Week 1

1

GNU/Linux

- Open-source operating system
  - **Kernel**: core of operating system
    - Allocates time and memory to programs
    - Handles file system and communication between software and hardware
  - **Shell**: interface between user and kernel
    - Interprets commands user types in
    - Takes necessary action to cause commands to be carried out
  - **Programs**

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Files and Processes

- Everything is either a **process** or a **file**:
  - **Process**: an executing program identified by PID
  - **File**: collection of data
    - A document
    - Text of program written in high-level language
    - Executable
    - Directory
    - Devices

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The Basics: Shell

CLI utilities from week 1 you should be familiar with:

- `pwd`
- `cd`
- `mv`
- `cp`
- `rm`
- `mkdir`
- `rmdir`
- `ls`
- `ln`
- `touch`
- `find`
- `whatis`
- `whereis`
- `man`
- `ps`
- `kill`
- `diff`
- `wget`

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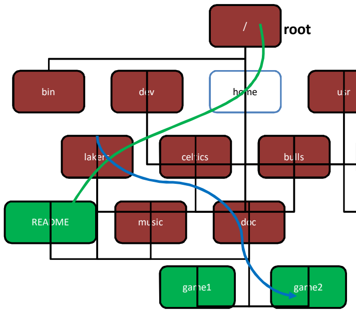
The Basics: Shell

- How do I find where files are on the system?
- How do I find out what options are available for a particular utility?
- When is a file a file and when is it a process?
- What types of links are there?

Absolute Path vs. Relative Path

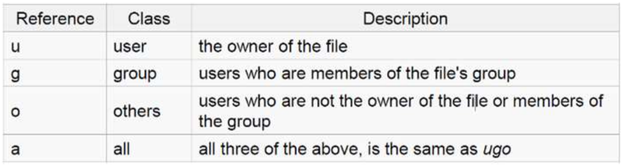


Current directory: home

What are the differences between absolute and relative paths?

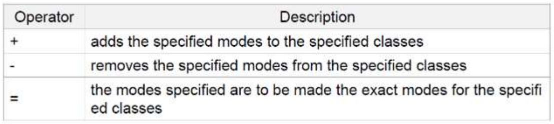
Linux File Permissions

- chmod
  - read (r), write (w), executable (x)
  - User, group, others
- Why do we have permissions at all?

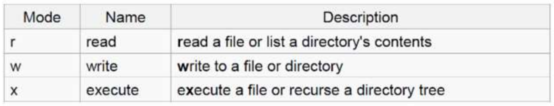


Reference	Class	Description
u	user	the owner of the file
g	group	users who are members of the file's group
o	others	users who are not the owner of the file or members of the group
a	all	all three of the above, is the same as *ugo*

The Basics: chmod (symbolic)

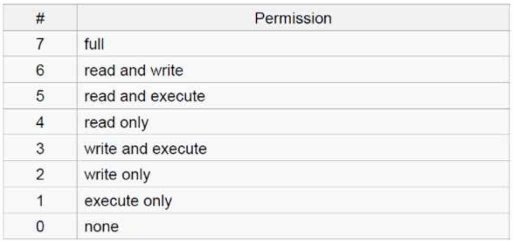


Operator	Description
+	adds the specified modes to the specified classes
-	removes the specified modes from the specified classes
=	the modes specified are to be made the exact modes for the specified classes



Mode	Name	Description
r	read	read a file or list a directory's contents
w	write	write to a file or directory
x	execute	execute a file or recurse a directory tree

The Basics: chmod (numeric)



#	Permission
7	full
6	read and write
5	read and execute
4	read only
3	write and execute
2	write only
1	execute only
0	none

- Usage

– chmod [''references''][''operator''][''modes''] ''file1'' ...
Example: **chmod** ug+rw mydir, **chmod** a-w myfile,
Example: **chmod** ug=rx mydir, **chmod** 664 myfile

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Week 2/3

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Locale

A locale

- Set of parameters that define a user’s cultural preferences
  - Language
  - Country
  - Other area-specific things
- What else does the locale affect?

`locale` command
prints information about the current locale environment to standard output

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Locale Settings Can Affect Program Behavior!!

Default sort order for the `sort` command depends:

- LC_COLLATE=‘C’: sorting is in ASCII order
- LC_COLLATE=‘en_US’: sorting is case insensitive except when the two strings are otherwise equal and one has an uppercase letter earlier than the other.

Other locales have other sort orders!

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Environment Variables

- Variables that can be accessed from any child process
- Why do we have these at all? What functions do they serve?

Common ones:

- **HOME**: path to user's home directory
- **PATH**: list of directories to search in for command to execute
- Change value:
  export VARIABLE=…

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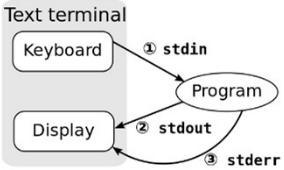
Standard Streams

- Every program has these 3 streams to interact with the world
  - stdin (0): contains data going into a program
  - stdout (1): where a program writes its output data
  - stderr (2): where a program writes its error msgs



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Redirection and Pipelines

- *program < file* redirects *file to program's stdin*:
  cat <file
- *program > file* redirects *program*'s stdout to *file2*:
  cat <file >file2
- *program 2> file* redirects *program*'s stderr to *file2*:
  cat <file 2>file2
- *program >> file* **appends** program's stdout to *file*
- *program1 | program2* assigns stdout of *program1* as the stdin of *program2; text 'flows' through the pipeline*
  cat <file | sort > file2

Why would we want to redirect I/O? What are some examples of use cases for I/O redirection? How do we implement this in C?

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Regular Expressions

- Notation that lets you search for text with a particular pattern:
  - For example: starts with the letter a, ends with three uppercase letters, etc.
- Why do these exist? Are the expressions the same across languages?
- What's the difference between a basic and an extended regular expression? When would I use either?
- How do I write a regular expression to accomplish x?

