CompTIA Linux+ (XK0-005)

- **Linux+**
  - *The new CompTIA Linux+ is for the IT pro who will use Linux to manage everything from cars and smartphones to servers and supercomputers, as a vast number of enterprises use Linux in cloud, cybersecurity, mobile and web administration applications. (CompTIA.org)*

- **Exam Description**
  - CompTIA Linux+ validates the skills of IT professionals with hands-on experience configuring, monitoring, and supporting servers running the Linux operating system. The new exam has an increased focus on the following topics: security, kernel modules, storage & virtualization, device management at an enterprise level, git & automation, networking & firewalls, server side & command line, server (vs. client-based) coverage, troubleshooting and SELinux.

- **Four Domains**
  - 32% System Management
  - 21% Security
  - 19% Scripting, Containers, and Automation
  - 28% Troubleshooting

- **Exam Details**
  - Up to 90 questions in 90 minutes
    - Multiple-choice
    - Performance-based/Simulations
    - Fill-in-the-Blank
      - Requires a 720 out of 900
      - Recommended Experience:
        - CompTIA A+, CompTIA Network+ and 12 months of Linux admin experience
  - Released: April 2, 2019 (XK0-004); July 12, 2022 (XK0-005)

- **Are You Ready?**
  - Take practice exams
  - Did you score at least 85% or higher?

- If you need more practice, take additional practice exams to hone your skills before attempting the exam

- **What kind of jobs can I get?**

Basic Linux Task

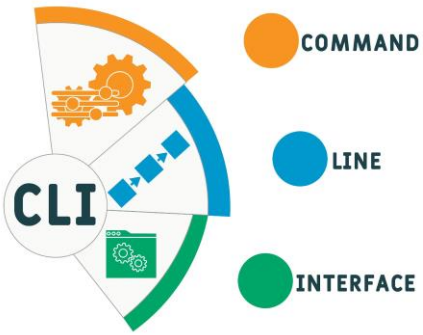
Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

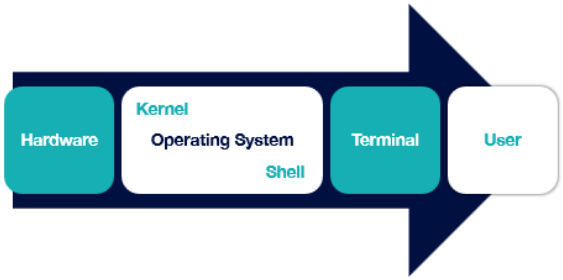
- **Linux Design Philosophy**
    - **Linux**
        - Family of open-source Unix-like operating systems
        - Linux is an open-source operating system that allows anyone to freely download, modify, and redistribute it
            - Ubuntu
            - Debian
            - Fedora Linux
    - **Open-Source**
        - Computer software in which the source code is readily available for public use or modified from the original design
    - **Proprietary**
        - Licensed software that has restrictions on what end users can do
            - General Public License
            - Apache License
            - MIT License
            - Creative Commons Zero
        - Linux follows the Unix philosophy of simplicity and modularity
        - Open-source software also comes with some caveats
            - Steep learning curve
            - Not well-supported
            - No definite/official version
            - No official vendor-provided support
    - **CentOS**

- Free software project and focuses on creating compatible open source and free versions of Red Hat and Enterprise Linux

- **CLI and The Shell**
  - **Command Line Interface (CLI)**
    - Text-based interface between the user and the operating system that accepts input in the form of typed commands



  - **Shell**
    - Contains the core portion of the operating system



    - The original Unix shell was called the Bourne shell (sh), and was replaced by Bourne-again (Bash)

  - **Syntax**
    - Proper way of structuring a command and any supporting information
      - Command
      - Options
      - Argument

- Commands entered into Bash are case sensitive
- Command line interface interacts directly with the shell. And the shell requires the user to use syntax when issuing commands

- **Bash Commands**
  - **Echo Command**
    - Repeats input back to the user on the screen
  - **LS Command**
    - Lists the content of a directory that can give options to view permissions and hidden files
  - **PWD Command**
    - Current working directory
  - **CD Command**
    - Change current working directory
  - **CP Command**
    - Copy file or directory to another location
  - **MKDIR Command**
    - Create new directory
  - **Clear Command**
    - Used to clear the command line interface of all text
  - **Cat Command**
    - Used to view the contents of a file without editing option
  - **Less Command**
    - Used to view the contents of a file that won't fit on one screen
  - **Vim**
    - Default text editor in Linux

- **Nano**
  - Simple and user-friendly text editor that needs to be installed before using it
- **Gedit**
  - GUI text editor that requires installation of a desktop environment like Gnome or KDE
- **Su (Substitute User) Command**
  - Allows to switch user credentials

- **Man Pages**
  - **Man Pages**
    - Contains the complete documentation for Linux commands
    - The most immediate source of help available
  - **Synopsis**
    - Provides the syntax of the command with examples of its use
  - **Bold text**
    - Type exactly as shown
  - **Italic text**
    - Replace with appropriate argument
      - **-abc**
        - Optional
      - **-a|-b**
        - Cannot be used together
      - **Italic text with ellipsis (…)**
        - Can be repeated
      - **-a**
        - Find matching queries

- **-D**
  - Display debugging information
- **-f**
  - Show command description
- **-h**
  - Display help options
- **-k**
  - Show lists of all manual pages
- **-K**
  - Search for the specific string
- **-t**
  - Format for printing

- **fsck command**
  - Used to check and repair a Linux file system

- General commands
- System calls
- C library functions
- Special files

- File formats and conventions
- Games and screensavers
- Miscellaneous
- System admin commands/daemons

- **Home Key**
  - Moves to beginning page

- **End Key**
  - Moves to end page

- **Page Up**
  - Scrolls up one page

- **Page Down**
  - Scrolls down one page

- **/**
  - Begins a search
- **n**
  - Moves to next occurrence
- **p**
  - Moves to previous occurrence
- **q**
  - Quits man page

- **Other Help Resources**
  - **Apropos**
    - Used to search the name section of all man pages
  - **Whatis**
    - Used to display a brief description of the given commands
  - **Info**
    - Used to display the information page of a command
    - Man pages contain all the information in a single page
      - man –h
      - man –-help
  - **/usr/share/doc/**
    - Official Ubuntu Documentation
  - **https://help.ubuntu.com/**
    - Linux Documentation Project
  - **https://tldp.org**

- GNU Coreutils Manual

- **https://www.gnu.org/**
  - software/coreutils/manual/

    - Usenet newsgroups
    - Mailing lists
    - Q&A websites
    - Forums
    - Social media

- **Usenet Newsgroup**
  - Online discussion repository

- **Mailing List**
  - Threaded discussions in the form of email messages among members of a specific community

- **Q&A Website**
  - Allows users to post questions that can be answered by other users

- **Stack Exchange**
  - https://unix.stackexchange.com/

- **Reddit**
  - https://www.reddit.com/r/linux/

- **Internet Forum**
  - A social knowledge sharing platform that typically uses threaded posts

- **Linux Questions**
  - https://www.linuxquestions.org/

Users and Groups

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **Superuser**
  - Each account in the Linux system uses a UID or user ID
    - Root
    - Standard
    - Service
  - **Root user accounts can do administrative tasks**
    - Password resets
    - System configuration changes
    - User account management
  - **Provides security for some applications and commands**
    - A Linux root user account is more powerful than the local admin account in Windows
    - Logging on the system using the root user is a bad security practice
      - rm –rf /*.*
  - **Standard**
    - User that runs applications, configures databases, and creates websites
    - To ensure system security, user accounts should not be shared
  - **Least Privilege**
    - The practice of giving users only as much access as needed to perform certain job functions
  - **Service**
    - Accounts that are specific to the service (HTTP for web service or mySQL for database service)
    - Service accounts run in the background and perform a single function

- **Superuser (Root)**
  - User with admin credentials
  - Always log into a system with a non-privileged user account
    - Managing users
    - Configuring devices
    - Configuring network settings
  - By giving the user only the access needed, the system will remain secure
- **Substitute/Switch User**
  - **Su**
    - **su**
      - Allows to switch the user credentials Windows running IIS ..\
    - **su -root**
      - Switches the credentials to root user
- **sudo**
  - Enables the server admin to delegate commands to users
  - List the user in the /etc/sudoers file using the visudo editor to delegate the user account
- **sudoedit**
  - Permits a user to edit a file with own credentials
    - % editors ALL = sudoedit /path/to/file
  - Do not edit /etc/sudoers with standard text editors like vi(m), nano, or gedit
- **visudo**
  - Verifies /etc/sudoers syntax before committing changes
    - **-c**
      - (Check file errors)
    - **-f**

- (Edit/check location)
- **-s**
  - (Check file in strict mode)
- **-x**
  - (Output in JSON)

- Wheel group members exercise root privileges with less potential for damaging the system

- **Polkit (PolicyKit)**
  - Controls system-wide privileges that allows non-privileged processes to communicate with privileged ones

- **PolKit Command**
  - **pkexec**
    - pkexec mkdir /Jason

  - **Sudo** is easier to use, more flexible, and has better security than **pkexec**

- **Create, Modify, and Delete Users**

  - useradd [options] [username]

    - Account is stored in /etc/passwd file
    - Configured according to options set in the /etc/login.defs file
    - Home directory is created in the /home/ <account name>
    - directory and populated using files from the /etc/skel directory

  - Useradd command does not set a password for the account

    - **-c**
      - (Comment field)

    - **-e**
      - (Expiration date)

- useradd –e 2021/12/31

- **-s**
  - (Default shell of the user)
    - useradd –s /bin/ksh

- **-D**
  - (View default configurations for new users)

- **passwd**
  - Used by the root user to set or reset a password

- **Username**
  - Contains the name the user use to log into the system

- **Password**
  - Contains assigned password to the user

- **User ID**
  - Unique number that represents the user to the system

- **Group ID**
  - Unique number of a user's primary group membership

- **Comment**
  - Represents full name of the user

- **Home Directory**
  - Path to the home directory of the user

- **Login Shell**
  - Shell that is launched when user logs in (/bin/bash or /bin/ksh)
    - useradd
    - usermod
    - userdel

- **/etc/shadow**
  - Modern storage location for hashed passwords and additional account information
  - Only root has the access to the content of /etc/shadow file

- **Fields of Information (/etc/shadow)**
  - Username
  - Password (Hashed format)
  - Days since password was changed
  - Days before password must be changed
  - Days until user is warned to change password
  - Days after password expires that account gets disabled
  - Days the account has been disabled
  - Unused field that is reserved for future use

    - /etc/passwd
    - /etc/shadow

- **Create, Modify, and Delete Groups**

  - Users can be members of more than one group
    - Administrator Group
    - Instructor Group
    - Accounting Group

  - **/etc/group**
    - Storage location for all groups

  - **Group Name**
    - User-friendly name of the group

  - **Password**
    - Password required to enter the group

  - **Group ID**

- Reference number on the system

- **Group List**
  - Refers to members of the group

- **groupadd**
  - Command to create a group

    - **Create Group**
      - groupadd -g

    - **Exit if group already exists**
      - groupadd -f

    - **Create group with non-unique group ID**
      - groupadd -o

    - **groupadd [options]{group names}**
      - groupadd –g instructors

- **groupmod**
  - Command to change the group's attributes
    - **Change group ID**
      - groupmod -g
    - **Rename group**
      - groupmod -n
        - groupmod [options]{group names}

- **groupdel**
  - Command to delete groups

  - Groupdel will not delete user accounts within a group, but only delete the group itself
    - groupdel [options]{groupname}

- **Query Users and Groups**
  - **whoami**
    - Used to display the username currently logged in to the system
    - To verify the current username, enter the whoami command
      - **Root User**
        - #
      - **Standard User**
        - $
  - **who**
    - Used to determine the details of the users currently logged in
      - Username
      - Name of the system
      - Date and time
    - **who [options]**
      - **-u**
        - (Idle time)
      - **.**
        - (Active user)
      - **old**
        - (Inactive over 24hrs)
      - **am i (who am i)**
        - (User information)
  - **w**
    - Used to display the details of users that are currently logged in to a system and their transactions
      - **First Line of Output**
        - Displays the status of the system

- **Second Line of Output**
  - Displays a table column list of the users logged in to the system

- **Last Column**
  - Indicates the current activities of the users
    - w [options] [username]

- **last**
  - Displays the history of user login and logout actions, and the actual time and date

- **First Terminal User Details**
  - last 1

  - The last command retrieves information from the /var/log/wtmp file
    - last [options]
- **id**
  - Used to display user ID (UID) and group ID (GID) information

  - Entering no options displays information about the user who is currently logged in
    - id [options] [username]

- **Account Profiles**

  - **.bashrc File**
    - **Enables customization of the user's own environment**
      - **Adapt to specific needs and preferences**
      - **Create environment variable**
      - **Set default directories and file permissions**
      - **Change default command prompt**
  - **bash_profile File**
    - **Provides the shell configuration for the initial login environment**
      - **bash_profile File**
        - **/etc/skel**
    - **When a new user account is created in /etc/skel/ directory, it is automatically copied into the new user's home directory**

- Files added to the /etc/skel/ directory after a user account is created will not be copied to existing users' home directories

- /etc/profile File
  - Provides system-wide environment variables that are used to apply certain settings to user accounts
    - ~/.bash_profile
    - ~/.bash_login
    - ~/.profile
- /etc/profile.d
  - Serves as a storage location for scripts that admins may use to set additional system-wide variables
  - Set the environment variables via scripts contained in /etc/profile.d
- /etc/bashrc
  - Provides system-wide configuration changes specific to Bash settings

Permissions and Ownership

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **File and Directory Permissions**
    - **Permission**
        - Access rights assigned to users that enable them to access or modify files and directories
    - **ls -l**
        - ls -l command gives a list of files and directories in the current working
            - **directory**
                - **Identify the item**
                    - Number of link
                - **Owner of the file or directory**
                    - Group with granted access
                - **Directory**
                    - **.**
                - **Parent Directory**
                    - **. .**
        - Lists the size file or directory
        - Date and time file was created/modified
            - Permissions define what users are allowed to do in a particular file or directory
    - **Files**
        - **read (r)**
            - (Access and view
        - **write (w)**
            - (Save changes)
        - **execute (x)**
            - (Run script/program/software

- **Directories**
  - **read (r)**
    - (List directory content
  - **write (w)**
    - (Create, rename, delete)
  - **execute (x)**
    - (Access directory, execute file, perform task)
  - **owner (u)**
    - (User)
  - **group (g)**
    - (File/directory's group)
  - **other (o)**
    - (All other users)
- **The output of the ls -l command shows the permission string**
- **ls –l Command Permission String**
  - **1st Character**
    - **d**
      - (directory)
    - **-**
      - (file)
  - **2nd 3rd 4th Characters**
    - Owner permissions
  - **5th 6th 7th Characters**
    - Group permissions
  - **8th 9th 10th Characters**
    - Other permissions

- **11th Character**
  - **.**
    - SELinux security context
  - **+**
    - Alternative access methods

- **chmod**
  - Enables the owner to modify the permissions of a file or directory
    - chmod [options] {mode} {file/directory name}
      - **-c**
        - (Report changes)
      - **-f**
        - (Hide error messages)
      - **-v**
        - (Diagnostic file entry)
      - **-R**
        - (Recursively modify permissions)

- **Symbolic Mode**
  - Enables to set permissions using three components
    - **Permission Contexts**
      - u/g/o/a
        - (user/group/other/applies permissions to all three contexts)
    - **Permission Operators**
      - +/-/=
    - **Permission Attributes**
      - **r/w/x**
        - (read/write/execute)
    - **Operator +**
      - Grants permission
    - **Operator -**

        - Denies permission
    - **Operator =**
        - Assigns permission

- chmod {access context} {operators} {permission attributes} {file/directory names}

- **Absolute Mode**
    - **Uses octal (base-8) numbers to specify permissions**
        - **4**
            - (Read)
        - **2**
            - (Write)
        - **1**
            - (Execute)

    - The complete permission is a three-digit number that corresponds to the owner, the group, and others
        - **chmod {number} {file/directory names}**

            - **752**
                - 7= User position
                    - (Read, Write, and Execute permissions)
                - 5= Group
                    - (Read and Execute permissions)
                - 2 = Others
                    - (Write permission)
            - **541**
                - 5= Read and Execute permission
                - 4= Read permission
                - 1= Execute permission
- **umask**
    - Used to set the default permissions for newly created files and folders

- **umask -S**
    - Current mask as symbolic value

- **umask -p**
  - Current mask in numeric format
    - umask [mask]

- **umask**
  - Change default permission for newly created files and folders

- **chmod**
  - Set permissions on files and folders that already exist

- **File and Directory Ownership**

  - **Ownership**
    - Refers to a property by which a user can apply and modify the permissions of a file or directory
    - Only the superuser (root user) can change the permissions of an object owned by others

  - **chown**
    - Used to change the owner and/or the group of a file or directory
      - chown {username} {file/directory name}
      - chown {username}:{group name} {file/directory name}
      - chown {username}: {file/directory name}
      - chown :{group name} {file/directory name}
      - chown {username}:{group name} {file/directory name}

    - Add the –**R option** to recursively change ownership throughout a directory structure

  - **chgrp**
    - Used to change the group ownership of a file or directory
      - chgrp {group name} {file/directory name}

- **Special Permissions and Attributes**
    - **Special Permission**
        - The less privileged users are allowed to execute a file by assuming the privileges of the file's owner or group
            - **Set user ID (SUID)**
                - User is allowed to have similar permissions as the owner of the file
            - **Set group ID (SGID)**
                - User is allowed to have similar permissions as the group owner of the files and directories
        - Users in a shared environment don't need to change their group
        - To give special permission, use the chmod command in either symbolic mode or absolute mode
    - **Determining SUID/SGID**
        - ls -la
            - **SUID (Symbolic Mode)**
                - chmod u+s {file names}
            - **SUID (Absolute Mode)**
                - chmod 4### {file names}
            - **SGID (Symbolic Mode)**
                - chmod g+s {directory names}
            - **SGID (Absolute Mode)**
                - chmod 2### {directory names}
        - To remove the SUID or SGID, use the **minus (-)** operator in symbolic mode, or set to 0 in absolute mode
    - **Sticky bit**

- Special permission bit that protects files in a directory

  - **Sticky bit (Symbolic Mode)**
    - chmod +t {directory names}
  - **Sticky bit (Absolute Mode)**
    - chmod 1### {directory names}

- Files can have one or more attributes set that define how the system interacts with files

- **Immutable Flag**
  - Attribute of a file or directory that prevents from being modified
  - Immutable flag is useful for files that are highly sensitive and important

- **List Attribute (lsattr)**
  - Used to list the attributes of a file or directory

    - lsattr [options] {file or directory names}

      - **-R**
        - (Recursively lists attributes of directories and content)
      - **-a**
        - (Lists all files)
      - **-d**
        - (Lists directories)
      - **-v**
        - (Version number of the file)

