

Process and Inter-Process Communication

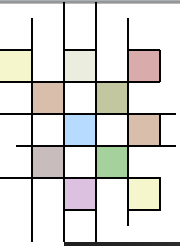


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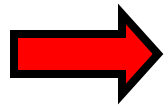
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دانشگاه صنعتی امیرکبیر
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Contents



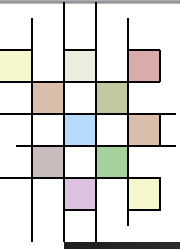
- What is a Process?
- Process Control
- Process Relationship
- Inter- Process Communication



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What is a Process?

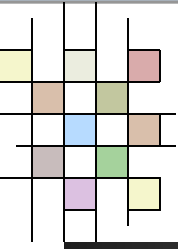
- Program
 - An executable file
- Process
 - An instance of a program that is being executed by the OS.
 - Every process has a unique ID (**PID**).



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Process Management

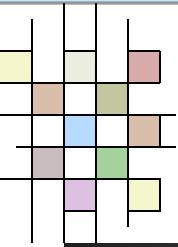
- The Unix OS is a time-sharing system.
- Each process is represented by a **task_struct** data structure.
- The **task_vector** is an array of pointers to every **task_struct** data structure in the system.



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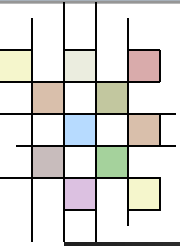
Process Statuses

- Running
 - The process is either running or it is ready to run.
- Waiting
 - The process is waiting for an event or for a resource.
- Stopped
 - The process has been stopped, usually by receiving a signal.
- Zombie
 - This is a halted process which, for some reason, still has a `task_struct` data structure in the task vector.



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Type of Processes

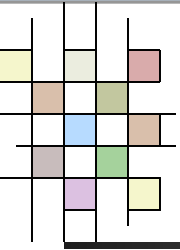
- Interactive Process
 - Initiated from (and controlled by) a shell
- Daemon Process
 - Run in the background until required



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Related Commands

- ps
 - Report process status.
- pstree
 - Display a tree of processes.
- nice
 - Run a program with modified scheduling priority.
- renice
 - Alter priority of running process.
- kill
 - Send signal to a process.





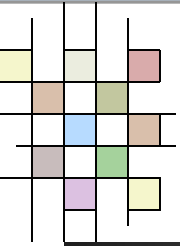
Related Commands (Cont.)

- top
 - Display top CPU processes.
- jobs
 - List the active jobs.
- bg
 - Place a job in background (similar to &);
- fg
 - Place a job in foreground.
- Ctrl+z
 - Stopped a process.
- Ctrl+c
 - Terminate a process.



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Contents

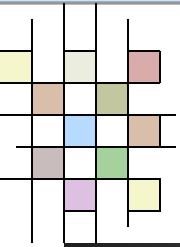
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Process Control

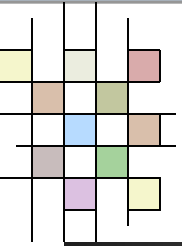
- fork and vfork
- exit
- wait and waitpid
- exec
- signal
- kill



