Process Control

15-123

Systems Skills in C and Unix

Process Management

- **A *process***
  - is an instance of a program that is currently running.
  - Example: an executing C program
- **A uni processor or a single core system**
  - A system with a single processor
  - A single **processor** can typically executes multiple **processes**
- **A call to a program spawns a process.**
  - If a mail program is called by n users then n processes or instances are created and executed by the unix system.
- Many operating systems including windows and unix **executes many processes** at the same time.
  - Shared systems

Process Status

- When a program is called, a **process is created** and a **process ID** is issued. The process ID is given by the function getpid() defined in <unistd.h>.

The prototype for pid( ) is given by

```
#include <unistd.h>
pid_t  getpid(void);
```

- ps command lists all the current processes

> **ps**

PID	TTY	TIME	CMD
10150	pts/16	00:00:00	csh
31462	pts/16	00:00:00	ps

ps command options

> ps –a
> ps -l
> ps -al

Information provided by each process may include the following.

PID	The process ID in integer form
PPID	The parent process ID in integer form
STAT	The state of the process
TIME	CPU time used by the process (in seconds)
TT	Control terminal of the process
COMMAND	The user command that started the process

More on processes

Sample Code

- printf("The current process %d \n",getpid());
- printf("The parent process is %d \n",getppid());
- printf("The owner of this process has uid %d \n",getuid());
- sleep(1);

- **Background Processes**
  - run a C program in the background
    - **> ./a.out &**
  - Ideal for long jobs

Concurrency

- Two events that overlap in time are called “concurrent”
- Single-core machines
  - Concurrent processes are **interleaved**
    - A way to organize jobs to increase performance
  - Concurrency can be enabled
    - when accessing slow I/O devices
  - Concurrency Can also be controlled from programmer level
    - Mix I/O and other operations
- In Multi-core machines, concurrency is
  - True parallelism @ OS level

Application level concurrency

- Exploited by “concurrent programs”
- Three basic approaches to building concurrent applications
  - Multiple Processes
    - Separate virtual address spaces
    - Communicate via IPC
  - I/O multiplexing
    - Application scheduling logical flows in a context of a single process
  - Threads
    - Logical flows that runs in the context of a single process called parent
    - Separate stack space for each thread

How to build concurrency in your program

- Using system calls
  - fork(), exec(), waitpid(), exit()
- Concurrency examples
  - Serving clients in a network
    - Accept requests by client
    - Create threads to handle each client
  - A broadcasting application
    - Data distributed to all nodes in a network by using multiple threads

Creating a child thread

- **fork( )**
  - #include <unistd.h>
    pid_t fork(void);
  - fork creates a new child process exactly identical to the parent
  - That is, Child gets an exact copy of the parent
    - inherits state
  - Child gets a unique process ID
  - Child also Inherits parents file descriptors and refer to the same open files

Forking new Processes

- Calling **fork( )**
  - creates a child process which is exactly identical to the parent process
  - The value zero gets returned to the child and PID gets returned to the parent.
- An example

```
if (fork() == 0) {
    printf("This is a message from the child\n");
}
else { printf("This is a message from the parent\n");}
```

- If the fork process is failed, no child process is created and fork returns -1.
  - **int PID = fork();**
  - **if (PID == -1) printf("the process creation failed\n");**

