



Lab1 Utils

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Lab1 Utils

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sleep

Experimental analysis

The sleep utility is a simple program that delays for a specified number of ticks (timer interrupts). This experiment teaches basic system call `sleep()` usage in xv6 and argument parsing from the command line.

Experimental process

The implementation requires:

1. Parsing the command line argument for sleep duration
2. Converting the string argument to an integer
3. Calling the sleep system call

```
#include "kernel/types.h"
#include "kernel/stat.h"
#include "user/user.h"

int main(int argc, char *argv[]) {
    if(argc != 2) {
        fprintf(2, "Usage: sleep <ticks>\n");
        //writes to file descriptor 2, \
        which is stderr (standard error)
        exit(1);
    }

    int ticks = atoi(argv[1]);
    sleep(ticks);
    exit(0);
}
```

pingpong

Experimental analysis

The pingpong utility demonstrates inter-process communication using pipes. Parent and child processes exchange a byte using two pipes, one for parent2child writing and reading, and the other for child2parent. `fork()`, `read`, `write()`, `pipe()`, and `getpid()` are involved in completing the task.

Experimental process

Implementation involves:

1. Creating two pipes for bidirectional communication
2. Forking a child process
3. Parent sends "ping", waits for "pong"
4. Child receives "ping", sends "pong"

```
#include "kernel/types.h"
#include "kernel/stat.h"
#include "user/user.h"

int main(int argc, char *argv[])
{
    int p2c[2]; // pipe parent to child
    int c2p[2]; // pipe child to parent
    char buf[1];

    // Create two pipes
    if (pipe(p2c) < 0 || pipe(c2p) < 0) {
        fprintf(2, "pipe creation failed\n");
        exit(1);
    }

    int pid = fork();
    if (pid < 0) {
        fprintf(2, "fork failed\n");
        exit(1);
    }

    if (pid == 0) { // child process
        close(p2c[1]); // close write end of parent to child pipe
        close(c2p[0]); // close read end of child to parent pipe

        // Read byte from parent
        if (read(p2c[0], buf, 1) != 1) {
            fprintf(2, "child read failed\n");
            exit(1);
        }
        printf("%d: received ping\n", getpid());
    }
```

```

    // Send byte back to parent
    if (write(c2p[1], buf, 1) != 1) {
        fprintf(2, "child write failed\n");
        exit(1);
    }

    close(p2c[0]);
    close(c2p[1]);
    exit(0);
} else { // parent process
    close(p2c[0]); // close read end of parent to child pipe
    close(c2p[1]); // close write end of child to parent pipe

    // Send byte to child
    buf[0] = 'P';
    if (write(p2c[1], buf, 1) != 1) {
        fprintf(2, "parent write failed\n");
        exit(1);
    }

    // Read byte from child
    if (read(c2p[0], buf, 1) != 1) {
        fprintf(2, "parent read failed\n");
        exit(1);
    }
    printf("%d: received pong\n", getpid());

    close(p2c[1]);
    close(c2p[0]);
    wait(0); // wait for child to exit
    exit(0);
}
}

```

primes

Experimental analysis

The prime sieve utility implements concurrent prime number generation using pipes. The sieve can be simulated by a pipeline of processes executing the following:

```
p = get a number from left neighbor
print p
loop:
  n = get a number from left neighbor
  if (p does not divide n)
    send n to right neighbor
```

To build the sieve, we should use `fork()` to build parent and child processes:

- In child process, we should recursively call the sieve process to create the right neighbour.
- In parent process, we should keep sending new numbers to the right neighbour.

Experimental process

The implementation involves:

1. Create the sieve:
 - i. Pipeline of processes to filter composite numbers using recurrence

```
// Create pipe for right neighbor
int right_pipe[2];
pipe(right_pipe);

if (fork() == 0) {
    // Child process
    close(right_pipe[1]); // Close write end of right pipe
    close(left_pipe[0]); // Close read end of left pipe
    sieve(right_pipe);   // Recursive call with new left pipe
}
```

- ii. Print the prime and send the proper number to the right neighbor:

```

int p;
// Read first number (prime) from left neighbor
if (read(left_pipe[0], &p, sizeof(int)) == 0) {
    close(left_pipe[0]);
    exit(0);
}

printf("prime %d\n", p);

/* intermediate codes */

// Parent process
close(right_pipe[0]); // Close read end of right pipe

int n;
// Keep reading numbers from left pipe
while (read(left_pipe[0], &n, sizeof(int)) > 0) {
    // If n is not divisible by p, send it to right neighbor
    if (n % p != 0) {
        write(right_pipe[1], &n, sizeof(int));
    }
}

close(left_pipe[0]); // Close read end of left pipe
close(right_pipe[1]); // Close write end of right pipe
wait(0); // Wait for child to finish
exit(0);

```

2. Recursive process creation for each prime number

```

if (fork() == 0) {
    // Child process
    close(first_pipe[1]); // Close write end
    sieve(first_pipe); // Start sieve with first pipe
} else {
    // Parent process

```

```

    close(first_pipe[0]); // Close read end
}

// Feed numbers 2 through 35 into the pipeline
for (int i = 2; i <= 35; i++) {
    write(first_pipe[1], &i, sizeof(int));
}

close(first_pipe[1]); // Close write end
wait(0); // Wait for all processes to finish
exit(0);
}

```

find

Experimental analysis

The find utility recursively searches directories for files with a specific name.

