Process Programming

Operating System Lab
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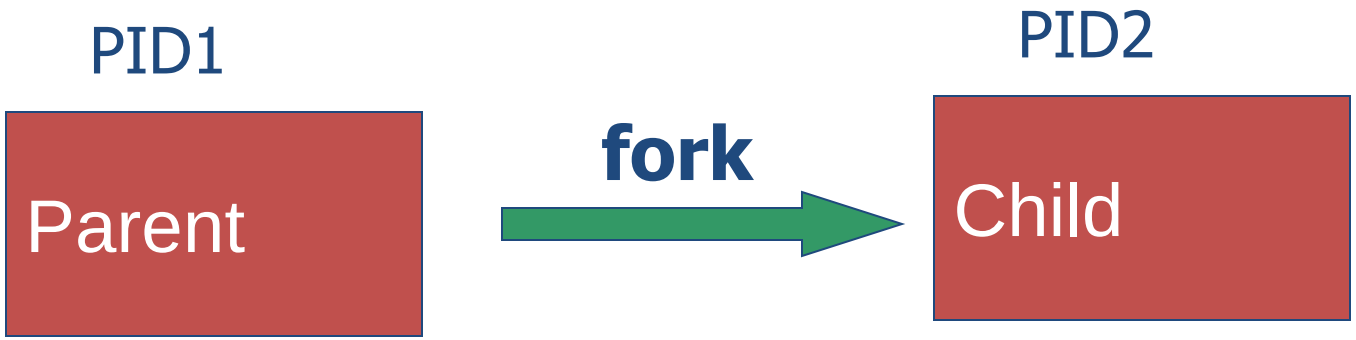
Process Control

- fork and vfork
- wait and waitpid
- exec
- system

Process Control

fork,vfork

fork



fork (cont.)

- int fork();
- The only way a new process is created by the Unix kernel.
  - The new process created is called the child process.
- The child is a copy of the parent.
  - The child gets a copy of the parent's data space, heap and stack.
  - The parent and child don't share these portions of memory.

fork (cont.)

- This function is called once, but return twice.
  - The process ID of the new child (to the parent).
    - A process can have more than one child.
  - 0 (to the child).

fork Sample

```
main()
{
    int pid;
    pid = fork();
   if (pid < 0)
        // error
    else if (pid == 0)
        //child
    else
        //parent
}
```

fork (cont.)

- We never know if the child starts executing before the parent or vice versa.
  - This depends on the scheduling algorithm used by the kernel.

vfork

- int = vfork();
- It has the same calling sequence and same return values as fork.
- The child doesn't copy the parent data space.
  - The child runs in the address space of the parent.
- With vfork, child runs first, then parent runs.

Process Control

wait,waitpid

exit

- Normal termination
  - Executing a return from the main function.
  - Calling the exit function.
  - Calling the _exit function.
- Abnormal termination
  - Calling abort.
  - Receives certain signals.

exit (cont.)

- int exit (int state);
- Sometimes we want the terminating process to be able to notify its parent how it terminated.
- For the exit and _exit function this is done by passing an exit status as the argument to these two functions.
- The parent of the process can obtain the termination status from either the wait or waitpid function.

Termination Conditions

- Parent terminate before the child
  - The init process becomes the parent process of any process whose parent terminated.

Termination Conditions

- Child terminate before the parent
  - The child is completely disappeared, but the parent wouldn't be able to fetch its termination status.
  - The kernel has to keep a certain amount of information for every terminating process.
  - The process that has terminated, but whose parent has not waited for it, is called zombie.

wait

- When a process terminates, the parent is notified by the kernel sending the parent the SIGCHLD signal.
- The parent of the process can obtain the termination status from either the wait or waitpid function.

wait (cont.)