- http://regexpal.com/ to test your regex expressions
- Simple regex tutorial http://www.icewarp.com/support/online_help/203030104.htm

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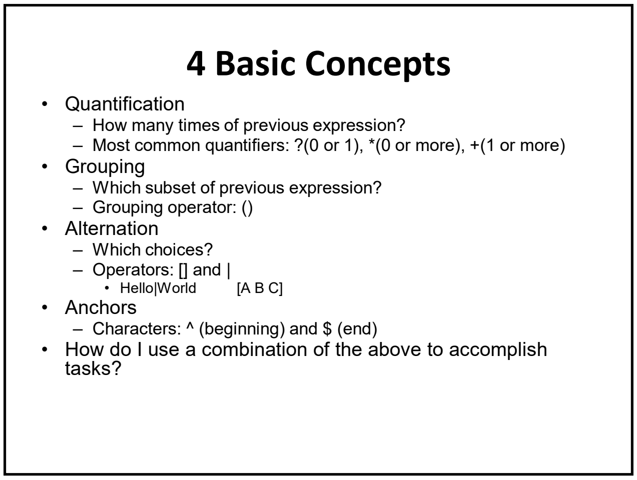

4 Basic Concepts

- Quantification
  - How many times of previous expression?
  - Most common quantifiers: ?(0 or 1), *(0 or more), +(1 or more)
- Grouping
  - Which subset of previous expression?
  - Grouping operator: ()
- Alternation
  - Which choices?
  - Operators: [] and |
    - Hello|World [A B C]
- Anchors
  - Characters: ^ (beginning) and $ (end)
- How do I use a combination of the above to accomplish tasks?

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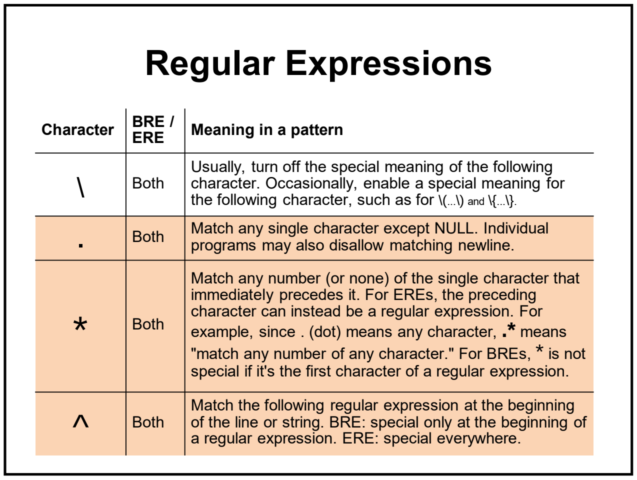

Regular Expressions

Character	BRE / ERE	Meaning in a pattern
\	Both	Usually, turn off the special meaning of the following character. Occasionally, enable a special meaning for the following character, such as for \(...\) and \{...\}.
.	Both	Match any single character except NULL. Individual programs may also disallow matching newline.
*	Both	Match any number (or none) of the single character that immediately precedes it. For EREs, the preceding character can instead be a regular expression. For example, since . (dot) means any character, .* means "match any number of any character." For BREs, * is not special if it's the first character of a regular expression.
^	Both	Match the following regular expression at the beginning of the line or string. BRE: special only at the beginning of a regular expression. ERE: special everywhere.

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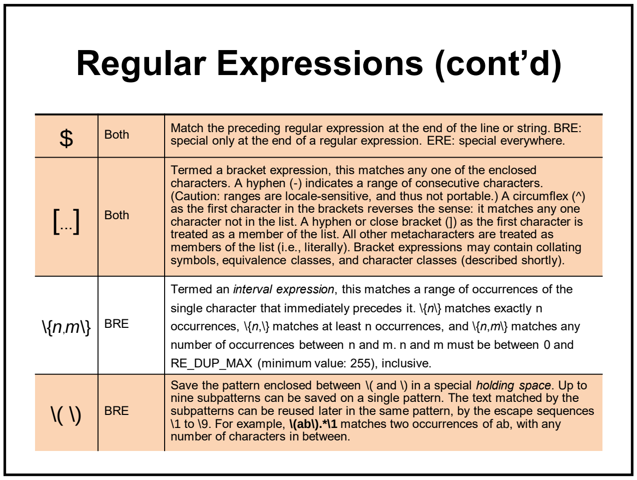

Regular Expressions (cont'd)

$	Both	Match the preceding regular expression at the end of the line or string. BRE: special only at the end of a regular expression. ERE: special everywhere.
[...]	Both	Termed a bracket expression, this matches any one of the enclosed characters. A hyphen (-) indicates a range of consecutive characters. (Caution: ranges are locale-sensitive, and thus not portable.) A circumflex (^) as the first character in the brackets reverses the sense: it matches any one character not in the list. A hyphen or close bracket (]) as the first character is treated as a member of the list. All other metacharacters are treated as members of the list (i.e., literally). Bracket expressions may contain collating symbols, equivalence classes, and character classes (described shortly).
\{*n*,*m*\}	BRE	Termed an *interval expression*, this matches a range of occurrences of the single character that immediately precedes it. \{*n*\} matches exactly n occurrences, \{*n*,\} matches at least n occurrences, and \{*n*,*m*\} matches any number of occurrences between n and m. n and m must be between 0 and RE_DUP_MAX (minimum value: 255), inclusive.
\(\)	BRE	Save the pattern enclosed between \(and \) in a special *holding space*. Up to nine subpatterns can be saved on a single pattern. The text matched by the subpatterns can be reused later in the same pattern, by the escape sequences \1 to \9. For example, **\(ab\).*\1** matches two occurrences of ab, with any number of characters in between.

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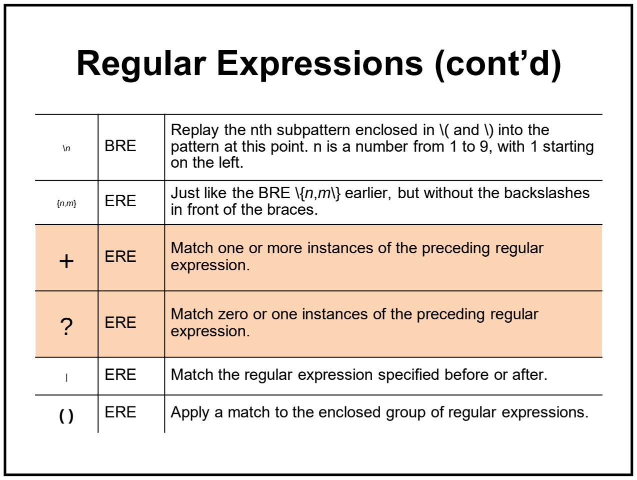

Regular Expressions (cont'd)

\n	BRE	Replay the nth subpattern enclosed in \(and \) into the pattern at this point. n is a number from 1 to 9, with 1 starting on the left.
{*n*,*m*}	ERE	Just like the BRE \{*n*,*m*\} earlier, but without the backslashes in front of the braces.
+	ERE	Match one or more instances of the preceding regular expression.
?	ERE	Match zero or one instances of the preceding regular expression.
|	ERE	Match the regular expression specified before or after.
( )	ERE	Apply a match to the enclosed group of regular expressions.