- The program implements depth-first search through the directory structure:
 - Processes current entry
 - If directory, recursively searches its contents
 - Maintains proper path construction throughout
- To print the path, we should dynamically manage the path:
 - Dynamically builds full paths for each entry
 - Handles path concatenation with proper separators
 - Checks for buffer overflow conditions
- Handles special directory entries:
 - Skips empty entries
 - Ignores "." (current directory)
 - Ignores ".." (parent directory)

Experimental process

1. Directory traversal using system calls

```
if((fd = open(path, 0)) < 0){  
    fprintf(2, "find: cannot open %s\n", path);  
    return;  
}  
  
if(fstat(fd, &st) < 0){  
    fprintf(2, "find: cannot stat %s\n", path);  
    close(fd);  
    return;  
}
```

2. File processing:

```
case T_FILE:  
if(strcmp(fmtname(path), filename) == 0){  
    printf("%s\n", path);  
}  
break;
```

3. Recursive search through subdirectories

i. Check path length limits:

```
if(strlen(path) + 1 + DIRSIZ + 1 > sizeof buf){  
    printf("find: path too long\n");  
    break;  
}
```

ii. Directory entry processing:

```
strcpy(buf, path);  
p = buf + strlen(buf);  
*p++ = '/';  
while(read(fd, &de, sizeof(de)) == sizeof(de)){
```

```

    if(de.inum == 0)
        continue;
    if(strcmp(de.name, ".") == 0 || strcmp(de.name, "..") == 0)
        continue;
    memmove(p, de.name, DIRSIZ);
    p[DIRSIZ] = 0;
    if(stat(buf, &st) < 0){
        printf("find: cannot stat %s\n", buf);
        continue;
    }
    find(buf, filename); // Recursive call for subdirectories
}
break;

```

xargs

Experimental analysis

The xargs utility reads lines from standard input and executes commands with those lines as arguments.

- Program receives a command and its arguments
- To execute the commands, we keep using `fork()` :

Parent xargs

```

|
| — Child 1 (executes command with first line)
|   └─ (waits for completion)
| — Child 2 (executes command with second line)
|   └─ (waits for completion)
└─ ... continues for each input line

```

Experimental process

1. Argument preparation:

```

// Copy command and its arguments to new_argv
for(int i = 1; i < argc; i++){
    new_argv[i-1] = argv[i];
}

```

2. Reading input line by line

```

//while(1){
int i = 0;
// Read until newline or EOF, character by character
while(i < MAXLINE - 1){
    n = read(0, &line[i], 1);
    if(n <= 0 || line[i] == '\n'){
        break;
    }
    i++;
}

if(i == 0 && n <= 0) break; // EOF with no data

line[i] = 0; // Null terminate the line

```

3. Command Execution:

```

// Set up the last argument as the line we just read
new_argv[argc-1] = line;
new_argv[argc] = 0; // Null terminate argv
// Fork and execute the command
int pid = fork();
if(pid == 0){
    // Child process
    exec(new_argv[0], new_argv);
    fprintf(2, "xargs: exec %s failed\n", new_argv[0]);
    exit(1);
} else if(pid > 0){

```

```
// Parent process
wait(0);
} else {
    fprintf(2, "xargs: fork failed\n");
    exit(1);
}
```

Experimental scoring

```
ubuntu@VM10034-OS-lab:~/xv6-labs-2020$ ./grade-lab-util
make: "kernel/kernel"已是最新。
== Test sleep, no arguments == sleep, no arguments: OK (1.2s)
== Test sleep, returns == sleep, returns: OK (1.0s)
== Test sleep, makes syscall == sleep, makes syscall: OK (0.9s)
== Test pingpong == pingpong: OK (1.0s)
== Test primes == primes: OK (0.9s)
== Test find, in current directory == find, in current directory: OK (1.3s)
== Test find, recursive == find, recursive: OK (1.1s)
== Test xargs == xargs: OK (1.2s)
== Test time ==
time: OK
Score: 100/100
ubuntu@VM10034-OS-lab:~/xv6-labs-2020$
```

Experimental summary

This lab provided practical experience with:

- System call usage in xv6
- Process management and IPC
- File system operations
- Command-line argument handling
- Shell utility implementation

Key learnings:

1. Understanding Unix pipeline concepts
2. Managing file descriptors properly

3. Process creation and synchronization
4. Directory traversal and file operations
5. Error handling in system programming