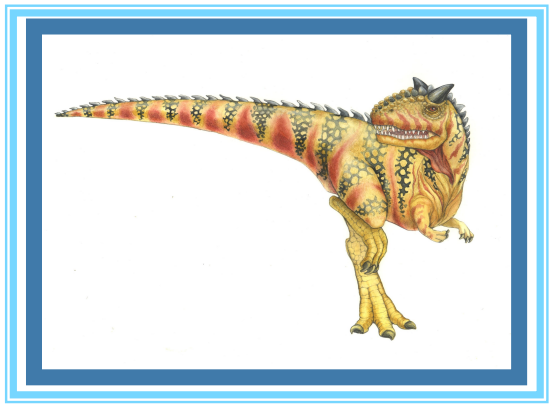
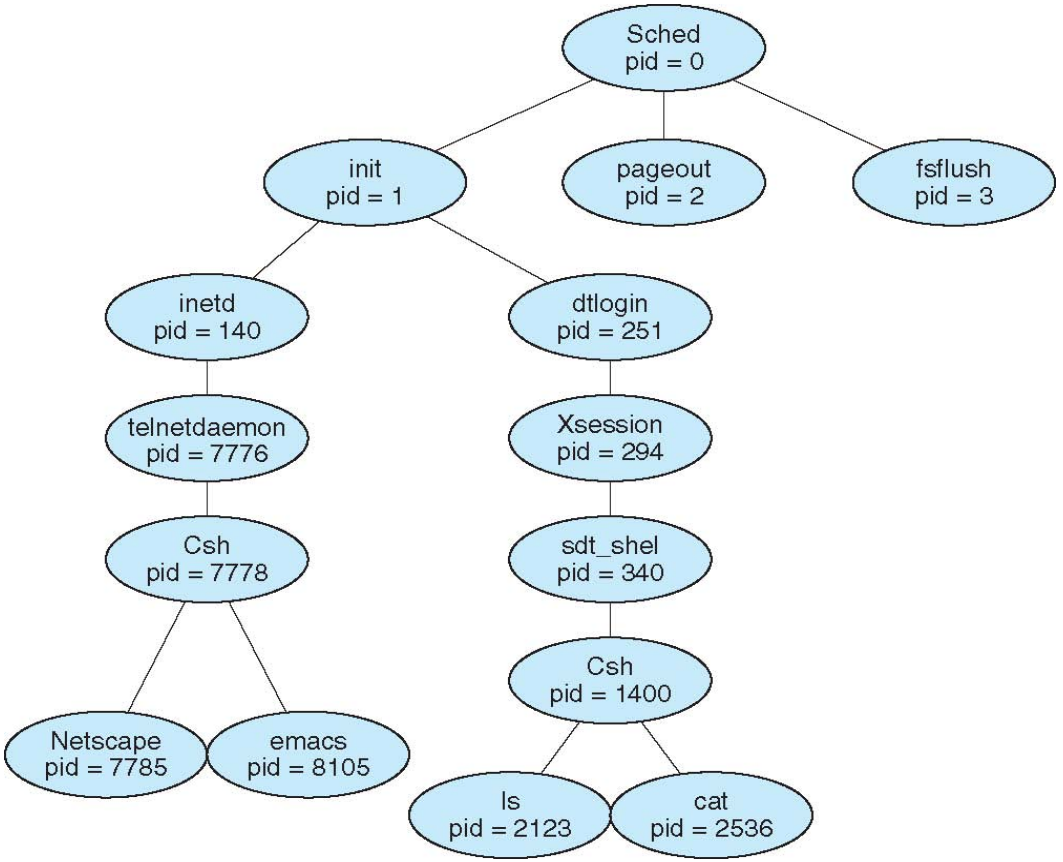
Chapter 3: Processes



Process Creation

- **Parent** process creates **children** processes, which, in turn create other processes, forming a tree of processes



Process Creation

- Generally, process identified and managed via **a process identifier** (**pid**)
- Resource sharing
  - Parent and children share all resources
  - Children share subset of parent's resources
  - Parent and child share no resources
- Execution
  - Parent and children execute concurrently
  - Parent waits until children terminate

Process Creation (Cont.)

- Address space
  - Child duplicate of parent
  - Child has a program loaded into it
- UNIX examples
  - **fork** system call creates new process
  - **exec** system call used after a **fork** to replace the process' memory space with a new program

Process Creation in Unix

```
int main()
{
pid_t  pid;
    /* fork another process */
    pid = fork();
    if (pid < 0) { /* error occurred */
         fprintf(stderr, "Fork Failed");
         return 1;
    }
    else if (pid == 0) { /* child process */
         execlp("/bin/ls", "ls", NULL);
    }
    else { /* parent process */
         /* parent will wait for the child */
         wait (NULL);
         printf ("Child Complete");
    }
    return 0;
}
```

