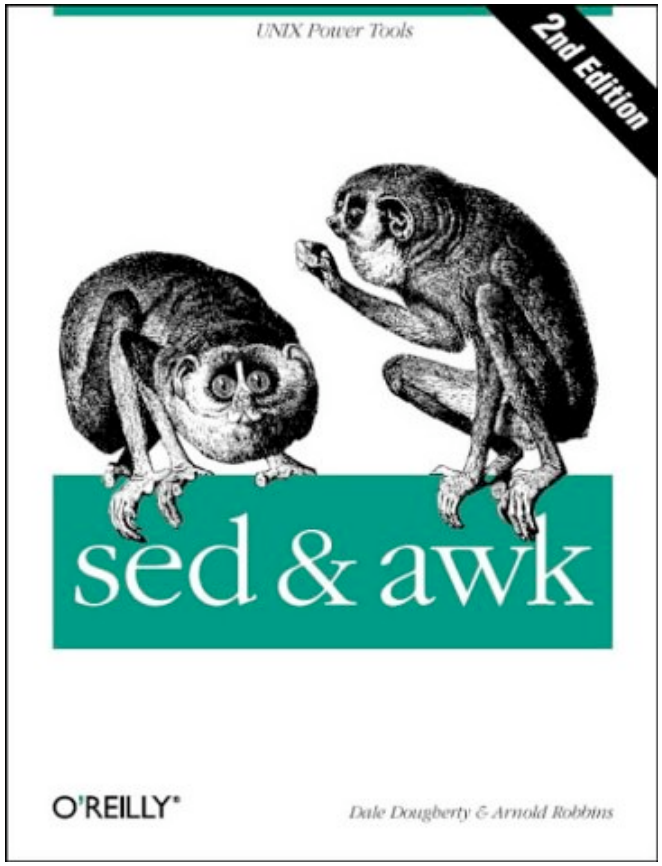
Last Time...