- **Change Attribute (chattr)**
  - Used to change the attributes of a file or directory

    - chattr [-R] [-v {version}] [+-{attributes}] {file or directory names}

- **-R**
  - (Recursively change attributes of directories and content)
- **-v**
  - (Version number of the file)
- **+I**
  - (Read only and immutable)
- **-I**
  - (Removes read-only)

- **Access control list (ACL)**

  - **Group** 1
    - r/w/x
  - **Group 2**
    - r/x

  - ACLs enable a more granular level of control than simply using file permissions

- **get file ACL (getfacl)**
  - Useful when retrieving the ACLs of files and directories

- **set file ACL (setfacl)**
  - Used to change the permissions associated with the ACL of a file or directory

    - setfacl [-bR] [-mx {acl_spec}] {file/directory names}

      - **-r**
        - (Recursively set ACL options)
      - **-s**
        - (Set ACL)
      - **-m**
        - (Modify existing ACL)

- **-x**
  - (Removes entries from existing ACL)
- **-b**
  - (Removes all entries except standard permissions)

- **ACL (Users)**
  - u:{user name}:{permissions}
- **ACL (Groups)**
  - g:{group name}: {permissions}

- **Troubleshooting Permissions Issues**
  - **Troubleshooting**
    - Begins with the identification of a problem and ends with service restored
    - Troubleshooting goal is to solve a problem efficiently with a minimal interruption of service
      - Identify the problem
      - Establish theory of probable cause
      - Test the theory to determine the cause
      - Establish action plan
      - Implement the solution
      - Verify full system functionality
      - Document findings, actions, and outcomes
  - Use ls -al command to verify the user and group ownership of a file or directory
    - **Group of a user**
      - **groups {user name}**
    - Use the **usermod command** to change group membership
      - lid
      - libuser-lid

- **getent**
  - Enables to retrieve group members of non-standard authentication methods

    - Follow overall Troubleshoot strategy
    - Verify permissions and ownership
    - Verify special permissions are set properly
    - Ensures proper owner and owning group set

Storage

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **Partitions**
  - **Hard disk drives**
  - **Solid-state devices**
  - **USB thumb drives**
  - **External storage drives**

  - **Block Devices**
    - Read/write in blocks of data (e.g., hard drives, solid-state devices)

  - **Character Devices**
    - Read/write in character streams of data (e.g., keyboards, mice, serial ports)

  - **File System**
    - A data structure is used by an operating system to store, retrieve, organize, and manage files and directories on storage devices

  - **File Allocation Table (FAT)**
    - An older file system compatible with different operating systems

  - **ext2**
    - Used to be the native Linux file system of some older releases

  - **ext3**
    - Much faster in recovering data and better ensures data integrity in abrupt system shutdowns

  - **ext4**
    - Supports volumes up to one exabyte and files up to 16 terabytes in size

  - **XFS**

- A 64-bit, high-performance journaling file system that provides fast recovery and can handle large files efficiently

    - Server Message Block (SMB)
    - Common Internet File System (CIFS)
    - Network File System (NFS)

    - Windows supports SMB by default and doesn't offer NFS support by default

- **Index Node (Inode)**
    - Stores metadata about a file or directory on a file system

        - Changes to be made
        - Background processes
        - Pending changes after reboot
        - Incomplete entries

    - File system labels are used for easy identification and may be up to 16 characters long

        - **e2label**
            - ext-based file systems

        - **xfs_admin**
            - XFS-based file systems

- **Partition**
    - A section of the storage drive that logically acts as a separate drive

        - **Partition Types**
            - **Primary**
                - Contains one file system or logical drive and is sometimes referred to as a volume

                    - Swap file system
                    - Boot partition

- **Extended**
  - Contains several file systems, which are referred to as logical drives

- **Logical**
  - Partitioned and allocated as an independent unit and functions as a separate drive

- **fdisk**
  - Used to create, modify, or delete partitions on a storage drive

- **-b {sector size}**
  - (Specify number of drive sectors)
- **-H {heads}**
  - (Specify number of drive heads)
- **-S {sectors}**
  - (Specify number of sectors per track)
- **-s {partition}**
  - (Print partition size in blocks)
- **-l**
  - (List partition tables for devices)
- **n**
  - (Create new partitions)
- **d**
  - (Remove partition)
- **p**
  - (List existing partitions)

- **w**
  - (Write drive changes and exit utility)
- **q**
  - (Cancel changes made and exit utility)

- **parted**
  - Used to create, destroy, and resize partitions and runs the GNU Parted utility
    - **select**
      - (Choose device or partition to modify)
    - **mkpart**
      - (Create partition with file system type specified)
    - **print**
      - (List partition table)
    - **resizepart**
      - (Resize or modify a partition's end position)
    - **rm**
      - (Delete a partition)
    - **quit**
      - (Quit GNU Parted utility)

- **partprobe**
  - Used to update the kernel with changes that now exist within the partition table

- **mkfs**
  - Used to build a Linux file system on a device, which is usually a drive partition
    - **man mkfs**

- **-v**
  - (Produce verbose output that keeps changing as the program processes)
- **-V**
  - (Produce verbose output, including all file system-specific commands executed)
- **-t {fs type}**
  - (Specify type of file system to build)
- **fs -options**
  - (Pass file system-specific options to the file system builder)
- **-c**
  - (Check the device for bad blocks before building the file system)
- **-l {filename}**
  - (Read the list of bad blocks from a specified file)

- mkfs [options] {device name}
- mkfs {file system type} [options] {device name}

- **fstab File**
  - Stores information about storage devices and partitions and where and how they should be mounted

- **Device/Partition Name**
  - Name of the device or file system to mount
- **Default Mount Point**
  - Where the file system is to be mounted
- **File System Type**
  - Type of file system used by the device or partition

- **Mount Options**
  - Set of comma-separated options that will be activated when the file system is mounted

- **Dump Options**
  - Indicates if the dump utility should back up the file system

- **fsck Options**
  - Order in which the fsck utility should check file systems

- **/etc/crypttab File**
  - Stores information about encrypted devices and partitions that must be unlocked and mounted on system boot

    - Partition storage device
    - Format partition with a file system
    - Add formatted partition to fstab file

- **/dev**
  - A special file that contains details about all the files and subdirectories housed within it

    - /dev/**sda1**
      - **sd**= type of controller
      - **a**=first whole drive
      - **1**=first partition

    - **/dev/disk/by-id**
      - Device's hardware serial number

    - **/dev/disk/by-path**
      - Shortest physical path to the device

    - **/dev/disk/by-uuid**
      - Universally unique identifier (UUID)

    - **/dev/null**

- A special type of virtual device that discards anything you send or redirect into it

- **/dev/zero**
  - A special type of virtual device that returns a null character anytime you read from it
  - dev/zero will send back the ASCII null character of 0x00
    - dd if=/dev/zero of=dev/sda1 bs=1GB count=1024

- **/dev/urandom**
  - A special type of virtual device that returns a randomized series of pseudorandom numbers
    - head -c5 /dev/urandom

- **Logical Volumes**

  - **Device Mapper**
    - Creates virtual device and passes data from that virtual device to one or more physical devices

  - **DM-Multipath**
    - Provides redundancy and improved performance for block storage devices
    - The configuration file for the multipath-tools package is found at /etc/multipath.conf

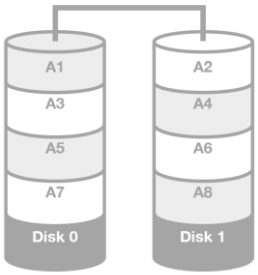
  - **mdadm**
    - A tool used to create and manage software-based RAID arrays

  - **RAID**
    - Redundant Array of Independent or Inexpensive Disks

  - **Striping**
    - Combines multiple smaller physical disks to logically act as a single larger disk

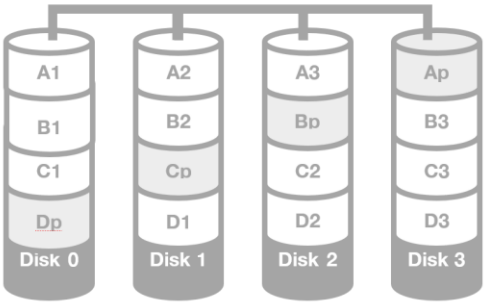
- **Mirroring**
  - Combines two physical hard drives into a single logical volume where an identical copy of everything is put on both drives

- **Parity**
  - Used in RAID drive arrays for fault tolerance by calculating the data in two drives and storing the results on a different drive



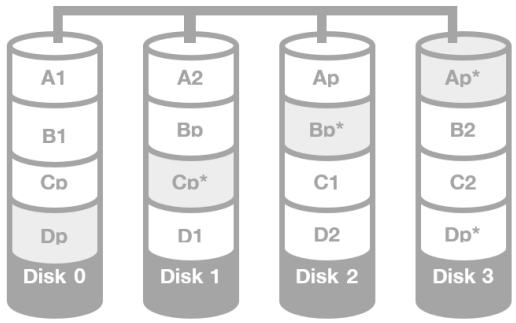
RAID 0
Striping

  - RAID 0 is great for speed but provides no data redundancy

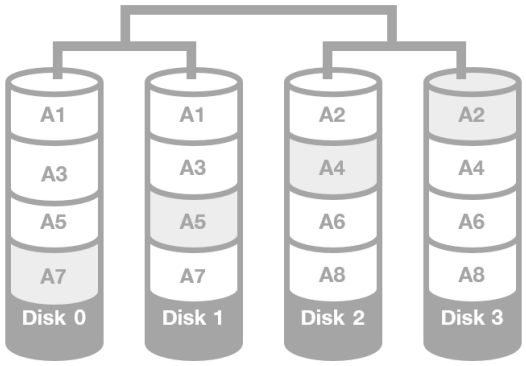


RAID 5
Striping with Parity

  - It is more efficient to create a RAID 5, in terms of space, than a RAID 1 using a mirrored array



RAID 6
Striping with Dual Parity



RAID 10
Mirroring + Striping

- **/proc/mdstat File**
  - Contains a snapshot of the kernel's RAID/md state
    - **cat /proc/mdstat**

```
Personalities : [raid6] [raid5] [raid4]
md0 : active raid5 sda1[0] sdd1[2] sdb1[1]
1465151808 blocks level 5, 64k chunk,
algorithm 2 [4/3] [UUU_]
unused devices : <none>
```

- **Logical Volume Manager (LVM)**
  - Maps whole physical devices and partitions into one or more virtual containers called volume groups

- Dynamically create, delete, and resize volumes
- Map logical volumes across physical devices
- Create virtual snapshots of each logical volume

/dev/mapper/<volume group name >-<logical volume name>

- **Physical volume tools**
  - **pvscan**
    - Scans for all physical devices being used as physical volumes
  - **pvcreate**
    - Initializes a drive or partition to use as a physical volume
  - **pvdisplay**
    - Lists attributes of physical volumes
  - **pvchange**
    - Changes attributes of a physical volume
  - **pvs**
    - Displays information about physical volumes
  - **pvck**
    - Checks the metadata of physical volumes
  - **pvremove**
    - Removes physical volumes
- **Volume Group Tools**
  - **vgscan**
    - Scans all physical devices for volume groups
  - **vgcreate**
    - Creates volume groups
  - **vgdisplay**

        - Lists attribute of volume groups

    - **vgchange**
        - Changes attributes of volume groups

    - **vgs**
        - Displays information about volume groups

    - **vgck**
        - Checks the metadata of volume groups

    - **vgrename**
        - Renames a volume group

    - **vgreduce**
        - Removes physical volumes from a group to reduce its size

    - **vgextend**
        - Adds physical volumes to volume groups

    - **vgmerge**
        - Merges two volume groups

    - **vgsplit**
        - Splits a volume group into two

    - **vgremove**
        - Removes volume groups

- **Logical Volume Tools**
    - **lvscan**
        - Scans all physical devices for logical volumes

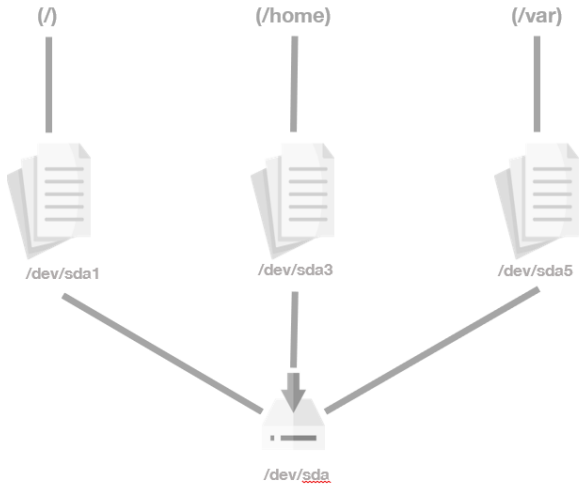
    - **lvcreate**
        - Creates logical volumes in a volume group

    - **lvdisplay**

- Lists attributes of logical volumes

- **lvchange**
  - Changes attributes of the volumes
- **lvs**
  - Displays information about logical volumes
- **lvrename**
  - Renames logical volumes
- **lvreduce**
  - Reduces the size of logical volumes
- **lvextend**
  - Extends the size of logical volumes
- **lvresize**
  - Resizes logical volumes
- **lvremove**
  - Removes logical volumes

- **Mounting File Systems**



- **Mount Point**
  - An access point that is typically an empty directory where a file system is loaded or mounted to make it accessible to users

- **mount**
  - Loads a file system to a specified directory to make it accessible to users and applications
    - mount [options] {device name} {mount point}

- **Mount Options**
  - **auto**
    - Device must be mounted automatically
  - **noauto**
    - Device should not be mounted automatically
  - **nouser**
    - Only the root user can mount a device or a file system
  - **user**
    - All users can mount a device or a file system
  - **exec**
    - Allow binaries in a file system to be executed
  - **noexec**
    - Prevent binaries in a file system from being executed
  - **ro**
    - Mount file system as read only
  - **rw**
    - Mount file system with read/write permissions
  - **sync**
    - Input and output operations should be done synchronously

- **async**
  - Input and output operations should be done asynchronously

- **Binary**
  - A source code that is compiled into an executable program

- **umount**
  - Disassociates a mounted file system from the directory
    - umount [options] {mount point}

- **Umount Options**
  - **-f**
    - Force unmount a file system
  - **-l**
    - Perform a “lazy” unmount
  - **-R**
    - Recursively unmount specified directory mount points
  - **-t {fs type}**
    - Unmount only the file system types specified
  - **-O**
    - Unmount only the file systems with specified options in the /etc/fstab file
  - **-fake**
    - Test the unmounting procedure

- **File System Table (fstab)**
  - A list of file systems to be mounted, their mount points, and any options that might be needed for specific file systems
    - systemd.mount can be used to create a new mount unit to mount the file system

- **Filesystem in USErspace (FUSE)**
  - Lets non-privileged users create own file systems without editing the underlying kernel code

- **Managing File Systems**

  - **/etc/mtab File**
    - Reports the status of currently mounted file systems
    - /proc/mounts is more accurate and includes more up-to-date information on file systems

  - **/proc/partitions File**
    - Contains information about each partition attached to the system
      - major
      - minor
      - #blocks
      - name
  - **lsblk**
    - Displays information about block storage devices currently available on the system
      - lsblk [options] [device name]

  - **lsblk Options**
    - **-a**
      - List empty devices
    - **-r**
      - List devices excluding provided output devices
    - **-f**
      - Display additional information
    - **-l**
      - Display results in list format
    - **-m**

- Display device permission information

- **blkid**
  - Prints each block device in a flat format and includes some additional information
    - blkid [options] [device name]
  - Some tools are designed to only work with specific file system types
    - e2fsck
    - resize2fs
    - tune2fs
    - dumpe2fs
- **fsck**
  - Used to check the correctness and validity of a file system
    - fsck [options] {device/file system name}
    - fsck -r {device/file system name}
- **resize2fs**
  - Used to resize ext2, ext3, or ext4 file systems
    - resize2fs [options] {device/file system name} [desired size]
- **tune2fs**
  - Used to adjust various tunable parameters of the ext2/ext3 file systems
  - tune2fs can also add a journal to an existing ext2 or ext3 file system
    - tune2fs [options] {device/file system name}
- **tune2fs Options**
  - **-j**
    - Used as an ext3 journal to the existing file system
  - **-i {d|m|w}**
    - Specify the maximum time interval

- **-c {maximum mounts count}**
  - Specify the maximum number of mounts
- **-C {mount count}**
  - Specify the number of possible mounts
- **-r {reserved blocks count}**
  - Specify the number of reserved file system blocks
- **-e {continue|remountro|panic}**
  - Specify the behavior of the kernel code
- **-l**
  - List the contents within the superblock
- **-U**
  - Set the specified UUID

- **Superblock**
  - Contains metadata about the file system, including its size, type, and status

- **dumpe2fs**
  - Prints the superblock and block group information for the selected device
    - dumpe2fs [options] {device/file system name}

- **dumpe2fs Options**
  - **-x**
    - Print a detailed report about block numbers
  - **-b**
    - Print the bad blocks
  - **-f**
    - Force display the file system status
  - **-i**

        - Display file system data from an image file created using the e2image command
    - **xfs_info**
        - Display details about the XFS file system
    - **xfs_admin**
        - Change the parameters of an XFS file system
    - **xfs_metadump**
        - Copy the superblock metadata of the XFS file system to a file
    - **xfs_growfs**
        - Expand the XFS file system to fill the drive size
    - **xfs_copy**
        - Copy the contents of the XFS file system to another location
    - **xfs_repair**
        - Repair and recover a corrupt XFS file system
    - **xfs_db**
        - Debug the XFS file system
- **lsscsi**
    - Used to list information about SCSI devices connected to a Linux system
- **fcstat**
    - Interacts with and displays statistics of Fibre Channel connected devices

- **Linux Directory Structure**

    - **Directories**
        - Containers for other files
    - **Special Files**
        - System files stored in the /dev directory
    - **Links**
        - Make a file accessible in multiple parts of the system's file tree
    - **Domain Sockets**
        - Provide inter-process networking that is protected by the file system's access control
    - **Named Pipes**
        - Enable processes to communicate with each other without using network sockets
    - **Filesystem Hierarchy Standard (FHS)**

- Specifies a set of guidelines for the names of files and directories and their locations on Linux systems
- **/bin**
  - Stores essential command-line utilities and binaries
- **/boot**
  - Stores the files necessary to boot the Linux operating system
- **/dev**
  - Stores hardware and software device drivers
- **/etc**
  - Stores basic configuration files
- **/home**
  - Stores users' home directories, including personal files
- **/lib**
  - Stores shared program libraries required by the kernel, command-line utilities, and binaries
- **/media**
  - Stores mount points for removable media such as CD-ROMs and floppy disks
- **/mnt**
  - Refers to the mount point for temporary mounting file systems
- **/opt**
  - Stores optional files for large software packages
- **/proc**
  - Represents continually updated kernel information to the user in a typical file format
- **/root**
  - Refers to the home directory of the root user
- **/sbin**
  - Stores binaries used for completing the booting process which are also used by the root user
- **/sys**
  - Stores information about devices
- **/tmp**
  - Stores temporary files that may be lost on system shutdown
- **/usr**
  - A read-only directory that stores small programs and files accessible to all users

    - **/var**
        - Stores variable files, or files that are expected to constantly change as the system runs

- **Current Working Directory (CWD)**
    - The location on the system being accessed at any point in time
    - CWD is represented as a single period (.)

