Advanced Unix Commands

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Outline

- ~~File and Directory Commands~~
- ~~File Viewing and Editing Commands~~
- Commands for File Analysis
- Process Management
- Security and Permissions

File Analysis Commands

Commands

- wc
- regex
- grep
- find
- cut

- paste
- sort
- uniq
- zip/tar
- redirection (>, >>, <)
- Pipe (|)

https://preview.redd.it/yjtwtofkxgy51.jpg?width=640&crop=smart&auto=webp&s=166b65dac9fb037c6d569744d12adbd3d84491ea

wc

- wc's motto: Every word counts!
- Counts the number of lines, words, and characters in a file or input from standard input
  - Will tell you if your file is too long, too short, or just right :-)
- Use Case:
  - Quickly obtaining statistics about text files
  - Often combined with other commands using pipes to process and analyze text
- Syntax : wc [OPTION] [FILES]
  - [FILES]: File(s) you want to analyze
    - If no file is provided, wc reads from standard input

- Output of wc typically consists of three numbers (when no specific option is used)
  - Number of Lines: Total number of lines in the file
  - Number of Words: Total number of words
  - Number of Bytes: Total size of the file in bytes
- Key Options
  - -l: Count lines
  - -w: Count words
  - -c: Count bytes
  - -m: Count characters
  - -L: Print the length of the longest line (in characters)

Demo

wc

https://xkcd.com/208/

Regular Expressions (regex)

- regex: a pattern that matches a set of strings
  - Used in text editors, programming languages, and command-line tools
- Metacharacters: characters with special meaning
  - "^" beginning of a line (Can also mean "not" if inside [])
  - "$" end of line
  - "." match any single character
  - "\" escape a special character
  - "|" or operation i.e. match a particular character set on either side

Quantifiers: specifying the number of occurrences of a character

- “*” Match the preceding item zero or more times
- “?” Match the preceding item zero or one time
- “+” Match the preceding item one or more times
- “{n}” Match the preceding item exactly n times
- “{n,} Match the preceding item at least n times
- “{,m}”Match the preceding item at most m times
- “{n,m}” Match the preceding item from n to m times

Groups and Ranges

- “ ( )” group patterns together
- “{ }” match a particular number of occurrences (seen before)
- “[ ]” match any character from a range of characters
  - ab[xyz]c "abxc" and "abyc"and "abzc"
  - [^…..] matches a character which is not defined in the square bracket
  - [a-z] matches letters of a small case from a to z
  - [A-Z] matches letters of an upper case from A to Z
  - [0-9] matches a digit from 0 to 9.

grep

- Grep: Global Regular Expression Print
- Searches for specific patterns within files or input provided via standard input
  - Used for text searching and processing
- Syntax : grep [OPTIONS] PATTERN [FILE...]
  - [OPTIONS]: Optional flags modify the behavior of grep
  - PATTERN: The regular expression pattern to search for
  - [FILE]: One or more files to search
    - If no file is specified, grep reads from standard input

- Key Options
  - -i: Ignore case (case-insensitive search)
  - -v: Invert match (show lines that do not match the pattern)
  - -r or -R: Recursively search directories
  - -n: Show line numbers with matching lines
  - -c: Count the number of matching line

- -H: Print the filename for each match
  - Useful when searching multiple files
- -o: Print only the matched parts of a line
- -E: Use extended regular expressions
- -w: match only whole words
- -A: Displays lines of text that appear after the matching line
- -B: Displays lines of text that appear before the matching line
- -C: Displays lines of text that appear both before and after the matching line

Demo

grep

find

- Used to search for files and directories based on various criteria
  - Can search for files by name, size, type
  - Can perform actions (execute commands) on found files
- Use case: Locate specific files, clean up old files, or performing actions on files that match certain conditions

- find [PATH] [OPTIONS] [CRITERIA] [ACTIONS]
  - [PATH]: The directory or directories to start the search from (default is the current directory)
  - [OPTIONS]: Optional flags that modify the behavior of find
  - [CRITERIA]: Conditions used to match files (e.g., by name, size, type)
  - [ACTIONS]: Actions to perform on the matched files (e.g., print, delete)

- Key Options and Criteria
  - -name: Search for files by name
  - -iname: Case-insensitive search for files by name
  - -type: Search for files by type
    - f: Regular file
    - d: Directory
  - -size: Search for files by size
    - +: Larger than
    - -: Smaller than
    - c: Size in bytes.