- The process that calls wait or waitpid can:
  - Block (if all of its children are still running)
  - Return immediately with the termination status of a child (if a child has terminated)
  - Return immediately with an error (if it doesn't have any child process)

wait and waitpid

- int wait (int *statloc);
- int waitpid (int pid, int *statloc, int options);
  - If statloc is not a null pointer, the termination status of the terminated process is stored in this location.
- The difference between these two function:
  - wait can block, while waitpid has an option that prevents it from blocking.
  - waitpid doesn't wait for the first child to terminate (it can control which process it waits for)

Process Control

exec

exec

- A process cause another program to be executed by calling one of the exec functions.
- When a process calls one of the exec functions, that process is completely replaced by the new program.
- The process ID doesn't change across an exec.

exec functions

- int execl (char *path, char *arg0, … /*(char *) 0 */);
- int execle (char *path, char *arg0, … /*(char *) 0, char *envp[] */);
- int execlp (char *filename, char *arg0, … /*(char *) 0 */);
- int execv (char *pathname, char *argv0[]);
- int execve (char *pathname, char *argv0[], char *envp[]);
- int execvp (char *filename, char *envp[]);

Process Control

system

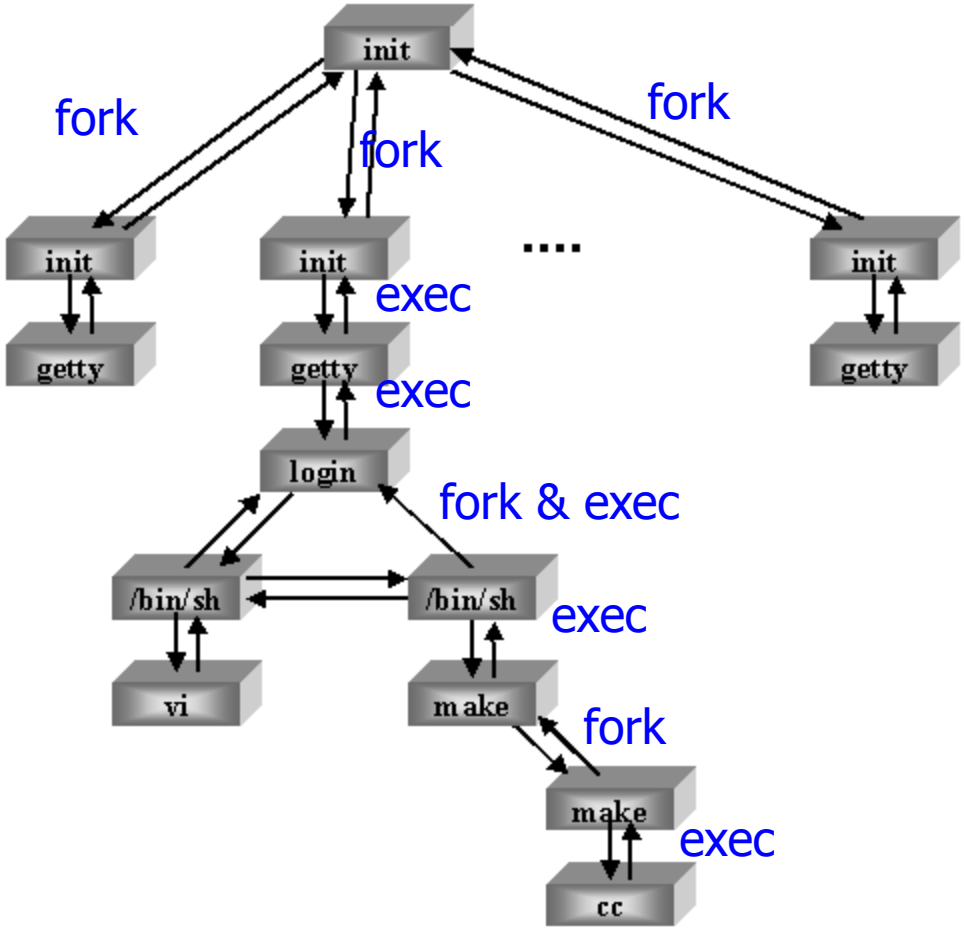
System

- execute a shell command.
- #include <stdlib.h>
- int system(const char *string);
- System() executes a command specified in string by calling /bin/sh –c string, and returns after the command has been completed.
- Return value: the value returned is -1 on error (e.g. fork failed), and the return status of the command otherwise.

What is the difference between system & exec?

- system() calls out to sh to handle your command line, so you can get wildcard expansion, etc. exec() and its friends replace the current process image with a new process image.
- With system(), your program continues running and you get back some status about the external command you called. With exec(), your process is obliterated.
- The exec function replace the currently running process image when successful, no child is created (unless you do that yourself previously with fork()). The system() function does fork a child process and returns when the command supplied is finished executing or an error occurs.