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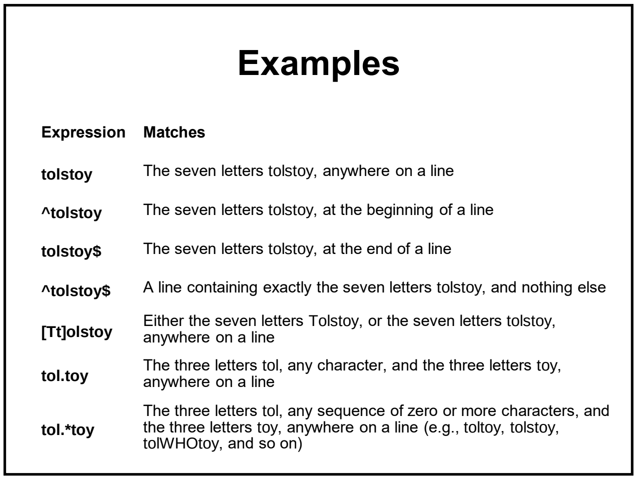

Examples

Expression	Matches
tolstoy	The seven letters tolstoy, anywhere on a line
^tolstoy	The seven letters tolstoy, at the beginning of a line
tolstoy$	The seven letters tolstoy, at the end of a line
^tolstoy$	A line containing exactly the seven letters tolstoy, and nothing else
[Tt]olstoy	Either the seven letters Tolstoy, or the seven letters tolstoy, anywhere on a line
tol.toy	The three letters tol, any character, and the three letters toy, anywhere on a line
tol.*toy	The three letters tol, any sequence of zero or more characters, and the three letters toy, anywhere on a line (e.g., toltoy, tolstoy, tolWHOtoy, and so on)

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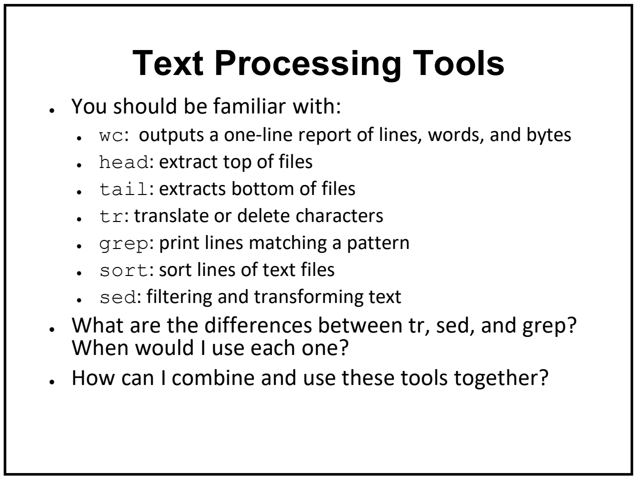

Text Processing Tools

- You should be familiar with:
  - `wc`: outputs a one-line report of lines, words, and bytes
  - `head`: extract top of files
  - `tail`: extracts bottom of files
  - `tr`: translate or delete characters
  - `grep`: print lines matching a pattern
  - `sort`: sort lines of text files
  - `sed`: filtering and transforming text
- What are the differences between tr, sed, and grep? When would I use each one?
- How can I combine and use these tools together?

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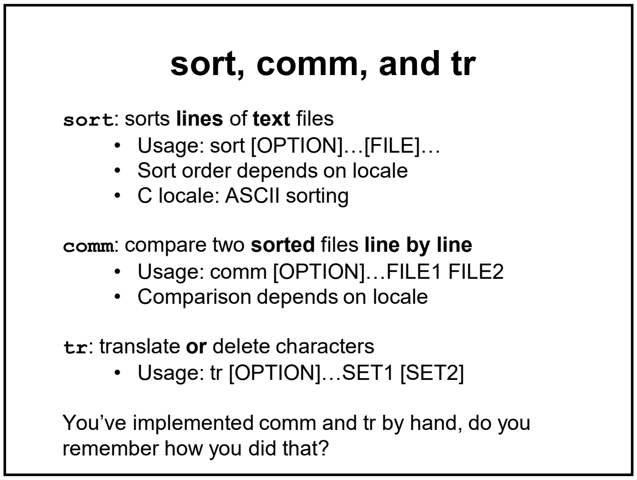

sort, comm, and tr

`sort`: sorts **lines** of **text** files

- Usage: sort [OPTION]…[FILE]…
- Sort order depends on locale
- C locale: ASCII sorting

`comm`: compare two **sorted** files **line by line**

- Usage: comm [OPTION]…FILE1 FILE2
- Comparison depends on locale

`tr`: translate **or** delete characters

- Usage: tr [OPTION]…SET1 [SET2]

You've implemented comm and tr by hand, do you remember how you did that?

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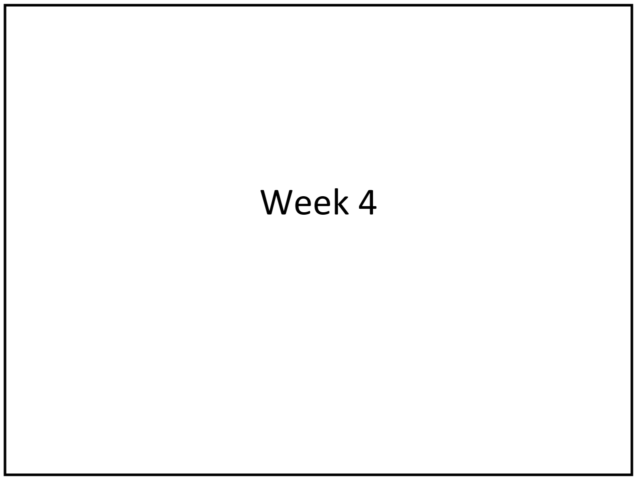

Week 4

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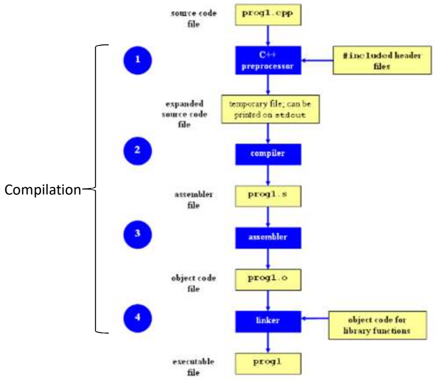
Compilation Process



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Compilation Process

- Why do we have this process?
- What are the different components of the process?
  - "I just typed gcc to compile my programs… does that mean gcc has all of the components within it?"
- Why can't I execute individual object code files?
- What are the differences between open source and closed source software? When would I want to use one or the other?

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Make

- Utility for managing large software projects
- Compiles files and keeps them up-to-date
- Efficient Compilation (only files that need to be recompiled)
- Why do we have make at all?

