Intro to the Shell with Fork, Exec, Wait

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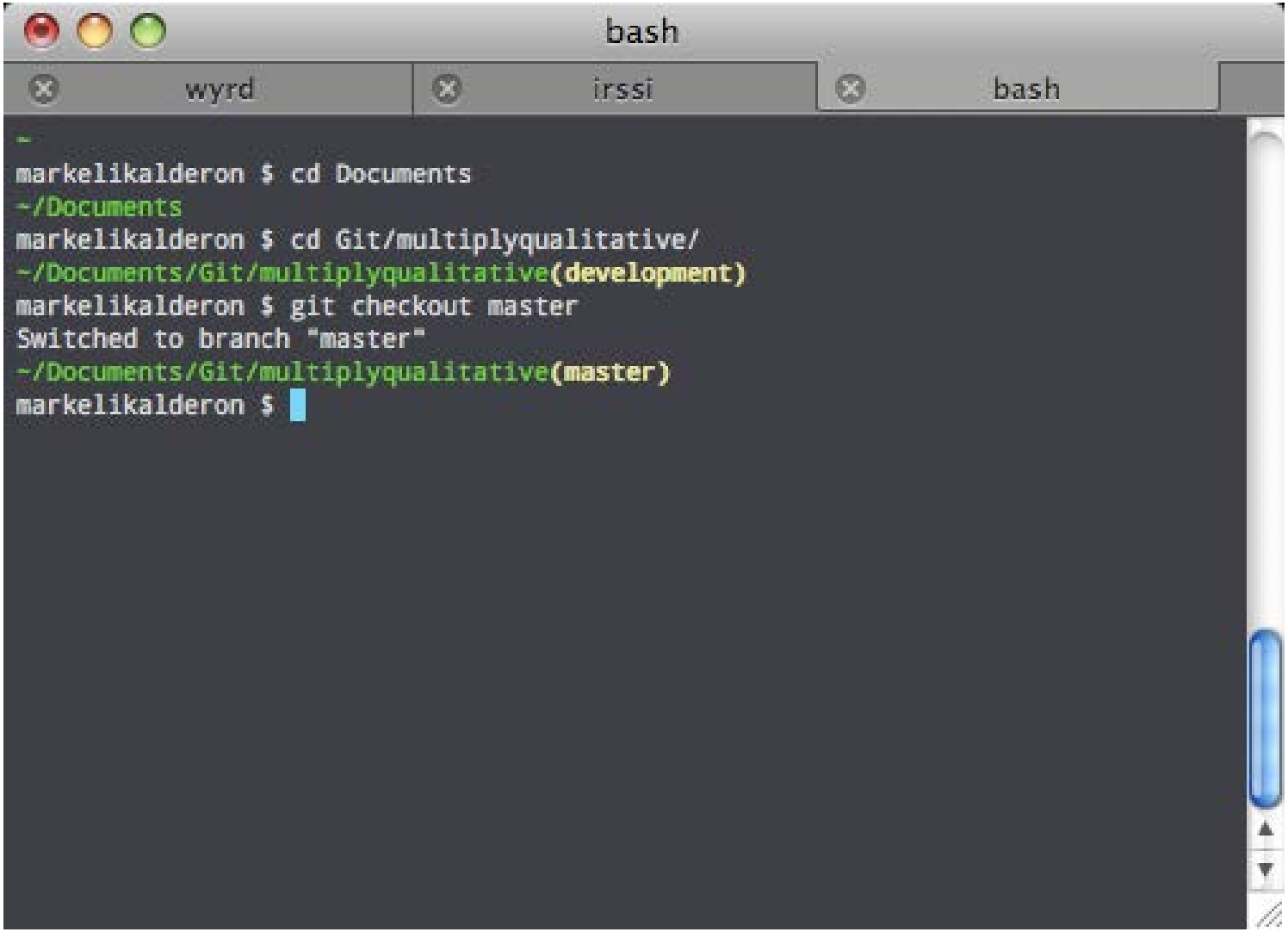
CS 3430


The shell!
The kernel!

Why is the Shell Important?

- Shells provide us with a way to interact with the core system
  - Executes programs on our behalf
  - Shows us our stuff
  - No OS should be without one!
- Can think of a shell as “built around” a component
- So what are some examples of shells?

Is this a Shell?