- **Parent Directory**
    - One level above the current working directory
    - Use the double period notation (..) to switch to the parent directory

- **Path**
    - Specifies a location in the file system

        - **Absolute Path**
            - The path to the specific location irrespective of the CWD or combined paths
        - **Relative Path**
            - The path relative to the current working directory

    - **File Navigation Commands**
        - **Cd**
            - Traverse the directory structure using absolute or relative paths to change the current working directory
        - **Ls**
            - List the files and directories in the current working directory or the relative/absolute path specified
        - **Pwd**
            - Print the current working directory to the console

Files and Directories

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **Create and Edit Text Files**
    - **Text Editor**
        - Application that enables users to view, create, or modify the contents of text files
        - Some text editors do not support formatting options that word processors do

            - **vi**
                - Visual text editor originally created for Unix and was later cloned into FOSS versions

            - **Vim**
                - Default text editor in most Linux distributions

            - **Emacs**
                - Flexible, powerful, and popular text editor used in Unix and Linux

            - **gVim**
                - Graphical version of the Vim editor

            - **gedit**
                - Simple and powerful GUI-based text editor used in the GNOME desktop environment

            - **GNU nano**
                - Small and user-friendly text editor

- Vim, a contraction of Vi and improved, and an extended version of the vi editor
    - Text completion
    - Syntax highlighting
    - Spell checking
- Vim supports multiple files being opened simultaneously

- **Vertical Split Screen**
    - ctrl+w+v
- **Horizontal Split Screen**
    - ctrl+w+s
- **Insert Mode**
    - Enables users to insert text by typing into the system
- **Execute Mode**
    - Enables users to execute commands within the editor
- **Command Mode**
    - Enables users to perform different editing actions using single keystrokes
- **Visual Mode**
    - Enables users to highlight or select text for copying and deleting

- **i**
    - Insert text to the left of the cursor
- **A**
    - Insert mode and add text at the end of a line
- **I**
    - Insert mode and insert text at the beginning of a line
- **o**

        - Insert mode and insert text on a new line below the cursor

    - **O**
        - Insert mode and insert text on a new line above the cursor

    - **v**
        - Visual mode to enable selection, one character at a time

    - **V**
        - Visual mode to enable selection, one line at a time

    - **:**
        - Execute mode to enable users to enter commands

    - **Esc**
        - Return to command mode

- When you enter the colon (:) operator, a small command prompt section appears at the bottom-left of the editor

    - **:w {file name}**
        - Save file with a file name if it's saved for the first time

    - **:q**
        - Quit when no changes are made after the last save

    - **:q!**
        - Quit while ignoring the changes made

    - **:qa**
        - Quit multiple files/ quit all

    - **:wq**
        - Write the file first and quit

    - **:e!**
        - Revert to last saved format without closing the file

- **:! {any Linux command}**
  - Execute the command and display the result in the Vim interface
- **:help**
  - Open Vim's built-in help documentation

- **Motions** are single-key shortcuts that are used to navigate through files in command mode
  - **h**
    - Move left one character
  - **j**
    - Move down one line
  - **k**
    - Move up one line
  - **l**
    - Move right one character
  - **^**
    - Move to the beginning of the current line
  - **$**
    - Move to the end of the current line
  - **w**
    - Move to the next word
  - **b**
    - Move to the previous word
  - **e**
    - Move to the end of the current word

- **Shift+L**
  - Move the cursor to the bottom of the screen
- **Shift+H**
  - Move the cursor to the first line of the screen
- **(Line no.) Shift+G**
  - Move cursor to specified line no.
- **gg**
  - Move the cursor to the first line of the file
- **Shift+G**
  - Move the cursor to the last line of the file
- **x**
  - Delete the character selected by the cursor
- **d**
  - Delete text
- **dd**
  - Delete the current line
- **p**
  - Paste text on the line below the cursor
- **P**
  - Paste text on the line above the cursor
- **/ {text string}**
  - Search through the document for specific text
- **? {text string}**
  - Search backward through document for specific text
- **y**

- Copy text

- **yy**
  - Copy the line directory above the cursor

- **c{range of lines}c**
  - Begins a change in the specific range

- **u**
  - Undo the latest change

- **U**
  - Undo all changes in the current line

- **ZZ**
  - Write a file only if changes are made, then quit editor

- **Count**
  - Number that multiplies the effect of keystrokes in Vim

- **Motion**
  - Multiplied according to count specified

- **Editing operator**
  - Repeated the number of times specified

    - Visually helpful
    - Does not have different modes
    - Support multiple open files

- In GNU nano, the functions used to work with text files and the editor are shortcuts

  - **Ctrl+G**
    - Open nano to the help screen

  - **Ctrl+X**

- Exit nano or close the current “buffer”

- **Ctrl+O**
  - Save currently open file
- **Ctrl+J**
  - Justify the current paragraph
- **Ctrl+R**
  - Insert another file into the current file
- **Ctrl+W**
  - Search the file
- **Ctrl+K**
  - Cut the currently selected line
- **Ctrl+U**
  - Paste the line that was cut
- **Ctrl+C**
  - Display the cursor’s position
- **Ctrl+V**
  - Navigate to the next page
- **Ctrl+Y**
  - Navigate to the previous page

- “Mark” to copy the part of text on a line using the Ctrl+^ shortcut

  - **Alt+^**
    - Copy the marked/highlighted text
  - **Ctrl+U**
    - Paste text to another location

- **Gedit** has a GUI with a menu-based design that makes it easy to work with
  - Syntax highlighting
  - Spell checking
  - Customized plugins

- **Search for Files**

  - **locate**
    - Performs a quick search for any specified file names and paths stored in the mlocate database

    - This database must be updated regularly for the search to be effective
      - locate [options] {string}

        - **-r**
          - Search file names using regular expressions

        - **-c**
          - Display the number of matching entries found

        - **-e**
          - Return only files that exist at the time of search

        - **-I**
          - Ignore the casing in file names or paths

        - **--n{number of entries}**
          - Return the first few matches up to the specified number

  - **updatedb**
    - Used to build a database of files based on the /etc/updatedb.conf file
    - Updatedb used to update the /var/lib/mlocate/mlocate .db database file

      - /etc/updatedb.conf

  - **PRUNEPATH**

- Used to specify a path that need not be included while building the database
    - PRUNEPATH="/etc“

- **find**
    - Enables users to search specific location for files and directories that adhere some search criteria
        - **Type of object**
            - -type
        - **d**
            - Directory
        - **f**
            - File
        - **Name of the object**
            - -name
    - Locate command searches the database and retrieves information on files present on the system
    - Find command performs a live search of the file system and in a specific location
        - **-print**
            - Displays the location of the files found
        - **-exec**
            - Executes the command that follows
        - **-ok**
            - Executes the command that follows interactively
        - **-delete**

        - Deletes the files found

    - **-fprint**
        - Stores the results in the target file

- **which**
    - Displays the complete path of a specified command by searching the directories assigned to the PATH variable

        - which [options] {program names}

- **whereis**
    - Used to display various details associated with a command

        - whereis [options] [directory name] {file name}

        - **-b**
            - Search only for binaries

        - **-m**
            - Search only for manual sections

        - **-s**
            - Search only for sources

        - **-u**
            - Search for unusual entries

- **Operations on Files and Directories**

    - **cat/concatenates**
        - Can display, combine, and create text files
        - Cat command does not have a screen scrolling capability

            - **-n**
                - Precede the output with its respective line number

            - **-b**
                - Number the lines, excluding the blank lines

- **-s**
  - Suppress output of repeated empty lines
- **-v**
  - Display non-printing characters as visible characters
- **-e**
  - Print a $ character at the end of each line, prior to the new line
- **-t**
  - Print tabs as ^I and form feed as ^L

- **head**
  - Displays the first 10 lines of each file
- **tail**
  - Displays the last 10 lines of each file
    - **-f**
      - Dynamically watches a file
    - **-n {number}**
      - Shows specified number of lines
- **less/more**
  - Enable users to display the contents of a file and a page through the contents if extended beyond the screen
    - **-e**
      - Exit the program the second time it reaches the end of the file
    - **-E**
      - Exit the program the first time it reaches the end of the file

- **-I**
  - Ignore the case in searches
- **-n**
  - Suppress line numbers
- **/**
  - Search a file for a particular text string
- **n or N**
  - Move to the next or previous instance of the searched string
- **q**
  - Quit the program

- **copy/cp**
  - Enables users to copy and then paste a file or directory
    - **-R option**
      - Copy specified directory recursively
- **move/mv**
  - Moves files and directories to other locations
  - mv is more like a cut and paste operation
- **touch**
  - Tests the permissions or creates files that will be processed by some applications
- **remove/rm**
  - Removes files and directories
    - **-R**
      - Recursively remove files, subdirectories, and the parent directory

- **rm -R ~/myfiles**
  - Remove files and directories

- **unlink**
  - Used to remove files but not directories

    - **-l**
      - Display permission list, number of hard links, owner, group, size, date, and file name

    - **-F**
      - Display the nature of a file

    - **-a**
      - Display all files present in the directory

    - **-R**
      - Recursively display all subdirectories

    - **-d**
      - Display information about symbolic links or directories

    - **-L**
      - Display all files in a directory, including symbolic links

- **Normal Text Default Colors**
  - Blue (Directory)
  - Skyblue (Symbolic link and audio file)
  - Green (Executable file)
  - Yellow with Black (Device)
  - Pink (Image file)
  - Red (Archive file)
  - Red with Black (Distinguishes broken link)

- **make directory/mkdir**
  - Used to create (or make) a directory

- **remove directory/rmdir**
  - Removes empty directories

    - **rm -R**
      - Delete directory with contents

- **Process Text Files**

  - **echo**
    - Built-in Linux feature that prints out arguments as the standard output

  - **printf**
    - Provides the user with more control over how the output is formatted

  - ****
    - Indicate when character are being used

  - **tr**
    - Perform operations like removing repeated characters, converting uppercase to lowercase, and basic character replacement and removal

  - **wc**
    - Allows users to count the number of lines, words, characters, and bytes in file and print the result

      - **-c**
        - Display byte count

      - **-m**
        - Display character count

      - **-l**
        - Display the newline count

      - **-w**
        - Display the word count

- **sort**
  - Command line utility for sorting lines of text files
    - **-k {column numbers}**
      - Specify filed values
    - **–k2**
      - Indicates second field
    - **-n**
      - Compares and sorts lines based on the string numerical value
    - **-r**
      - Sort fields in descending order
    - **-t**
      - Separate one field from another
- **cut**
  - Extracts the specified lines of text from a file
    - **-c**
      - Specify the number of the character to cut from each line
    - **-d {delimiter}**
      - Separate one field from another
    - **-f {field numbers}**
      - Specify the field numbers to cut on as separated by the delimiter
    - **-f2**
      - Field between the first and second instances of the delimiter

- **-s**
  - Suppress a line if the delimiter is not found

- **paste**
  - Used to merge lines from text files horizontally
  - Paste command uses a tab space delimiter to separate each column

- **-d**
  - Specify different delimiter

- **diff**
  - Used to compare text files

- **<**
  - Line should be removed from the first file

- **>**
  - Line should be added from the second file

- **Diff command**
  - Denotes the line numbers for each file that would be affected by deletion, addition, and change operations

    - **-b**
      - Ignore spacing differences

    - **-i**
      - Ignore case differences

    - **-t**
      - Expand tab characters in output lines

    - **-w**
      - Ignore spacing differences and tabs

    - **-c**
      - Display a list of differences with three lines of context

- **-u**
  - Output results in unified mode

- **grep**
  - Used to search the contents of a file for a particular string of text
    - **-E {pattern}**
      - Match a pattern as an extended regular expression
    - **-F {pattern}**
      - Match a pattern as a list of fixed strings
    - **–f {file name}**
      - Match patterns contained in a specified file
    - **-i**
      - Ignore casing
    - **-v**
      - Output only lines that don't match the provided pattern
    - **-c**
      - Print only the number of matching lines
    - **-l**
      - Print only the files that have matching lines
    - **-o**
      - Print only the matching part of a line
  - Use grep to search a directory to locate a certain file

- **awk**
  - Performs pattern matching on files
  - Awk keyword is followed by the pattern, the action to be performed, and the file name

- Extracting text matching a certain pattern
- Deleting text matching a certain pattern
- Adding text matching a certain pattern

▪ Awk scripts user can provide patterns with blocks of code

○ **/regular_expression/**
▪ Retrieves all the records beginning with “a”, “b”, or “c”

○ **relational_expression**
▪ Retrieves all the records containing the value “abc” in the first field

○ **pattern_1 && pattern_2**
▪ Retrieves all the records that contain the value “abc” in the first field and the second field contains the value “01”

○ **pattern_1 || pattern_2**
▪ Retrieves records that satisfy the condition that the first field contains or the second field contains or both

○ **pattern_1 ? pattern_2 : pattern_3**
▪ Evaluate and match pattern 1 to pattern 2 and pattern 3, then the record will print on the screen

○ **pattern_1, pattern_2**
▪ Prints a range of records from the record in the first field and goes in the second field

○ **sed/stream editor**
▪ Program that users can use to modify text files according to various parameters

- **d**
  - (Delete the lines that match a specific pattern/line number)

- **-n,p**
  - (Print only the lines that contain the pattern)

- **s**
  - (Substitute the first occurrence of the string in the file)
- **s,g**
  - (Globally substitute the original string with the replacement string for each occurrence)

- **link/ln**
  - Used to create a link to a file
  - Any changes to the link will reflect in the target file
    - **-backup**
      - Back up existing destination files
    - **-f**
      - Remove existing destination files
    - **-s**
      - Make symbolic links
    - **-i**
      - Prompt to remove destination files
    - **-v**
      - Print the name of a file before linking
- **Hard Link**
  - Reference to another file
  - If the original file or directory is deleted after a hard link is created, the contents are still available
- **Symbolic Link**
  - Reference to a file/directory that can span multiple file systems
  - If the original file or directory is deleted after a symbolic link is created, the contents are lost

- **Target**
  - where / backup/backup-report
- **Link**
  - ~/backup-report

- **Manipulate File Output**
  - **Text Stream**
    - Sequence of lines of text that can be leveraged to read or write to a particular device or system component
  - **Standard Input/stdin**
    - Acts as the source for command input
  - **Standard Output/stdout**
    - Acts as the destination for command output
  - **Standard Error/stderr**
    - Used as the destination for error messages

      - **>**
        - Redirect the standard output to a file
      - **>>**
        - Append standard output to the end of the destination file
      - **2>**
        - Redirect the standard error message to a file
      - **2>>**
        - Append standard error message to the end of the destination file
      - **&>**

- Used to redirect standard output and the standard error message to a file

- **<**
  - Used to read the input from a file rather than from the keyboard or mouse

- **<<**
  - Used to provide input data from the current source and top when a line containing the provided string occurs

- **Here Document**
  - Refers to a special block of code

- **pipe**
  - Lets users use commands such that the output of one command serves as input to the next
  - **Pipe '|'**
  - Pipes help users to mash-up two or more commands at the same time and run them consecutively

- **xargs**
  - Reads streams of data from standard input, then generates and executes command lines
  - The find command searches all files in /foo that have a .pdf extension, then pipes the result to the xargs command

    - **-I {replacement string}**
      - Consider each line as a single argument

    - **-L {number of lines}**
      - Read specified number of lines and cat in one long string

    - **-p**
      - Prompt the user before each command

    - **-n {number of arguments}**

- Read the maximum number of arguments and insert at the end of the command template

- **-E {end of string}**
  - Represent the end of the standard input

- **-t**
  - Write command to standard error output before executing the command

- **-s {max size}**
  - Set maximum allowable size of an argument list

- **tee**
  - Reads the standard input, sends the output to the default output device, and copies the output to each specified file

    - **-a**
      - Append output

  - Whatever is written in /dev/null will be discarded and forgotten

Kernel Modules

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **The Linux Kernel**
  - **Kernel**
    - The core of an operating system
      - File system access
      - Memory
      - Processes
      - Devices
      - Resource allocation of a system
  - **Kernel Space**
    - Where the kernel executes services
  - **User Space**
    - Area of memory outside the kernel space
  - **Monolithic Kernel**
    - All system modules, such as device drivers or file systems, run in kernel space
  - **Microkernel Architecture**
    - Kernel runs the minimum amount of resources necessary to implement a fully functional operating system
  - **Device Driver**
    - Enables operating systems to identify the characteristics and functions of a hardware device
  - **Linux Kernel**
    - Free and open-source monolithic kernel that manages all other resources on an operating system

- Virtual memory management
- Support for TCP/IP networking
- Shared libraries
- Modularity

- **uname**
  - Prints the name of the kernel

    - **uname -r**
      - View kernel version number of the current system

    - **uname -i**
      - View the hardware platform

    - **uname -a**
      - Print all information

- **System Call Interface (SCI)**
  - Handles system calls sent from user applications to the kernel

- **Process Management**
  - Handles different processes by allocating separate execution space on the processor

- **Memory Management**
  - Manages the computer's memory

- **File System Management**
  - Manages the filesystem

- **Virtual File System (VFS)**
  - Provides an abstract view of the underlying data that is organized under complex structures

- **Device Management**

- Manages devices by controlling device access and interfacing between user applications and hardware devices on the computer

- **Installing and Configuring Kernel Modules**
  - **/usr/lib/modules/**
    - Contains the modules of different kernel versions
  - **arch**
    - Contains modules for the architecture-specific support
  - **crypto**
    - Contains modules for encryption and other cryptographic functions
  - **drivers**
    - Contains modules for various types of hardware
  - **fs**
    - Contains modules for various types of file systems
  - **net**
    - Contains modules for networking components
  - **lsmod**
    - Used to display the currently loaded kernel modules
  - **modinfo**
    - Used to display information about a particular kernel module
  - **insmod**
    - Used to install a module into the currently running kernel
  - **rmmod**
    - Used to remove a module from the currently running kernel
  - **modprobe**

- Used to add or remove modules from a kernel
    - **-a**
        - Add a module
    - **-r**
        - Unload a module
    - **-f**
        - Force a module to be inserted or removed
    - **-n**
        - Conduct a dry run
    - **-s**
        - Print errors to the system log
    - **-v**
        - Enable verbose mode

