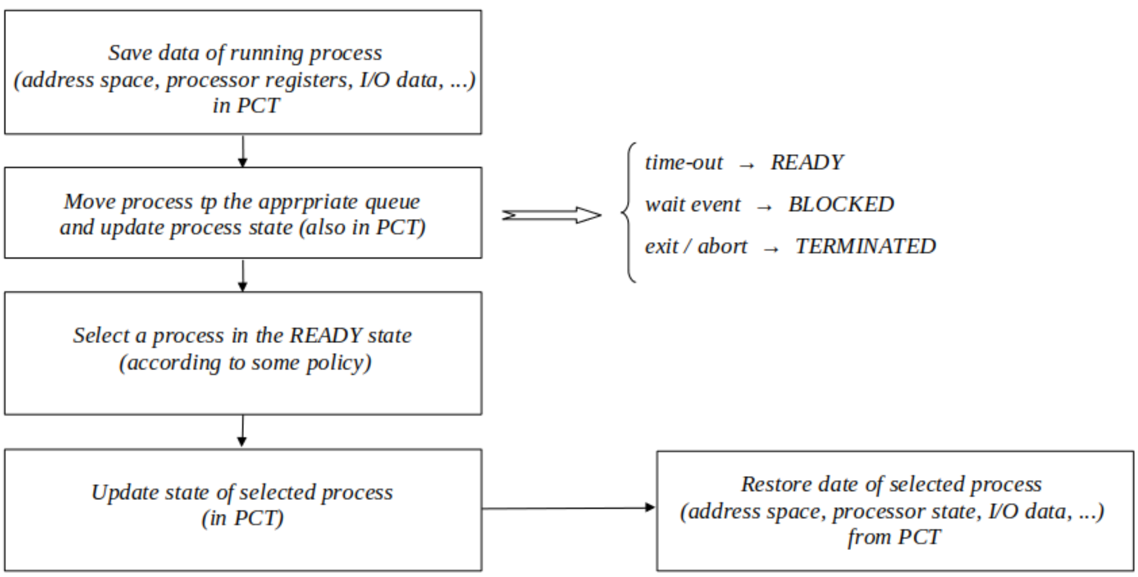
- The operating system should function in supervisor mode
  - in order to have access to all the functionalities of the processor
- Thus kernel functions (including system calls) must be fired by
  - hardware (interrupt)
  - trap (software interruption)
- This establishes a uniform operating environment: exception handling

- Context switching is the process of storing the state of a process and restoring the state of another process
- Context switching occurs necessarily in the context of an exception, with a small difference on how it is handle

Process
Processing a (normal) exception

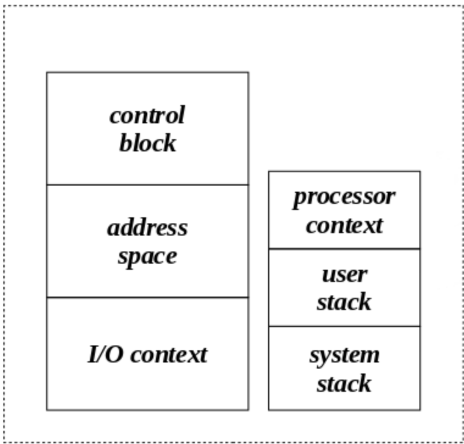


Process
Processing a process switching



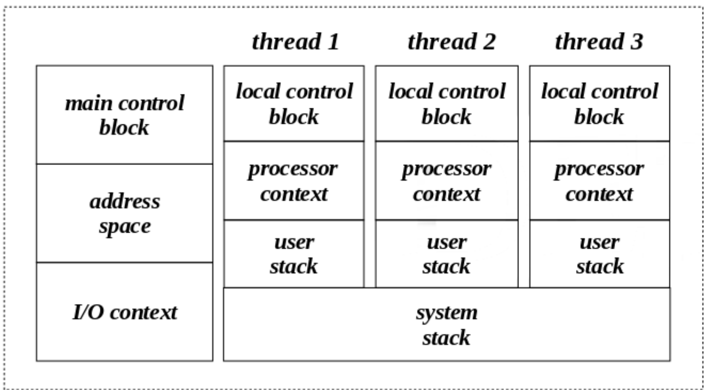
Threads
Single threading

- In traditional operating system, a process includes:
  - an address space (code and data of the associated program)
  - a set of communication channels with I/O devices
  - a single thread of control, which incorporates the processor registers (including the program counter) and a stack
- However, these components can be managed separetely
- In this model, thread appears as an execution component within a process



Single threading

Threads
Multithreading

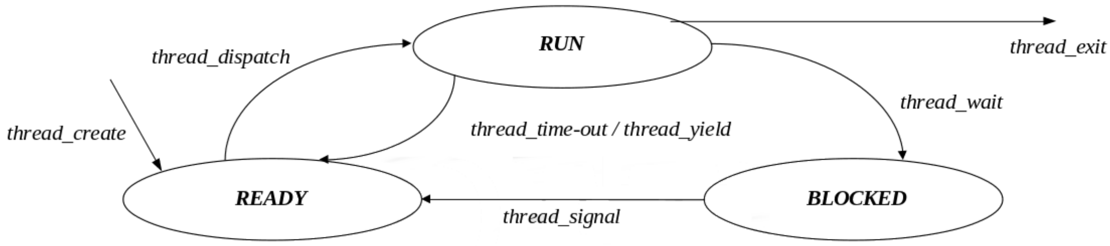


Multithreading

- Several independent threads can coexist in the same process, thus sharing the same address space and the same I/O context
  - This is referred to as *multithreading*
- Threads can be seen as *light weight processes*

Threads

State diagram of a thread



- Only states concerning the management of the processor are considered (short-term states)
- states suspended-ready and suspended-blocked are not present:
  - they are related to the process, not to the threads
- states new and terminated are not present:
  - the management of the multiprogramming environment is basically related to restrict the number of threads that can exist within a process

Bibliography

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  - Chapter 3: Process Description and Control (sections 3.1 to 3.5 and 3.7)
  - Chapter 4: Threads (sections 4.1, 4.2 and 4.6)
- Operating Systems Concepts, A. Silberschatz, P. Galvin and G. Gagne, John Wiley & Sons, 9th Ed, 2013
  - Chapter 3: Processes (sections 3.1 to 3.3)
  - Chapter 4: Threads (sections 4.1 and 4.4.1)
- Modern Operating Systems, A. Tanenbaum and H. Bos, Pearson Education Limited, 4th Ed, 2015
  - Chapter 2: Processes and Threads (sections 2.1 and 2.2)