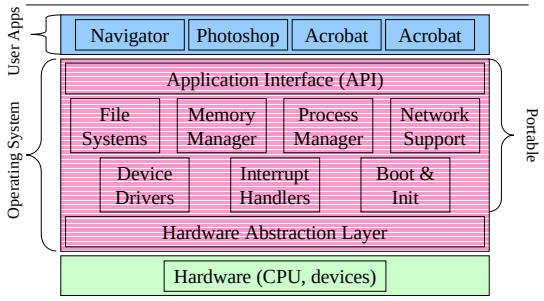
Processes

CSE 410 - Computer Systems
November 14, 2001

Readings and References

- Reading
  - Chapter 4 through Section 4.5.4, *Operating System Concepts*, Silberschatz, Galvin, and Gagne
- Other References
  - *Inside Microsoft Windows 2000*, Third Edition, Solomon and Russinovich

Example OS in operation



Programs and Processes

- A ***program*** is passive
  - a file on disk with code that can be run
- A ***process*** is active
  - an instance of a program in execution
  - also called *job*, *task*, *sequential process*
- There are always many processes running
- Some may be running the same program
  - but they are still separate and independent processes

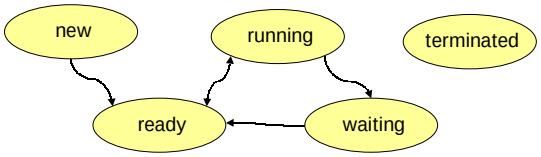
What are the parts of a process?

- code for the running program
- data for the running program
  - heap, stack
- location of the next instruction (PC)
- current state of the general-purpose registers
- list of open resources
  - files, network connections
- lots of OS management data

Process State

- Each process has an execution state that indicates what it is currently doing:
  - **ready**: waiting to be assigned to the CPU
  - **running**: executing instructions on the CPU
  - **waiting**: waiting for an event, e.g., I/O completion, so that it can be made ready
- As a program executes, the OS moves the process from state to state

Process State Changing



Processes move from state to state as a result of actions they perform (e.g., system calls), OS actions (rescheduling) and external actions (interrupts)

Process Data Structures

- At any time, there are many processes active in a system
- The OS has data structures representing each process
  - › primary structure is the Process Control Block (PCB)
- PCB contains info about a process
  - › including pointers to other related data blocks

PCBs and Hardware State

- When a process runs, its PC, SP, and registers, are loaded on the CPU
- When the OS switches to a new process, it
  - › saves the current process's register values to its PCB
  - › loads the next process's register values from its PCB
- This is called a **context switch**. It occurs 100-1000 times per second
  - › why so often?
  - › why not more often?

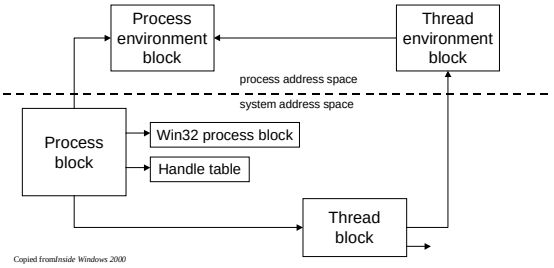
Context switch is pure overhead

- Switching processes can be expensive
  - › register reload
  - › OS data structures
- Lightweight context reduces cost of switch
  - › threads
- Special hardware reduces cost of switch
  - › larger register files with register windows
  - › remember "load multiple register" instruction?

Simple Process Control Block

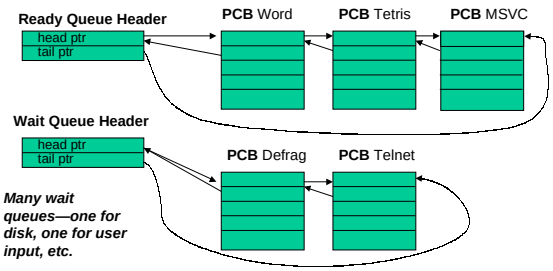
process state
process number
program counter
stack pointer
32 general-purpose registers
memory management info
username of owner
queue pointers for state queues
scheduling info (priority, etc.)
accounting info