- **depmod**
    - Used to update database of dependencies
    - Depmod command searches the contents of **/lib/modules/** for each module
    - **Modprobe command can add or remove modules**
        - **Alias Command**
            - alias {alternative name} {module name}
        - **Blacklist Command**
            - blacklist {module name}
        - **Install Command**
            - install {module name} {command}
- **/proc/sys/**

- Lists the parameters to configure on a system
- Powerful Linux command which acts as an interface to dynamically change the kernel parameters
- The parameters available for modification can be found under /proc/sys directory

- **-a**
  - Display all parameters and current values
- **-w {parameter}={value}**
  - Set a parameter value
- **-p[file name]**
  - Load sysctl settings from the specified file
- **-e**
  - Ignore errors
- **-r {pattern}**
  - Apply command to parameters matching a given pattern

- **/etc/sysctl.conf**
  - Enables configuration changes to a running Linux kernel

- **Monitoring Kernel Modules**

  - **/proc/**
    - Virtual file system (VFS) that provides information about the kernel's running process
  - **/proc/cmdline**
    - Contains options passed to the kernel by the boot loader
  - **/proc/cpuinfo**
    - Contains CPU information

- **/proc/devices**
  - Contains a list of character and block device drivers loaded into the currently running kernel
- **/proc/filesystems**
  - Contains a list of file systems types that are supported by the kernel
- **/proc/meminfo**
  - Contains information about RAM usage
- **/proc/modules**
  - Contains information about modules currently installed on the system
- **/proc/stat**
  - Contains various statistics about the system's last reboot
- **/proc/version**
  - Specifies several points of information about the Linux kernel
- **GNU Compiler Collection (GCC)**
  - Used to compile the kernel, the user name, and the time the kernel was compiled
- **dmesg**
  - Used to print messages that have been sent to the kernel's message during and after system boot
  - **Drivers can also send diagnostic messages to the kernel in case they encounter errors**
    - **-c**
      - Clear the kernel buffer after printing
    - **–f {facility list}**
      - Restrict output to the specified comma-separated list of facilities

- **-l {level list}**
  - Restrict output to the specified comma-separated list of levels
- **-e**
  - Display a human-readable version of the time messages
- **-L**
  - Color-code messages for easier readability
- **-H**
  - Output in a human-friendly format
- **-h**
  - List the available options

The Linux Boot Process

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **Linux Boot Components**
  - **Booting**
    - Process of starting or restarting a computer and loading an operating system
  - **Boot Loader**
    - Small program stored in ROM that loads the kernel from a storage device
    - Boot loaders protect the boot process with a password
  - **Boot Sector Program**
    - Loads the second boot loader on startup
  - **Second Stage Boot Loader**
    - Loads the operating system and contains a kernel loader
  - **Boot Loader Installer**
    - Controls the installation of drive sectors and runs only when booting
  - **BIOS**
    - Enables to test the various hardware components in a computer as well as run a boot loader
  - **UEFI**
    - Operates with a greater amount of memory, accesses storage drives and hardware types, and has improved security protections
  - **Preboot eXecution Environment (PXE)**
    - Enables a client to retrieve the necessary boot loader and system files from a server over the network

- Basic input/output system (BIOS)
- Unified Extensible Firmware Interface (UEFI)
- Booting from ISO
- Booting from Network File System (NFS)

- **Master Boot Record (MBR)**
  - Sector that the BIOS reads in and starts when the machine is first booted

- **GUID Partition Table (GPT)**
  - Partition structure with a more modern design and is part of the UEFI standard

- **Raw Partition**
  - Enables users and applications to read from and write to a block storage without using the system cache

- **Initial RAM Disk (initrd)**
  - Root file system that is temporarily loaded into memory upon system boot

- **initrd image**
  - Archive file that contains all the essential files that are required for booting the operating system

    - Initrd image is stored in the **/boot directory**

- **mkinitrd**
  - Used to create the initrd image for preloading the kernel modules

    - **--preload={module name}**
      - Load a module in the initrd image before the loading of other modules

    - **--with={module name}**
      - Load a module in the initrd image after the loading of other modules

- **-f**
  - Overwrite an existing initrd image file

- **–nocompress**
  - Disable the compression of the initrd image

- **/boot**
  - Contains files that are used to facilitate the Linux boot process

    - **GRUB**
      - /boot/grub

    - **GRUB 2**
      - /boot/grub2

    - **ESP**
      - /boot/efi

    - **initramfs image**
      - /boot/initramfs-<kernel version>.img

    - **Linux kernel**
      - /boot/vmlinuz-<kernel version>

- **dracut**
  - Used to generate an initramfs image

  - The processor checks the BIOS/UEFI firmware
  - The BIOS/UEFI checks for bootable media
  - The BIOS/UEFI loads the primary boot loader
  - GRUB 2 selects the operating system
  - The boot loader determines the kernel and locates the kernel binary
  - The kernel configures the available hardware drivers
  - The kernel mounts the main root partition and releases unused memory
  - The systemd program searches for the default.target file
  - The system authenticates the user
  - The system is ready to use

- **GRUB 2**
    - **GNU Grand Unified Bootloader (GNU GRUB)**
        - Enables users to choose which operating system or kernel version to boot
        - GRUB 2 offers more control over the boot process, boot devices, and boot behavior
            - Non-86 architecture platforms
            - Boot OS from storage media
            - Partition UUIDs and loading modules
            - Configure boot loader through scripts
            - Customization features
        - GRUB 2 became the default boot loader on almost all modern Linux distributions
        - grub2-install applies to BIOS systems
            - **--modules {module names}**
                - Reload specified kernel modules
            - **--install-modules {module names}**
                - Install only the specified modules and dependencies
            - **--directory {directory name}**
                - Install files from the specified directory
            - **--target {target platform}**
                - Specify the target platform
            - **--boot-directory {directory name}**
                - Specify the boot directory
            - **–force**
                - Install GRUB 2

- **GRUB 2**
  - grub.cfg
- **BIOS**
  - /boot/grub2/
- **UEFI**
  - /boot/efi/EFI//

- **/etc/grub.d/**
  - Contains scripts that are used to build the main grub.cfg file
  - To add a custom script in the directory, place the **##_ file name prefix**
  - Add the script to the existing 40_custom file to execute last by default

- **/etc/grub.d/40_custom**
  - Enables customization of the menu presented to the user during the boot process

- **/etc/default/grub**
  - Contains GRUB 2 display menu settings that are read by the **/etc/grub.d/** scripts

- **grub2-mkconfig**
  - Generates a new grub.cfg configuration file and is used to update the existing grub.cfg file
  - To update grub2 configuration file, use update-grub2 command

System Components

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **Localization Options**
  - **Localization**
    - Adapting system components for use within a distinct culture
  - **Cron daemon**
    - Uses the system's time zone for executing cron jobs
  - **/usr/share/zoneinfo**
    - A container for all the regional time zones the system can use
    - Create a symbolic link to one of the individual time zone files to the /etc/localtime file
  - **/etc/timezone**
    - Lists the time zone by the region structure seen in the /usr/share/zoneinfo directory
  - **date**
    - Prints the date in a specified format based on the /etc/localtime file
      - **date Options**
        - **%A**
          - Print the full weekday name
        - **%B**
          - Print full month name
        - **%F**
          - Print the date in yyyy-mm-dd format
        - **%H**
          - Print the hour in 24-hour format
        - **%I**

        - Print the hour in 12-hour format
    - **%j**
        - Print the day of the year
    - **%S**
        - Print seconds
    - **%V**
        - Print the week of the year
    - **%x**
        - Print the date representation based on the locale
    - **%X**
        - Print the time representation based on the locale
    - **%Y**
        - Print the year

- **timedatectl**
    - Sets system date and time information

        - **timedatectl Subcommands**
            - **status**
                - Show the current date and time information
            - **set-time**
                - Set the system's time to the time provided
            - **set-timezone**
                - Set the system's time zone to the time zone provided
            - **list-timezones**
                - List all available time zones in the format specified

- **set-ntp {0|1}**
    - Enable or disable synchronization with an NTP server

        - **timedatectl Options**
            - **-H {remote host}**

- Execute the operation on the remote host specified by IP address or hostname

- **--no-ask-password**
  - Prevent the user from being asked to authenticate when performing a privileged task

- **--adjust-system-clock**
  - Synchronize the local (system) clock based on the hardware clock when setting the hardware clock

- **-M {local container}**
  - Execute the operation on a local container

- **Local Clock**
  - Local current time
- **Universal Time Clock**
  - UTC/GMT
- **Hardware Clock**
  - Hardware level

- **hwclock**
  - Allows for the viewing and setting of the hardware clock

- **Systematic Drift**
  - The predictable amount of time that the hardware clock gains or loses each day

- **/etc/adjtime File**
  - Records information about when and by how much the hardware clock is changed

- **hwclock Options**
  - **–set**
    - Set the hardware clock to the provided date and time

- **-u**
  - Set the hardware clock to UTC
- **-s**
  - Set the system time from the hardware clock
- **–adjust**
  - Add or subtract time from the hardware clock to account for systematic drift

- **localectl**
  - Views and configures the system locale and keyboard layout settings

- **localectl Subcommands**
  - **status**
    - Show the current locale and keyboard layout
  - **set-locale**
    - Set the system locale to the locale provided
  - **list-locales**
    - List all available locales on the system
  - **set-keymap**
    - Set the keyboard layout to the provided layout
  - **list-keymaps**
    - List all available keyboard layouts on the system

- **localectl Options**
  - **-H {remote host}**
    - Execute the operation on the remote host specified by IP address or hostname
  - **--no-ask-password**
    - Prevent the user from being asked to authenticate when performing a privileged task

    - **--no-pager**
        - Prevent the output from being piped into a paging utility

    - **--no-convert**
        - Prevent a keymap change for the console from also being applied to the X display server, and vice versa

- **Character Encoding**
    - Converts text into bytes

- **Character Decoding**
    - Converts bytes into text

- Default encoding is generally UTF-8 using the Unicode character set
- C is associated with the positional number U+0043 in Unicode

- **Graphical User Interface**

    - **Graphical User Interface (GUI)**
        - Enables users to interact with a system or application through visual design elements

    - **Display Server**
        - Constructs and manages the windowing system and other visual elements that can be drawn on the screen

            - Better screen sharing
            - Better remote desktop connection
            - Easier to recover from crashes

    - **Virtual Network Computing (VNC)**
        - A cross-platform remote desktop service that enables full remote control of a desktop environment
    - **xrdp**

- Free and open-source utility that constructs a Remote Desktop Protocol (RDP)-like server for non-Windows systems

- **NoMachine (NX)**
  - Cross-platform proprietary remote desktop software that offers support for multi-session environments and account management

- **Simple Protocol for Independent Computing Environments (SPICE)**
  - Free and open-source protocol designed specifically for use in virtual environments

- **Console Redirection**
  - The process of forwarding input and output through a serial connection rather than through any I/O peripherals that are directly attached to the system
  - Console redirection enables administrators to remotely configure systems in a pre-boot environment like BIOS/UEFI

- **Secure Shell**
  - A remote access protocol that encrypts transmissions over a network

- **SSH Port Forwarding**
  - The process of tunneling an application through SSH to secure it in the transmission
  - In local forwarding, local client listens for connections and then tunnels any active connection on a remote server using SSH
  - In remote forwarding, the SSH server forwards inbound traffic to another system on a different port

- **Services**

  - **Services**

- Running programs or processes that provide support for requests and monitoring from other processes or external clients

- **init**
  - The backend service that controls when and how services are started

- **init Daemon**
  - A configuration file that initiates the processes listed in it

- **systemd**
  - Provides an init method for initializing a system and is now the dominant init method in modern Linux distributions

- **systemctl**
  - Enables the control of the systemd init daemon

  - **systemctl Subcommands**
    - **status {service}**
      - Retrieve the current status of a service
    - **enable {service}**
      - Enable a service to be started on boot
    - **disable {service}**
      - Disable a service so that it is no longer started on boot
    - **start {service}**
      - Activate a service immediately
    - **stop {service}**
      - Deactivate a service immediately
    - **restart {service}**
      - Restart a service immediately
    - **set-default {target}**
      - Set the default target for the system to use on boot

- **isolate {target}**
  - Force the system to immediately change to the provided target

- **mask {unit file}**
  - Prevent the provided unit file from being enabled or activated

- **daemon-reload**
  - Reload the systemd init daemon, including all unit files

  - **systemctl Options**
    - **-t {unit file type}**
      - Specify the unit file types to perform the operation on

    - **-a**
      - List all unit files or properties, regardless of state

    - **no-reload**
      - Prevent the reloading of configuration changes when enabling or disabling a service

    - **--no-ask-password**
      - Prevent users from being asked to authenticate when performing privileged operations

    - **--runtime**
      - Make changes temporary so that they will not be present after a reboot

    - **-H {remote host}**
      - Execute the operation on the remote host specified by IP address or hostname

    - **--no-pager**
      - Prevent the output from being piped into a paging utility

- **hostnamectl**
  - Shows the system's network hostname and other information about the system's hardware and the Linux kernel it is running

- **SysVinit**
  - An older init method that has been largely replaced by system
  - SysVinit make use of runlevels which determine what types of daemons should be running
  - **SysVinit Runlevels**
    - **0**
      - Shuts down the system
    - **1**
      - Starts single-user mode
    - **2**
      - Starts multi-user mode without remote networking
    - **3**
      - Starts multi-user mode with remote networking
    - **4**
      - Unused
    - **5**
      - Starts multi-user mode with networking and GUI capabilities
    - **6**
      - Reboots the system

- **telinit**
  - Switches the current runlevel of the system

- **runlevel**

- Prints the previous and current runlevels of the system, each separated by a space

- **/etc/inittab File**
  - Stores details of various processes related to system initialization on SysVinit

- **/etc/init.d**
  - Stores initialization scripts for services

- **/etc/rc.local File**
  - Executed at the end of the init boot process, typically used to start custom services

- **chkconfig**
  - Controls services in each runlevel and can also start or stop services during system startup

  - **chkconfig Subcommands/Options**
    - **{service} on**
      - Enable a service to be started on boot
    - **{service} off**
      - Disable a service to keep from starting on boot
    - **{service} reset**
      - Reset the status of a service
    - **--level {runlevel}**
      - Specify the runlevel in which to enable or disable a service

- **service**
  - Controls SysVinit services through SysVinit scripts

  - **service Subcommands/Options**
    - **{service} status**
      - Print the current state of a service

- **{service} start**
  - Start a service immediately
- **{service} stop**
  - Stop a service immediately
- **{service} restart**
  - Restart a service immediately
- **{service} reload**
  - Re-read a service's configuration files while the service runs

- **Process Issues**
  - **Running state**
    - The process is currently executing in user space or kernel space
  - **Interruptible sleep state**
    - The process relinquishes access to the CPU and waits to be reactivated by the scheduler
  - **Uninterruptible sleep state**
    - The process will only wake when the resource it's waiting for is made available to it
  - **Zombie state**
    - A process was terminated but not yet released by its parent process so it cannot accept a kill signal
  - **Stopped state**
    - The process was stopped by a debugger or through a kill signal
  - **Process ID (PID)**
    - A non-negative integer used to identify a process and increases for each new process started

- **pgrep**
  - Identifies a process based on multiple factors when the exact PID is not known

- **pidof**
  - Finds the process ID of a named running program

- **ps**
  - Displays the process table which summarizes the current running processes on a system4

  - **ps Options**
    - **a**
      - List all user-triggered processes
    - **-e**
      - List all processes
    - **-l**
      - List processes using a long-listing format
    - **u**
      - List processes along with the username and start time
    - **r**
      - Exclude processes that are not running currently
    - **x**
      - Include processes without a terminal
    - **T**
      - Exclude processes started by other terminals
    - **-U**
      - Display the processes based on the specified user
    - **-p {PID}**

- Display only the process associated with the specified PID

- **-C {command}**
  - Display all processes by command name

- **--tty {terminal number}**
  - Display all processes running on the specified terminal

- **top**
  - Acts as a process management tool that allows for interactive process prioritization, sorting, or termination

  - **top Options**
    - **Enter key**
      - Refresh the status of all processes

    - **Shift+N**
      - Sort processes in the decreasing order of their PID

    - **M**
      - Sort processes by memory usage

    - **P**
      - Sort processes by CPU usage

    - **u**
      - Display processes belonging to the user specified

    - **k**
      - Terminate the process specified

    - **r**
      - Alter the scheduling priority of the process specified

    - **q**
      - Exit the process list

- **htop**
  - A newer version of an interactive system monitor, process viewer, and process manager
  - htop is not installed by default on all Linux distributions
    - **top**
      - Text-only black and white interface
    - **htop**
      - Text-based graphics with colorful interface
- **systemd-analyze**
  - Retrieves performance statistics for boot operations
- **lsof**
  - Prints a list of all files currently opened to all active processes
- **nice**
  - Runs a command with a different nice value than the default
    - **-n option**
      - Increments the nice value by the given integer
- **renice**
  - Alters the scheduling priority of an already running process
    - **-n option**
      - Specifies the new nice value for a running process
    - **-g option**
      - Alters the nice value of the processes in a process group
    - **-u option**
      - Alters the nice value of all processes owned by the user
- **fg (foreground)**

- **bg (background)**
  - **fg %{job ID}**
    - Brings a job to the foreground
  - **Ctrl+Z**
    - Halts a job temporarily to allow the use of the bg command
  - **bg %{job ID}**
    - Pushes a job to the background
  - **&**
    - Starts a command running in the background when added to the end of a command
- **jobs**
  - Lists out all jobs either in the foreground or in the background
    - **Ctrl+Z**
      - Stops a foreground job and places it in the background
    - **Ctrl+C**
      - Force quits a running program via the command line environment
    - **Ctrl+D**
      - Logs out the current user session
- **nohup (no hangup)**
  - Prevents a process from ending when the user logs off
- **kill**
  - Sends any specified signal (termination) to one or more processes
- **pkill**
  - Sends any specified signal (termination) to processes based on a matching pattern

- **killall**
  - Sends any specified signal (termination) to all processes matching the name specified

    - **user**
      - Own processes
    - **root**
      - Any processes

  - **Kill Signals**
    - **SIGHUP (1)**
      - Send to a process when its controlling terminal is closed
    - **SIGINT (2)**
      - Interrupt a process from the terminal
    - **SIGKILL (9)**
      - Kill the process immediately
    - **SIGTERM (15)**
      - Terminate a process
    - **SIGSTOP (17, 19, 23)**
      - Pause a process
    - **SIGSTP (18, 20, 24)**
      - Pause a process from the terminal

- **ps**
  - Print information on all running processes, including CPU usage

- **top**
  - Retrieve a dynamic and interactive list of all running processes

- **systemd-analyze blame**
  - Determine what startup processes are slowing down boot operations

- **lsof**
  - Identify which processes have open files
- **nice/renice**
  - Prioritize certain processes over others
- **fg/bg**
  - Manage foreground and background processes
- **nohup**
  - Keep a command running even after logging off
- **kill**
  - Terminate problem processes

