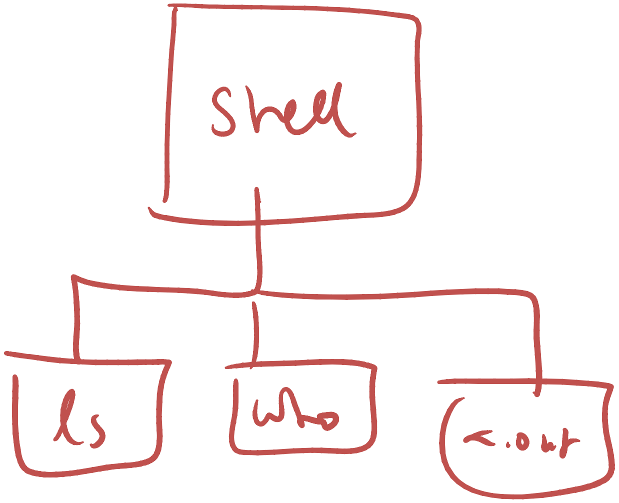
Process Control

15-123

Systems Skills in C and Unix

A Process



- **A *process***
  - is an instance of a program that is currently running.
- **A uni processor system**
  - 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.
- 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);
```

063522

Process Status

- ps command lists all the current processes

```
> ps
```

```
> kill -9 10150
```

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

ps command options

> ps –a — Shows all processes

> 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

>ps

> ls

> return

Concurrency

2, 3, 10, 15

2
5
15
30

4 | 52

13

- Two events that overlap in time
- Single-core machines
  - Concurrent processes are interleaved
  - Concurrency can be enabled when accessing slow I/O devices
  - Can also be controlled from programmer level
    - Mix I/O and other operations
- Multi-core machines
  - True parallelism
  - OS level

10, 2, 3, 15

10
12
15
30

4 | 67

17 sec/Job

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

ls | sort

Building a concurrent program

- Using system calls
  - fork(), exec(), waitpid(), exit()
- Example
  - 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

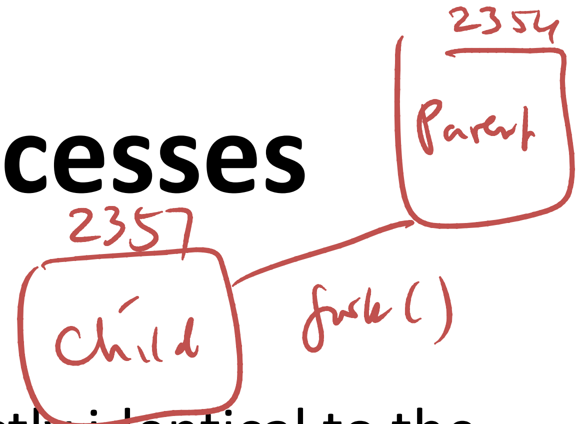
No fork bombs please

Process related commands

- **Process related Commands**
  - **fork( )**
    - #include <unistd.h>
      pid_t fork(void);
    - A new child process is created
    - An exact copy of the parent – inherits state
    - With a unique child process ID
    - Inherits parents file descriptors and refer to the same open files

↓ global

Forking new Processes



- The **fork( )** function
  - 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 of using fork( ) is
  - **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

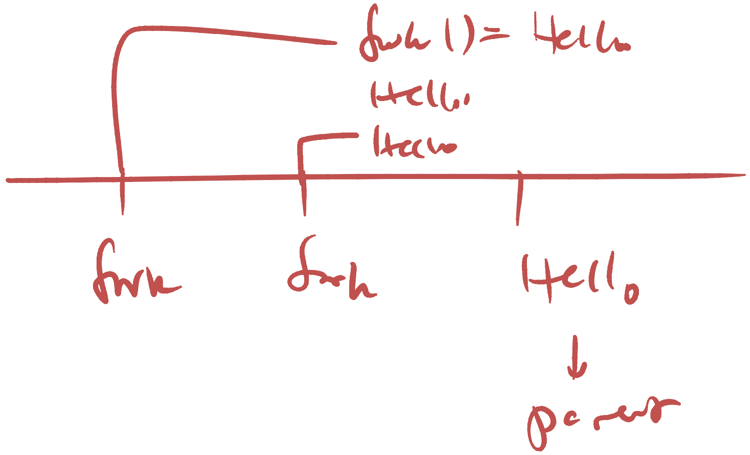
```
int A[]={1,2,3,4,5,6};
int sum=0, pdt=1, PID, i;
if ((PID=fork())==0){
   for (i=0;i<6;i++) sum += A[i];
   printf("This is child process computed sum %d \n", sum);
}
else
if (PID <0) {
    fprintf(stderr,"problem creating a process \n");
}
else
if (PID >0) {
    for (i=0;i<6;i++) pdt *= A[i];
 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

