Inter-process communication (IPC)

CS350
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Some simple forms of IPC

- Parent-child
  - Command-line arguments,
  - wait(…), waitpid(…)
  - exit(…)
- Reading/modifying common files
  - Servers commonly use 'pid' file to determine other active servers.
- Signals
  - Event notification from one process to another

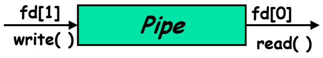
Some more forms of IPC…

- Shared Memory
  - Common piece of read/write memory.
  - Needs synchronization for access
- Semaphores
  - Locking and event signaling mechanism between processes
- Pipes
  - Uni-directional (if used cleanly)
  - 'ps -aux | more'
  - Can be used bi-directionally with some synchronization effort
- Sockets
  - Bi-directional
  - Not just across the network, but also between processes.

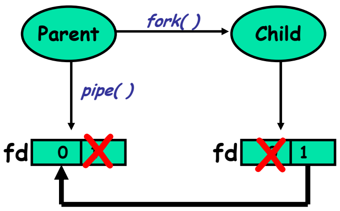
Pipes

Pipe Abstraction

- Write to one end, read from another
- pipe( )

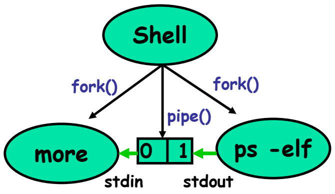


Parent-child communication using pipe



Here's an example.

'ps -elf | more'



Here's an example.

Being careful with read()/write()

- read(fds[0], buf, 6);
  - Doesn't mean read will return with 6 bytes of data!
  - It could be less. Why?
- Some reasons
  - read() could reach end of input stream (EOF).
  - Other endpoint may abruptly close the connection
  - read() could return on a signal.
- So you MUST incorporate error handling with every I/O call (actually with any system call)

Error handling…

- You must
  - First check the return value of every read(…)/write(…) system call.
  - Then either…
  - Wait to read/write more data OR
  - Handle any error conditions

More convinient to write a wrapper function

```
 /* Write "n" bytes to a descriptor. */
ssize_t    writen(int fd, const void *vptr, size_t n)
{
        size_t          nleft;
        size_t         nwritten;
        const char      *ptr;

        ptr = vptr;
        nleft = n;
        while (nleft > 0) {

               if ((nwritten = write(fd, ptr, nleft))<=0){

                     if (errno == EINTR)
                        nwritten = 0;  /* call write() again*/
                     else return(-1);  /* error */

                 }

                 nleft -= nwritten;
                 ptr   += nwritten;
        }
        return(n);

}
```

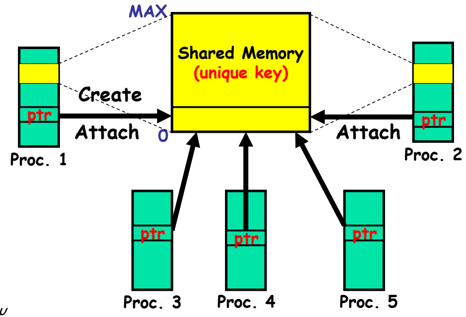
Shared Memory, Semaphores

Man pages : shmget, shmat, shmdt, shmctl
semget, semop, semctl

Also in Section 15.8 and 15.9 in APUE book

Shared Memory

Common chunk of read/write memory among processes



Creating Shared Memory

```
   int shmget(key_t key, size_t size, int shmflg);

Example:
    key_t key;
    int shmid;

    key = ftok("<somefile>", 'A');

    shmid = shmget(key, 1024, 0644 | IPC_CREAT);
```

Here's an example.

Attach and Detach Shared Memory

```
void *shmat(int shmid, void *shmaddr, int shmflg);
             int shmdt(void *shmaddr);
```

```
Example:
    key_t key;
    int shmid;
    char *data;

    key = ftok("<somefile>", 'A');
    shmid = shmget(key, 1024, 0644);
    data = shmat(shmid, (void *)0, 0);
      ⋮
    shmdt(data);
```

Here's an example.

Deleting Shared Memory

```
int shmctl(int shmid, int cmd, struct shmid_ds *buf);
```

```
shmctl(shmid, IPC_RMID, NULL);
```

Example

Command-line IPC control

- ipcs
  - Lists all IPC objects owned by the user
- ipcrm
  - Removes specific IPC object

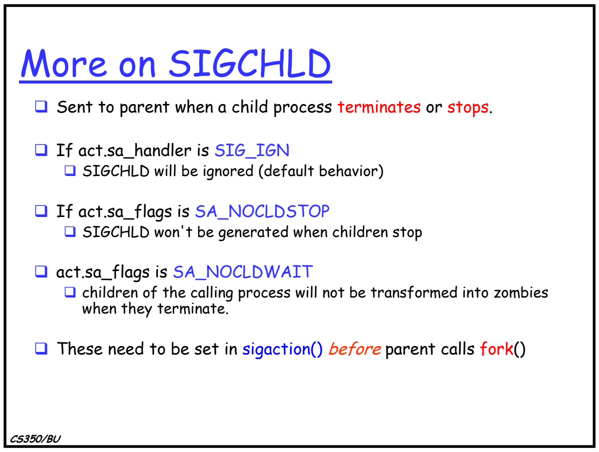
Signals

Signals Overview

- Signal is a notification to a process that an event has occurred.
  - Could come from another process or from the OS
- Type of event determined by type of signal
- Try listing all signal types using
  `% kill -l`
- Some interesting signals
  - SIGCHLD, SIGTERM, SIGKILL, SIGSTOP