- **CPU and Memory Issues**
  - **/proc/cpuinfo File**
    - Identifies characteristics about the CPU that might indicate issues related to performance or lack of support for features
  - **sysctl**
    - Enables the viewing of kernel parameters at runtime
  - **uptime**
    - Displays the time from when a system started running
    - The load average field is the most relevant in CPU troubleshooting
  - **sar**
    - Displays system usage reports based on data collected from system activity
    - sysctl also retrieves CPU-based kernel parameters at runtime
  - **lscpu**
    - Displays information about the CPU architecture

- Not enough total memory for all processes
- Not enough free memory for new processes
- Processes unable to access memory
- Processes accessing too much memory
- Leaving other processes without memory
- System cannot access files from cache/buffer
- RAM performs to specification
- Memory consumption is at expected rate
- System has enough available memory

- **/proc/meminfo Fields**
  - **MemTotal**
    - Total amount of physical memory in the system
  - **MemFree**
    - Total amount of physical memory currently used
  - **Cached**
    - Total amount of physical memory that is being used as cache memory
  - **SwapTotal**
    - Total amount of swap space on the system
  - **SwapFree**
    - Total amount of swap space that is currently unused
  - **Dirty**
    - Total amount of memory that is waiting to be written to storage
  - **Writeback**
    - Total amount of memory currently being written to storage
- **free**
  - Parses the /proc/meminfo file for easier analysis of memory usage statistics

- **free Options**
    - **-b, -k, -m, -g, -tera**
        - Display memory in bytes, kilobytes, megabytes, gigabytes, and terabytes
    - **-s {seconds}**
        - Update memory statistics at a delay of the specified seconds
    - **-o**
        - Disable the display of the buffered or cached information
    - **-t**
        - Display total line that combines physical RAM with swap space
    - **-h**
        - Make the output more human-readable
- **Buffers**
    - Caches file system metadata
- **Cached**
    - Caches actual file contents

- **vmstat**
    - Displays various statistics about virtual memory, as well as process, CPU, and I/O statistics

- **vmstat Statistics**
    - **Memory-based**
        - Total virtual memory available
        - Total virtual memory that is free for use
        - Total memory used in buffers and cache

- Total memory used in swap space

- **CPU-based**
  - Time spent running user space
  - Time spent running in kernel space
  - Time spent idle
  - Time spent waiting for I/O

- **Out-of-Memory (OOM) Killer**
  - Determines processes to kill when the system is extremely low on memory
  - OOM killer leverages an algorithm that assigns each process an OOM score
  - You can mount the OOM control group at the desired mount point

- **Device Swap Space**
  - Used to run large applications

- **File System Swap Space**
  - An emergency resource when the available swap space runs out

- **Pseudo Swap Space**
  - Enables large applications to run on computers with limited RAM

- **Swap Partition**
  - An area of virtual memory on a storage device to complement the physical RAM in the computer

- **mkswap**
  - Creates swap space on a storage partition

  - **mkswap Options**
    - **-c**
      - Verify the device is free from bad sectors before mounting the swap space

    - **-p**

        - Set the page size to be used by the mkswap command

    - **-L**
        - Activate the swap space using labels applied to partitions or file systems

- **swapon**
    - Activates a swap partition
- **swapoff**
    - Deactivates the swap space

    - **swapon/swapoff Options**
        - **swapon –e**
            - Skip devices that do not exist

        - **swapon –a**
            - Activate all of the swap space

        - **swapoff –a**
            - Deactivate all of the swap space

- **/proc/cpuinfo File**
    - Identify key information about the CPU and its logical cores

- **uptime**
    - Identify CPU load averages

- **sar**
    - Identify the component causing heavy load on the CPU and when

- **/proc/meminfo File**
    - Identify key information about memory usage

- **free**
    - Easily analyze memory usage information

- **vmstat**
    - Retrieve more information on both CPU and memory usage

- **OOM Killer**
  - Spare or sacrifice specific processes when low on memory

- **Swap Space**
  - Created if adding physical memory is not feasible

Devices

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **Linux Devices**
    - **Device Drivers**
        - Act as an interface between the operating system and hardware devices
    - **Client Device/Thin Client**
        - Any lightweight computing device that connects to a more powerful server
            - **Server**
                - Processing and storing data
            - **Thin Client**
                - Acts as a user interface
                - A thin client has fundamental I/O devices like a keyboard, mouse, and monitor connected to it
    - **Universal Serial Bus (USB)**
        - De facto standard for connecting input devices, external storage devices, and mobile devices
        - Linux registers USB storage devices attached to the system in /dev/sd# format
    - **Wireless Devices**
        - Transmit and receive signals over the air
    - **Wi-Fi**
        - Technology used primarily in establishing wireless local area connections (WLAN)
    - **Bluetooth**
        - Technology used primarily for establishing a personal area network (PAN)

- Bluetooth enables users to listen to audio without the need for cables

- **Near Field Communication (NFC)**
  - Communications protocol used by mobile devices and peripherals

- **Video and Audio Devices**
  - Input or output peripherals that are attached to client systems

    - **Microphone**
      - Common audio input
    - **Speakers or headphones**
      - Common audio output

  - When connecting video or audio to a system, check the connection type

  - Most modern printers offer local connection support through a USB interface

- **Network Adapter**
  - Acts as an interface that allows computer devices to have access to a network

- **Network Interface Card**
  - Device that provides an interface with which hosts exchange data over a network

- **General-Purpose Input/Output (GPIO)**
  - Pins on a circuit board that have no designated purpose
  - GPIO is controlled through software

- **Serial AT Attachment (SATA)**
  - Computer bus interface standard for attaching storage devices to traditional computers

- **PCI Express**
  - Supports raw data rates of up to 16 Gb/s

- **Small Computer System Interface (SCSI)**
  - Computer bus interface for connecting devices to computers
  - SCSI is used for storage

- **Serial Attached SCSI (SAS)**
  - Developed to apply a serial interface to SCSI technology
  - SAS4 offers speeds up to 24 Gb/s and supports higher-capacity drives

- **Host Bus Adapter (HBA)**
  - Hardware component that connects a host system to a storage device
  - HBAs may be built into the motherboard or a separate expansion card

- **Peripheral Component Interconnect (PCI)**
  - Used as an expansion bus for attaching peripheral devices

- **PCI Express (PCIe)**
  - Supports greater transfer speeds, more reliable error detection, and is physically smaller than PCI
  - PCIe is the dominant expansion bus technology

- **Configure Devices**

  - **Device Files**
    - Represent information about hardware devices and settings

  - **/proc/**
    - Contains various files that represent system information reported by the kernel

  - **/proc/devices**
    - Contains list of device drivers that the kernel is currently running

  - **/sys/**
    - Virtual file system that focuses on creating a hierarchical view of device information

- **/sys/devices/**
  - Includes files that shows details about specific devices

- **/dev/**
  - Enables the system and users to access devices

    - **/dev/sda1**
      - Storage device
    - **/dev/mapper/**
      - Logical and encrypted volumes

- **/etc/**
  - Contains configuration files for components that interface with devices

- **/etc/X11/**
  - Contains configuration files for I/O devices affecting X.Org server

- **Hot-Pluggable**
  - Can be physically added or removed from the system without requiring a reboot

    - **Hot-Pluggable**
      - Detected by the system
    - **Cold-Pluggable**
      - Not detected by the system

- **udev**
  - Handles module loading for cold-pluggable and hot-pluggable devices
  - Udev manages the automatic detection and configuration of hardware devices

    - **/etc/udev/rules.d/**
      - Used to configure rules for udev functions
      - /etc/udev/rules.d/ directory is used for local administration of udev

    - **/usr/lib/udev/rules.d/**

- Contains rules generated by the system

- **udevadm**
  - Used to manage udev

- **Info Subcommand**
  - Used to view the device's vendor ID, product ID, and serial number

- **Control Subcommand**
  - Modifies the running state of udev
  - The --reload-rules option ensures udev is reading from the newly added rules files

- **Trigger Subcommand**
  - Executes rules that apply to any device that is currently plugged in
  - The -c option is used to add, remove, or change rules

- **Monitor Subcommand**
  - Used to watch for events sent by the kernel or by a udev rule

- **Test Subcommand**
  - Used to simulate udev events and present results as output

- **Printer**
  - Bundled with software utilities that enable users to configure settings

- **Common Unix Printing System (CUPS)**
  - Print management system for Linux that enables a computer to function as a print server
  - Changes made in CUPS modify the /etc/cups/cupsd.conf and /etc/cups/cups-files.conf files

- **lpr**
  - Submits files for printing

- **-E**
  - Force encryption
- **-P {destination}**
  - Send print job
- **-# {copies}**
  - Set number of copies to print
- **-T {name}**
  - Set job name
- **-l**
  - Print formatted file
- **-o**
  - Set job option
- **-p**
  - Print specified files
- **-r**
  - Delete file after printing

- **Monitor Devices**
  - **lsdev**
    - Displays hardware information from the interrupts, ioports, and dma files in the /proc directory
  - **/proc/interrupts**
    - Lists each logical CPU core and its associated interrupt requests (IRQ)
  - **IQR**
    - Signal sent by a device to the processor
    - The IRQ address lists the signals that were sent to each CPU core

- **/proc/ioports**
  - Lists input/output ports and the mapped hardware devices
- **/proc/dma**
  - Lists all Industry Standard Architecture (ISA) direct memory access (DMA) channels on the system
- **ISA DMA**
  - Hardware controller that supports legacy technology like floppy disks
- **lsusb**
  - Used to display information about devices connected to the system's USB buses
    - **-v flag**
      - Device information
    - **bus -s**
      - Filter result
    - **-d**
      - Vendor/product
- **lspci**
  - Used to display information about devices connected to the system's PCI/PCIe buses
- **lpq**
  - Shows the status of the print queue
    - **+interval**
      - Reports update every second
- **lsblk**
  - Identify block storage devices
- **dmesg**
  - Print all messages sent to kernel's buffer

- Use dmesg output to monitor issues related to device drivers and hardware

- **Troubleshooting Hardware Issues**

  - Keyboard mapping issues
  - Communication port issues
  - Printer issues
  - Memory issues
  - Video issues
  - Storage adapter issues

  - **Identify the layout of the physical keyboard**
  - **Use localectl status to verify the layout**
  - **Identify the correct layout and set it up on the system**

  - **SSH client (PuTTY)** enables users to change the effects of keystrokes on the environment

    1. Ensure that the device is correctly slotted into the port
    2. Ensure that power is being supplied to the bus adapter
    3. Ensure that drivers are installed and loaded into the kernel

  - Linux will assign the port an interface at /dev/ ttyS#

    1. Consult the printer's manual and/ or the manufacturer's website
    2. Ensure the printer is supported y Linux-compatible drivers
    3. Use network diagnostic tools (ping)

  - **lpq**
    - Check status of print job
  - **lprm**
    - Stop a job

  - Use memory monitoring tools (free) and the process monitoring tools (top) to identify the problem

- If the message contains error-correcting code (ECC) errors, one of the memory modules has failed

- Ensure the monitor and other devices are properly connected and compatible

- **GPU Driver**
  - Video-intensive application

- The problem might be with the physical HBA or HBA used like SCSI or SATA

  1. Ensure that the Host Bus Adapter (HBA) is powered on
  2. Ensure the device connecting to the HBA uses the right interface
  3. Ensure that all devices are properly slid and that all cables are connected and damage-free

- **RAID Arrays**
  - The mdadm command is used to manage RAID arrays

    - -F
      - Activates monitor mode
    - -f
      - Mark specified device
    - -r
      - remove specified device
    - --re-add
      - Add removed device
    - -a
      - Add device as hot-spare

- **lshw**
  - Lists detected hardware components on the system and provides device details

    - **lshw -c network**
      - Output details about network-class devices

- **lshw -short | sort -k2**
  - Display list of classes currently in use in the system

- **dmidecode**
  - Dumps the system's Desktop Management Interface (DMI) table and presents in a readable format
- **DMI Table**
  - Industry standard for tracking information about hardware components
  - Do not rely on DMI tables as the sole source of hardware information
- **Automatic Bug Reporting Tool (ABRT)**
  - Analyzes and reports problems detected during system runtime
  - ABRT runs as the abrtd daemon and can be configured using abrt-cli or abrt-gui

1. Ensure that hardware devices are supported by robust drivers
2. Ensure that necessary drivers are installed and loaded in the kernel
3. Ensure that hardware devices are compatible with the Linux software
4. Verify that the system has the correct keyboard layout and language set
5. Verify that a network-enabled printer is identifiable
6. Use the lprm command to stop large or numerous print jobs
7. Check the mcelog for memory errors
8. Run a utility like memtester to stress test RAM modules
9. Download the latest GPU drivers from the vendor's website
10. Ensure that storage and peripheral devices are properly slotted into the correct buses
11. Ensure the connected cables are not loose or damaged
12. Use a command like lshw to identify connected hardware
13. Be aware that dmidecode may produce inaccurate results
14. Review crash data compiled by the ABRT utility

- Troubleshooting requires knowledge and familiarity with the command line and system messages

Networking

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **TCP/IP Fundamentals**
  - **TCP/IP**
    - Family of network protocols offers various services
  - **Open Systems**
    - Interconnection (OSI)
    - Standardizes networking functions

      - **7 Layers of OSI Model**
        - **7**
          - Application supports applications and end-users
        - **6**
          - Presentation formats data for use
        - **5**
          - Session establishes, maintains, and tears down a connection
        - **4**
          - Transport enables reliable transmission of information
        - **3**
          - Network enables logical addressing
        - **2**
          - Data link enables physical addressing
        - **1**
          - Physical enables physical network connectivity

  - TCP/IP is used to govern network communications and the internet

  - **Node**
    - Devices with an identity on the network

  - **MAC Address**

- Physical address

- **IP Address**
  - Logical address

- **Hostname**
  - Human-readable name of the device

- **Switch**
  - Acts as a concentrator, centralizing all network connection

- **Router**
  - Acts as a control point for communications between network segments
  - Routers work with IP addresses at Layer 3 of the OSI model

- **Media**
  - Actual path of an electrical signal travels from one component to another

- **Network Cable**
  - Twisted pair Ethernet cable
  - Twisted pair may come shielded (STP) or unshielded (UTP)

    - **Packet**
      - Network layer (Layer 3)
    - **Frame**
      - Data link layer (Layer 2)

- **Domain Name System (DNS)**
  - Service provides name resolution
  - DNS is implemented as a database hosted on one or more servers

    - **Static Configuration**
      - For servers and network devices
    - **Dynamic configuration**
      - End-user workstations

- **Dynamic Host Configuration Protocol (DHCP)**

- Service provides dynamic configuration

- **IP Address**
  - Provide an addressing system for managing network identities

- **Network Identifier**
  - Defines network host segment

- **Host Identifier**
  - Uniquely identify the host in segment

- **Each class provides a specified number of networks and the number of hosts available**
  - **Class A**
    - 0.0.0.0 – 127.0.0.0
  - **Class B**
    - 128.0.0.0 – 191.255.00
  - **Class C**
    - 192.0.0.0 – 223.255.255.255
  - **Class D**
    - 224.0.0.0 – 239.255.255.255
  - **Class E**
    - 240.0.0.0 – 255.255.255.255

- **Due to the depletion of IPv4, three IP address ranges are reserved for internal use only**
  - **Class A Reserved**
    - 10.0.0.0 – 10.255.255.255
  - **Class B Reserved**
    - 172.16.0.0 – 172.13.255.255
  - **Class C Reserved**
    - 192.168.0.0 – 192.168.255.255

- **Loopback Address**
  - Used for diagnostics and to allow the system to network to itself

- **Link-local Range**

        - Used for zero-configuration LANs or when the DHCP lease generation process fails (APIPA)

    - **IPv6**
        - Addresses IPv4's weaknesses, has a larger address space, built-in encryption, and more efficient routing

    - **Network Port Numbers**
        - Numeric values assigned to application-layer protocols

    - **Humans work with HTTP, while computers need to work by port number**
        - **22**
            - Secure Shell
        - **25**
            - Simple Mail Transfer Protocol
        - **80**
            - Hypertext Transfer Protocol
        - **110**
            - Post Office Protocol version 3
        - **443**
            - Hypertext Transfer Protocol Secure

    - **Network administrators divide the network into segments to manage network traffic**
        - **Subnet**
            - Logical divisions of the network
        - **Network ID**
            - Part of the IP address each node is using
    - All nodes in a subnet have the same network ID

- **Linux Server Roles**

    - **Network Time Protocol (NTP)**
        - Enables the synchronization of nodes time with a designated and definitive time source

- **Crony**
  - Designed to utilize NTP and perform in a large range of conditions

- **Secure Shell (SSH)**
  - Provides an authenticated and encrypted method of connecting to a remote or local system

- **Web Servers**
  - Host the files and images on the websites

    - **HTTP**
      - TCP port 80
    - **HTTPS**
      - TCP port 443

  - The web services on Linux are hosted through Apache or Nginx

- **Certificate**
  - Provide a means of identity guarantee

- **Certificate authority (CA)**
  - manage the enrollment, approval, expiration, and revocation of certificates

- **Domain Name System (DNS)**
  - Performs name resolution for easy-to-remember hostnames
  - DNS server may contain records for a company's internal network

- **Dynamic Host Control Protocol (DHCP)**
  - Provides configurations including IP addresses, subnet masks, and default gateways

- **Simple Network Management Protocol (SNMP)**
  - Capable of passing information of performance and workloads to a central management database

- **Centralized Authentication**

- Holds information about user identities in a directory store

- **Proxy**
  - With direct access to the Internet and an internal network connection

- **Logging**
  - Used to centralize log files from the Linux servers

- **Monitoring**
  - Monitor specific applications

    - **ApacheTop**
      - Provides log file analysis for Apache and connection response time
    - **Monit**
      - Simple monitoring utility for Linux

- **Load Balancing**
  - Used to distribute inbound connection requests across multiple servers

  - Multiple web servers create a load balance service needed to ensure connections to servers
  - Node is a server inside a cluster and can accept client connections

- **File and Print**
  - Allows file storage and printing

- **Samba**
  - Windows compatible file sharing system that runs on SMB
  - Server Message Block (SMB) compatible file sharing protocol

- **NFS**
  - Used to provide access to directories stored on a server

- **Database**
  - Used to store large quantities of data and make easy queries

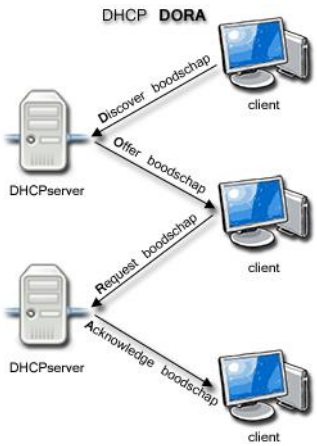
- **SQL**
  - Uses relational tables
- **NoSQL**
  - Unorganized relational tables
- **Virtual Private Network (VPN)**
  - Enables remote users to connect to the internal company network and access internal resources
- **Email**
  - Responsible for the distribution of electronic mail
    - Sendmail
    - Postfix
    - Simple Mail Transfer Protocol (SMTP)
    - Post Office Protocol (POP3)
    - Internet Message Access Protocol (IMAP)