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Build Process

- **configure**
  – Script that checks details about the machine before installation
    - Dependency between packages
  – Creates 'Makefile'
- **make**
  – Requires 'Makefile' to run
  – Compiles all the program code and creates executables in current temporary directory
- **make install**
  – make utility searches for a label named install within the Makefile, and executes only that section of it
  – executables are copied into the final directories (system directories)

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Patching

- A patch is a piece of software designed to fix problems with or update a computer program
- It’s a diff file that includes the changes made to a file
- A person who has the original (buggy) file can use the patch command with the diff file to add the changes to their original file
- Why not just change the original source code to fix it? Why do we have patches?

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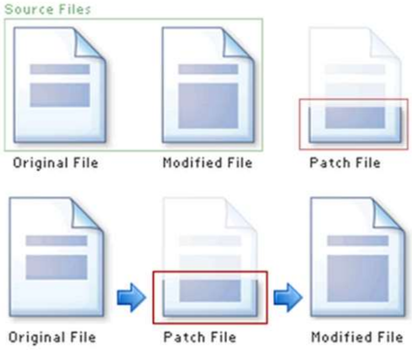
Applying a Patch



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diff Unified Format

- diff –u original_file modified_file

- --- path/to/original_file
- +++ path/to/modified_file

- @@ -l,s +l,s @@
  - @@: beginning of a hunk
  - l: beginning line number
  - s: number of lines the change hunk applies to for each file
  - A line with a:
    - - sign was deleted from the original
    - + sign was added to the original
    - stayed the same

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What is Python?

- Not just a scripting language
- Object-Oriented language
  - Classes
  - Member functions
- Not as fast as C but easy to learn, read and use
- You should know how to write basic programs in python

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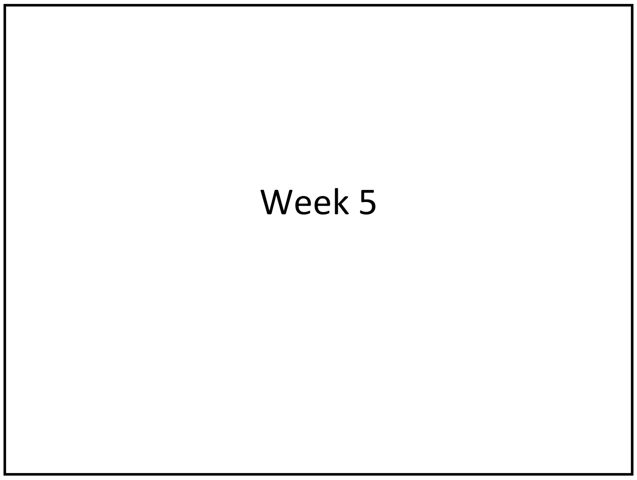

Week 5

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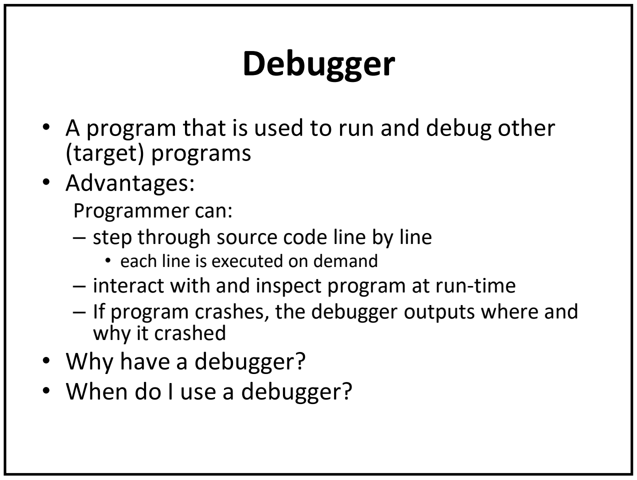

Debugger

- A program that is used to run and debug other (target) programs
- Advantages:

  Programmer can:
  - step through source code line by line
    - each line is executed on demand
  - interact with and inspect program at run-time
  - If program crashes, the debugger outputs where and why it crashed
- Why have a debugger?
- When do I use a debugger?

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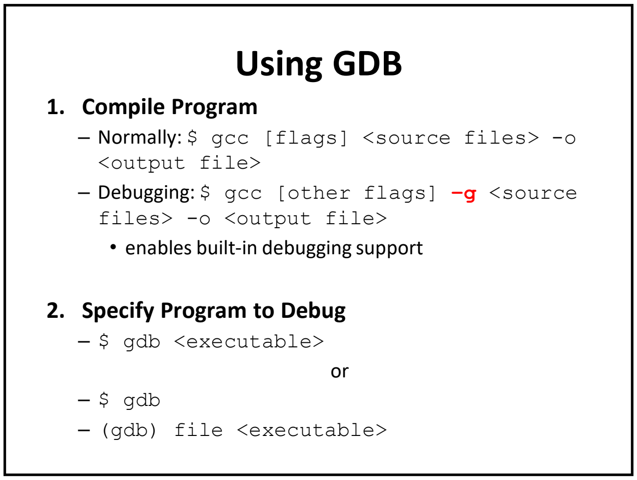

Using GDB

1. **Compile Program**
   - Normally: `$ gcc [flags] <source files> -o <output file>`
   - Debugging: `$ gcc [other flags] -g <source files> -o <output file>`
     - enables built-in debugging support

2. **Specify Program to Debug**
   - `$ gdb <executable>`

     or
   - `$ gdb`
   - `(gdb) file <executable>`

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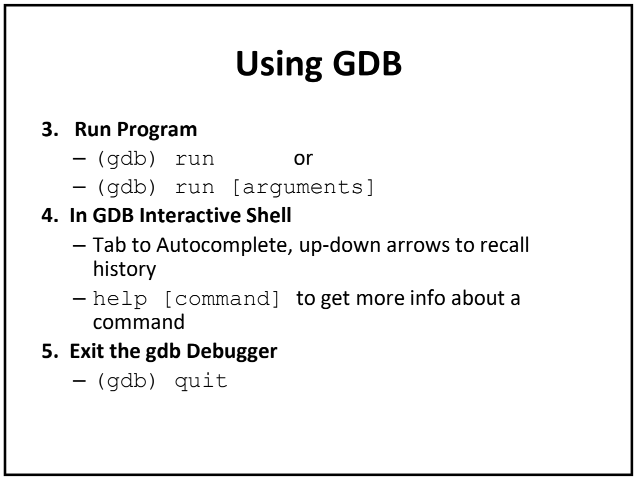

Using GDB

3. **Run Program**
   - `(gdb) run` or
   - `(gdb) run [arguments]`
4. **In GDB Interactive Shell**
   - Tab to Autocomplete, up-down arrows to recall history
   - `help [command]` to get more info about a command
5. **Exit the gdb Debugger**
   - `(gdb) quit`

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Run-Time Errors

- Segmentation fault
  - Program received signal SIGSEGV, Segmentation fault. 0x0000000000400524 in *function* (arr=0x7fffc902a270, r1=2, c1=5, r2=4, c2=6) at *file.c*:12
    - Line number where it crashed and parameters to the function that caused the error
- Logic Error
  - Program will run and exit successfully
- How do we find bugs?