- **What is the output?**

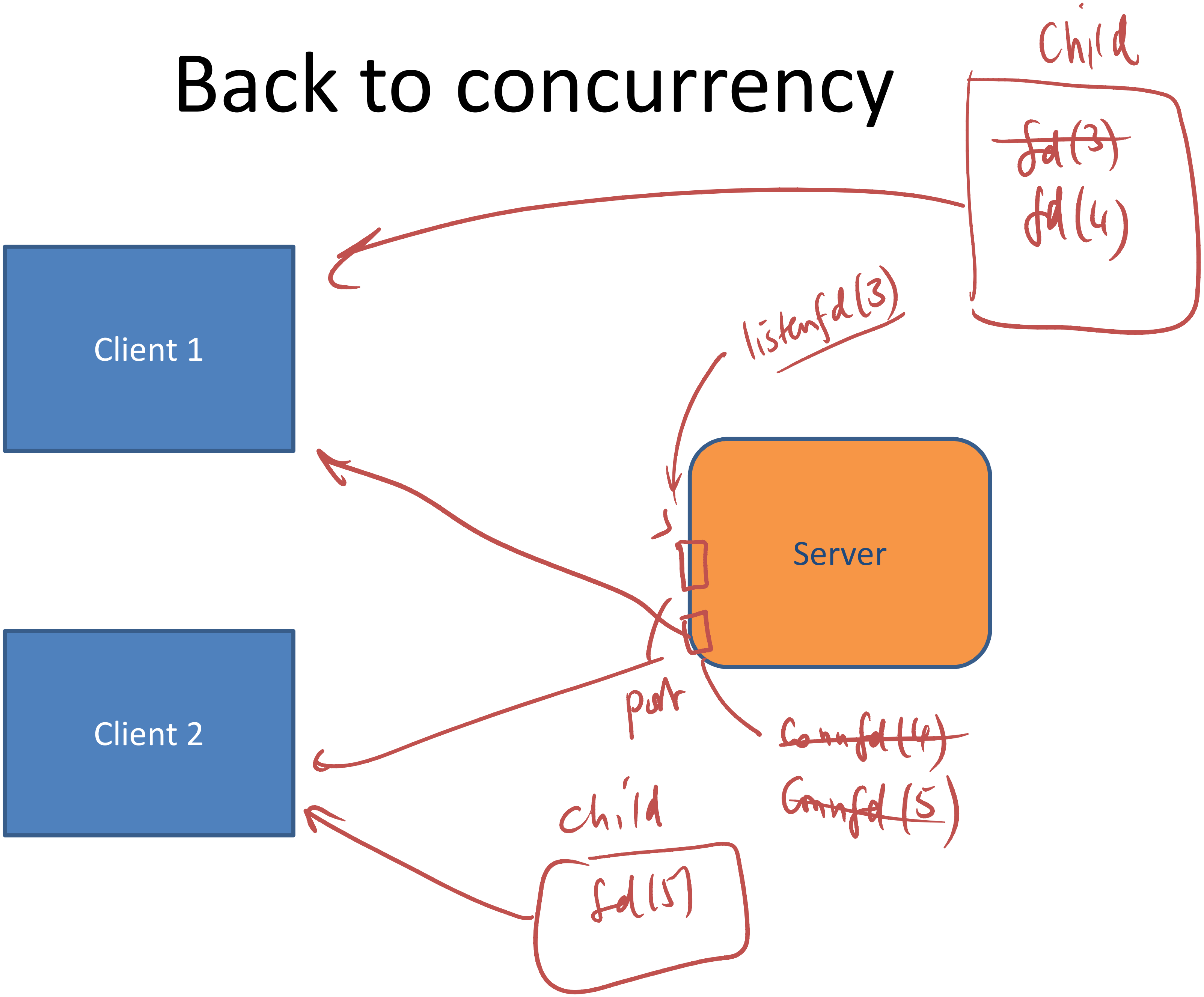
```
int main(){
    fork();
    printf("Hello");
}
```

```
printf("Hello")
```

```
~~fork();~~
fork();
printf("Hello");
```



Back to concurrency



Executing another process

- Processes
  - Share state information
    - Gets a copy of the state variables
  - Have 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

Process 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>0, 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) /* loop terminates if type 'e'*/
       exit(0);
 /* creates a new process. Parent gets the process ID. Child gets 0 */
  if ((PID=fork()) > 0)
      wait(NULL);
  else if (PID == 0) /* child process */
     {   execlp (cmd,cmd,NULL);
       /* exec cannot return. If so do the following */
       fprintf (stderr, "Cannot execute %s\n", cmd);
       exit(1); /* exec failed */
     }
   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