- **Connecting to a Network**
  - **Computer Network**
    - Two or more computers connected through network media
  - **Device/System Hostname**
    - Used to easily recognize a machine within a network
    - For a computer to participate in a network, it must have a valid identity
    - Errors or misconfigurations in values will result in not participating in the network
  - **NetworkManager**
    - Aids in the proper configuration of the IP information
  - **nmcli**
    - Contains subcommands to view and configure network information
  - **general status**
    - View summary of network connectivity data

- **connection show**
  - View identification information for each NIC
- **con up {device ID}**
  - Enable specified NIC
- **con down {device ID}**
  - Disable specified NIC
- **con edit {device ID}**
  - Enter interactive mode to configure specified NIC
- **device status**
  - Display current status of each NIC
- **nmtui**
  - Uses a text-based user interface (TUI)
    - Moves the cursor from field to field
    - Make selections within the field
    - Activate setting (OK or Quit)
    - Check or uncheck a check box
- **nmgui**
  - Enables IPv4 and IPv6 configuration
- **ifconfig**
  - Shows IP address, subnet mask, broadcast ID, MAC address, basic performance information, and NIC name
    - IP address
    - Subnet mask
    - MAC address
- **ip adder show**
  - Shows the IP address information
- **ip link**
  - Shows the status of each interface
- **ip link set eth1 up**
  - Enables the interface identified as eth1
- **ip link set eth1 down**
  - Disables the interface identified as eth1
- **iwconfig**
  - Used to provide wireless NIC configurations

- **nick {name}**
  - Set a nickname
- **mode {mode}**
  - Set the operating mode
- **freq {number}**
  - Set the Wi-Fi frequency
- **channel {number}**
  - Set the Wi-Fi frequency
- **retry {number}**
  - Set the maximum number of MAC retransmissions

- **Configure DHCP and DNS Client Services**
  - **Static IP address configuration**
    - The settings are implemented manually by an administrator
  - **Dynamic IP address configuration**
    - The settings are retrieved from a server
  - **The DHCP service must be installed on the server and allow client machines to lease configurations**
  - **DORA**
    - Discover Offer Request Acknowledge



- **/etc/dhcp/dhclient.conf**
  - Enables the configuration of DHCP client settings
- **NetworkManager**
  - Serves as a network configuration service for multiple network settings
  - TCP/IP data packets must include a source IP address nd a destination IP address
-
- **DNS**
  - Static text files
  - Dynamic database
-
- **/etc/hosts**
  - Used in special case situations where a particular system
- **/etc/resolv.conf**
  - Informing the system of the IP address of one or more DNS servers
- **/etc/nsswitch.conf**
  - Includes several configuration options
-
- **/etc/hosts → DNS**
  - Command-line
  - Text-based
  - Graphical interface utilities
-
- **nslookup**
  - Used to test name resolution
- **host**
  - Used to query DNS server
- **whois**
  - Host information about the owner of the domain name

- **Cloud Technologies**
  - **Cloud computing is a relatively new and rapidly changing aspect of the IT industry**
    - On-demand self-service
    - Broad network access

- Resource pooling
- Rapid elasticity
- Measured service

- **Cloud services indicate flexibility in terms of deployment, scale, support, and fault tolerance**

  - **Software as a Service (SaaS)**
    - Provides applications to the end-users
    - In SaaS, work and storage of the data is done by the cloud services, not on the installed application

  - **Platform as a Service (PaaS)**
    - Virtualization of the environment's operating system layer
    - The PaaS model provides services to developers and database administrators

  - **Infrastructure as a Service (IaaS)**
    - Includes physical devices that are virtualized and owned by a cloud service provider

- **Public Clouds**
  - Hardware resources that can be shared by multiple customers

- **Private Clouds**
  - The use of cloud technologies as an on-premise solution

- **Hybrid Clouds**
  - Enabling more effective cost management combined with strict security management

- **Amazon Web Services (AWS)**
  - Supports deployment options of a variety of cloud-based services
  - Amazon Linux AMI solution is free and open-source

- **Microsoft Azure (Azure)**
  - Supports deployment options and services like AWS

- Microsoft Azure does support both Windows and Linux servers

- **Google Cloud Platform (GCP)**
  - Allows for the deployment of SaaS, PaaS, and IaaS services on Linux and Windows servers

- **Red Hat**
  - Provides Linux-based cloud solution, designed as a full-featured private cloud for organizations

- **Virtualization Technologies**

  - **Virtualization**
    - Enables the use of hardware and provides fault tolerance, disaster recovery, and scalability

  - **Hypervisor**
    - Software layer that provides control between the virtual machines and the physical hardware

      - **Type 1 Hypervisors**
        - Run directly on the hardware called bare metal deployment

      - **Type 2 Hypervisors**
        - Run as a service on top of Linux, Windows, or OS X

  -
  - **Kernel-Based Virtual Machine (KVM)**
    - Enables Linux virtual machines with the attributes of type 1 and type 2 hypervisors

  - **Open Virtualization Format (OVF)**
    - Format contains configuration files, packages, and settings for virtual machines and network devices

  - **JavaScript Object Notation (JSON)**

- Used by most programming languages to store information

- **YAML Ain't Markup Language (YAML)**
  - Used to store configuration information on the newly deployed virtual machines

- **Container Image**
  - Used by a specialized type of virtual machine called container

- **Bootstrapping**
  - Refers to the adage "pulling yourself up by the bootstraps"

- **Cloud-init**
  - Cloud-based Linux mechanism to customize a virtual machine during the first boot up

- **Anaconda**
  - Used by Linux distributions to manage deployments

- **Kickstart**
  - Used to customize the installation and provide an automated and unattended installation of new virtual machines

- **Storage**
  - Used to store virtual machines and to process data

- **Virtual Storage**
  - File that resides on the physical drive

- **Virtual Machine**
  - Treats files like a physical drive

- **Virtual Drive**
  - Treats files like a physical device

- **Thin Provisioning**
  - Maintaining large storage pools

- **Thick Provisioning**
  - Reserves the allocated space for the virtual device
  - The benefit of thick provisioning is the guaranteed space available

- **Blobs and buckets** can be used to store audio, video, other multimedia, and text files

- **Blocks**
  - Written to the storage device (physical or virtual)

- **Virtualization Hypervisor**
  - Configured to provide access to networking services

- **Network Address Translation (NAT)**
  - Provide virtualized network functionality in physical networks

- Virtualized networks may be thought of as “overlay networks”

  - **“Headless” Mode**
    - virtualization host servers that runs Linux without a GUI

  - **virsh**
    - Interactive shell to control the virtual machines

      - **help**
        - Get help

      - **list**
        - Get VM list

      - **shutdown {VM}**
        - Shutdown

      - **start {VM}**
        - Start

- **reboot {VM}**
  - Reboot
- **create {XML file name}**
  - Create
- **save {VM} {file name}**
  - Save the state
- **console {VM}**
  - Open console

- **Troubleshooting Network Issues**
  - Check if the device is powered or plugged in
  - Verify and configure the network interface
  - Check if network interface is detected by Linux
  - **Name resolution**
    - Ping a destination by hostname and by IP address
    - Use host and nslookup to test the system's ability to perform DNS
  - **Network traffic**
    - Use the netstat command to check if the latency is high or saturation is occurring
  - **Failing Network Interface Card**
    - Replace the network card or check the other side connection
  - **Application performance**
    - The localhost method creates a full network connection
    - Use Unix sockets (Unix domain sockets)
    -
  - **Unrecognized network adapters**
    - Verify the appropriate driver has been installed
  - **ping**

- Generate a response request from the sending computer
    - **<host>**
        - Connection successful
    - **Destination unreachable**
        - No path destination

- **timeout**
    - Request reached the destination but a response did not return to the source computer

- **Ping only shows that something is wrong, not what is wrong**
    - **-c**
        - Send number of pinging attempts
    - **-v**
        - Specify verbose output

- **traceroute**
    - Used to report the network path between the source and destination
- **hop**
    - Process of a packet traveling from one router to another

- **Routing loops in which traffic is routed back and forth and never reaches its destination**

- **netstat**
    - **Used to gather information about TCP connections to the system**
        - **-v**
            - Activate verbose mode
        - **–i [interface]**
            - Display interface information
        - **-c**
            - Print information
        - **-l**
            - Show port/s being listened
-

- **ss (socket state)**
  - Information gathering utility with simpler output and syntax

    - **Missing socket**
      - Service is not running
    - **Closed socket**
      - Premature termination of connection

    - **-l**
      - Show currently listening sockets
    - **dst {host}**
      - Show host statistic connection
    - **-i**
      - Show ports that being listened

- **Name resolution is one of the most important network services**

- **dig**
  - Used for gathering information and testing name resolution
- **nslookup**
  - Tool for gathering name resolution information and testing name resolution
- **host**
  - Capable of gathering information and testing name resolution
-
- **ip**
  - Replaced the ifconfig command for interacting with the NIC
  - Verify all settings are correct
  - Use ip addr command to ensure the configuration is accurate
-
- **route**
  - Used to view the routing table

    - **route add default gw {IP address}**
      - Default gateway by IP address
    - **route add -host {IP address}**
      - Reject command

- **Network Mapper (nmap)**
  - Tool for exploring a network environment

- **Wireshark**
  - Common packet sniffer and network analyzer
  - Wireshark has the ability to see moving or not moving packets through an NIC

- **Network analyzer tcpdump**
  - One of the most popular packet sniffers available

    - **-i**
      - **Specify the interface to use**
    - **-n**
      - **Not resolve hostnames**
    - **-v**
      - **Specify verbose mode**

- **netcat (nc)**
  - Used to test connectivity and send data across network connections

- **iftop**
  - Displays bandwidth usage information for the system

- **iperf**
  - Used to test the maximum throughput of an interface

    - **Bandwidth**
      - Potential amount of data
    - **Throughput**
      - Actual amount of data

- **mtr**
  - Combination of ping and traceroute that enables testing the quality of a network connection

- **Lost packets is a strong indicator of a network issue along the path**

- **Address Resolution Protocol (ARP)**
  - Used to relate IP and MAC addresses
- **whois**
  - Provides information on Internet DNS registrations
- **Use ping, traceroute, and iftop when experiencing slow network performance**

Packages and Software

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **Package Managers**
  - **Package Managers**
    - **Install, update, inventory, and uninstall packaged software**
    - Compiling code is more common for Linux administrators than for Windows or macOS users
    - Many Linux applications are modular and depend on dependencies
    - Compiling the software is the traditional method of managing software
    - Software packages that are prepared for **RPM** use the **.rpm** file extension
      - **Inventory Software**
        - One of RPM's most useful features
  - **Yellowdog Updater, Modified (YUM)**
    - Offers a more elegant set of commands and greater flexibility for using software repositories and handling dependencies
  - **Dandified YUM (DNF)**
    - Uses fewer resources while still maintaining support for RPM
  - **Zypper**
    - An openSUSE package manager that supports .rpm packages
  - Software packages with the .**deb** file extension can be managed using **dpkg**
  - **Advanced Package Tool (APT)**
    - Preferred package management method in Debian-derivatives

- **RPM Packages and YUM**
  - **rpm**
    - Manages RPM packages on Red Hat-derived distributions
    - **rpm Options**
      - **-i {package name}**
        - Install the specified software
      - **-e {package name}**
        - Erase or uninstall the package
      - **-v**
        - Enable verbose mode to provide more detail
      - **-h**
        - Enable verbose mode, providing more detail
      - **-V {package name}**
        - Verify the software components of the package exist
  - **rpm -qa**
    - List all installed software
  - **rpm -qi {package name}**
    - List information about a particular package
  - **rpm -qc {package name}**
    - List the configuration files for a particular package
  - **-U**
    - Upgrade or install a package
  - **-F**
    - Freshen installed package
  - **yum**
    - Improves on the functionality of rpm while still using .rpm packages and maintaining an RPM database
      - Automatic handling of dependencies
      - Use of repositories

- **yum Subcommands**
  - **install {package name}**
    - Install the package from any configured repository
  - **localinstall {package name}**
    - Install the package from the local repository
  - **remove {package name}**
    - Uninstall the package
  - **update [package name]**
    - Update the package
  - **update**
    - Update all installed packages
  - **info {package name}**
    - Report information about the package
  - **provides {file name}**
  - Report what package provides specified files/libraries

- **-y**
  - Automatically answer yes to installing additional software dependencies

- **Debian Packages and APT**
  - **dpkg**
    - Debian's main package management program
    - **dpkg Options**
      - **-i {package name}**
        - Install the package
      - **-r {package name}**
        - Remove or uninstall the package

- **-l {package name}**
  - List information about the specified package
- **-l**
  - List all installed packages
- **-s {package name}**
  - Report whether the package is installed

- dpkg ensures all the necessary components and dependencies are installed

- **APT**
  - A front-end manager to the dpkg system
    - **apt-get**
    - **apt-cache**
  - **apt Subcommands**
    - **install {package name}**
      - Install the package
    - **remove {package name}**
      - Uninstall the package and keep its configuration files
    - **purge {package name}**
      - Uninstall the package and remove its configuration files
    - **show {package name}**
      - Report information about the package
    - **version {package name}**
      - Display version information about the package
    - **update**
      - Update APT database of available packages
    - **upgrade [package name]**

- Upgrade the package

- **upgrade**
  - Upgrade all packages

- The apt-get and apt-cache commands are still functional and have more specific controls

- **apt-cache show {package name}**
  - Display package information

- **apt Update**
  - Does not install any software
- **apt Upgrade**
  - Upgrades all installed software

- Run the apt update command prior to running apt upgrade

- **Repositories**

  - **Repositories (Repos)**
    - Storage locations for available software packages

  - **Local Repository**
    - Stored on the system's local storage drive

  - **Centralized Internal Repository**
    - Stored on one or more systems within the internal LAN

  - **Vendor Repository**
    - Maintained on the Internet, often by the distribution vendor

  - **createrepo**
    - Updates the XML files used to reference the repository location

- **.repo Configuration File**

- Provides additional information about the repository and is stored in the /etc/yum.repos.d/ directory

- **.repo File Components**
  - **[repo-name]**
    - Repository name
  - **name=Repository Name**
    - Human-friendly name of the repository
  - **baseurl=**
    - Path to the repository
  - **enabled=1**
    - Enables the repository
  - **gpgcheck=0**
    - Disables GPG checking

- **yum Subcommands**
  - **repolist**
    - See all available repositories
  - **makecache**
    - Locally cache information about available repositories
  - **clean all**
    - Clear out-of-date cache information

- **Mirroring**
  - Enables the synchronization of an online repository to a local storage location

- **reposync**
  - Manages the mirroring process

- **Acquire Software**
  - **wget/curl**
    - Can be written into scripts to automate the process of downloading package files

wget	curl
Command-line utility only	Cross-platform
Can download files recursively	Cannot download files recursively
Supports HTTP/S and FTP only	Supports more network protocols
Downloads files	Builds/manages complex requests

- Tape Archiver (tar)
  - Bundles together multiple files into a single tarball with a .tar extension

tar Options	
-c	Create the tarball
-x	Extract the tarball
-v	Enable verbose mode
-r	Append more files to an existing tarball
-t	Test the tarball or see what files are included in the tarball
-f	Specify the name of the tarball in the next argument

- **gzip**
  - Compression utility that produces files with the .gz extension
  - It is common to compress a tarball to create the .tar.gz or .tgz extension
    - **gzip {file name}**
      - Compress the file and appends the .gz extension
    - **gzip -d {file name}**
      - Decompress the file
  - .tar.bz2 indicates the tarball was compressed with the bzip2 utility

- **Building Software from Source Code**

- **Compiler**
  - Translates source code written in a human-friendly programming language into machine-readable binaries

    - **Header files** (.h file extension)
    - **Library files** (.a file extension)

- **Program Libraries**
  - Chunks of compiled code that can be used in programs to accomplish common tasks

- **Shared Libraries**
  - Enable more modular program builds and reduce time when compiling the software

    - **/usr/lib/**
      - General access
    - **/lib/**
      - Essential binary access

- **ldd**
  - Enables a user to view shared library dependencies

Software Compilation Process	
1	Decrypt the downloaded program using tar and gzip commands and change into the directory that gets created
2	Run the ./configure command to gather system information needed by the application
3	Use the make command to compile the application using the information stored in the makefile
4	Use the make install command to install the resulting binaries

- **makefile**
  - Contains instructions used by a compiler to build a program from source code

- **Troubleshooting Software Dependency Issues**
    - **If you are using a package manager, first check the configuration files for your specific package manager**
        - **APT**
            - /etc/apt/sources.list.d /etc/apt.conf
        - **YUM**
            - /etc/yum.repo.d
            - /etc/yum.conf
        - **DNF**
            - /etc/dnf/dnf.conf
    -
    - **Use the verify command to check if the software and its dependencies were properly installed**
    -
    - **Run the apt update command first to get the latest versions of the dependency packages**
    -
    - **Check the documentation for the compiler for issues with the compiling software itself**
    -
    - **When necessary, run the make install command using sudo to assume root privileges to run certain programs or code**
    -
    - **Always ensure a solid backup and restoration plan when updating and upgrading software**
    -
    - **If things go wrong, check the installation logs immediately**

Securing Linux Systems

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **Cybersecurity Best Practices**
    - Linux is the operating system used on most network devices and security appliances
    - **Cybersecurity**
        - Protection of computer systems and digital information resources from unauthorized access, attack, theft, or data damage
            - **Confidentiality**
                - Keeps the information and communications private and protected from unauthorized access
                - Confidentiality is controlled through encryption and access controls
            - **Integrity**
                - Keeps the organizational information accurate, error-free, and without unauthorized modifications
                - Integrity is controlled through hashing, digital signatures, certificates, and change control
            - **Availability**
                - Ensures that computer systems run continuously, and authorized users can access data
                - Availability is controlled through redundancy, fault tolerance, and patching
    - **Authentication**
        - Enables an organization to trust the users
    - **Token**

- Any unique object (physical or digital) used to verify identity

- **Biometrics**
  - Authentication scheme that verifies a user's identity based on physical characteristics

- **Remote Authentication Dial-In User Service (RADIUS)**
  - Internet standard protocol that provides authentication, authorization, and accounting (AAA) services

- **Terminal Access Controller Access-Control System (TACACS)**
  - Provides AAA services for remote users

- **TACACS+**
  - More secure and scalable than RADIUS

- **Lightweight Directory Access Protocol (LDAP)**
  - TCP/IP-based directory service protocol