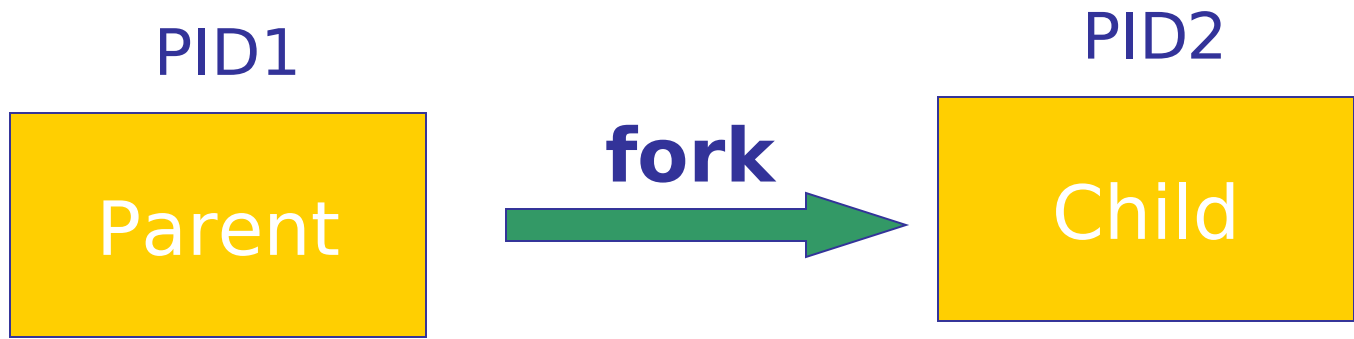
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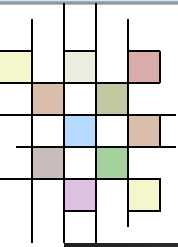
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fork





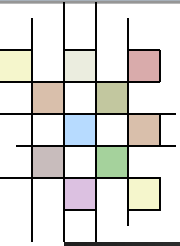
fork (cont.)

- `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.



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fork (cont.)

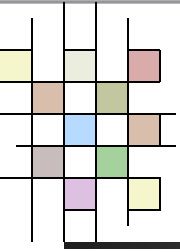
- This function is called **once**, but return **twice**.
 - The process ID of the new child (to the parent).
 - A process can have more than one child.
 - 0 (to the child).



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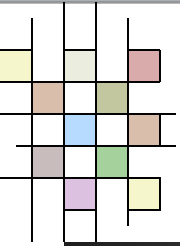
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fork Sample

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





fork (cont.)

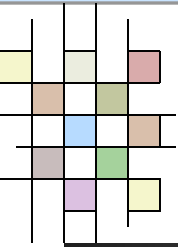
- We never know if the child starts executing before the parent or vice versa.
 - This depends on the **scheduling algorithm** used by the kernel.



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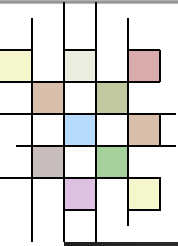
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vfork

- `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.





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.



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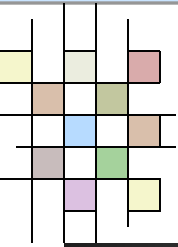
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exit (cont.)

- `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

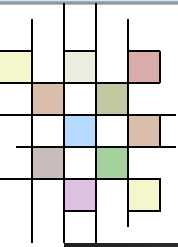
- Parent terminate before the child
 - The **init** process becomes the parent process of any process whose parent terminated.



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Termination Conditions

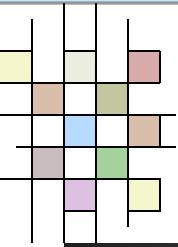
- Child terminate before the parent
 - The child is completely disappeared, but the parent wouldn't be able to fetch its termination status.
 - The kernel has to keep a certain amount of information for every terminating process.
 - The process that has terminated, but whose parent has not waited for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



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wait

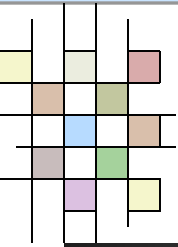
- When a process terminates, the parent is notified by the kernel sending the parent the **SIGCHLD** signal.
- The parent of the process can obtain the termination status from either the **wait** or **waitpid** function.



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wait (cont.)

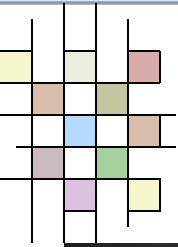
- The process that calls wait or waitpid can:
 - Block (if all of its children are still running)
 - Return immediately with the termination status of a child (if a child has terminated)
 - Return immediately with an error (if it doesn't have any child process)



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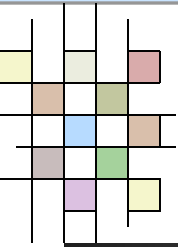
wait and waitpid

- `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)



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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.