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Setting Breakpoints

- Breakpoints
  - used to stop the running program at a specific point
  - If the program reaches that location when running, it will pause and prompt you for another command
- Example:
  - `(gdb) break file1.c:6`
    - Program will pause when it reaches line 6 of file1.c
  - `(gdb) break my_function`
    - Program will pause at the first line of `my_function` every time it is called
  - `(gdb) break [`*`position`*`] if `*`expression`*
    - Program will pause at specified position only when the expression evaluates to true
- How do we know where to set breakpoints?
- What do we do once we've stopped at a breakpoint?

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Deleting, Disabling and Ignoring BPs

- `(gdb) delete [bp_number | range]`
  - Deletes the specified breakpoint or range of breakpoints
- `(gdb) disable [ `*`bp_number`*` | `*`range`*`]`
  - Temporarily deactivates a breakpoint or a range of breakpoints
- `(gdb) enable [ `*`bp_number`*` | `*`range`*`]`
  - Restores disabled breakpoints
- If no arguments are provided to the above commands, all breakpoints are affected!!
- `(gdb) ignore `*`bp_number iterations`*
  - Instructs GDB to pass over a breakpoint without stopping a certain number of times.
    - bp_number: the number of a breakpoint
    - Iterations: the number of times you want it to be passed over

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Displaying Data

- Why would we want to interrupt execution?
  - to see data of interest at run-time:
  - `(gdb) print [/format] `*`expression`*
    - Prints the value of the specified expression in the specified format
  - Formats:
    - d: Decimal notation (default format for integers)
    - x: Hexadecimal notation
    - o: Octal notation
    - t: Binary notation
- What's the point of displaying data?
- What sort of data might we want to display?

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Resuming Execution After a Break

- When a program stops at a breakpoint
  - 4 possible kinds of gdb operations:
    - **c or continue**: debugger will continue executing until next breakpoint
    - **s or step**: debugger will continue to next source line
    - **n or next**: debugger will continue to next source line in the current (innermost) stack frame

What is the difference between ‘s’ and ‘n’?
When would we use each one of the above?

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Stack Info

- A program is made up of one or more functions which interact by calling each other
- Every time a function is called, an area of memory is set aside for it. This area of memory is called a **stack frame** and holds the following crucial info:
  - storage space for all the local variables
  - the memory address to return to when the called function returns
  - the arguments, or parameters, of the called function
- Each function call gets its own stack frame. Collectively, all the stack frames make up the **call stack**
- Why does the stack exist at all? How is the stack different than the heap?

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Dynamic Memory

- Memory that is allocated at runtime
  - Why?
- Allocated on the heap
  - Why not the stack?

void *malloc (size_t size);
- Allocates *size* bytes and returns a pointer to the allocated memory

void *realloc (void *ptr, size_t size);
- Changes the size of the memory block pointed to by *ptr* to *size* bytes

void free (void *ptr);
- Frees the block of memory pointed to by *ptr*

- What happens if I never call free?
- What happens if I try to put data into dynamic memory but I haven’t yet called malloc?

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Week 6

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Processor Modes

- Operating modes that place restrictions on the type of operations that can be performed by running processes
  - User mode: restricted access to system resources
  - Kernel/Supervisor mode: unrestricted access
- System resources?
  - Memory
  - I/O Devices
  - CPU
- Why have different modes?

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User Mode vs. Kernel Mode

- Hardware contains a mode-bit, e.g. 0 means kernel mode, 1 means user mode
- User mode
  - CPU **restricted** to unprivileged instructions and a specified area of memory
- Supervisor/kernel mode
  - CPU is **unrestricted**, can use all instructions, access all areas of memory and take over the CPU anytime
- What happens if user code is given unrestricted access to CPU?

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Why Dual-Mode Operation?

- System resources are shared among processes
- OS must ensure:
  - **Protection**
    - an incorrect/malicious program cannot cause damage to other processes or the system as a whole
  - **Fairness**
    - Make sure processes have a fair use of devices and the CPU

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How to Achieve Protection and Fairness

- Goals:
  - **I/O Protection**
    - Prevent processes from performing illegal I/O operations
  - **Memory Protection**
    - Prevent processes from accessing illegal memory and modifying kernel code and data structures
  - **CPU Protection**
    - Prevent a process from using the CPU for too long

=> instructions that might affect goals are privileged and can only be executed by *trusted code*

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System Calls

- Special type of function that:
  - Used by user-level processes to request a service from the kernel
  - Changes the CPU's mode from user mode to kernel mode to enable more capabilities
  - Is part of the kernel of the OS
  - Verifies that the user should be allowed to do the requested action and then does the action (kernel performs the operation on behalf of the user)
  - Is the ***only way*** a user program can perform privileged operations
- When do I need to use system calls?

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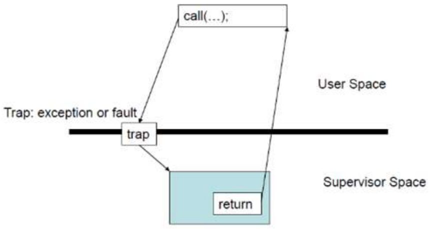
System Calls

- When a system call is made, the program being executed is interrupted and control is passed to the kernel
- If operation is valid the kernel performs it



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System Call Overhead

- System calls are expensive and can hurt performance
- The system must do many things
  - Process is interrupted & computer saves its state
  - OS takes control of CPU & verifies validity of op.
  - **OS performs requested action**
  - OS restores saved context, switches to user mode
  - OS gives control of the CPU back to user process

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Library Functions

- Functions that are a part of standard C library
- To avoid system call overhead use equivalent library functions
  - getchar, putchar vs. read, write (for standard I/O)
  - fopen, fclose vs. open, close (for file I/O), etc.
- How do these functions perform privileged operations?
  - They make system calls
- What are the benefits and tradeoffs of using either system calls or C library functions?

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Unbuffered vs. Buffered I/O

- **Unbuffered**
  - Every byte is read/written by the kernel through a system call
- **Buffered**
  - collect as many bytes as possible (in a buffer) and read more than a single byte (into buffer) at a time and use one system call for a block of bytes

⇒Buffered I/O decreases the number of read/write system calls and the corresponding overhead

Which is faster in what applications? When would you use buffered or unbuffered I/O?

