A Tutorial on Unix System Calls

Inter-Process Communication (IPC)

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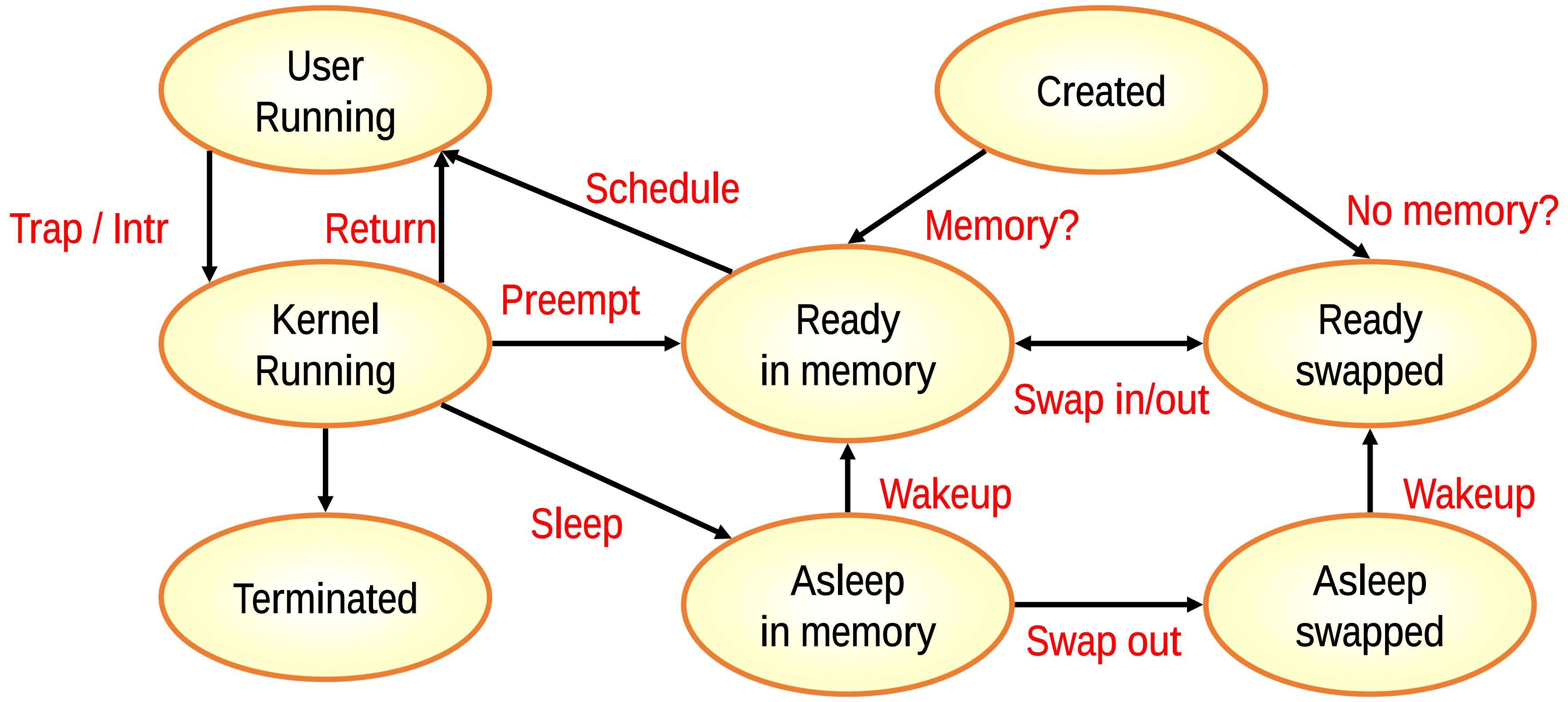
Process

- A process is a program in execution
- Contents
    - Process control block
        - Process identification
        - Process state information
        - Process control information
    - User stack
    - Private user address space (program, data)
    - Shared address space

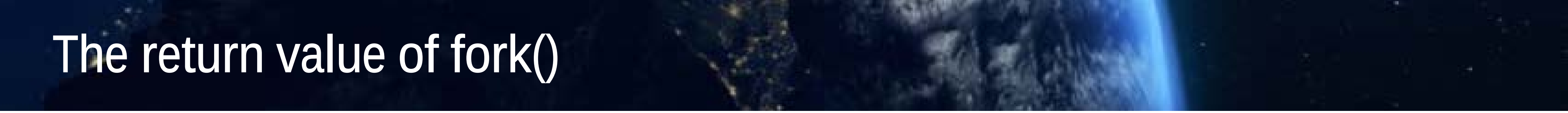
Process State Transitions



How to create a new process?