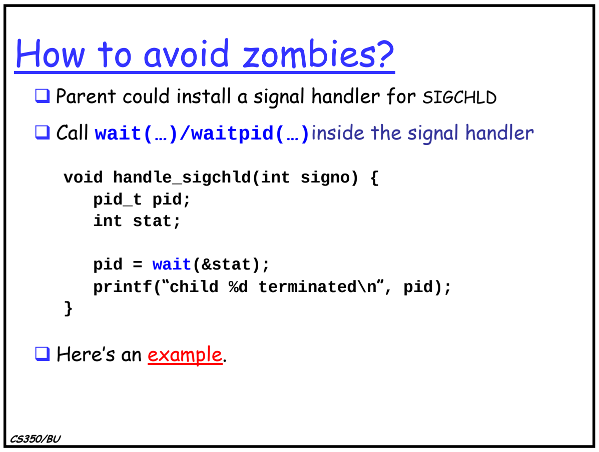
Handling Signals

- Signals can be caught – i.e. an action can be associated with them
  - SIGKILL and SIGSTOP cannot be caught.
- Actions to signals can be customized using
  `sigaction(…)`
  which associates a signal handler with the signal.
- Default action for most signals is to terminate the process
  - Except SIGCHLD and SIGURG are ignored by default.
- Unwanted signals can be ignored
  - Except SIGKILL or SIGSTOP
- Here's an example



More on SIGCHLD

- ❑ Sent to parent when a child process terminates or stops.
- ❑ If act.sa_handler is SIG_IGN
  - ❑ SIGCHLD will be ignored (default behavior)
- ❑ If act.sa_flags is SA_NOCLDSTOP
  - ❑ SIGCHLD won't be generated when children stop
- ❑ act.sa_flags is SA_NOCLDWAIT
  - ❑ children of the calling process will not be transformed into zombies when they terminate.
- ❑ These need to be set in sigaction() *before* parent calls fork()

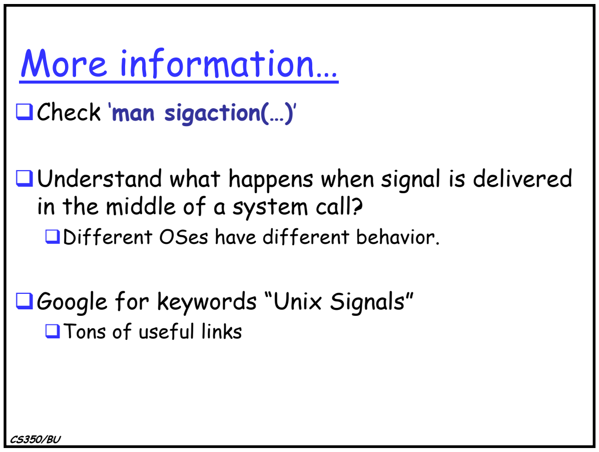


How to avoid zombies?

- ❑ Parent could install a signal handler for SIGCHLD
- ❑ Call **wait(…)/waitpid(…)** inside the signal handler

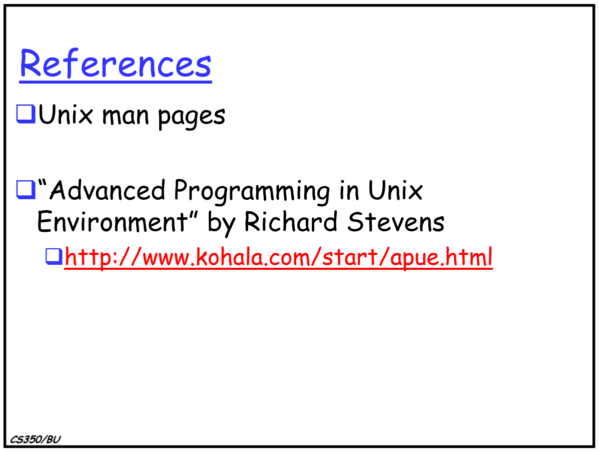
```
void handle_sigchld(int signo) {
   pid_t pid;
   int stat;

   pid = wait(&stat);
   printf(“child %d terminated\n”, pid);
}
```

- ❑ Here’s an example.



More information…

- ❑ Check ‘**man sigaction(…)**’
- ❑ Understand what happens when signal is delivered in the middle of a system call?
  - ❑ Different OSes have different behavior.
- ❑ Google for keywords “Unix Signals”
  - ❑ Tons of useful links



References

- ❑ Unix man pages
- ❑ “Advanced Programming in Unix Environment” by Richard Stevens
  - ❑ http://www.kohala.com/start/apue.html