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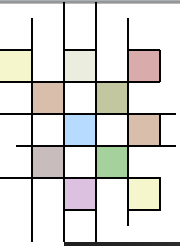
exec functions

- `int execl (char *path, char *arg0, ... /*(char *) 0 */);`
- `int execl_e (char *path, char *arg0, ... /*(char *) 0, char *envp[] */);`
- `int execl_p (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[]);`



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signal

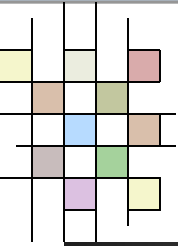
- Signals are software interrupts.
- The name of signals all begin with the three character SIG : **SIG**ABRT



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signal (cont.)

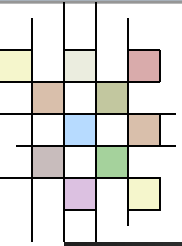
- `void (*signal (int signo, void (*func) (int))) (int);`
- Kernel do when a signal occurs:
 - Ignore the signal
 - Can not ignore : SIGKILL, SIGSTOP
 - Catch the signal
 - Let the default action apply



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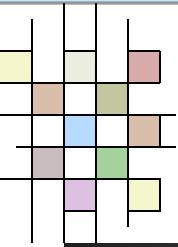
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signal Sample

```
main()
{
    signal (SIGUSER, sig_user);
    while (1);
}
//-----
void sig_user (int signo)
{
    if (signo == SIGUSER)
        printf ("receive signal\n");
    return;
}
```





kill

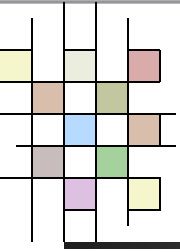
- `int kill (int pid, int signo);`
- Send a signal to a process or group of the processes.



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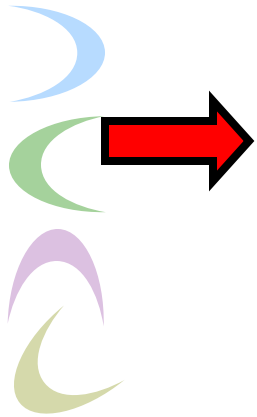
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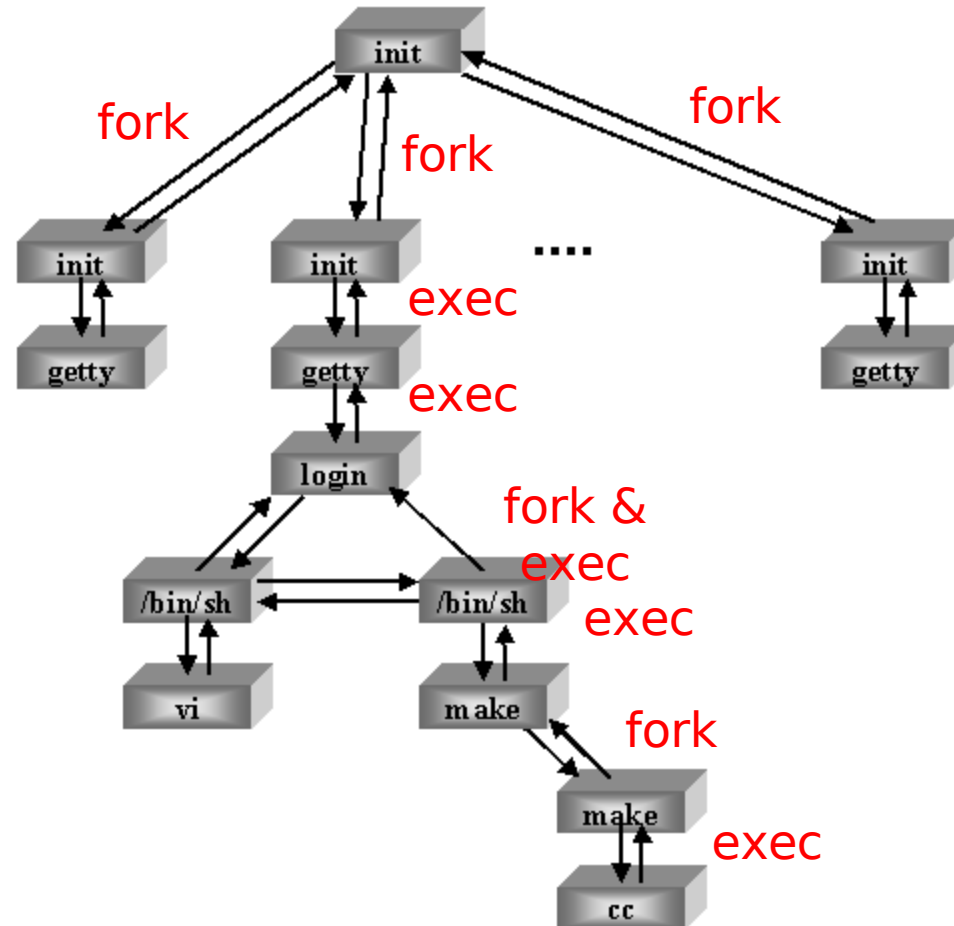