Process Relationship



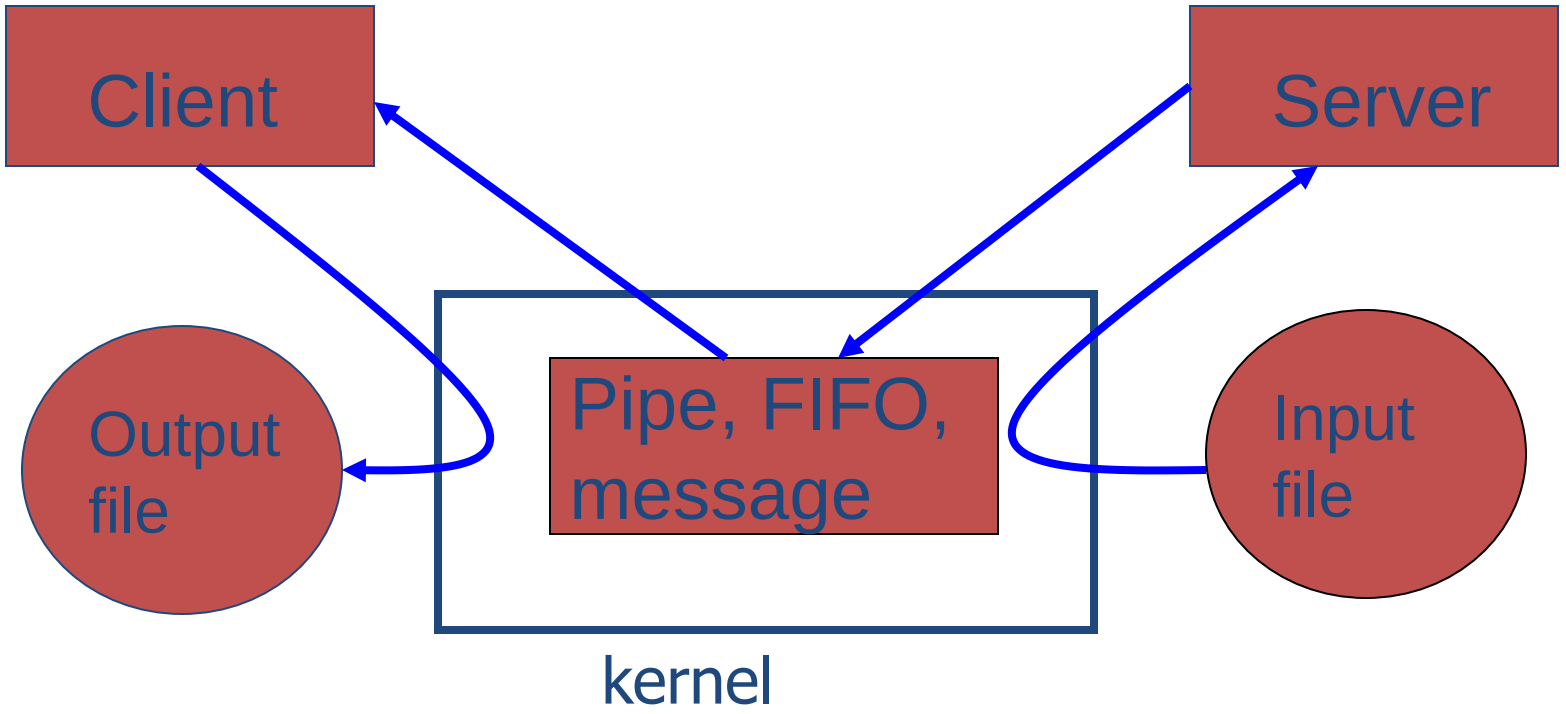
Inter Process Communication (IPC)

- shared memory
- mapped memory
- pipe
- fifo
- socket
- message passing
- shared semaphore