- **Kerberos**
  - Authentication service based on a time-sensitive ticket-granting system

- **kinit**
  - Authenticate Kerberos ticket if successful

    - **kpassword**
      - Change the user's Kerberos password
    - **klist**
      - List the user's ticket cache
    - **kdestroy**
      - Clear the user's ticket cache
    - **klist –v**
      - Verify ticket

- **Privilege Escalation**
  - User is given access additional resources or functionality

- While changing a permission (SUID/SGID), consider using the lowest permissions needed for the task

- **Chroot Jail**
  - Way to isolate a process and its children from the rest of the system

- **Encryption**
  - Cryptographic technique that converts data from plaintext form into coded or ciphertext

- **Decryption**
  - Converts ciphertext back to plaintext

- **Algorithm (Cipher)**
  - Responsible for the conversion process

- Encryption is one of the most fundamental cybersecurity techniques for upholding the confidentiality of data

- **Full Drive/Disk Encryption (FDE)**
  - Encrypts a storage drive, partition, or volume using hardware/software utilities

- **File Encryption**
  - Encrypts individual files and folders using software utilities

- **Linux Unified Key Setup (LUKS)**
  - Used to encrypt storage devices in a Linux
  - LUKS standardizes the format of encrypted devices

- **shred**
  - Used to securely wipe a storage device

- **cryptsetup**
  - Used as the front-end to LUKS and dm-crypt

    - **isLuks**

    - Identify if a device is a LUKS device
  - **luksOpen**
    - Open a LUKS storage device
  - **luksClose**
    - Remove a LUKS storage device
  - **lucksAddKey**
    - Associate new key with a LUKS device
  - **luksDelKey**
    - Remove key material from a LUKS device

- **Hashing**
  - Transforms plaintext input into an indecipherable, fixed-length output

- **Best Practices in Network Configurations**
  - Enable SSL/TLS
  - Configure SSH
  - Change service defaults (SSH and HTTP/S)

- **SECURITY THROUGH OBSCURITY**
  - Generate OpenSSL
  - Download and install mod_ssl package (/etc/httpd/conf.d/ssl.conf)
  - Point SSLCertificateFile
  - Point SSLCertificateKeyFile
  - Restart Apache
  - Open the browser and verify certificate

1. Protect the boot loader configuration with a password
2. Enable password protection in the system's BIOS/UEFI

  - **lsmod**
    - Search for USB storage an any dependent modules
  - **modprobe -r**
    - Unload relevant modules from kernel
  - **/etc/modprobe.d/**
    - Create a blacklist file

3. Ensure user IDs are not being shared

4. Establish a public key infrastructure
5. Restrict access to cron (Linux job scheduler)
6. Disable the use of Ctrl+Alt+Del
7. Enable the auditd service
8. Add a banner message to /etc/issue
9. Separate operating system data and other types of data
10. Monitor regularly the Common Vulnerabilities and Exposures (CVE) database
11. Harden the system by disabling or uninstalling unused and/or insecure services

- **Identity and Access Management**
  - **Security process that provides identity, authentication, and authorization** mechanisms
  - **SSH Protocol**
    - Supports many authentication method
  - **Public Key Authentication**
    - Used for interactive and automated connections
      - Security
      - Usability benefits
      - Automated passwordless login
  - **~/.ssh/**
    - Contains files related to SSH keys
  - **id_rsa**
    - Contains the user's private key
  - **id_rsa.pub**
    - Contains the user's public key
  - **authorized_keys**

- Lists the public keys that server accepts

- **known_hosts**
  - Contains the lists the public keys that the client accepts

- **config**
  - Configures SSH connection settings

- **ssh-keygen**
  - Generate public/private key pair

- **ssh-copy-id**
  - Append user's public keys to remote server's authorized_keys file

- **ssh-add command**
  - Add private key identities to the SSH key agent

- **/etc/ssh/sshd_config**
  - Used to configure an SSH server

- **PasswordAuthentication**
  - Used to enable or disable password-based authentication

- **PubkeyAuthentication**
  - Used to enable or disable public key-based authentication

- **UsePAM**
  - Enables or disables support for Pluggable Authentication Modules (PAM)

- **Port**
  - Used to change the port number to bind the SSH service

- **SyslogFacility**
  - Used to change the logging level of SSH events

- **ChrootDirectory**
  - Used to reference a chroot jail path for a user

- **AllowUsers/AllowGroups**
  - Used to enable user-specific access by allowing the specified users or groups access over SSH

- **DenyUsers/DenyGroups**
  - Used to restrict the specified users or groups from accessing the server over SSH

- **PermitRootLogin**
  - Used to enable or disable the ability for the root user to log in over SSH

- **TCP Wrapper**
  - Checks the allowed and denied hosts before permitting the host to connect with the SSH service

    - **/etc/hosts.allow**
      - Allow host
    - **/etc/hosts.deny**
      - Deny host

- **Pluggable Authentication Modules (PAM)**
  - Used to help applications make proper use of user accounts in Linux
  - PAM configuration files are located in /etc/pam.d/ directory

    - <module interface>
    - <control flag>
    - <module name>
    - <module arguments**>**

- **Module Interface**
  - Defines functions of the authentication and authorization process contained within a module

- **Control Flag**
  - Indicates what should be done upon a success or failure of the module

- **Module Argument**
  - Additional options that can pass into the module
  - password required pam_cracklib.so retry=5
- **Account Module**
  - Checks user accessibility
- **Auth**
  - Used to verify passwords and set credentials (Kerberos tickets)
- **Password**
  - Used to change and verify passwords
- **Session**
  - Configures and manages user sessions
- Control flags tell PAM what to do with the result
  - **Optional**
    - Module result is ignored
  - **Required**
    - Module result must be successful for authentication to continue
  - **Requisite**
    - Notifies the user of the first failed required/requisite module
  - **Sufficient**
    - Module result is ignored upon failure
- **password requisite pam_pwquality.so local_users_only**
  - Requires the user to entera strong password
- **password requisite pam_pwhistory.so remember=90**
  - Enforce a password history for 90 days
- **password sufficient pam_unix.so sha512 use_authtok**

- Allow the module not to do any password checks

- **pam_faillock**
  - Recommended as it is newer and improves upon pam_tally2

- **pam_tally2**
  - Supports user lockout when authentication is done

  - Place user lockout directives in /etc/pam.d/password-auth and /etc/pam.d/system-auth

- **pam_ldap**
  - Specifies other directives (log in/access resources)

- **/etc/securetty**
  - Determines the controlling terminals the root user has access to

- PKI can be publicly available or maintained privately by an organization

  - **Digital Signature**
    - Encrypted message digest with a user's private key

  - **Digital Certificate**
    - Electronic document that associates credentials with a public key

  - **Certificate Authority**
    - Issues digital certificates for entities and maintains the associated private/public key pair

  - **Certificate Signing Request (CSR)**
    - Message sent to the certificate authority in which an entity applies for a certificate

- **OpenSSL**
  - Open-source implementation of the SSL/TLS protocol for securing data in transit using cryptography

- OpenSSL is one of the most common tools for generating and managing components of a PKI

- **Internet Protocol Security (IPSec)**
  - Used to secure data traveling across the network or the Internet

    - **Transport Mode**
      - Packet contents are encrypted, whereas the header is not
    - **Tunnel Mode**
      - Both the packet contents and header are encrypted

- **StrongSwan**
  - Can set up username and password authentication and generate digital certificates

- **/etc/strongswan/ipsec.conf**
  - Contains the main configuration file for StrongSwan

- **/etc/strongswan/ipsec.secrets**
  - File where user accounts are configurable

- **SSL/TLS**
  - Used as a VPN authentication and encryption protocol

- **OpenVPN**
  - Supports password-based, certificate-based, and smart card-based authentication mechanisms for clients
  - Configuration files are stored in the /etc/openvpn/ directory

- **Datagram Transport Layer Security (DTLS)**
  - Implements SSL/TLS over datagrams

    - Users must have set up proper credentials and transmit them to SSH or VPN
    - Check if user remote connection attempts are triggering a policy violation
    - Sign on with the local account (service issue or networking issue)

- Ensure the user identities are correctly configured
- Lax PAM policies are leading to unauthorized users accessing resources they shouldn't
- Privileged access should be granted on an as-needed basis

- **SELinux or AppArmor**
    - **Mandatory Access Control (MAC)**
        - System-enforced access control based on subject clearance and object labels
    - **Context-Based Permissions**
        - Permission scheme that defines various properties for a file or process
    - **Discretionary Access Control (DAC)**
        - Each object has a list of entities that are allowed to access it
    - **SELinux**
        - Default context-based permissions scheme provided with CentOS and Red Hat Enterprise Linux
            - **User**
                - Defines what users can access the object
                    - **unconfined_u**
                        - All users
                    - **user_u**
                        - Unprivileged users
                    - **sysadm_u**
                        - System administrators
            - **Root**
                - Root user
            - **Role**
                - Permits or denies users access to domains
    - The object_r role applies to files and directories
    - **Type**

- Groups objects together that has similar security requirements or characteristics

- **Level**
  - Describes the sensitivity level called “Multi-level security”

- **Disabled**
  - SELinux is turned off and the DAC method will be prevalent

- **Enforcing**
  - SELinux security policies are enforced

- **Permissive**
  - SELinux is enabled but the security policies are not enforced

- **Targeted Policy**
  - Default SELinux policy used in Red Hat Enterprise Linux and CentOS

- **Strict Policy**
  - System subject and object is enforced to operate on MAC

- **semanage**
  - Configure SELinux policies

- **sestatus**
  - Get SELinux status

- **getenforce**
  - Display SELinux mode

- **setenforce**
  - Change SELinux mode

    - **setenforce 1**
      - Enable enforcing mode
    - **setenforce 0**
      - Enable permissive mode

- **getsebool**
  - Display the on or off status
- **setsebool**
  - Change the on or off status of a SELinux Boolean value
- **ls-Z**
  - List directory contents
    - **ls -Z {file or directory name}**
      - List directory contents along with each object's security context
- **ps-Z**
  - List running process
    - **ps –Z {PID}**
      - Check the context of a specific process
- **chcon**
  - Change the security context of a file
    - **Basic Syntax**
      - chcon {-u|-r|-t} {context value} {file or directory name}
- **restorecon**
  - Restore the default security context
    - **Restore Objects**
      - restorecon {file or directory name}

- Violation occurs when an attempt to access an object or an action goes against an existing policy
  - **sealert**
    - Alert message
  - **audit2why**
    - Translate violation
      - **audit2allow**

        - Used to gather information from the denied operations log
    - **audit2allow -w -a**
        - Read the audit log and display the human-readable description of the blocked activity
    - **audit2allow -a -M [RuleName]**
        - Generate a loadable module to allow the activity to occur

            - RuleName.pp
                - Policy package file
            -
            - RuleName.te
                - Type enforcement file

- **AppArmor**
    - Alternative context-based permissions scheme and MAC implementation for Linux

        - AppArmor
            - Works with file system objects
        - SELinux
            - References inodes directly

- **Capabilities**
    - Provide the executable in question access to system functionality

- **Path Entries**
    - Enable the executable to access a specific file on the file system

- **Complain Mode**
    - Profile violations are logged but not prevented

- **Enforce Mode**
    - Profile violations are both logged and prevented

- **Tunables**

        - Mechanism for tuning configuration in AppArmour without profile adjustments

    - **/etc/apparmor.d/ tunables/home**
        - Most common tunable to adjust

            - **apparmor_status**
                - Display the current status
            - **aa-complain**
                - Place a profile in complain mode
            - **aa-enforce**
                - Place a profile in enforce mode
            - **aa-disable**
                - Disable profile
            - **aa-unconfined**
                - List processes with open network sockets

    - AppArmor is configured to reduce the potential attack surface and provide greater in-depth defense

    - AppArmor can only do so much to protect against exploits in application codes

- **Firewalls**

    - **Firewall**
        - Program interface between a private network and the Internet

    - **Packet Filters**
        - Make decisions based on rules that correspond to network packet attributes
        - Packet filtering firewalls are also called stateless firewalls

    - **Stateful**
        - Identifies past traffic related to a packet

    - **Application Layer Firewall**

- Inspects the contents of application layer traffic

- **Stateless Firewall's ACL**
  - Allows or denies packets based on various factors

    - **Accept**
      - Traffic is allowed through the firewall and sent to its destination

    - **Reject**
      - Traffic is blocked at the firewall and the firewall notifies the sender

    - **Drop**
      - Traffic is blocked at the firewall and does not notify the sender

- **iptables**
  - Applies to a certain context and consists of rule sets (chains)

    - **Filter table**
      - Default table used for typical packet filtering functionality

    - **Nat table**
      - Used to implement Network Address Translation rules

    - **Mangle table**
      - Used to alter the packets' TCP/IP header

    - **Raw table**
      - Used to configure exceptions involved in connection tracking

    - **Security table**
      - Used to mark packets with SELinux security contexts

    - **CentOS/RHEL**

- Install the iptables-services package and issue the service iptables save command

- **Debian-based Distros**
  - Install the iptables persistent package
  - Iptables-persistent service will automatically run at boot and load rules after installation

    - **iptables -N LOGCHN**
      - Create a new chain

    - **iptables -I INPUT -j LOGCHN**
      - Ensure all incoming packets not processed by any prior rules will jump to the LOGCHN chain

    - **iptables -I LOGCHN -j DROP**
      - Performs the actual dropping of packets

  - Events for iptables are written to the /var/log/messages or /var/log/kern.log files

- **Uncomplicated Firewall (UFW)**
  - Makes the iptables service easier to configure

    - **ufw allow http/tcp**
      - Allow rule for HTTP

    - **ufw logging**
      - Turn on logging

    - **ufw enable**
      - Enable firewall

- **/etc/default/ufw**
  - Configure high-level settings like policy defaults and kernel module usage

- **/etc/ufw/ directory**

- Contains more granular configuration files

- **Firewall Daemon (firewalld)**
  - Used to dynamically manage a firewall without requiring a restart
  - Firewall zones are the rule sets that apply to network interfaces
    - **drop**
      - Zone with the lowest level of trust
    - **firewall-cmd**
      - Configure firewalld by querying, adding, modifying, and deleting zones and services as desired
    - **firewall-cmd --get-zones**
      - Lists Available firewalld Zones
    - **firewall-cmd --zone=dmz --list-all**
      - Lists Details dmz Zone
    - **firewall-cmd --zone=dmz – change-interface=<device ID>**
      - Add Specified Interface to the dmz Zone
    - **firewall-cmd --zone=dmz --add-service=http**
      - Add HTTP Service to the dmz Zone
    - **firewall-cmd --zone=dmz --add-port=21/tcp**
      - Add TCP Port 21 (FTP) to the dmz Zone
    - **firewall-cmd --zone=dmz --remove-service=http**
      - Remove HTTP Service from the dmz Zone
    - **firewall-cmd --zone=dmz --remove-port=21/tcp**
      - Remove TCP Port 21 (FTP) from the dmz Zone
    - **firewall-cmd --reload**
      - Reloads Zone's Configuration

- **--permanent**
  - Persist Change

- **Netfilter**
  - Handles packets that traverse a network interface
  - Netfilter (nftables) was designed as a replacement for iptables and is installed by default on Debian

- **IP Forwarding**
  - Enables incoming traffic on one network interface to another
- **IP Set**
  - Stored collection of IP and MAC addresses, network ranges, port numbers, and network interface names
  - iptables tool leverages IP sets for more efficient rule matching

- **ipset**
  - Create and modify IP sets

- The test subcommand is used to test the entry exists

  - **Internet Assigned Numbers Authority (IANA)**

- **0–1023**
  - Trusted Ports/Privileged Ports

  - Check the firewall rule set to ensure there are no overtly blocked ports in the system
  - ACL can be configured to only block specific source ports

- **Intrusion Prevention System (IPS)**
  - Monitors and evaluates a system for attack signs and blocks traffic that it determines malicious
  - IPS is a second layer of defense that monitors traffic

- **DenyHosts**
  - Protects SSH servers from brute force password cracking attacks

- **Fail2ban**
  - Monitors log files with an authentication component

- **/etc/denyhosts.conf**
  - Primary configuration file for DenyHosts

    - **ADMIN_EMAIL**
      - Define email address to send alert

    - **BLOCK_SERVICE**
      - Define services to be blocked from unauthorized users

    - **DENY_THRESHOLD_VALID**
      - Defines number of times a user can attempt to log in

-
- **/etc/fail2ban/jail.conf**
  - Primary configuration file for Fail2ban
  - Copy file to /etc/fail2ban/jail.local or make a custom .conf file within /etc/fail2ban/jail.d/

- **Bantime**
  - Defines a host being blocked from accessing a resource

- **Maxretry**
  - Defines the number of times a host can fail before being blocked

- **ignoreip**
  - Defines a whitelist of accepted hosts

- **Logging Services**

  - **Operating System Log**
    - Provides a wealth of diagnostic information about a computer

  - **System Log**
    - Records of system activities and events

- **Remote Logging**
  - Centralized logging server that receives and processes syslog data

    - **/var/log/ directory**
      - System Logs
    - **/var/log/syslog**
      - All Types of System Events
    - **/var/log/auth.log**
      - Authentication Messages
    - **/var/log/messages**
      - General Non-critical System (Red Hat/CentOS)
    - **/var/log/kern.log**
      - Kernel Messages
    - **/var/log/ [application]**
      - Miscellaneous Applications (cron, firewalld, mailog)

- **Log Rotation**
  - Practice of creating new versions of a log file

    - **logrotate**
      - Used to perform automatic rotation of logs

        - **/etc/logrotate.d/**
          - Log Rotation Behavior
        - **/etc/rsyslog.conf**
          - rsyslogd Service

- The first column lists message facilities and/or severities
- The second column defines actions for the messages

- **syslog-ng**
  - Replacement for syslogd

- The syslog standard is not universally supported on all platforms

- **Agent**
  - A software program that acts on behalf of some other program or service

    - **journalctl**
      - Enables the viewing and querying of log files
      - Print journal log

    - **journald**
      - Used in syslogd or rsyslogd
      - /etc/systemd/journald.conf

        - **-n {number of lines}**
          - Specify number of lines of journal logs to display

        - **-o {output format}**
          - Specify format of the output

        - **-f**
          - Display most recent journal entries

        - **-p**
          - Filter journal log output by severity

        - **-u**
          - Filter journal log output by the name of service

        - **-b [boot ID]**
          - Show log message from Boot ID specified

    - **systemd Journal**
      - Stores logs in memory

- **/var/log/journal/**
  - journald Logs After Reboot
    - **last**
      - Displays the user's history of login and logout events
    - **last 1**
      - User Log (tty)
- **lastlog**
  - Lists all users and the last time a user logged in
- **/var/log/lastlog**
  - Retrieve Information