- -perm: Search for files or directories based on their permissions
- -mtime: Search for files based on modification time
  - +: More than n days ago
  - -: Less than n days ago
  - n: Exactly n days ago
- -exec: Execute a command on each found file
  - -delete: Delete files that match the search criteria
  - -print: Print the path of each found file (default action)

Demo

find

cut

- Used to extract specific sections of text from each line of input data
  - Useful for processing and filtering columns of data from text files, logs, or command output
  - Effective with structured data, such as CSV files or delimited text,
- Syntax: cut [OPTIONS] [FILE...]
  - FILE...: The file(s) to process
    - If no file is specified, cut reads from standard input

- Key Options
  - -f: Specifies the fields to be extracted
    - Fields are separated by a delimiter (tab is default)
  - -d: Defines the delimiter that separates fields in the input data
    - Default behavior: use the input delimiter as the output delimiter
  - -c: Extracts specific characters from each line of the input
  - -b: Extracts specific bytes from each line of input
  - --complement: Complement the selection
    - Displays all bytes, characters, or fields except the selected
  - --output-delimiter: Allows to specify a different output delimiter string

Demo

cut

paste

- Used to merge lines of files horizontally, creating columns of data
  - Combines corresponding lines from each file specified as arguments, separating them by a delimiter (which defaults to a tab)
- Use case:
  - Useful for joining data from multiple files or streams
    - Creates side-by-side comparisons or concatenated outputs
  - cat command merges files vertically (one after the other)
  - paste merges files horizontally, placing lines from different files side by side

- Syntax: paste [OPTIONS] [FILE...]
  - FILE...: The files to be merged
    - If no files are specified, paste reads from standard input
- Key Options
  - -d: Specifies a custom delimiter to use between merged lines
  - -s: Merges lines from one file sequentially, rather than in parallel with other files.
  - -: Indicates that standard input should be used in place of a file.

Demo

paste

sort

- Used to arrange lines of text files or input data in a specific order
  - By default, sorts lines alphabetically or numerically based on the first character, but can be customized
- Use case: Organize data for better readability, prepare data for further processing
- Syntax : sort [OPTIONS] [FILE...]
  - FILE...: The files to be sorted
    - If no files are specified, sort reads from standard input

- Key Options
  - -n: Sorts numerically, treating the first part of each line as a number
    - Useful for sorting lists of numbers or data that includes numeric fields.
  - -r: Reverses the sort order
  - -k: Sorts based on a specific field within each line
  - -t: Specifies a custom delimiter that separates fields in the input.
  - -u: Removes duplicate lines from the output, showing only unique entries
  - -M: Sorts lines based on the first three characters of the month name

Demo

sort

uniq

- Used to filter out or report repeated lines in a file or input data
  - Only works on adjacent lines
    - Identifies or removes duplicates that are directly next to each other
  - Does not perform any fuzzy matching
  - Only identifies lines that are exactly the same
- Use case: Commonly used in combination with sort to process sorted data

- Syntax : uniq [OPTIONS] [INPUT] [OUTPUT]
  - INPUT: The file to be processed
    - If no input file is specified, uniq reads from standard input
  - OUTPUT: The file where the results will be written
    - If no output file is specified, results are written to standard output

- Key Options
  - -c: Prefixes each line with the number of times it appears in the input
    - Useful for counting occurrences of each line
  - -d: Displays only the lines that are repeated (duplicates)
  - -u: Displays only the lines that are unique, excluding all repeated lines
  - -i: Ignores case when comparing lines
  - -f: Skips a specified number of fields before performing comparisons
  - -s: Skips a specified number of characters before performing comparisons.

zip

- Used to create compressed archive files
  - Bundles multiple files and directories into a single .zip file
  - Supports both compression and file management tasks
    - File management: can add, update, and delete files within an archive
  - .zip files are supported on many operating systems
- Use case: Helps create backups, package and distribute files
- Syntax: zip [OPTIONS] ARCHIVE FILES…
  - ARCHIVE: The name of the output .zip file to create or update
  - FILES...: The files and directories to include in the archive.