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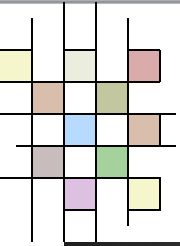
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Process Relationship



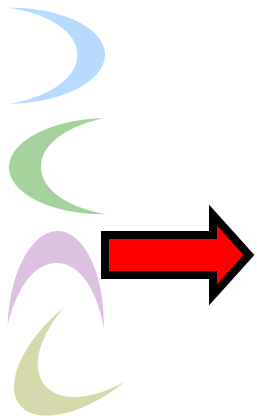
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Contents

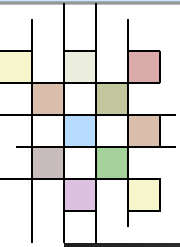
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IPC

- Pipe
- FIFO
- Message queue
- Shared memory
- socket



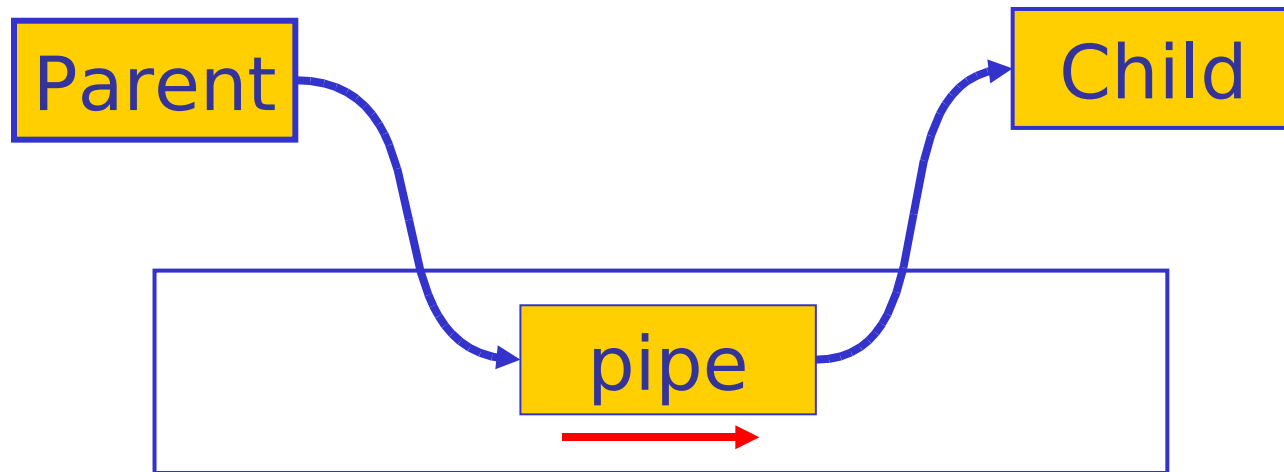
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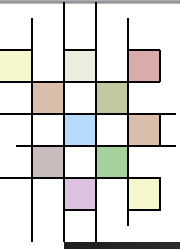
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pipe