- The fork() system call
  - It creates a new process as a *child process* of the calling process (*parent*)
  - Both have similar code segments
  - The child gets a copy of the parents data segment at the time of forking

- How can the child realize that it is the child and not the parent?
- How can we make the child and parent do different things?



The return value of fork()

fork( ) returns a value to both parent and child

- The parent receives the process id of the child
- The child receives 0 (zero)

Key idea:

```
if (fork() == 0)
        { /* I am the child process */ }
else
        { /* I am the parent process */ }
```

The first program: fork1.c

```
#include <stdio.h>
#include <sys/ipc.h>
main( )
{
    if (fork( ) == 0) {  /* Child */
            while (1) {              for (i=0; i<100000; i++) ;
                                     printf("\t\t\t Child executing\n ");         }
    }
    else {                 /* Parent */
            while (1) {              for (i=0; i<100000; i++) ;
                                     printf("Parent executing\n");  }
    }
}
```

Waiting for child termination

- The parent process can wait for the child process to terminate using the call:

```
waitpid( pid, NULL, 0 )
```

-- where pid is the identifier of the child process (returned by fork( ))

-- what are the other two parameters?

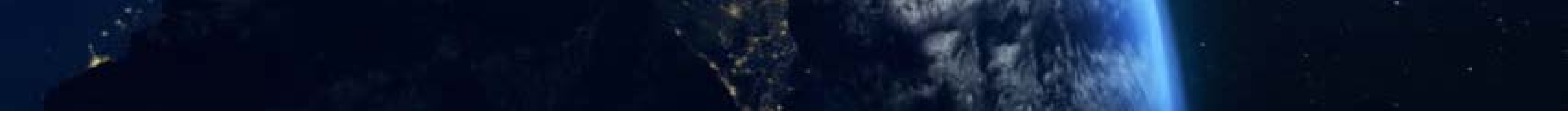
The second program: fork2.c

```
#include <stdio.h>
#include <sys/ipc.h>
main()
{
   int i, x = 10, pid1, pid2 ;
   printf("Before forking, the value of x is %d\n", x);

   if ( ( pid1 = fork( ) ) == 0) {  /* First child process */
            for (i=0 ; i < 5; i++) {
              printf("\t\t\t At first child: x= %d\n", x);
              x= x+10;
              sleep(1) ; /* Sleep for 1 second */
            }
   }
else {      /* Parent process */

   if ( ( pid2 = fork( ) ) == 0) {  /* Second child */
           for (i=0 ; i < 5; i++) {
              printf("\t\t\t\t\t\t At second child: x= %d\n", x);
              x= x+20;  sleep(1) ; /* Sleep for 1 second */
           }
   }
   else {   /* Parent process */
           waitpid(pid1, NULL, 0);
           waitpid(pid2, NULL, 0);
           printf("Both children terminated\n");
   }
}}
```

Points to ponder: fork3.c

```
#include <stdio.h>
#include <sys/ipc.h>
main( )
{
    int x=0, pid;
    printf("Hello!");

    if ( ( pid = fork() ) == 0) {   /* Child */
      printf("\nChild:\t Address of x: %x\t
                            Value of x: %d \n", &x, x);
      x = 20;
      printf("Child:\t Address of x: %x\t
                            Value of x: %d \n", &x, x);
    }
    else {   /* Parent */
      waitpid(pid, NULL, 0);
      printf("\nParent:\t Address of x: %x\t
                            Value of x: %d \n", &x, x);
      x = 10;
      printf("Parent:\t Address of x: %x\t
                            Value of x: %d \n", &x, x);

    }
}
```

- How many times is Hello! printed?
- Is the address of x printed by the parent and child the same, or different?