on the website

Lecture 6

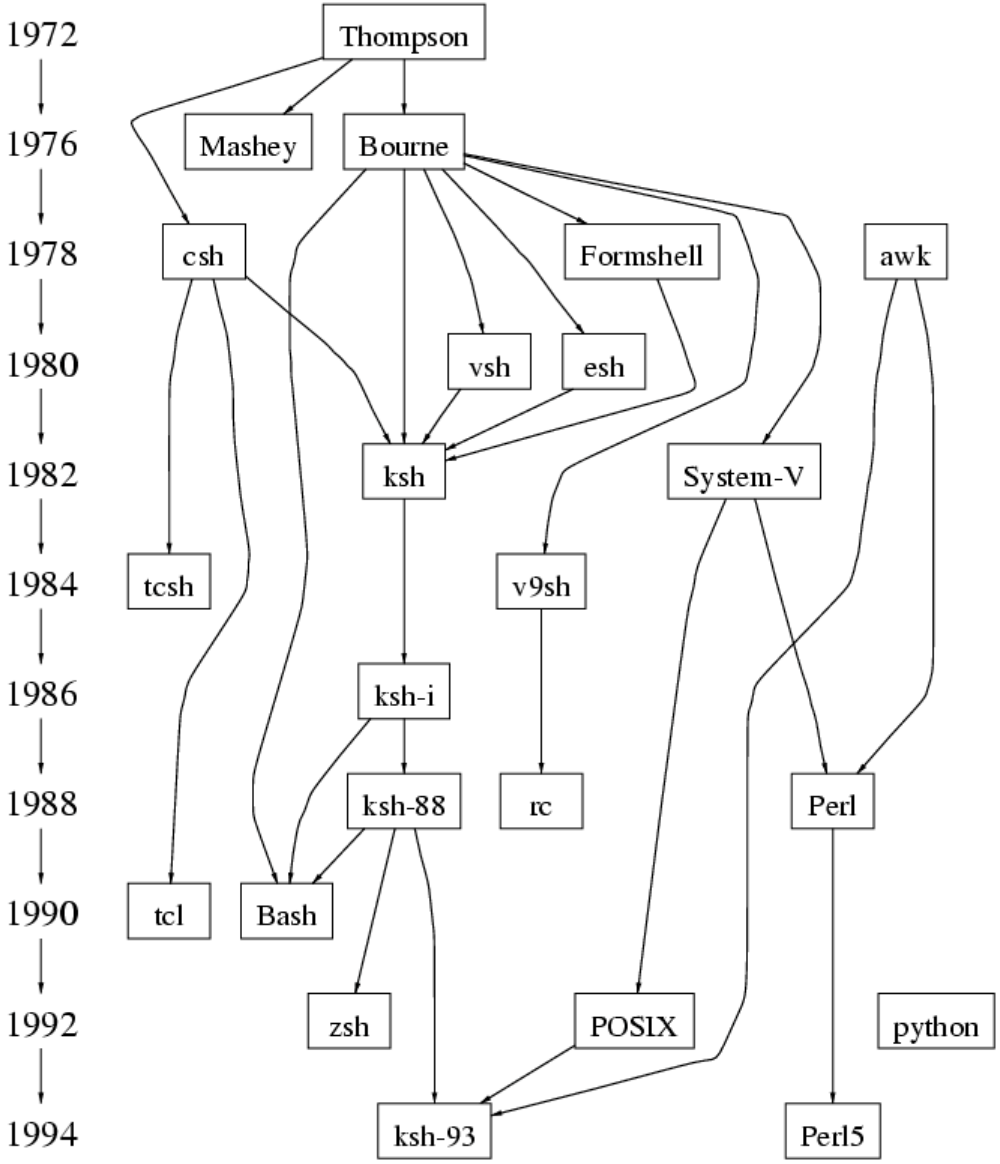
Shell Scripting

What is a shell?

- The user interface to the operating system
- Functionality:
  - Execute other programs
  - Manage files
  - Manage processes
- Full programming language
- A program like any other
  - This is why there are so many shells

Shell History

- There are many choices for shells
- Shell features evolved as UNIX grew



Most Commonly Used Shells

- /bin/csh C shell
- /bin/tcsh Enhanced C Shell

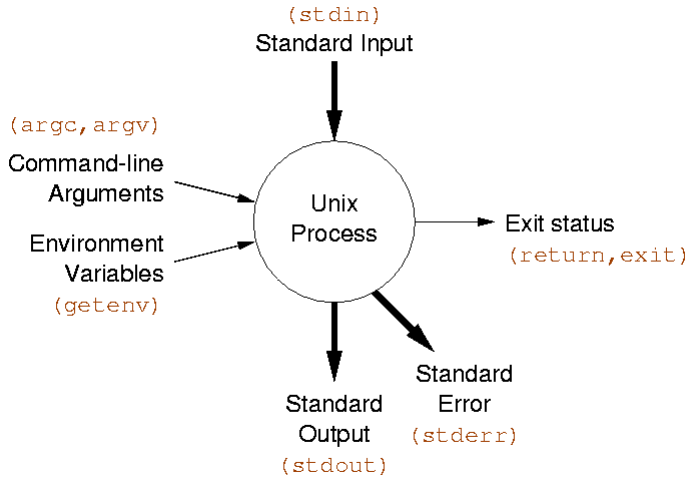
- /bin/sh The Bourne Shell / POSIX shell
- /bin/ksh Korn shell
- /bin/bash Korn shell clone, from GNU

Ways to use the shell

- **Interactively**
  - When you log in, you interactively use the shell
- **Scripting**
  - A set of shell commands that constitute an executable *program*

Review: UNIX Programs

- **Means of input**:
  - Program arguments [control information]
  - Environment variables [state information]
  - Standard input [data]



- **Means of output**:
  - Return status code [control information]
  - Standard out [data]
  - Standard error [error messages]

Shell Scripts

- A shell script is a regular text file that contains shell or UNIX commands
  - Before running it, it must have execute permission:
    - **`chmod +x` *`filename`***
- A script can be invoked as:
  - **`ksh name`** ***`[ arg`*** *…* ***`]`***
  - **`ksh < name`** ***`[ args`*** *…* ***`]`***
  - **`name`** ***`[ arg`*** *…**`]`***

Shell Scripts

- When a script is run, the **kernel** determines which shell it is written for by examining the first line of the script
  - If 1st line starts with **`#!`*`pathname-of-shell`***, then it invokes *pathname* and sends the script as an argument to be interpreted
  - If **`#!`** is not specified, the current shell assumes it is a script in its own language
    - leads to problems

Simple Example

```
#!/bin/sh

echo Hello World
```

Scripting vs. C Programming

- Advantages of shell scripts
  - Easy to work with other programs
  - Easy to work with files
  - Easy to work with strings
  - Great for prototyping. No compilation
- Disadvantages of shell scripts
  - Slow
  - Not well suited for algorithms & data structures

The C Shell

- C-like syntax (uses `{ }`'s)
- **Inadequate for scripting**
  - Poor control over file descriptors
  - Can't mix flow control and commands
  - Difficult quoting `"I say \"hello\""` doesn't work
  - Can only trap SIGINT
- Survives mostly because of interactive features.
  - Job control
  - Command history
  - Command line editing, with arrow keys (**tcsh**)