- 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`



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FIFO

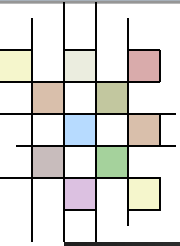
- It is similar to a pipe.
- Unlike pipes, a FIFO has a name associated with it (**named pipe**).
- It uses a file as a communication way.
- `int mknod (char *path, int mode, int dev)`
 - mode is or'ed with `S_IFIFO`
 - dev is equal 0 for FIFO.



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Name Space

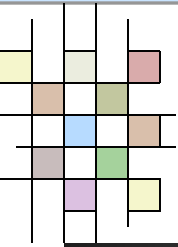
- The set of possible names for a given type of IPC is called its name space.
- The name is how the client and server **connect** to exchange messages.
- `key_t ftok (char *path, char proj);`



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Message Queue

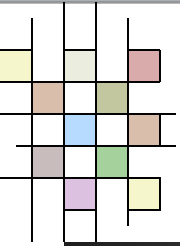
- Message queues are a **linked list** of messages stored within the kernel.
- We don't have to fetch messages in a first-in, first-out order.
 - We can fetch messages based on their type field.
- A process wants to impose some structure on the data being transferred.



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Message Queue (cont.)

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




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Message Queue (cont.)

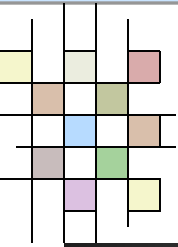
- 
- `int msgsnd(int msgid, void *ptr, size_t len, int flag);`
 - Data is placed onto a message queue by calling `msgsnd`;
 - `ptr` points to a long integer that contains the positive integer message `type`, and it is immediately followed by the message `data`.
 - Struct `my_msg`

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

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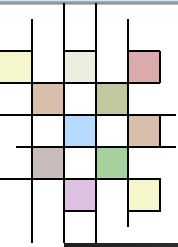
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Message Queue (cont.)

- `int msgrcv (int msgid, void *ptr, size_t 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.