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Week 7

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Parallelism

- Executing several computations simultaneously to gain performance
- Different forms of parallelism
  - **Multitasking**
    - Several processes are scheduled alternately or possibly simultaneously on a multiprocessing system
  - **Multithreading**
    - Same job is broken logically into pieces (threads) which may be executed simultaneously on a multiprocessing system
- What's the point of parallelism? Isn't it just too complicated?
- How can you decide whether your application should use multiple processes or multiple threads? Or both?

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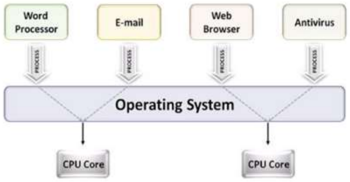
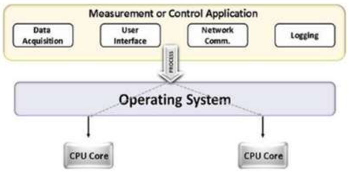
Multitasking vs. Multithreading



Multitasking

Multithreading



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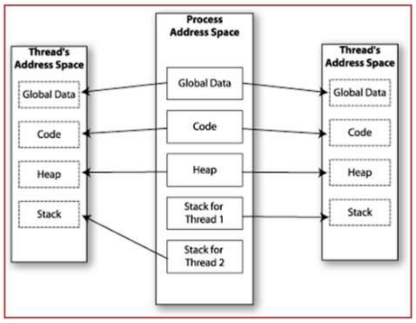
Multithreading vs Multitasking

- **Multithreading**
  - Threads share the same address space
    - Light-weight creation/destruction
    - Easy inter-thread communication
    - An error in one thread can bring down all threads in process
- **Multitasking**
  - Processes are insulated from each other
    - Expensive creation/destruction
    - Expensive IPC
    - An error in one process cannot bring down another process

Memory Layout: Multithreaded Program



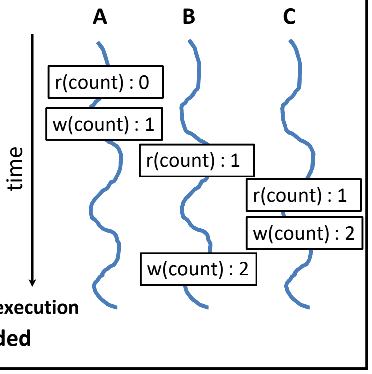
Why share the same code?
Why share the same heap?

Shared Memory

- Makes multithreaded programming
  - **Powerful**
    - can easily access data and share it among threads
  - **More efficient**
    - No need for system calls when sharing data
    - Thread creation and destruction less expensive than process creation and destruction
  - **Non-trivial**
    - Have to prevent several threads from accessing and changing the same shared data at the same time (synchronization)

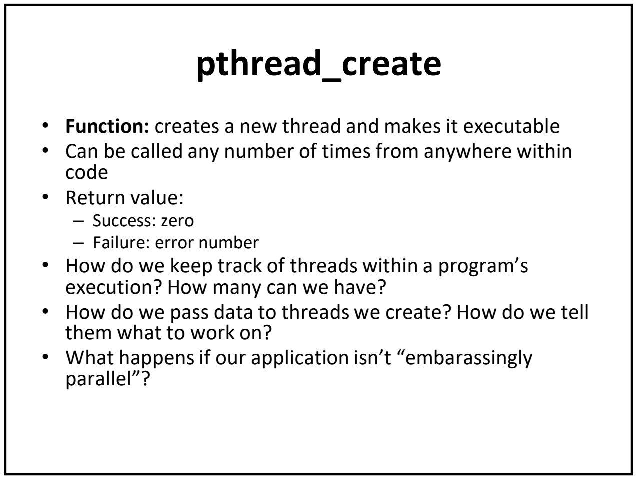
Race Condition

```
int count = 0;
void increment()
{
  count = count + 1;
}
```



Result depends on order of execution

=> Synchronization needed



pthread_create

- **Function:** creates a new thread and makes it executable
- Can be called any number of times from anywhere within code
- Return value:
  - Success: zero
  - Failure: error number
- How do we keep track of threads within a program's execution? How many can we have?
- How do we pass data to threads we create? How do we tell them what to work on?
- What happens if our application isn't "embarassingly parallel"?

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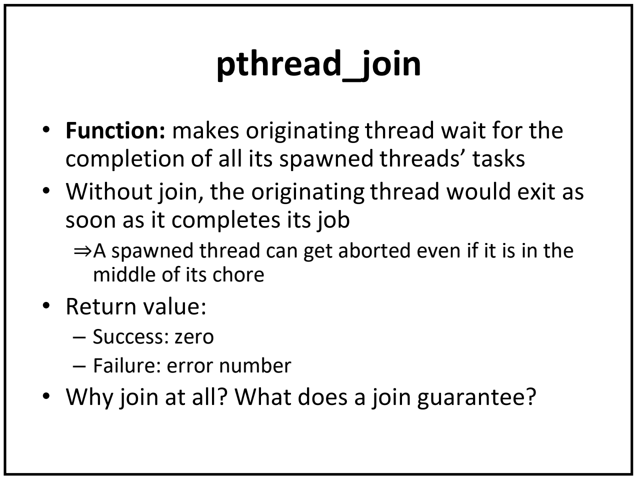

pthread_join

- **Function:** makes originating thread wait for the completion of all its spawned threads' tasks
- Without join, the originating thread would exit as soon as it completes its job
  - ⇒A spawned thread can get aborted even if it is in the middle of its chore
- Return value:
  - Success: zero
  - Failure: error number
- Why join at all? What does a join guarantee?

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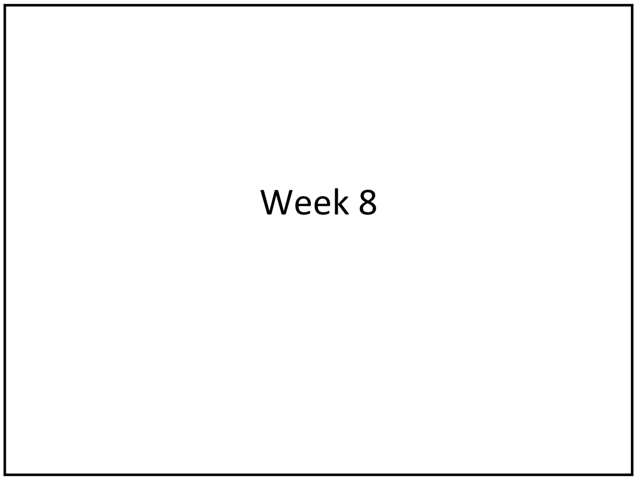