The Bourne Shell

- Slight differences on various systems
- Evolved into standardized POSIX shell
- Scripts will also run with **ksh**, **bash**
- Influenced by ALGOL

Simple Commands

- ***simple command***: sequence of non blanks arguments separated by blanks or tabs.
- 1st argument (numbered zero) usually specifies the name of the command to be executed.
- Any remaining arguments:
  - Are passed as arguments to that command.
  - Arguments may be filenames, pathnames, directories or special options

Background Commands

- Any command ending with "&" is run in the background.

```
netscape &
```

- **`wait`** will block until the command finishes

Complex Commands

- The shell's power is in its ability to hook commands together
- We've seen one example of this so far with pipelines:

```
cut -d: -f2 /etc/passwd | sort | uniq
```

- We will see others

Redirection of input/ouput

- Redirection of output: >
  - example: `$ ls -l > my_files`
- Redirection of input: <
  - example: `$ cat <input.data`
- Append output: >>
  - example: `$ date >> logfile`
- Arbitrary file descriptor redirection: *fd*>
  - example: `$ ls -l 2> error_log`

Multiple Redirection

- **`cmd 2>file`**
  - send standard error to file
  - standard output remains the same
- **`cmd > file 2>&1`**
  - send both standard error and standard output to file
- **`cmd > file1 2>file2`**
  - send standard output to file1
  - send standard error to file2

Here Documents

- Shell provides alternative ways of supplying standard input to commands (an *anonymous file*)
- Shell allows in-line input redirection using << called here documents
- **format**

```
command [arg(s)] << arbitrary-delimiter
command input
  :
  :
arbitrary-delimiter
```

- `arbitrary-delimiter` should be a string that does not appear in text

Here Document Example

```
#!/bin/sh

mail steinbrenner@yankees.com <<EOT
  You guys really blew it
  Monday.  Good luck next year.
  Yours,
  $USER
EOT
```

Shell Variables

- Write
  `name=value`
- Read: **`$var`**
- Turn local variable into environment:
  `export variable`

Variable Example

```
#!/bin/sh

MESSAGE="Hello World"
echo $MESSAGE
```

Environmental Variables

NAME	MEANING
$HOME	Absolute pathname of your home directory
$PATH	A list of directories to search for
$MAIL	Absolute pathname to mailbox
$USER	Your login name
$SHELL	Absolute pathname of login shell
$TERM	Type of your terminal
$PS1	Prompt

Parameters

- A parameter is one of the following:
  - A variable
  - A *positional parameter*, starting at 1
  - A *special* parameter
- To get the value of a parameter: **`${param}`**
  - Can be part of a word (**`abc${foo}def`**)
  - Works within double quotes
- The **`{ }`** can be omitted for simple variables, special parameters, and single digit positional parameters.

Positional Parameters

- The arguments to a shell script
  - **`$1, $2, $3`** …
- The arguments to a shell function
- Arguments to the **set** built-in command
  - **`set this is a test`**
    - **`$1=this, $2=is, $3=a, $4=test`**
- Manipulated with **shift**
  - **`shift 2`**
    - **`$1=a, $2=test`**
- Parameter 0 is the name of the shell or the shell script.

Example with Parameters

```
#!/bin/sh

# Parameter 1: word
# Parameter 2: file
grep $1 $2 | wc -l
```

```
$ countlines ing /usr/dict/words
3277
```

Special Parameters

- `$#` Number of positional parameters
- `$-` Options currently in effect
- `$?` Exit value of last executed command
- `$$` Process number of current process
- `$!` Process number of background process
- `$*` All arguments on command line
- `"$@"` All arguments on command line individually quoted `"$1" "$2" ...`

Command Substitution

- Used to turn the output of a command into a string
- Used to create arguments or variables
- Command is placed with grave accents ` ` to capture the output of command

```
$ date
Wed Sep 25 14:40:56 EDT 2001
$ NOW=`date`

$ sed "s/oldtext/`ls | head -1`/g"

$ PATH=`myscript`:$PATH
$ grep `generate_regexp` myfile.c
```

File name expansion

- Wildcards (patterns)
  - * matches any string of characters
  - ? matches any single character
  - [**list**] matches any character in **list**
  - **[lower-upper]** matches any character in range **lower-upper** inclusive
  - **[!list]** matches any character not in list

File Expansion

- If multiple matches, all are returned and treated as separate arguments:

```
$ /bin/ls
file1 file2
$ cat file1
a
$ cat file2
b
$ cat file*
a
b
```