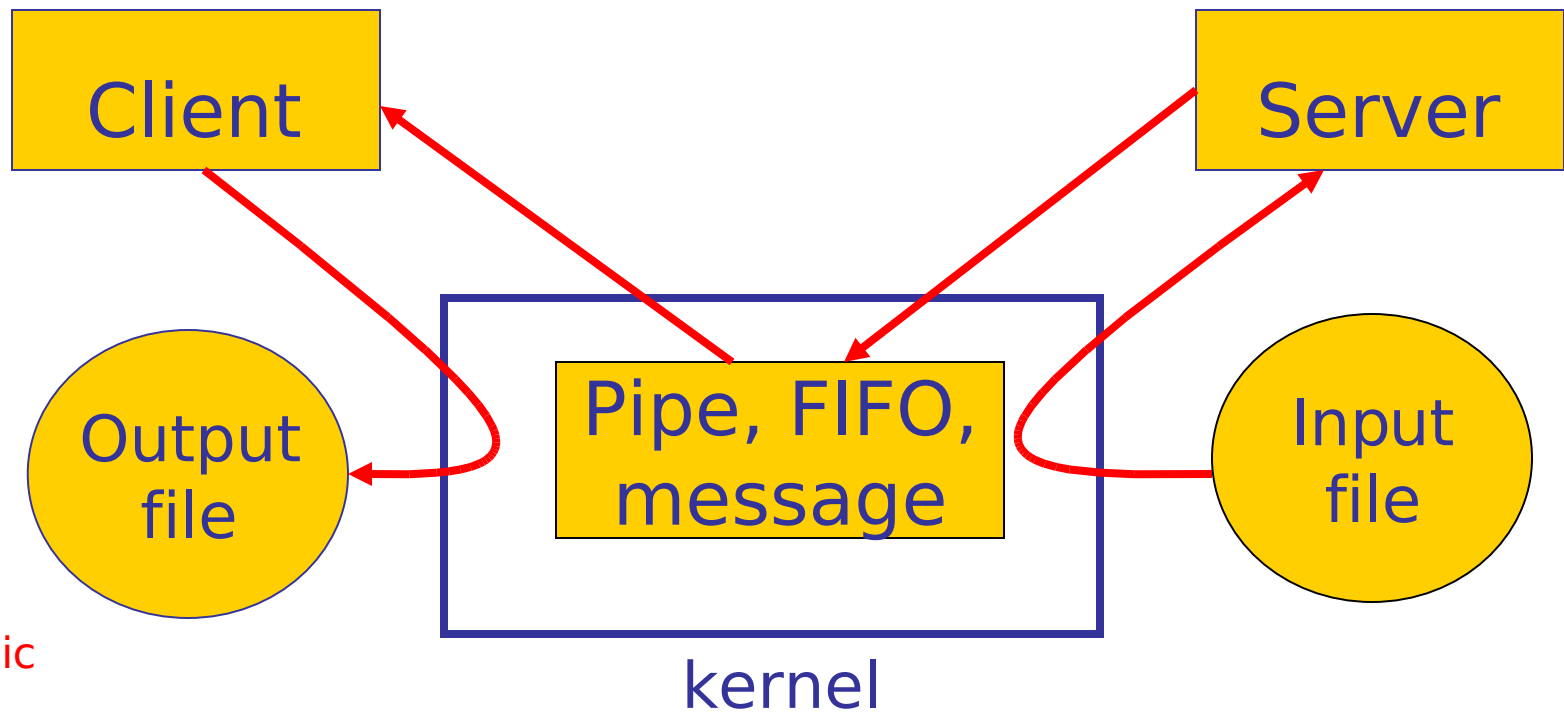


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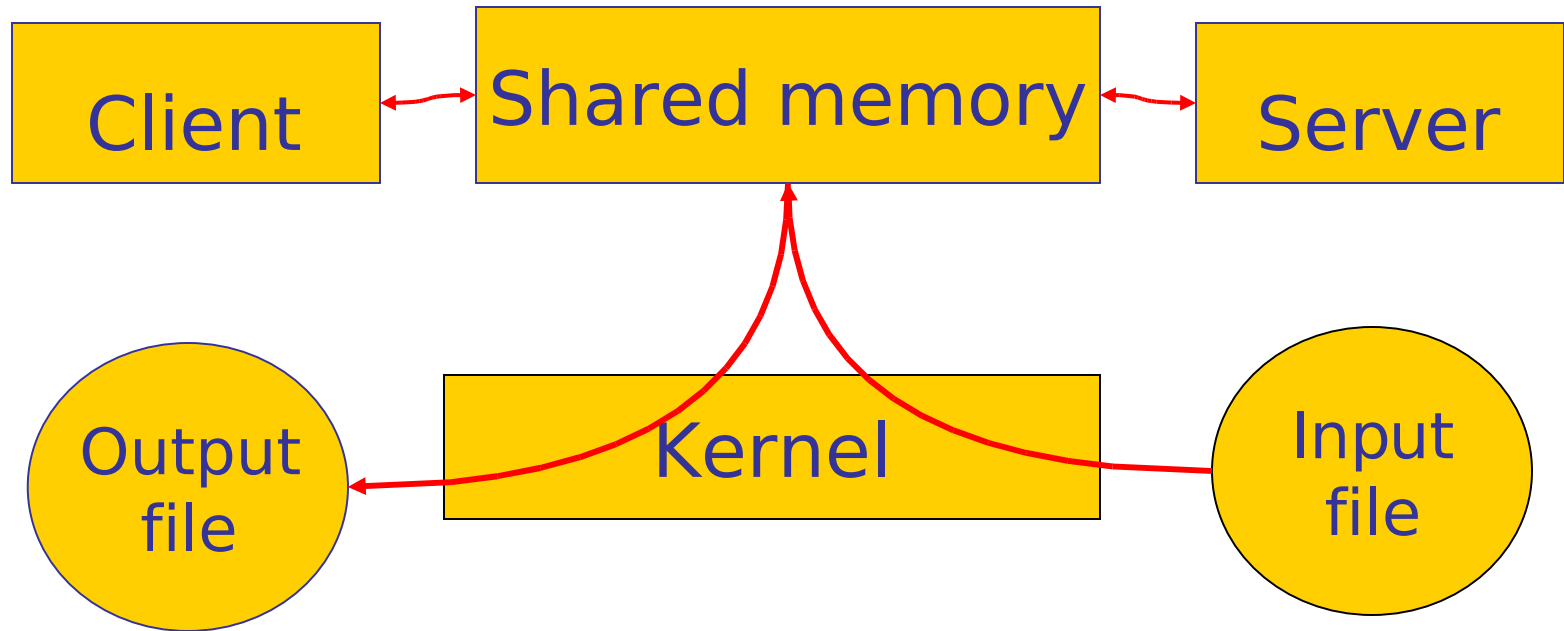
Shared memory