Week 8

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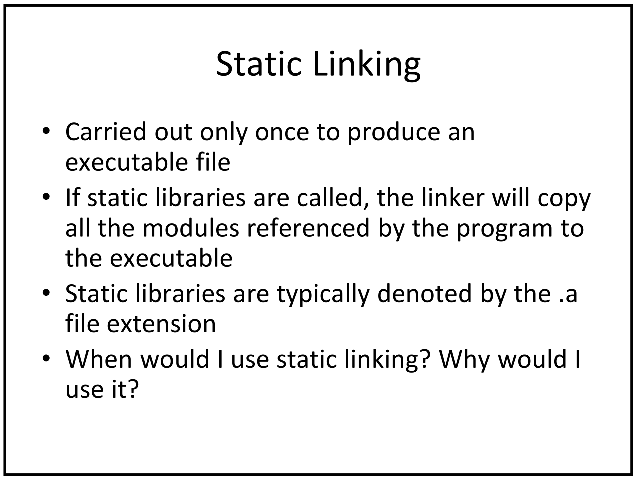

Static Linking

- Carried out only once to produce an executable file
- If static libraries are called, the linker will copy all the modules referenced by the program to the executable
- Static libraries are typically denoted by the .a file extension
- When would I use static linking? Why would I use it?

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Dynamic Linking

- Allows a process to add, remove, replace or relocate object modules during its execution.
- If shared libraries are called:
  - Only copy a little reference information when the executable file is created
  - Complete the linking during loading time or running time
- Dynamic libraries are typically denoted by the .so file extension
  - .dll on Windows
- When would I use dynamic linking? Why would I use it?

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How are libraries dynamically loaded?

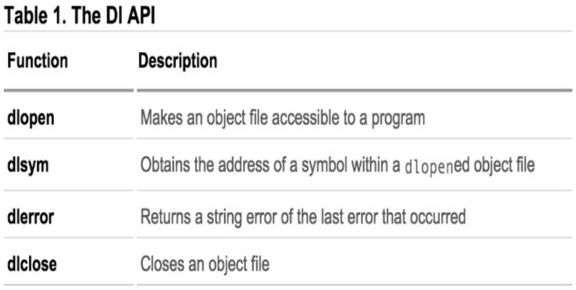

Table 1. The Dl API

Function	Description
dlopen	Makes an object file accessible to a program
dlsym	Obtains the address of a symbol within a `dlopen`ed object file
dlerror	Returns a string error of the last error that occurred
dlclose	Closes an object file

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Advantages of dynamic linking

- The executable is typically smaller
- When the library is changed, the code that references it does not usually need to be recompiled
- The executable accesses the .so at run time; therefore, multiple programs can access the same .so at the same time
  - Memory footprint amortized across all programs using the same .so
- What other advantages are there of dynamic linking?

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Disadvantages of dynamic linking

- Performance hit
  - Need to load shared objects (at least once)
  - Need to resolve addresses (once or every time)
  - Remember back to the system call assignment…

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Week 9

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Communication Over the Internet

- What type of guarantees do we want?
  - **Confidentiality**
    - Message secrecy
  - **Data integrity**
    - Message consistency
  - **Authentication**
    - Identity confirmation
  - **Authorization**
    - Specifying access rights to resources

- Why do we want these guarantees?

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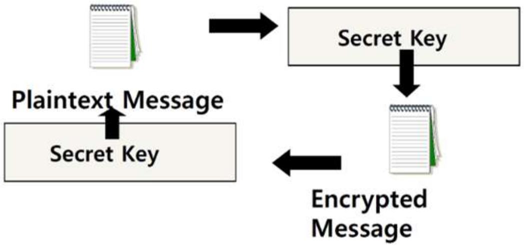
Secret Key (symmetric) Cryptography

- A single key is used to both encrypt and decrypt a message



Secret Key

Plaintext Message

Secret Key

Encrypted Message

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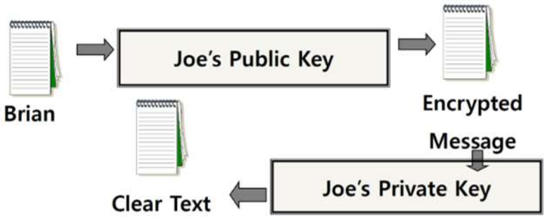
Public Key (asymmetric) Cryptography

- Two keys are used: a public and a private key. If a message is encrypted with one key, it has to be decrypted with the other.



Brian

Joe's Public Key

Encrypted Message

Joe's Private Key

Clear Text

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Encryption questions

- Why have encryption?
- What are the differences between symmetric and asymmetric encryption? When would I use one or the other?
- What is used on the Internet? What is a certificate authority?
- How can I trust a message came from someone?

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Digital Signature

- An electronic stamp or seal
  - almost exactly like a written signature, except more guarantees!
- Is appended to a document
  - Or sent separately (detached signature)
- Ensures data integrity
  - document was not changed during transmission
- How are signatures different than encryption?

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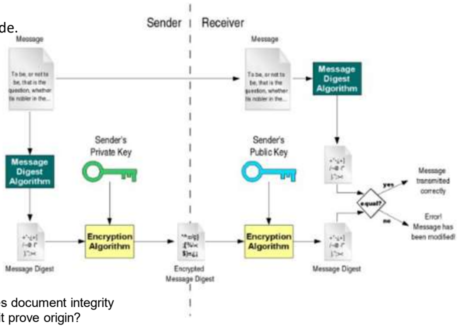
Digital Signature

You should understand this entire slide.



- Verifies document integrity
- Does it prove origin?
- Who is Certificate Authority (CA) ?

Image Source : gdp.globus.org

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Detached Signature

- Digital signatures can either be *attached* to the message or *detached*
- A detached signature is stored and transmitted separately from the message it signs
- Commonly used to validate software distributed in compressed tar files
- You can't sign such a file internally without altering its contents, so the signature is created in a separate file
- Why detach at all? Why are signatures useful?
- Who can create a signature? How do I verify a signature?