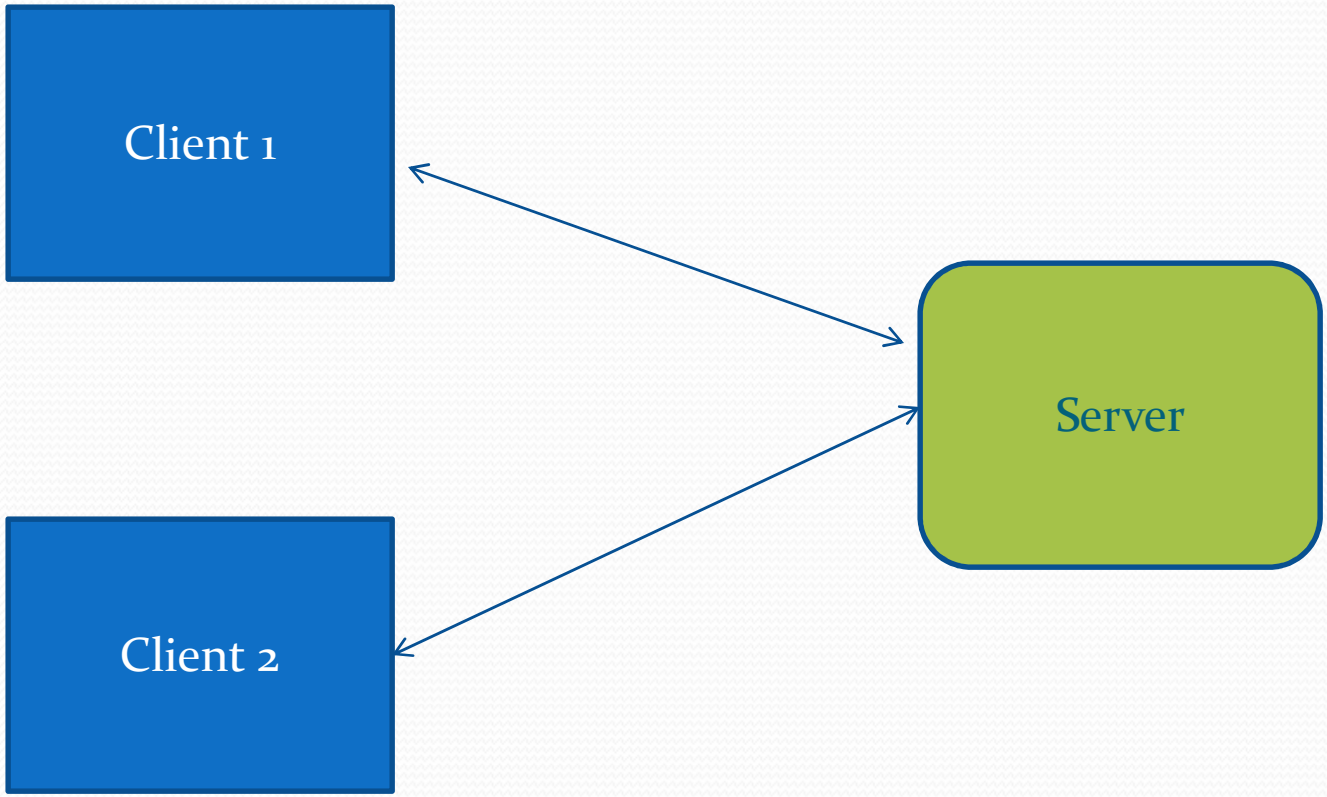
Sample Code

```
int A[]={1,2,3,4,5,6};
int sum=0, pdt=1, PID, i;
if ((PID=fork())==0){
   for (i=0;i<6;i++) sum += A[i];
   printf("This is child process computed sum %d \n", sum);
}
if (PID <0) {
    fprintf(stderr,"problem creating a process \n");
}
if (PID >0) {
    for (i=0;i<6;i++) pdt *= A[i];
    printf("The parent process completed the product %d \n", pdt);
}
```

- **What is the output?**

Being Bad
fork bomb

Server-Client Architectures



More about processes

- Parent and child processes share state information
  - Gets a copy of the state variables
- Parent and children have their own address spaces
  - One process cannot overwrite another
- Drawbacks
  - Hard to share state information
    - However waitpid and signals can send small messages to processes running on the same host
  - Have to use explicit IPC
    - to share information on different hosts

Other Process Management Commands

- **exec( )** [many variations of this]
  - See next slide
- **wait( )**
  - #include <sys/wait.h>
    pid_t wait(int *_stat_loc_);
    - Suspends the execution of the calling thread until a child has returned
  - **pid_t waitpid(pid_t _pid_, int *_stat_loc_, int _options_);**
    - If pid>o, this requests the status of a child process
    - Options defined in <sys/wait.h>
- **exit( )**
  - #include <stdlib.h>
    void exit(int _status_);
  - Status can be EXIT_SUCCESS, EXIT_FAILURE or any other value
  - 8 Least significant bits available to a calling process
  - Value can be retrieved by wait

Executing another process

- **execl** --- takes the path name of a binary executable as its first argument, the rest of the arguments are the command line arguments ending with a NULL.
  - **Example**: execl("./a.out", NULL)

- **execv** – takes the path name of a binary executable as its first argument, and an array of arguments as its second argument.
  - **Example**: static char* args[] = {“ “, "cat.txt", "test1.txt", NULL};
  - execv("/bin/cp", args);

- **execlp** --- same as execl except that we don’t have to give the full path name of the command.
  - execlp("ls", NULL)

Writing a (fake) Shell

```
int PID; char cmd[256];
while (1) {
 printf("cmd: "); scanf(“%s”, cmd);
 if ( strcmp(cmd,"e")==0)
     exit(0);
 if ((PID=fork()) > 0)
    wait(NULL);
 else if (PID == 0) /* child process */
   {   execlp (cmd,cmd,NULL);
       fprintf (stderr, "Cannot execute %s\n", cmd);
       exit(1);
   }
  else if ( PID == -1)
     {  fprintf (stderr, "Cannot create a new process\n");
        exit (2);
     }
}
```

Wait Examples

wait, waitpid - wait for a child process to stop or terminate

#include <sys/wait.h>

pid_t wait(int *_status_);

pid_t waitpid(pid_t _pid_, int *_status_, int _options_);

It returns the PID of the child and the exit status gets placed in status.

```
main() {
  int child_status, pid, pidwait;
  if ((pid = fork()) == 0) {
    printf("This is the child!\n");
  }
  else {
    pidwait = wait(&child_status);
    printf("child %d has terminated\n", pidwait);
  }
  exit();
}
```

Coding Examples