Is this a Shell?

```
                                MS-DOS Shell
 File  Options  View  Tree  Help
 C:\DOS
[A:]  [B:]  [C:]

        Directory Tree                          C:\*.*
 [-] C:\                          ▶ WINA20   .386        9,349  08-19-94
  ├[ ] DOS                          AUTOEXEC.BAT           85  04-04-09
  └[ ] MOUSE                        COMMAND .COM       54,869  08-19-94
                                    CONFIG  .SYS          109  04-04-09
                                    IO      .SYS       40,774  08-19-94
                                    MSDOS   .SYS       38,138  08-19-94

[A:]  [B:]  [C:]

        Directory Tree                          C:\DOS\*.*
 [-] C:\                          ▶ MONOUMB .386         8,783  08-19-94
 →├[ ] DOS                          VFINTD  .386         5,295  08-19-94
  └[ ] MOUSE                        DRVSPACE.BIN        66,294  08-19-94
                                    CHOICE  .COM         1,754  08-19-94
                                    COMMAND .COM        54,869  08-19-94
                                    DISKCOMP.COM        10,748  08-19-94

 F10=Actions  Shift+F9=Command Prompt                          5:39p
```

Is this a Shell?

Is this a Shell?

How do we Crack the Shell?

- In other words, how will our shell interact with the soft and chewy kernel?
  - The mechanism we will explore today is through system calls
  - Other ways
    - /proc in Linux

System Calls

- What are system calls, again?
- Some important ones
  - fork()
  - execvp()
  - waitpid()
- We will need to use all three above to make a fully-functioning shell

Shell Basics (Project 1)

- Basic shell components
  - Prompt and accept user input
  - Execute the command OR perform some built-in functionality
  - (Loop back to first step)

Inside main()

- Continuous loop
  - Parse user input
  - Make something happen

Inside main()

```
while(1)
{

}
```

Inside main()

```
while(1)
{
    */ Get user input */




}
```

Inside main()

```
while(1)
{
    */ Get user input */
    */ Exit? */




}
```

Inside main()

```
while(1)
{
    */ Get user input */
    */ Exit? */
    */ Do something with input */



}
```

I/O Streams

Standard I/O Stream	File descriptor
Standard input (stdin)	0
Standard output (stdout)	1
Standard error (stderr)	2

- User input goes to virtual file descripter 0
- Regular program output goes to virtual file descriptor 1
- Sometimes error messages are printed to virtual file descriptor 2

Getting Input / Printing Output

- Use the fgets() library call to get input from stdin
  - char *fgets(char *s, int size, FILE *stream);

- Use printf() to print to stdout
- Use fprintf() to print to any file
  - To see how to use printf, take a look at the end of section 2 of the short C tutorial
  - Also ‘man printf’ for a list of all specifiers

fgets and printf

```
#include <stdio.h>
#include <stdlib.h>

#define MAX_LINE 80

int main(int argc, char *argv[])
{
    char cmd[MAX_LINE];

    /* Get user input */
    fgets(cmd, MAX_LINE, stdin);
    printf("The input was [%s]\n",cmd);

    return 0;
}
```

strtok

```
#include <string.h>
#include <stdio.h>

int main()
{
   const char str[80] = "This is a sample string 1 2 34";
   const char s[2] = " ";
   char *token;

   /* get the first token */
   token = strtok(str, s);

   /* walk through other tokens */
   while( token != NULL )
   {
      printf( " %s\n", token );

      token = strtok(NULL, s);
   }

   return(0);
}
```

- We can use strtok to walk through a string and get each token
  - See ‘man strtok’ for more info

Processes

- Our shell process must continually run
  - …but we need to execute other stuff on the user's behalf
- How can we create "children" processes to do our work?
- Fork!

Fork

- Child pid==0
- Parent pid==something else

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>

int main() {
  pid_t pid;
  if ((pid = fork()) == 0) {
    printf("I am a child with pid %d\n", pid);
  } else {
    printf("I am the parent with pid %d\n", pid);
  }
  return 0;
}
```

A **fork** Example, **Nag.c**

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>

int main() {
  pid_t pid;
  if ((pid = fork()) == 0) {
    while (1) {
      printf("child's return value %d:  I want to play…\n", pid);
    }
  } else {
    while (1) {
      printf("parent's return value %d:  After the project…\n", pid);
    }
  }
  return 0;
}
```