Process Creation in Unix

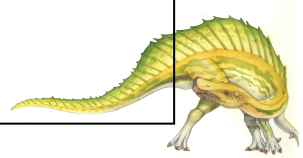
```
int main() {
   ...
   pid = fork();
```

parent process

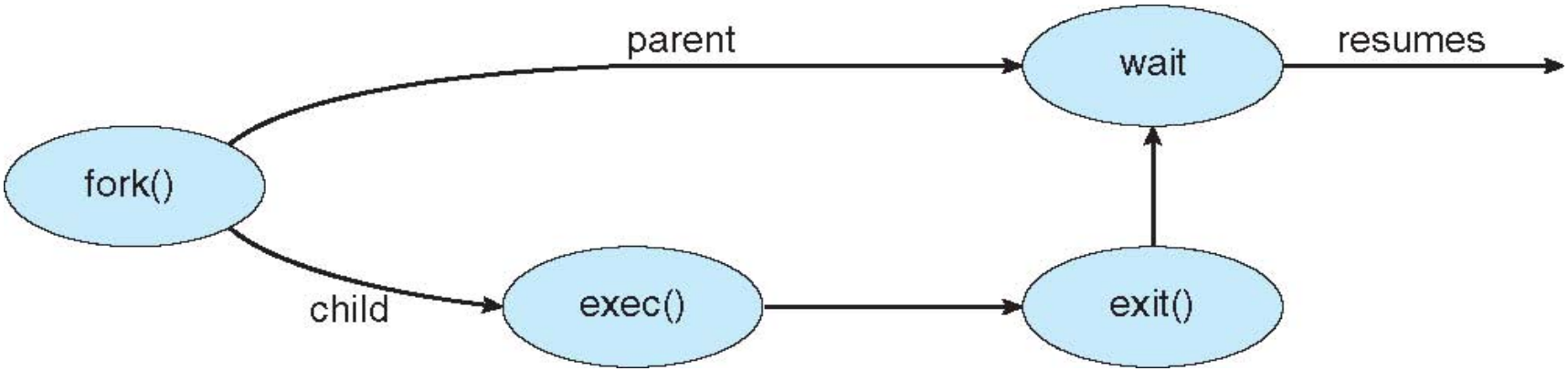
new child process
process id = 1234

```
// pid is 1234
if (pid < 0) {
     fprintf(stderr, "Fork
Failed");
     return 1;
}
else if (pid == 0) {
     execlp("/bin/ls", "ls",
NULL);
}
else {
     wait (NULL);
     printf ("Child
Complete");
}
return 0;
}
```

```
// pid is 0
if (pid < 0) {
     fprintf(stderr, "Fork
Failed");
     return 1;
}
else if (pid == 0) {
     execlp("/bin/ls", "ls",
NULL);
}
else {
     wait (NULL);
     printf ("Child
Complete");
}
return 0;
}
```



Process Creation



Process Creation in Win32

```
int main(VOID) {
        //...
        // create child process
        if (!CreateProcess(NULL, // use command line
                "C:\\WINDOWS\\system32\\mspaint.exe”
                NULL, //inherit process handle
                NULL, //don't inherit thread handle
                FALSE, //disable handle inheritance
                0, // no creation flags
                NULL, //use parent's environment block
                NULL, //use parent's existing directory
                &si, &pi)) {
                        fprintf(stderr, "Create Process Failed");
                        return -1;
          }
        WaitForSingleObject(pi.hProcess, INFINITE);
        printf("Child Complete");
}
```

Quiz: fork()

- What are the outputs?

(parent pid: 2600

child pid: 2603)

```
int main()
{
pid_t pid, pid1;

    /* fork a child process */
    pid = fork();

    if (pid < 0) { /* error occurred */
       fprintf(stderr, "Fork Failed");
       return 1;
    }
    else if (pid == 0) { /* child process */
       pid1 = getpid();
       printf("child: pid = %d",pid); /* A */
       printf("child: pid1 = %d",pid1); /* B */
    }
    else { /* parent process */
       pid1 = getpid();
       printf("parent: pid = %d",pid); /* C */
       printf("parent: pid1 = %d",pid1); /* D */
       wait(NULL);
    }

    return 0;
}
```

Quiz: fork()

- What is the outp

```
int value = 5;

int main()
{
pid_t pid;

   pid = fork();

   if (pid == 0) { /* child process */
      value += 15;
      return 0;
   }
   else if (pid > 0) { /* parent process */
      wait(NULL);
      printf("PARENT: value = %d",value); /* LINE A */
      return 0;
   }
}
```

Quiz: cascading fork()s

- How many processes are created?

```
#include <stdio.h>
#include <unistd.h>

int main()
{
    /* fork a child process */
(1) fork();

    /* fork another child process */
(2) fork();



    return 0;
}
```

Quiz: fork()

```
main(){
   int a, x, y;
   a=-5;
   x=-15;
   y=-20;
   a=fork();

   if(a==0)
       y=fork();

   printf("x=%d y=%d a=%d\n", x, y,
   a);
}
```

Current process ID = 100

New process ID = parent process ID + 1

Quiz: fork()

```
main(){
   int a, x, y, n;
   a=-5;
   n=1;
   x=-15;
   y=-20;
   a=fork();

   if(a==0)
       y=fork();

   while (n<3){
       if(y==0)
              x=fork();
       n++;
   }
   printf("x=%d y=%d a=%d\n", x, y,
   a);
}
```

Current process ID = 100

New process ID = parent process ID + 1

Process Termination

- Process executes last statement and asks the operating system to delete it (**exit**)
  - Output data from child to parent (via **wait**)
  - Process' resources are deallocated by operating system
- Parent may terminate execution of children processes (**abort**)
  - Child has exceeded allocated resources
  - Task assigned to child is no longer required
  - If parent is exiting
    - Some operating systems do not allow child to continue if its parent terminates
      - All children terminated - **cascading termination**