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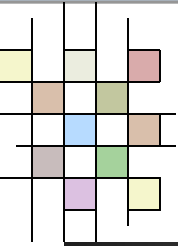
Shared memory (cont.)



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Shared memory (cont.)

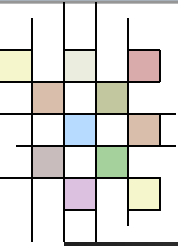
- `int shmget (key_t key, int size, int flag);`
- A shared memory segment is created, or an existing one is accessed with the `shmget` system call.



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Shared memory (cont.)

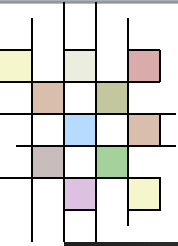
- `Char *shmat (int shmid, char *shmaddr, int shmflg);`
- The `shmget` does not provide access to the segment for the calling process.
- We must attach the shared memory segment by calling the `shmat` system call.



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Shared memory (cont.)

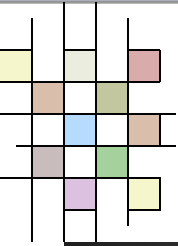
- `int shmdt (char *shmaddr);`
- When a process is finished with a shared memory segment, it detaches the segment by calling the `shmdt` system call.
- This call does not delete the shared memory segment.



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Shared memory (cont.)

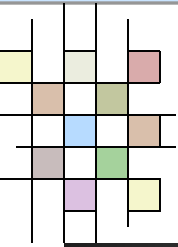
- `int shmctl (int shmid, int cmd, struct shmid_ds *buf);`
- The `msgctl` function performs various operations in a shared memory segment.



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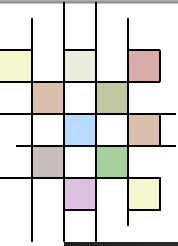
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Semaphore

- 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.

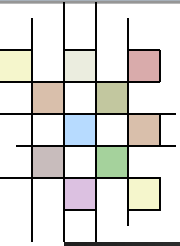




Semaphore (cont.)

- `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`

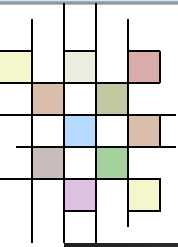
```
{  
    ushort sem_num;  
    short sem_op;  
    shoet sem_flag;  
}
```



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Semaphore (cont.)

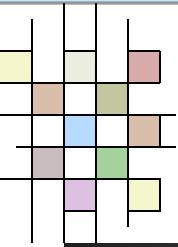
- Each particular operation is specified by a `sem_op` value:
 - $\text{sem_op} > 0$, this correspond to the release of resources. The `sem_op` value is added to the current value;
 - $\text{sem_op} == 0$, the caller wants to wait until the semaphore's value become zero.
 - $\text{sem_op} < 0$, this correspond to the allocation of 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.



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Question?



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