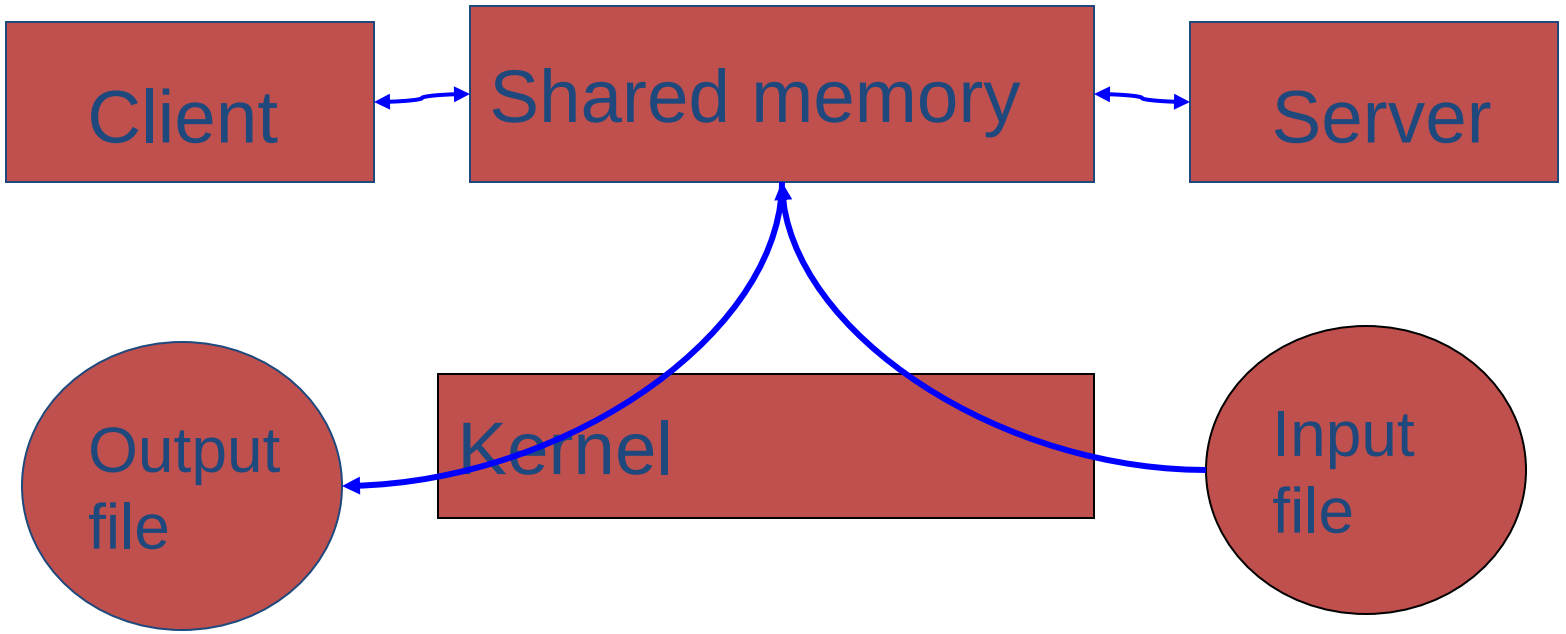
Inter Process Communication (IPC)

Shared memory

Shared memory



Shared memory (cont.)



Shared memory (cont.)

- int shmget (key_t key, int size, int flag);
- A shared memory segment is created, or an existing one is accessed with the shmget system call.

Shared memory (cont.)

- Char *shmat (int shmid, char *shmaddr, int shmfalg);
- The shmget dose not provide access to the segment for the calling process.
- We must attach the shared memory segment by calling the shmat system call.

Shared memory (cont.)

- int shmdt (char *shmaddr);
- When a process is finished with a shared memory segment, it detaches the segment by calling the shmdt system call.
- This call dose not delete the shared memory segment.

Shared memory (cont.)

- int shmctl (int shmid, int cmd, struct shmid_ds *buf);
- The msgctl function performs various operations in a shared memory segment.

Inter Process Communication (IPC)