Simplified W2K Process Data



Copied from *Inside Windows 2000*

Process State Queues



PCBs and State Queues

- PCBs are data structures in OS memory
- A PCB is created for a process when it starts and put on the ready queue
- While the process is active, PCB is on one of the state queues
- When the process is terminated, its PCB is deallocated *(after a little while)*

Getting control back

- How does the OS get control back from a running process?
  - The process could explicitly return control to the OS (in many real-time systems)
  - Generally, we can't trust the process to do this
- OS sets a timer on the CPU (privileged instruction) and starts a user process
- When the timer expires control passes to OS
  - impact on "hard real-time" system?

Scheduling a process

- Batch processes tend to be scheduled over a long period by a job scheduler
  - explicit dollar value on priority
  - longer time in CPU once loaded and started
- Interactive or soft real time processes are started as needed and compete for CPU
  - dynamic priorities
  - rapid context switching of many processes

Creating a process

- The OS creates processes upon request
- The first few processes are all part of the operating system itself
  - services, sessions, spoolers, network tools, ...
- Further processes created as response to login, user command, scheduled events
  - winlogin, sshd, navigator, photoshop, ...

create-process

- OS provides create-process system call
  - parent process creates one or more children
  - each child can create more children
  - the result is a process tree
- Parent can wait or continue immediately
  - create a process and block (synchronous)
  - create a process and continue (asynchronous)

"tlist -t" on my laptop

```
System Process (0)
System (8)
  smss.exe (140)
    csrss.exe (164)
    winlogon.exe (160) NetDDE Agent
      services.exe (212)
        svchost.exe (392)
        spoolsv.exe (420)
        Avsynmgr.exe (476)
          VsStat.exe (744) NAI_VS_STAT
            Vshwin32.exe (760) VShieldWin_Class
          Avconsol.exe (872)
        svchost.exe (496)
        HPConfig.exe (536) OleMainThreadWndName
        regsvc.exe (580)
        MSTask.exe (600) SYSTEM AGENT COM WINDOW
        WinMgmt.exe (636)
        mspmspsv.exe (724)
        Mcshield.exe (556)
      lsass.exe (224)
```

```
Explorer.EXE (1076) Program Manager
  ESSD.exe (1132) ESS Daemon
  s3hotkey.exe (1160) S3HotKey
  S3trayhp.exe (1180) S3
  SynTPLpr.exe (1196) Touchpad driver helper
    SynTPEnh.exe (1228) Touchpad driver tray
    motmon.exe (1220) motmon
  mpbtn.exe (1256) hpisButton
  CP32NBTN.EXE (1280) One-Touch
    CDRomMnt.EXE (888) CD-Rom Monitor
    KBOSDCtl.EXE (1116) Dritek OSD Window
    CP32NKCC.EXE (1264) Dritek HotKey
  OSA.EXE (1308) Reminder
  AcroTray.exe (1316) AcrobatTrayIcon
  CMD.EXE (984) Command Prompt - tlist -t
    tlist.exe (1112)
```


Fork Example

```
#include <stdio.h>
int main(int argc,char *argv[]) {
  int pid;
  int thisPid;
  thisPid = getpid();
  printf("Forking in (%i).\n",thisPid);
  pid = fork();
  if (pid < 0) {
    fprintf(stderr,"Fork Failed\n");
    exit(-1);
  }
  else if (pid ==0) {
    execlp("/bin/ls","ls",NULL);
  }
  else {
    printf("Waiting in (%i) for (%i).\n",thisPid,pid);
    wait(NULL);
    printf("Child (%i) Complete.\n",pid);
    exit(0);
  }
}
```

```
aspen $ gcc fork.c
aspen $ ./a.out
Forking in (20946).
Waiting in (20946) for (20947).
a.out  fork.c  fork.c~
Child (20947) Complete.
```

W2K *CreateProcess* function

- Open the program file to be executed
- Create the W2K executive process object
- Create the initial thread (stack, context, ...)
- Notify Win32 subsystem about new process
- Start execution of the initial thread
- Complete initialization (eg, load dlls)
- Continue execution in both processes

Copied from *Inside Windows 2000*