EXEC, PIPE, DUP

Exec

- System calls that allow a process to execute a specified program
  - Process identifier remains the same.
  - There is no return from exec.

```
#include <stdio.h>
#include <unistd.h>
#include <sys/ipc.h>
main()
{
    execlp("cal","cal","2001",NULL);
    printf("This statement is not executed if execlp succeeds.\n");
}
```

Pipe

- The pipe( ) system call
  - Creates a pipe that can be shared between processes
  - It returns two file descriptors,
    - One for reading from the pipe, the other for writing into the pipe

```
#include <stdio.h>

#include <unistd.h>   /* Include this file to use pipes */

#define BUFSIZE 80

main()

{

    int fd[2], n=0, i;

    char line[BUFSIZE];


    pipe(fd);  /* fd[0] is for reading, fd[1] is for writing */
```

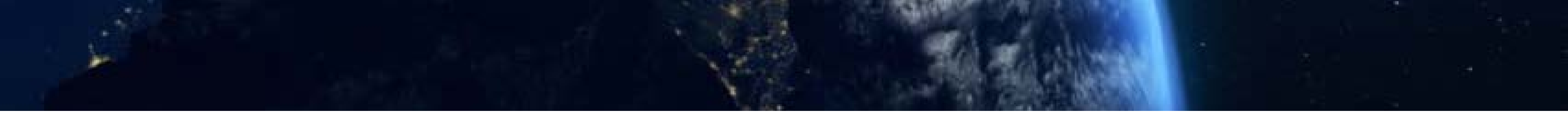
```
    if (fork() == 0) {

      close(fd[0]);      /* The child will not read */

      for (i=0; i < 10; i++) {

                sprintf(line,"%d",n);
                write(fd[1], line, BUFSIZE);

                printf("Child writes: %d\n",n);  n++; sleep(2);

    }}

    else {

      close(fd[1]); /* The parent will not write */

      for (i=0; i < 10; i++) {

                read(fd[0], line, BUFSIZE);

                sscanf(line,"%d",&n);
                printf("\t\t\t Parent reads: %d\n",n);

}  }}
```

Dup

- The dup(fd) system call:
  - Copies the descriptor, fd, into the first empty slot in the file descriptor table of the process
  - Recall that the 0th location of the FD table is for stdin and the 1st location of the FD table is for stdout.
  - We can use this information to use close( ) and dup( ) for redirecting stdin and/or stdout.

```
#include <stdio.h>
#include <unistd.h>
#include <sys/ipc.h>
main( )
{
   int fd[2], n=0, i;
   pipe(fd);
```

```
   if (fork() == 0) {   /* Child process */
         close(1) ; dup(fd[1]) ; /* Redirect the stdout of this process to the pipe. */
         close(fd[0]);
         for (i=0; i < 10; i++) { printf("%d\n",n);  n++; }
   }
   else {               /* Parent process */
         close(0) ; dup(fd[0]) ; /* Redirect the stdin of this process to the pipe */
         close(fd[1]);
         for (i=0; i < 10; i++) {  scanf("%d",&n); printf("n = %d\n",n); sleep(1);  }
} }
```



SHARED MEMORY

Shared Memory System Calls

- Creation:

  int shmid = shmget(IPC_PRIVATE, <no of bytes>, 0777|IPC_CREAT)

  - This call creates the shared memory segment and returns its identifier

- Attach:

  char * shmat(shmid, 0, 0)

  - This call attaches the shared memory segment with the logical address space of the calling process and returns the logical address

Using shared memory: shm.c

```
#include <stdio.h>
#include <sys/ipc.h>
#include <sys/shm.h>
main()
{
    int shmid, *a, *b, i;

    /* Acquire a shared array of 2 integers */
    shmid = shmget( IPC_PRIVATE,
                            2*sizeof(int), 0777|IPC_CREAT);
```

```
    if ((pid = fork()) == 0) {          /* Child */
            b = (int *) shmat( shmid, 0, 0 );   /* Attach to child */
            for( i=0; i< 10; i++) {
                    sleep(1);
                    printf("\t\t\t Child reads: %d,%d\n",b[0],b[1]);
    }       }
    else {                  /* Parent */
            a = (int *) shmat( shmid, 0, 0 );  /* Attach to parent */
            a[0] = 0; a[1] = 1;
            for( i=0; i< 10; i++) {
                    sleep(1); a[0] = a[0] + a[1]; a[1] = a[0] + a[1];
                    printf("Parent writes: %d,%d\n",a[0],a[1]);
            }
            waitpid( pid );
}}
```