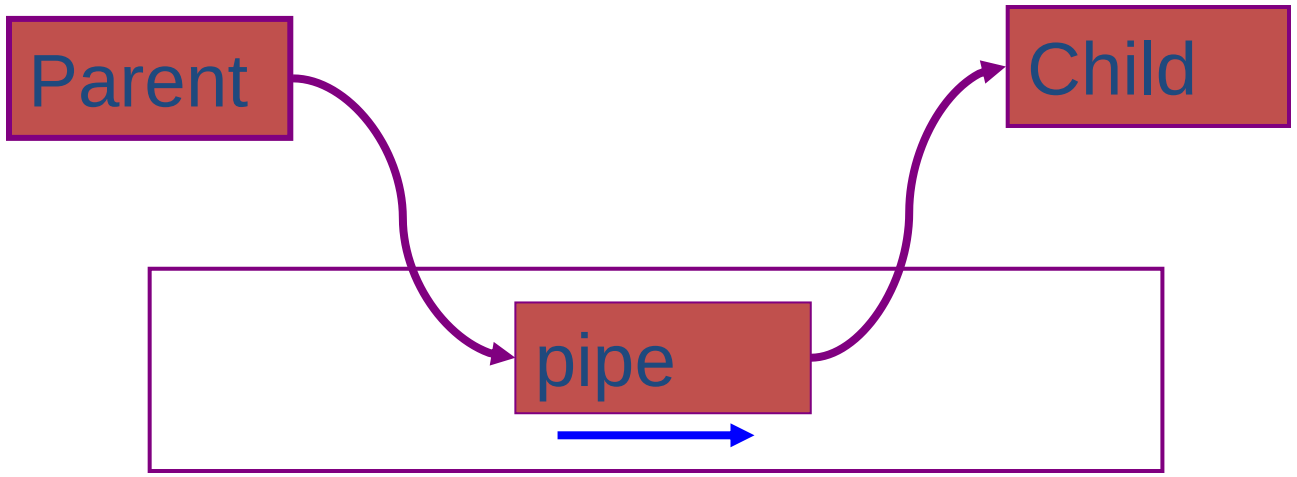
mapped memory

Inter Process Communication (IPC)

pipe

pipe

- It provides a one-way flow of data.
- It is in the kernel
- It can only be used between processes that have a parent process in common.



pipe (cont.)

- int pipe (int *filedes);
- filedes[0] : open for reading
- filedes[1] : open for writing
- pipe command :
  - who | sort | lpr

Inter Process Communication (IPC)

fifo

FIFO

- It is similar to a pipe.
- Unlike pipes, a FIFO has a name associated with it (named pipe).
- It uses a file as a communication way.
- int mknod (char *path, int mode, int dev)
  - mode is or'ed with S_IFIFO
  - dev is equal 0 for FIFO.

Inter Process Communication (IPC)

socket

Inter Process Communication (IPC)

Message passing

Message Queue

- Message queues are a linked list of messages stored within the kernel.
- We don’t have to fetch messages in a first-int, first-out order.
  - We can fetch messages based on their type field.
- A process wants to impose some structure on the data being transferred.

Message Queue (cont.)

- int msgget (key_t key, int msgflag);
- A new queue is created, or an existing queue is open by msgget.

Message Queue (cont.)

- int msgsnd(int msgid, void *ptr, size_t len, int flag);
- Data is placed onto a message queue by calling msgsnd;
- ptr points to a long integer that contains the positive integer message type, and it is immediately followed by the message data.
  - Struct my_msg

```
{
  long type;
  char data[SIZE];
}
```

Message Queue (cont.)

- int msgrcv (int msgid, void *ptr, sizet len, long mtype, int flag);
- The type argument lets us specify which message we want:
  - mtype == 0, the first message on the queue
  - mtype > 0, the first message on the queue whose type equals mtype.
  - mtype < 0, the first message on the queue whose type is the lowest value less or equal to the absolute value of mtype.

Message Queue (cont.)

- int msgctl (int msgid, int cmd, struct msgid_ds *buf);
- The msgctl function performs various operations in a queue.

Inter Process Communication (IPC)

Shared semaphore

Semaphore

- Semaphores are a synchronization primitive.
- To obtain a shared resource:
  - Test the semaphore that controls the resource.
  - If the value is positive the process can use the resource. The process decrements the value by 1.
  - If the value is 0, the process goes to sleep until the value is greater than 0.

Semaphore (cont.)

- int semget (key_t key, int nsems, int flag);
- This function get a semaphore ID.

- int semctl (int semid, int semnum, int cmd, union semun arg);
- The semctl function performs various operations in a semaphore.

Semaphore (cont.)

- int semop (int semid, struct sembuf *semop, size_t nops);
- Struct sembuf

```
{
        ushort sem_num;
        short sem_op;
        shoet sem_flag;
}
```

Semaphore (cont.)

- Each particular operation is specified by a sem_op value:
  - sem_op > 0, this correspond to the release of resources. The sem_op value is added to the current value;
  - sem_op == 0, the caller wants to wait until the semaphore's value become zero.
  - sem_op < 0, this correspond to the allocation od resources. The caller wants to wait until the value become greater or equal the absolute value of sem_op. then the absolute value of sem_op is subtracted from the current value.