- Key Options
  - -r: Recursively include directories and their contents
  - -u: Update an existing archive with new or changed files
  - -d: Delete files from an existing archive
  - -x: Exclude files or directories from the archive
  - -e: Encrypt the archive with a password
  - -s : splits a large archive into multiple smaller files

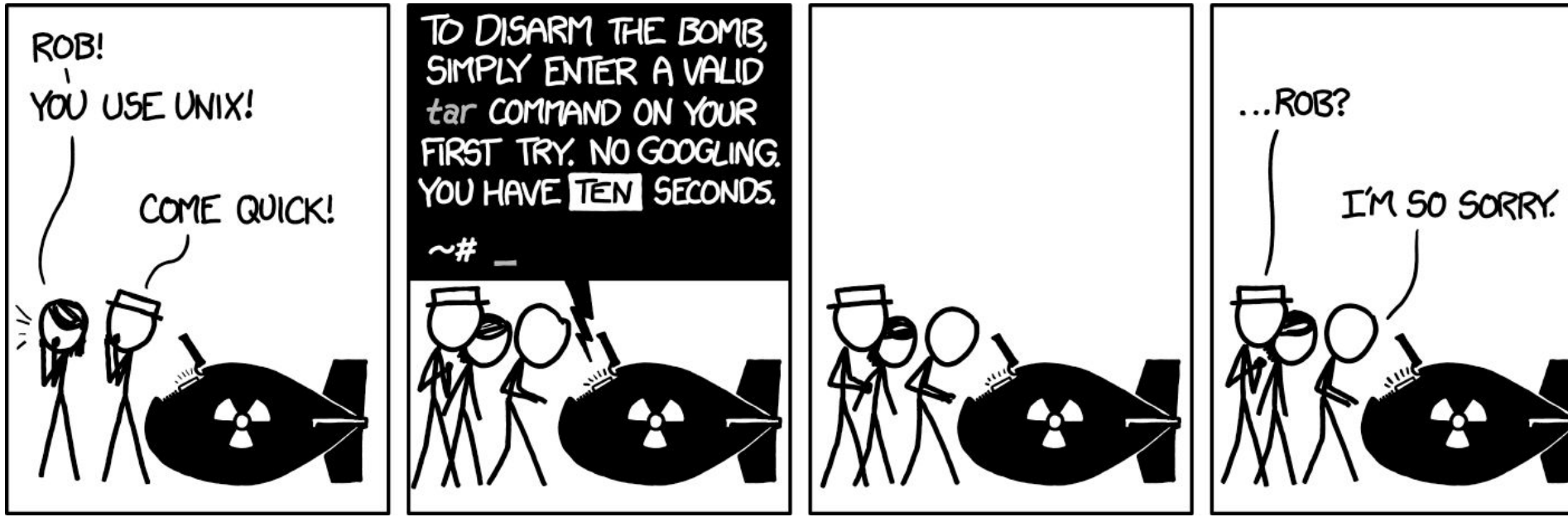
- Key Options
  - -d: Specify the directory to extract files into
  - -l: List the contents of the archive without extracting
  - -o: Overwrite existing files without prompting
  - -n: Never overwrite existing files
  - -x: Exclude specific files from extraction.

tar

- Used to create and manipulate archive files
  - Can bundle multiple files and directories into a single archive file, often with a .tar extension
  - Can extract files from archives
  - Supports various compression methods to reduce the archive using gzip, bzip2, or xz
  - Preserves file metadata such as permissions, ownership, and timestamps
    - Very useful for backups and transfers

- Syntax : tar [OPTIONS] [ARCHIVE] [FILES...]
  - ARCHIVE: The name of the archive file to create, extract, or manipulate
  - FILES...: The files and directories to include in the archive or extract from it.