- Handled by the shell (exec never sees the wildcards)
  - argv[0]: /bin/cat
  - argv[1]: file1
  - argv[2]: file2

NOT

  - argv[0]: /bin/cat
  - argv[1]: file*

Compound Commands

- Multiple commands
  - Separated by semicolon or newline
- Command groupings
  - pipelines
- Subshell

```
( command1; command2 ) > file
```

- Boolean operators
- Control structures

Boolean Operators

- Exit value of a program (**exit** system call) is a number
  - 0 means success
  - anything else is a failure code
- *cmd1* **`&&`** *cmd2*
  - executes cmd2 if cmd1 is successful
- *cmd1* **`||`** *cmd2*
  - executes cmd2 if cmd1 is not successful

```
$ ls bad_file > /dev/null && date
$ ls bad_file > /dev/null || date
Wed Sep 26 07:43:23 2001
```

Control Structures

```
if expression
then
   command1
else
   command2
fi
```

What is an expression?

- Any UNIX command. Evaluates to true if the exit code is 0, false if the exit code > 0
- Special command **`/bin/test`** exists that does most common expressions
  - String compare
  - Numeric comparison
  - Check file properties
- **`/bin/[`** often linked to **`/bin/test`** for syntactic sugar (or builtin to shell)
- Good example UNIX tools working together

Examples

```
if test "$USER" = ”mohri"
then
      echo "I know you"
else
      echo "I dont know you"
fi
```

```
if [ -f /tmp/stuff ] && [ `wc -l < /tmp/stuff` -gt 10
]
then
      echo "The file has more than 10 lines in it"
else
      echo "The file is nonexistent or small"
fi
```

test Summary

- **String based tests**

`-z string`	Length of string is 0
`-n string`	Length of string is not 0
`string1 = string2`	Strings are identical
`string1 != string2`	Strings differ
`string`	String is not NULL

- **Numeric tests**

`int1 -eq int2`	First int equal to second
`int1 -ne int2`	First int not equal to second
`-gt, -ge, -lt, -le`	greater, greater/equal, less, less/equal

- **File tests**

`-r file`	File exists and is readable
`-w file`	File exists and is writable
`-f file`	File is regular file
`-d file`	File is directory
`-s file`	file exists and is not empty

- **Logic**

`!`	Negate result of expression
`-a, -o`	and operator, or operator
`( expr )`	groups an expression

Arithmetic

- No arithmetic built in to **`/bin/sh`**
- Use external command **`/bin/expr`**
- **`expr expression`**
  - Evaluates expression and sends the result to standard output
  - Yields a numeric or string result

```
expr 4 "*" 12
expr "(" 4 + 3 ")" "*" 2
```

Control Structures Summary

- `if … then … fi`
- `while … done`
- `until … do … done`
- `for … do … done`
- `case … in … esac`

for loops

- Different than C:

```
for var in list
do
 command
done
```

- Typically used with positional params or a list of files:

```
sum=0
for var in "$@"
do
  sum=`expr $sum + $var`
done
echo The sum is $sum

for file in *.c ; do echo "We have $file"
done
```

Case statement

- Like a C switch statement for strings:

```
case $var in
  opt1) command1
        command2
        ;;
  opt2) command
        ;;
  *)    command
        ;;
 esac
```

- * is a catch all condition

Case Example

```
#!/bin/sh

echo "Say something."
while true
do
    read INPUT_STRING
    case $INPUT_STRING in
        hello)
            echo "Hello there."
            ;;
        bye)
            echo "See ya later."
            ;;
        *)
            echo "I'm sorry?"
            ;;
    esac
done
echo "Take care."
```

Case Options

- **opt** can be a shell pattern, or a list of shell patterns delimited by **|**
- Example:

```
case $name in
    *[0-9]*)
        echo "That doesn't seem like a name."
        ;;
    J*|K*)
        echo "Your name starts with J or K, cool."
        ;;
    *)
        echo "You're not special."
        ;;
esac
```

Types of Commands

All behave the same way

- Programs
  - Most that are part of the OS in /bin
- Built-in commands
- Functions
- Aliases

Built-in Commands

- Built-in commands are internal to the shell and do not create a separate process. Commands are built-in because:
  - They are intrinsic to the language (**exit**)
  - They produce side effects on the process (**cd**)
  - They perform much better
    - No fork/exec
- Special built-ins
  - : . break continue eval exec export exit readonly return set shift trap unset

Important Built-in Commands

exec	:	replaces shell with program
cd	:	change working directory
shift	:	rearrange positional parameters
set	:	set positional parameters
wait	:	wait for background proc. to exit
umask	:	change default file permissions
exit	:	quit the shell
eval	:	parse and execute string
time	:	run command and print times
export	:	put variable into environment
trap	:	set signal handlers

Important Built-in Commands

continue	:	continue in loop
break	:	break in loop
return	:	return from function
:	:	true
.	:	read file of commands into current shell; like `#include`

Functions

Functions are similar to scripts and other commands except that they can produce side effects in the callers script. The positional parameters are saved and restored when invoking a function. Variables are shared between caller and callee.