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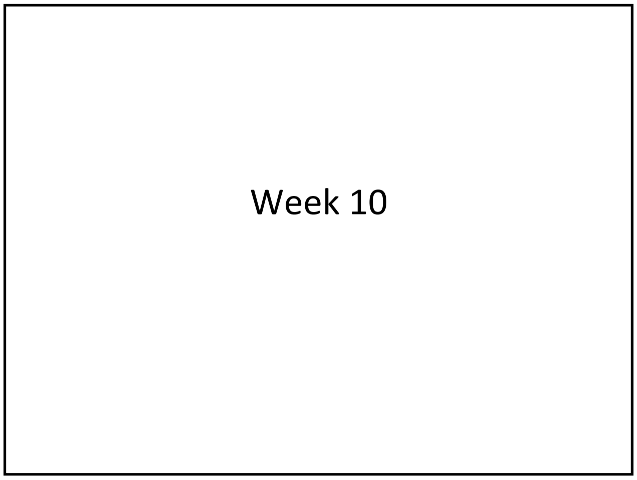
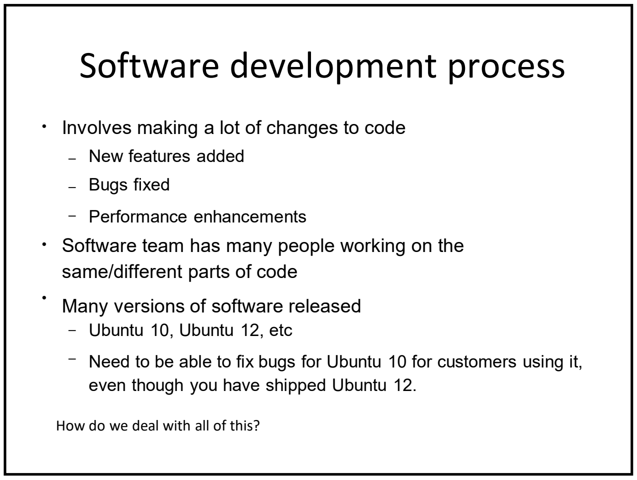


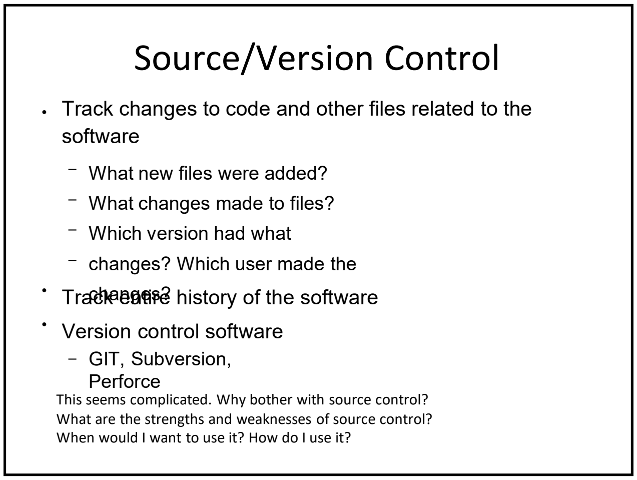
Week 10



Software development process

- Involves making a lot of changes to code
  - New features added
  - Bugs fixed
  - Performance enhancements
- Software team has many people working on the same/different parts of code
- Many versions of software released
  - Ubuntu 10, Ubuntu 12, etc
  - Need to be able to fix bugs for Ubuntu 10 for customers using it, even though you have shipped Ubuntu 12.

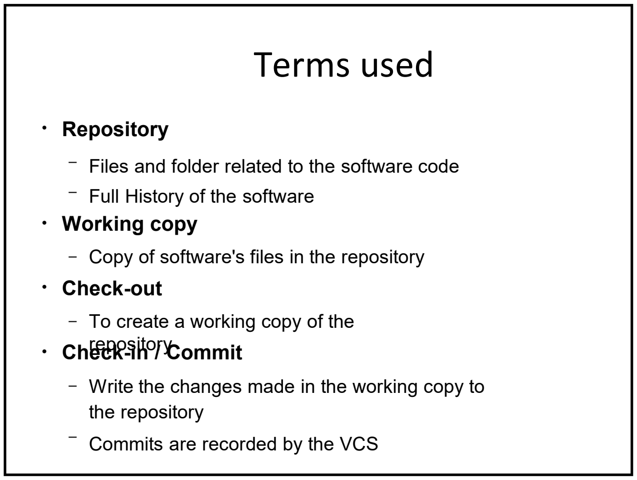
How do we deal with all of this?



Source/Version Control

- Track changes to code and other files related to the software
  - What new files were added?
  - What changes made to files?
  - Which version had what
  - changes? Which user made the changes?
- Track entire history of the software
- Version control software
  - GIT, Subversion, Perforce

This seems complicated. Why bother with source control?
What are the strengths and weaknesses of source control?
When would I want to use it? How do I use it?



Terms used

- **Repository**
  - Files and folder related to the software code
  - Full History of the software
- **Working copy**
  - Copy of software's files in the repository
- **Check-out**
  - To create a working copy of the repository
- **Check-in / Commit**
  - Write the changes made in the working copy to the repository
  - Commits are recorded by the VCS

Terms used

- Head
  - Refers to a commit object
  - There can be many heads in a repository
- HEAD
  - Refers to the currently active head
- Detached HEAD
  - If a commit is not pointed to by a branch
  - This is okay if you want to just take a look at the code and if you don't commit any new changes
  - If the new commits have to be preserved then a new branch has to be created
    - git checkout v3.0 -b BranchVersion3.1
- Branch
  - Refers to a head and its entire set of ancestor commits
- Master
  - Default branch

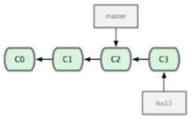


Image Source: git-scm.com

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What Is a Branch?

- A pointer to one of the commits in the repo (head) + all ancestor commits
- When you first create a repo, are there any branches?
  - Default branch named ‘master’
- The default master branch
  - points to last commit made
  - moves forward automatically, every time you commit

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Questions

- What is the difference between a working copy and the repository?
- What is a commit? What should be in a commit?
- What is HEAD and HEAD^2?
- Why bother having branches at all? Why can’t we just all work on the same single master branch?
- What happens when we perform a merge? How does it work?

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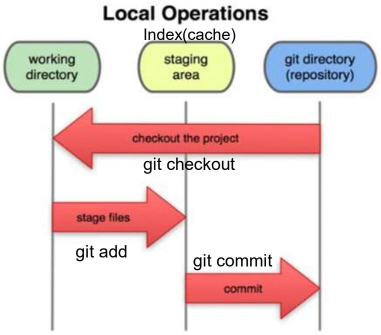
Git States



Index(cache)

git checkout

git add

git commit

Image Source: git-scm.com

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Git commands

- Repository creation
  - $ git init (Start a new repository)
  - $ git clone (Create a copy of an exisiting repository)
- Branching
  - $ git checkout <tag/commit> -b <new_branch_name> (creates a new branch)
- Commits
  - $ git add (Stage modified/new files)
  - $ git commit (check-in the changes to the repository)
- Getting info
  - $ git status (Shows modified files, new files, etc)
  - $ git diff (compares working copy with staged
  - $ git log files) (Shows history of commits)
  - $ git show (Show a certain object in the repository)
- Getting help
  - $ git help

You should be familiar with how these commands work and when to use them.

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Good luck for the finals week!

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