- Key Options
  - -c: Create a new archive
  - -x: Extract files from an archive
  - -t: List the contents of an archive without extracting
  - -f: Specifies the archive file name
    - Must be followed by the name of the archive file
  - -z: Compress or decompress using gzip
  - -j: Compress or decompress using bzip2
  - -J: Compress or decompress using xz
  - -v: Verbose mode, displays the progress of the operation



https://xkcd.com/1168/

- Zip:
  - Combines both compression and archiving in a single step
  - Often used for cross-platform compatibility
- Tar:
  - Primarily used for bundling files, with compression applied separately
  - Favored for its efficiency and detailed preservation of file attributes

Input/Output

- A process is an instance of a program that is being executed
- Stream: a special file that either continuously receives text in or pushes text out
- When you run a command, OS creates a process to execute that command

- Whenever a process starts, process is given access to three “standard” streams
  - fd is file descriptor
  - Standard input (stdin; fd is 0)
  - Standard output (stdout, fd is 1)
  - Standard error (stderr, fd is 2); used when an error has occurred
- When a process starts
  - stdout and stderr are configured to print whatever they receive to the terminal screen
  - stdin is configured to read input from the user’s keyboard

Redirection

- Redirection controls where the output of a command goes and where input comes from
  - Allows you to redirect standard input (stdin), standard output (stdout), and standard error (stderr)
- > (Output Redirection) : Redirects the standard output (stdout) of a command to a file
  - If the file already exists, it will be overwritten
  - Syntax: command > file

- >> (Append Redirection) : Redirects the standard output (stdout) of a command to a file, but instead of overwriting, appends output end of the file
  - Syntax: command >> file
- < (Input Redirection): Redirects the standard input (stdin) for a command from a file
  - Instead of typing input directly into the command, it reads the input from the specified file
  - Syntax: command < file

- command > file same as command 1> file (stdout redirected, stderr still screen)
- command 2> file (send stderr to file, stdout is screen)
- command 2> error.txt 1> out.txt (send both to different files)
- command > file 2>&1 (send both to same file)
- command 2> /dev/null (suppress error messages)
  - /dev/null is a special file that discards anything written to it

pipe

- How many files and folders in /etc ?
  - ls /etc > temp.txt; wc -l temp.txt; rm temp.txt
- A pipe (|) allows the output of one command to be used as input for another command
  - Shell connects the stdout of the first command directly to the stdin of the second command
    - Operates entirely in memory
    - Unidirectional: flows from left to right

  - Enables chaining of multiple commands together to perform complex operations
- Use case: Process data through a series of commands without needing to store intermediate results in temporary files
- Syntax: command1 | command2 | command3 ...

Command Substitution

- How to use the output of a command in the arguments of another
  - Note: pipes are great for sharing stdin and stdout between processes
- Command substitution: Output of a command replaces the command itself
  - $(command) or
  - `command`

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Process Management

Commands

- ps
- pkill

Process Management

- Methods and tools to control, monitor, and interact with processes running on the system
- A process is a running instance of a program
  - Each process in Linux has a unique Process ID (PID)
  - From a process, another process can be created
    - Achieved via fork system call

- Parent-child relationship exists between the two processes
  - PID (Process ID): A unique identifier assigned to each process.
  - PPID (Parent Process ID): The PID of the process that started (or "parented") the current process.
- init has process id 1
  - Parent of all processes
  - Executed by the kernel during the booting of a system

- Process States:
  - Running: The process is currently executing
  - Sleeping: The process is waiting for an event (e.g., I/O completion)
  - Stopped: The process has been stopped, usually by receiving a signal
  - Zombie: The process has completed execution but still has an entry in the process table

ps

- Displays information about the currently running processes on the system
  - Default output is a list of the processes associated with the command-line
  - Shows unique process id (pid), terminal used, amount of CPU time, and the program name
- Use case: Commonly used to monitor running processes, check for specific processes, or troubleshoot system performance issues
- Syntax: ps [options]

- Key Options
  - -e or -A: Lists all processes running on the system
  - -f: Displays full-format listing
  - -u username: Shows processes owned by the specified user
  - -p PID: Displays information about the specified process ID(s)
  - -C command_name: Filters processes by the command name
  - aux: Displays detailed information about all processes
    - “a”: display the processes of all users
    - “u”: user-oriented format → more details
    - “x”: list the processes without a controlling terminal
      - Started on boot time and running in the background

