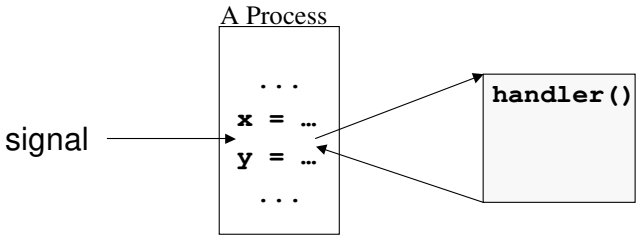
Signals

CS 217

Signals

- Outside world interrupts (signals) the process
  - user types ^C, ^Z, …
  - phone or terminal hangs up
  - illegal instruction, bus error, …
- Process responds to the signal



Signals (cont)

- Register a signal handler (system call)

```
void (* signal(int sig, void (* handler)(int)) (int);
```

  - function handler will be invoked on signal sig
  - return the old handler on success; -1 on error

- Example

```
#include <signal.h>
...
signal(SIGINT, SIG_IGN);
signal(SIGSTOP, SIG_DFL);
signal(SIGALRM, handler);
```

Signals (cont)

- Predefined signals
  - SIGKILL terminate (can't catch)
  - SIGILL illegal instruction
  - SIGTERM software termination
  - SIGSTOP suspend (^Z)
  - SIGALRM alarm clock
  - SIGINT interrupt (^C)
- Send a signal (command and system call)

```
kill -9 %2
int kill(pid_t pid, int sig);
```

Example

```
#include <signal.h>
char *tmpfile = "temp.xxx";
void cleanup(int sig); {
   unlink(tmpfile);
   exit(1);
}
void main(void) {
   int fd;

   signal(SIGINT, cleanup);
   fd = open(tmpfile, O_CREAT, 0666);
      ...
   close(fd);
}
```

Example (cont)

- Same handler as previous slide, but…

```
void main(void) {
   int fd;

   if (signal(SIGINT, SIG_IGN) != SIG_IGN)
      signal(SIGINT, cleanup);
   fd = open(tmpfile, O_CREAT, 0666);
      ...
   close(fd);
}
```

PL Support

- Some programming languages (e.g., C++) provide explicit support for exception handling
- Throw an exception

```
throw("out of memory");
```

- Try and catch

```
try {
   ... nested calls that can raise
       exceptions ...
}
catch("out of memory") {
  ... exception handler ...
}
```

Try, Throw, Catch Example 1

```
int main()
{
   char *buf;
   try {
      buf = new char[512];
      if( buf == 0 )
        throw "Memory allocation failure!";
   }
   catch( char * str ) {
      fprintf(stderr, "Exception: %s\n", str);
   }
   ...
   return 0;
}
```

Try, Throw, Catch Example 2

```
void ComputeSomething(void)
{
    ...
    if (error3) throw "whoops: error 3";
    ...
}

...
try {
   ComputeSomething();
}
catch( char * str ) {
   fprintf(stderr, "Exception: %s\n", str);
}
```

Signals with Fork

- Signals are sent to all your processes
- Parent may want to ignore signals but let child process them

```
#include <signal.h>
...
if (fork() == 0)
   execlp(...)
else {
   h = signal(SIGINT, SIG_IGN);
   wait(&status);
   signal(SIGINT, h);
}
```

Blocking Signals

- Keep signals from being delivered (sys call)

```
int sigblock(int mask);
int sigmask(int sig);
```

these are BSD-style; alternative POSIX calls

- Used to protect critical sections of code

```
mask = sigmask(SIGTERM);
oldmask = sigblock(mask);
...critical section...
sigblock(oldmask);
```

Setjmp/Longjmp

- Interrupt a long printout and go back to the main processing loop

```
#include <signal.h>
#include <setjmp.h>

void handler(int sig) {
   signal(SIGINT, handler);
   fprintf(stderr, "Interrupted\n");
   longjmp(jmpbuf, 0);
}
```

Setjmp/Longjmp (cont)

```
void main(void)
{
   if (signal(SIGINT, SIG_IGN) != SIG_IGN)
      signal(SIGINT, handler);
   setjmp(jmpbuf);
   for ( ; ; ) {
      ...
   }
}
```

Alarms

- Create a child process and kill it in 20 secs

```
#include <signal.h>
int pid;

void OnAlarm(int sig) {
   kill(pid, SIGKILL);
}
...
pid = fork();
if (pid == 0)
   execlp(...)
else {
  signal(SIGALRM, OnAlarm);
  alarm(20);
}
```

Alarms (cont)

- Used to implement timeouts
  - TCP: retransmit if don't receive an ACK
  - NFS: decide that server is not responding
- What if you want smaller granularity?

```
unsigned ualarm(unsigned value,
                unsigned interval);

int setitimer(int which,
              struct itimerval *value,
              struct itimerval *ovalue);

which = ITIMER_REAL, ITIMER_VIRTUAL, ITIMER_PROF
```

Reading the Clock

- System call

```
gettimeofday(struct timeval *tv,
             struct timezone *tz);
```

- Example:

```
#include <sys/time.h>
...
gettimeofday(start, NULL);
... activity you want to measure ...
gettimeofday(stop, NULL);
print_elapsed_time(start, stop)
```

Precision

- Time structures

```
struct timeval {
    long tv_sec;
    long tv_usec;
}
```

  - structure **`itimerval`** is similar
- Limitations
  - system clock (~10ms)
  - scheduling delays
- Solution: read/write the CPU cycle counter