Parent process

A **fork** Example, **Nag.c**

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>

int main() {
  pid_t pid;
  if ((pid = fork()) == 0) {
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    }
  } else {
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    }
  }
  return 0;
}
```

Parent process

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      printf("child's return value %d:  I wa
    }
  } else {
    while (1) {
      printf("parent's return value %d:  Aft
    }
  }
  return 0;
}
```

Parent process

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>

int main() {
  pid_t pid;
  if ((pid = fork()) == 0) {
    while (1) {
      printf("child's return value %d:  I want to p
    }
  } else {
    while (1) {
      printf("parent's return value %d:  After the
    }
  }
  return 0;
}
```

Child process

A **fork** Example, **Nag.c**

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>

int main() {
  pid_t pid;
  if ((pid = 3128) == 0) {
    while (1) {
      printf("child's return value %d:  I wa
    }
  } else {
    while (1) {
      printf("parent's return value %d:  Aft
    }
  }
  return 0;
}
```

Parent process

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>

int main() {
  pid_t pid;
  if ((pid = 0) == 0) {
    while (1) {
      printf("child's return value %d:  I want to p
    }
  } else {
    while (1) {
      printf("parent's return value %d:  After the
    }
  }
  return 0;
}
```

Child process

A **fork** Example, **Nag.c**

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>

int main() {
  pid_t pid;
  if ((pid = 3128) == 0) {
    while (1) {
      printf("child's return value %d:  I wa
    }
  } else {
    while (1) {
      printf("parent's return value %d:  Aft
    }
  }
  return 0;
}
```

Parent process

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>

int main() {
  pid_t pid;
  if ((pid = 0) == 0) {
    while (1) {
      printf("child's return value %d:  I want to p
    }
  } else {
    while (1) {
      printf("parent's return value %d:  After the
    }
  }
  return 0;
}
```

Child process

Nag.c Outputs

```
>a.out
child’s return value 0:  I want to play…
child’s return value 0:  I want to play…
child’s return value 0:  I want to play…
…// context switch
parent’s return value 3218:  After the project…
parent’s return value 3218:  After the project…
parent’s return value 3218:  After the project…
…// context switch
child’s return value 0:  I want to play…
child’s return value 0:  I want to play…
child’s return value 0:  I want to play…
^C
>
```

The **`exec`** System Call Family

- A **`fork`** by itself is not interesting
- To make a process run a program that is different from the parent process, you need ***`exec`*** system call
- exec starts a program by overwriting the current process

A **exec** Example, **train.c**

A process

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>
#include <string.h>
#include <malloc.h>

#define ARGV_SIZE 2

int main(int argc, char *argv[]) {
  char fullPathName[] ="/usr/games/sl";
  char *myArgv[ARGV_SIZE];  // an array of pointers to strings

  myArgv[0] = fullPathName;
  myArgv[1] = NULL;  // last element should be a NULL pointer

  execvp(fullPathName, myArgv);
  return 0; // should not be reached
}
```

At a shell prompt:
>whereis sl

Wait up?

- How does our parent process know to wait until the child is done?
  - waitpid()
- Performing a wait allows the system to release the resources associated with the child
  - If child is not *waited on*, it will become a **zombie**!

Zombie?

- Process that shows up with a “Z” status or the word <defunct>
- Child process has terminated, but parent has not waited on it
- Child process stays allocated on the system until
  - Wait() or waitpid() is called by the parent
  - The parent exits, and init “adopts” the zombie processes and performs a wait()

waitpid()

```
int waitpid(pid_t pid, int
    *status, int options);
```

- **pid** – type of children to wait on
  - For this project, pid==-1 to mean wait for any child process created by our parent
- ***status** – returns the status of the child process
- **options** – return if additional things have happened to the child

waitpid()

- Comment waitpid() line to see a defunct process for 10 seconds through ‘ps’

```
#include <stdio.h>
#include <unistd.h>
#include <sys/types.h>
#include <stdlib.h>
#include <sys/wait.h>

int main() {
  pid_t pid;
  if ((pid = fork()) == 0) {
    printf(“I am a child with pid %d\n”, pid);
  } else {
    printf(“I am the parent\n”);
    waitpid(-1, NULL, 0);
    sleep(10);
  }
  return 0;
}
```

In Summary

- Pieces necessary for project 1
  - Basic structure of shell
  - Command line parsing
  - Command execution

Any Questions?