Syntax:

```
name ()
{
    commands
}
```

Aliases

- Like macros (#define in C)
- Shorter to define than functions, but more limited
- Not recommended for scripts
- Example:

```
alias rm='rm -i'
```

Search Rules

- Special built-ins
- Functions
  - *command* bypasses search for functions
- Built-ins not associated with PATH
- PATH search
- Built-ins associated with PATH
- Executable images

Parsing and Quoting

How the Shell Parses

- Part 1: Read the command:
  - Read one or more lines a needed
  - Separate into *tokens* using space/tabs
  - Form commands based on token types
- Part 2: Evaluate a command:
  - Expand word tokens (command substitution, parameter expansion)
  - ***Split words into fields***
  - Setup redirections, environment
  - Run command with arguments

Useful Program for Testing

/home/unixtool/bin/showargs

```
#include <stdio.h>
int main(int argc, char *argv[])
{
  int i;
  for (i=0; i < argc; i++) {
    printf("Arg %d: %s\n", i, argv[i]);
  }
  return(0);
}
```

Shell Comments

- Comments begin with an unquoted **#**
- Comments end at the end of the line
- Comments can begin whenever a token begins
- Examples

```
# This is a comment
# and so is this
grep foo bar # this is a comment
grep foo bar# this is not a comment
```

Special Characters

- The shell processes the following characters specially unless quoted:

  `| & ( ) < > ; " ' $ ` ` *space tab newline*

- The following are special whenever patterns are processed:

  `* ? [ ]`

- The following are special at the beginning of a word:

  `# ~`

- The following is special when processing assignments:

  `=`

Token Types

- The shell uses spaces and tabs to split the line or lines into the following types of tokens:
  - Control operators
  - Redirection operators
  - Reserved words
  - Assignment tokens
  - Word tokens

Operator Tokens

- Operator tokens are recognized everywhere unless quoted. Spaces are optional before and after operator tokens.
- I/O Redirection Operators:

  `> >> >| >& < << <<- <&`

  – Each I/O operator can be immediately preceded by a single digit
- Control Operators:

  `| & ; ( ) || && ;;`

Shell Quoting

- Quoting causes characters to loose special meaning.
- `\` Unless quoted, `\` causes next character to be quoted. In front of new-line causes lines to be joined.
- `'...'` Literal quotes. Cannot contain `'`
- `"..."` Removes special meaning of all characters except `$`, `"`, `\` and `` ` ``. The `\` is only special before one of these characters and new-line.

Quoting Examples

```
$ cat file*
a
b
```

```
$ cat "file*"
cat: file* not found
```

```
$ cat file1 > /dev/null
$ cat file1 ">" /dev/null
a
cat: >: cannot open
```

```
FILES="file1 file2"
$ cat "$FILES"
cat: file1 file2 not found
```

Simple Commands

- A simple command consists of three types of tokens:
  - Assignments (must come first)
  - Command word tokens
  - Redirections: *redirection-op* + *word-op*
  - The first token must not be a reserved word
  - Command terminated by new-line or **;**
- Example:
  - ```
    foo=bar z=`date`
    echo $HOME
    x=foobar > q$$ $xyz z=3
    ```
    ```

Word Splitting

- **After parameter expansion**, **command substitution**, and arithmetic expansion, the characters that are generated as a result of these expansions that are not inside double quotes are checked for split characters
- Default split character is *space* or *tab*
- Split characters are defined by the value of the **`IFS`** variable (**`IFS=""`** disables)

Word Splitting Examples

```
FILES="file1 file2"
cat $FILES
a
b

IFS=
cat $FILES
cat: file1 file2: cannot open
```

```
IFS=x v=exit
echo exit $v "$v"
exit e it exit
```

Pathname Expansion

- **After** word splitting, each field that contains pattern characters is replaced by the pathnames that match
- Quoting prevents expansion
- **`set -o noglob`** disables
  - Not in original Bourne shell, but in POSIX

Parsing Example