- PID: Process ID - The unique identifier for the process.
- TTY: Terminal type associated with the process.
- TIME: Total CPU time the process has consumed.
- COMMAND: The command that started the process.
- USER: The user who owns the process (shown with options like aux).
- %CPU: The percentage of CPU usage (shown with options like aux).
- %MEM: The percentage of memory usage (shown with options like aux).
- VSZ: Virtual memory size (shown with options like aux).
- RSS: Resident Set Size, the non-swapped physical memory that the task has used (shown with options like aux).
- STAT: Process state (e.g., R for running, S for sleeping) (shown with options like aux).
- START: The start time of the process

pkill

- Used to send signals to processes to request actions like termination, suspension, or restarting
  - Targets processes based on their names or other attributes, rather than process ID (PID)
    - Kill another command which is similar but needs PIDs
- Use Case: Control processes by sending them specific signals
  - Request actions like termination, suspension, or restarting
- Syntax: pkill [options] pattern

- Key Options
  - -s SIGNAL: Specifies the signal to send to the matching processes
    - If omitted, the default signal is SIGTERM
    - To know what SIGNALs available, use kill -l
  - -f: Matches against the full command line of the processes, not just the process name
  - -u USER: Targets processes owned by the specified user
  - -t TTY: Targets processes associated with the specified terminal
  - -P PID: Targets child processes of the specified parent PID

https://i.redd.it/2ndv691za33a1.png

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Security and Permissions

Commands

- su
- sudo
- Access control

Superuser

- Superuser: user with super powers
  - A real user account (often root) that can do just about anything (modify/delete files, run any programs etc)
- For security reasons, “su” was introduced
  - Can mean ‘superuser’ or ‘switch user’
  - Helps change to another user without having to log out and in
    - Terminal session switched to the other user
    - Requires password of the other user
  - Administrators spend most time using normal account, when needed switch to superuser, do task and logout

- Syntax: su [options] [username]
  - username: User you want to switch to
    - If not specified, command switches to root
- Key Options:
  - -c [command]: Executes a single command as the specified user and returns to previous user after command is run
  - -s [shell]: Specifies which shell to use when switching users
  - -p or --preserve-environment: Preserves the current environment variables instead of loading the new user’s environment

- Further improvement, “sudo” was introduced
  - “switch user and do this command”
    - Does not fully switch to that user’s environment
  - Asks for the current user's password (not root's)
    - Permissions for using sudo are defined in the /etc/sudoers file
      - Administrators can specify which users are allowed to run which command
    - Runs the command with elevated privileges
    - Entered password is cached for a default period (usually 15 minutes)
      - No need to re-enter it for subsequent sudo commands

  - Prevents long-lived terminal sessions with dangerous powers
- Use Case: Grants users temporary access to perform administrative tasks
  - Tasks otherwise restricted to root user or a system administrator
- Be very careful when using sudo or su

- Key Options:
  - -u [user]: Runs the command as a specified user, instead of root
  - -l: Lists the commands that the current user is allowed to run with sudo
  - -k: Invalidates the current user’s cached credentials, forcing sudo to prompt for a password again.
  - --preserve-env or -E: Preserves the current environment variables when running a command

- Why Use sudo Instead of su?
  - More Secure: Unlike su, sudo doesn’t require sharing the root password, which limits security risks
  - Granular Control: Administrators can limit which commands users can run with sudo
  - Auditability: Actions performed with sudo can be logged, helping track which users executed which commands

Access Control

- UNIX is a multi-user system
- Every file and directory (in your account) can be protected from or made accessible to other users. How?
- Permissions for a file or directory may be any or all of
  - r - read; w - write; x - execute
  - a directory must have both r and x permissions if the files it contains are to be accessed

- Each permission (rwx) can be controlled at three levels:
  - u (user = yourself)
  - g (group, a set of users)
  - o (others, everyone else)
- File access permissions are displayed using “ ls -l”
- Use Case: Sensitive information is protected and only accessible to authorized personnel

- First field: - for File, d for Directory, l for Link
- Second,third,fourth fields: permissions for owner, group and others
- Fifth field: specifies the number of links or directories inside this directory
- Sixth field: user
- Seventh field: group
- Eighth field: size in bytes (use -lh option for better understanding)
- Ninth field: date of last modification
- Tenth field: name of the file/directory

References

- https://ubuntu.com/tutorials/command-line-for-beginners#1-overview
- https://linuxize.com/ (good resource, use search box for info on different commands!)