- **Backup, Restore, and Verify Data**
  - **Backup Strategy**
    - Data protection that directs data backup and recovery policy actions
  - **Backup**
    - Copy of data that exists in another logical or physical location
  - **Full Backup**
    - All selected files are backed up
  - **Differential Backup**
    - Focuses on the files that have changed since the last full backup
  - **Incremental Backup**
    - Only backs up the changed data found in files
  - **Snapshot**
    - Records the state of a storage drive at a certain point in time
  - **Image-Based Backup**
    - Saves the state of an operating system in an image file format

- **Cloning**
  - Copies all the contents of a storage drive to another storage medium

- **tar**
  - Enables the creation of data archives

    - **tar -xvf**
      - Restores the contents of a source file

- **dar (disk archiver)**
  - Offers more backup and archiving functionality

    - **dar -R mydata -c full.bak**
      - Full Backup
    - **dar -R mydata -c diff1. bak -A full.bak**
      - Differential Backup
    - **-x (extract)**
      - Recover a Backup
    - **-w**
      - Overwrites Changes

- **cpio**
  - Copies files to and from archives

    - **Copy-out**
      - Used to copy files into an archive
    - **Copy-in**
      - Used to copy files from an archive
    - **Copy-pass**
      - Used to copy files from one directory tree to another

        - **ls | cpio -o > dir_archive**
          - Archive Directory Content
        - **cpio -i < dir_archive**
          - Extract Archive (copy-in)

- **dd (disk duplicate)**
  - Copies and converts files to be transferred from one type of media to another

    - **if={file name}**
      - Specify file to be read
    - **of={file name}**
      - Specify file to be written
    - **bs={bytes}**
      - Block size to read and write in bytes
    - **count={count}**
      - Specify number of blocks to be written
    - **status={level}**
      - Specify information to print to standard error
    - **dd if=/dev/sda of=/dev/sdb**
      - Copy Full Backup of Storage

- **mirrorvg**
  - Creates copies of logical volumes in a specified logical volume group

    - **mklvcopy**
      - Mirrors individual logical volumes in a volume group

        - **-m#**
          - lvcreate Command

- **off-site**
  - Physical location outside of the main site that stores copies of data

- **scp**
  - Used to copy data to or from a remote host over SSH

- **Secure File Transport Protocol (SFTP)**
  - Uses an SSH tunnel as a transportation mechanism to encrypt data

- **rsync**
  - Used to copy files locally and to remote systems

Bash Scripting

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **The Bash Shell Environment**
  - **Shell Environment**
    - Mechanism by which Bash maintains settings and other behavioral details
  - **Shell Spawning**
    - Process of creating a new session
  - **Script**
    - Any computer program that automates the execution of tasks
  - **Variable**
    - Entity whose values change from time to time
      - **${VARIABLE NAME}**
        - Variable Reference
      - **echo ${MYVARIABLE}**
        - Retrieve Variable Value
  - **Environment Variable**
    - Variable that is inherited from parent shell processes and passed to the child processes
      - **HOSTNAME={hostname}**
        - Specifies the system hostname
      - **SHELL={shell path}**
        - Specifies the system shell path
      - **MAIL={mail path}**

- Specifies the mail path storage

- **HOME={home directory}**
  - Specifies user's home directory

- **PATH={user path}**
  - Specifies the search path

- **HISTSIZE={number}**
  - Specifies the command history

- **USER={username}**
  - Specifies the user's name

- **/etc/locale.conf**
  - Local Configuration

    - **LC_*={locale}**
      - Collection of Localization Environment Variables

    - **LANG={locale}**
      - Locale for LC_* variables

    - **LC_ALL={locale}**
      - Locale for All Options

    - **TZ={time zone}**
      - System Time Zone

- **env**
  - Used to run a command with modified environment variables

- **set**
  - Use without arguments to print all shell variables, environment variables, and shell functions

    - **export**

        - Change the variable value for child processes

    - **env**
        - View or change variables for a specific command

    - **set**
        - View or change the value of a shell command

- **Search Path**
    - Sequence of various directory paths to locate files

- **HISTFILESIZE**
    - Sets the maximum number of lines in the command history file
    - Default history file value is 1000

- **alias**
    - Used to customize the shell environment by generating command-line aliases

- **time**
    - Used to gather information about how long to execute a command
        - Elapsed real time between invocation and termination
        - User CPU time
        - System CPU time

1. When adding an alias, check the syntax
2. When executing scripts, add their location to the PATH variable
3. Use the export command to set a variable for all shell child processes
4. Configure environment variables in the ~/.bash_profile file
5. Ensure values are set for any environment variables that a software package has a dependency on

- **Scripting and Programming Fundamentals**

    - **Bash**
        - Powerful scripting language

- Bash scripts support modern programming elements (loops and conditional statements)
- Bash script syntax is similar to CLI

- **#!/bin/bash**
  - Instructs the operating system to use the Bash shell interpreter

- **Assigning Variable**
  - Symbolically associate a piece of information with a name
  - All Bash variables are treated as strings

- **Substitution or Parameter Expansion**
  - Act of referencing/retrieving the value of a variable

- **Operators**
  - Objects that can evaluate expressions in different ways

- **Operands**
  - Values being operated on

- **Arithmetic operators**
  - Includes addition, subtraction, multiplication, division, and other operations

    - **Comparison operators**
      - Includes checking if operands are equal

    - **Logical operators**
      - Connect multiple values (AND, OR, and NOT)

    - **String operators**
      - Used in operations that manipulate strings

- **String Literal**
  - Any fixed value that represents a string of text within source code

- **Escape Character**

- Used to remove special meaning
- Escape character in Bash is a single backlash (\)

- **array**
  - Enables to store multiple values in a single variable
  - Compound assignment in Bash arrays uses parentheses with a value separated by a space

- **function**
  - Block of code that can reuse to perform a specific task

- **#**
  - Every character after it is part of a comment

- **Metacharacters**
  - Special characters that the Bash shell will interpret in a certain way

    - **>**
      - Output redirection
    - **>>**
      - Output redirection (in different manner)
    - **<**
      - Input redirection
    - **<<**
      - Input redirection (here documents)
    - **|**
      - Piping
    - **“**
      - Weak string literals
    - **‘**
      - Strong string literals
    - **`**
      - Breaking out a string literal
    - ****
      - Escaping characters
    - **=**
      - Variable assignment

- **$**
  - Variable substitution and other types of shell expansion
- **#**
  - Commenting
- **||**
  - Logical OR operations
- **&&**
  - Logical AND operations
- *****
  - Wildcard matching
- **?**
  - Wildcard matching applied in a single character matched
- **[ ]**
  - Wildcard matching applied any characters between brackets matched
- **{ }**
  - Parameter substitution and arrays
- **( )**
  - Grouping commands
- **&**
  - Running a process in background
- **;**
  - Separating multiple commands on the same line
- **!**
  - Referencing command history

- **exit Code/Exit Status**
  - Programs can pass a value to a parent process while terminating
    - **Status code of 0**
      - Successful
    - **Exit code 1 or higher**
      - Error

- **stdout/stderr/ stdin**
  - Redirection and Piping (CLI)

- **Shell Expansion**

- Process by which the shell identifies special tokens

- **Variable Substitution**
  - Identifies the $ special character and expands into its actual value

- **Globbing**
  - Used for matching or expanding specific types of patterns

    - **Asterisk (*)**
      - Used to match any number of characters
    - **Question mark (?)**
      - Used to match a single character
    - **Square brackets ([ ])**
      - Used to match any of the characters listed

- **Positional Parameter**
  - Variable within a shell script that is assigned to an argument when the script is invoked

- **exec**
  - Replaces the bash with the command to be executed
- **source**
  - Used to execute another command within the current shell process

- File extensions in Linux are optional
- Adding .sh as an extension to a shell script does not imbue the script with any special meaning
- Use two permissions for each user that needs to run the script

1. Execute (x) bit on the script
2. Write (w) and execute (x) bits on the directory containing the script

Task Automation

Objective 1.1

- **OBJ 1.1:** Identify basic concepts of data schemas and dimensions.

- **Schedule Jobs**
    - **Bash Scripting**
        - Powerful part of system administration and development
        - Bash contains sets of commands which are used to automate the execution of tasks
            - **Cron**
                - Repetitive task
            - **At service**
                - One-time task
    - **at**
        - Schedules a command to run once at a particular time
            - **-m**
                - Send mail to the user
            - **-M**
                - Prevent sending mail to the user
            - **-f {file name}**
                - Read a job from a file
            - **-t {time}**
                - Run the job at the specified time value
            - **-v**
                - Time the job will be executed
                    - **Noon**
                        - 12 P.M.
                    - **Teatime**
                        - 4 P.M.
                    - **Midnight**

- 12 A.M.
- **3 minutes from now**
  - now + 3 minutes
- **1 hr from now**
  - now + 1 hour

- **atq**
  - Used to view the current queue of tasks scheduled by at command

- **atrm**
  - Used to delete a scheduled task

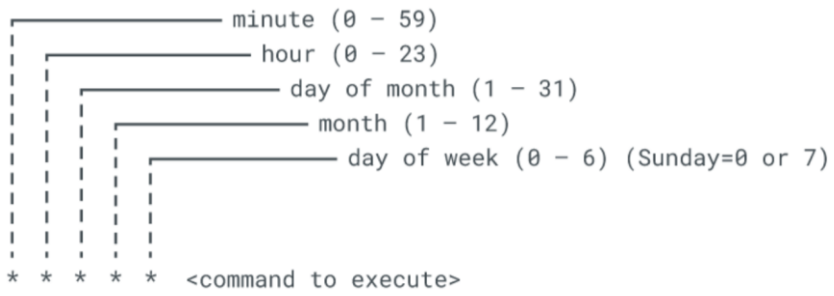
- **Cron Daemon**
  - Used to manage scheduled tasks called cronjobs
  - Crontab command can create, view, and delete crontab files

    - **-e**
      - Edit crontab for current user
    - **-l**
      - View crontab for current user
    - **-r**
      - Delete current crontab file
    - **-u**
      - Create crontab file for specified user

- **Crontab**
  - Used by system administrators to do tasks at routine intervals inside Linux

    - *** * * * * /path/to/command**
      - 45 23 * * 6 /home/user/scripts/exportdump.sh

Each line in this file represents a job, and is formatted as follows:



Cron Job

- *** 20 * * 1-5 /path/to/command**
  - 8 P.M., Monday through Friday
- **15 2 * * * /path/to/command**
  - 2:15 A.M., daily
- **30 4 1 * * /path/to/command**
  - 4:30 A.M. on the first day of each month
- **Scheduled crontab Files**
  - /etc/cron.d/ directory
  - /var/spool/cron/ directory

- The Root User and Services can use the /etc/cron.d/directories file to schedule system-wide tasks
- Regular users are not allowed to populate the /etc/cron directories
- Standard users can schedule tasks in a personal directory located at /var/spool/cron
  - /etc/cron.hourly
  - /etc/cron.daily
  - /etc/cron.weekly
  - /etc/cron.monthly

- **Version Control using Git**
    - **Git**
        - Mature, actively maintained open-source project
    - **Git Repository**
        - Storage area where versions of code and related files are stored
            - **config**
                - Set options for repository or Git users
            - **init**
                - Create Git repository or reinitialize an existing one
            - **clone**
                - Create a copy of an existing repository
            - **add**
                - Add files to be tracked by Git repository
            - **commit**
                - Update the Git repository with changes (snapshot)
            - **status**
                - Display status of the repository
            - **branch**
                - Manage branches (after changes)
            - **merge**
                - Integrate changes into a master branch
            - **pull**
                - Acquire and merge changes
            - **push**
                - Upload local working copy of a repository to a remote repository
            - **log**
                - Display the changes made (local repository)
            - **checkout**
                - Switch to a specific branch
    - Configure global settings including username
    - Create a directory where the project will reside

- Change into the created directory and then initialize it with Git to designate it as a Git repository
- Add project files to the repository
- Commit the changes to take a snapshot of the project

- **Branching**
  - Feature available in most modern version control systems

    - **git branch newbranch**
      - Branch Master Copy
    - **git merge newbranch**
      - Change and Save to Master Branch

- Changes made locally can be uploaded to the central repository using the Git push command

- **.gitignore**
  - Identifies files that should be ignored during a commit action
- ***.git/**
  - Contains all files Git uses to manage version control for a project

- **Orchestration Processes and Concepts**

  - **Orchestration**
    - Automation of multiple steps in a deployment process

  - **Automation**
    - Process of accomplishing a configuration task without human intervention

      - **Automation**
        - Single task

      - **Orchestration**
        - Series of tasks

- Orchestration is the automation of the automations
- Rapid elasticity computing would not be possible without orchestration

    - Resource Orchestration
    - Workload Orchestration
    - Service Orchestration

- Third-party orchestration platform is protection from vendor lock-in

    - **Chef**
        - Uses “cookbooks” to deliver configuration declarations to cloud and on-premises managed systems

    - **Puppet**
        - Uses manifest files to define infrastructure as code for application, cloud, and infrastructure orchestration

    - **Ansible**
        - Uses YAML files to create repeatable “playbooks”

    - **Docker**
        - Open platform for developing, shipping, running, and deploying applications using container- based virtualization

    - **Kubernetes**
        - Provides container deployment and application orchestration for cloud and on-premises container environments

    - **OpenStack**
        - Deployed as an IaaS solution to manage cloud resources

    - **GitHub**
        - Service that allows the developers to share code

- **Agent-Based Orchestration**
    - Requires a software component to reside on the managed device

- **Agentless**
  - Does not require additional software to exist on the managed system

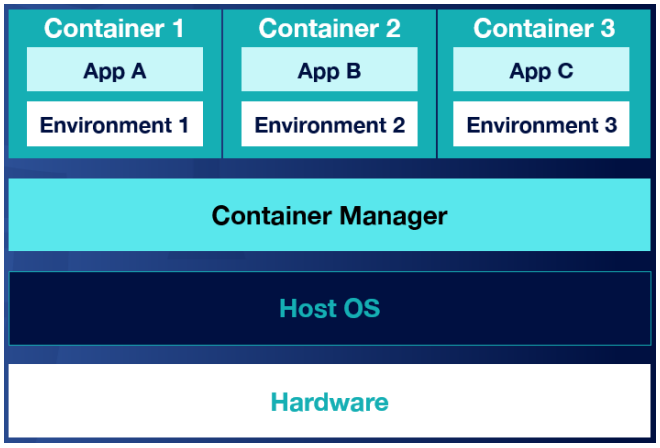
- **Orchestration tools**
  - Inventory Management of Hardware
  - Virtual machines
  - Operating systems
  - Applications
  - Configurations

- Consistent configured system
- Enforced security
- Service-level agreements
- Efficient change management

- **Containerization**

  - **Containerization**
    - A type of virtualization applied by a host OS to provision an isolated execution environment for an application

      - Docker
      - Parallels Virtuozzo
      - OpenVZ



- **Kubernetes**
  - An open-source system for the automated deployment, scaling, and management of containerized applications

- **Node**
  - An object that runs the containerized applications

- **Pod**
  - One or more containers that have shared storage and network resources

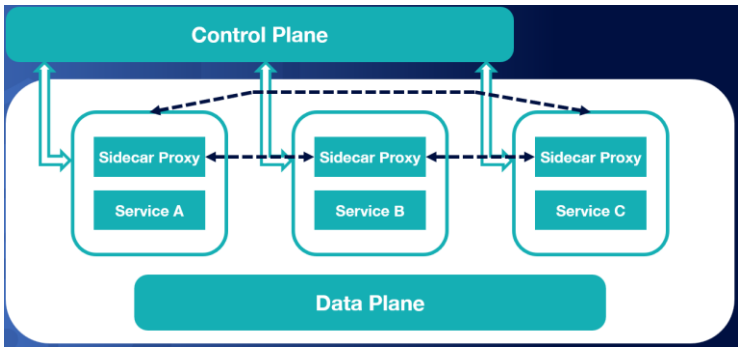
- **Sidecar**
  - Designed to run alongside the main container or pod
  - Sidecars enhance and extend the functionalities of the main container without modifying its codebase

- **Ambassador Container**
  - A special type of sidecar container that simplifies the process of accessing data and services outside of a given pod

    - PersistentVolume
    - PersistentVolumeClaim

- **Container Registry**
  - A place to store, manage, and secure container images

- **Service Mesh**
  - Manages the network traffic between different services, containers, and pods



- **Container Operations**
    - **podman build**
        - Build a container image
    - **podman push**
        - Push a container image to a specified destination
    - **podman pull**
        - Pull a container image from a container registry
    - **podman images**
        - List out the container images available on the local system
    - **podman rmi {Image ID}**
        - Remove a container image
    - **Podman uses the exact same syntax as Docker**
        - Starting/stopping containers
        - Inspecting containers
        - Listing containers
        - Deploying existing images
        - Connecting to containers
        - Logging actions in containers
        - Exposing ports for containers

- **Sandboxed Applications**
    - **Improves security**
    - **Increases application integrity**
    - **Snap**
        - A bundle that contains an app and its dependencies that work without modification across all Linux distributions

        - To manage and maintain Snaps or applications, run the snapd (Snap daemon)

    - **snap (command)**
        - Used to find a snap or application to install
        - By default, applications are installed under the /snap/bin directory

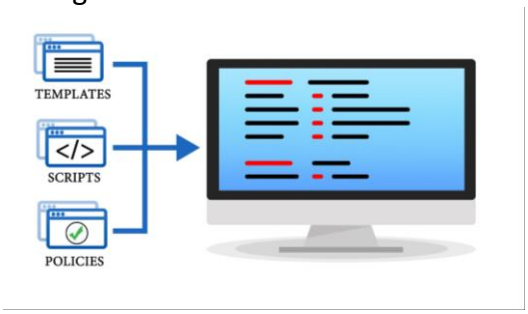
    - **snapd**
        - The backend daemon that runs the Snaps on a system

    - **Flatpak**
        - Runs in a sandbox that contains everything needed for the programs to operate

    - **AppImage**
        - A universal package manager where the apps are installed without modifying system libraries or system preferences
        - Create a directory under the home directory to put all the AppImage applications

- **Infrastructure as Code (IaC)**

    - **Infrastructure as Code (IaC)**
        - A provisioning architecture in which deployment of resources is performed by scripted automation and orchestration
        - Infrastructure as Code allows for the use of scripted approaches to provisioning infrastructure in the cloud



    - **Robust orchestration** can lower overall IT costs, speed up deployments, and increase security

- **Snowflake Systems**
  - Any system that is different in its configuration compared to a standard template within an IaC architecture
  - Lack of consistency leads to security issues and inefficiencies in support

- **Idempotence**
  - A property of IaC where an automation or orchestration action always produces the same result, regardless of the component's previous state
  - IaC uses carefully developed and tested scripts and orchestration runbooks to generate consistent builds

- **Terraform**
  - A modern method used to provision, change, and version resources on any cloud-based environment using automation and orchestration

    - IaC and multi-cloud deployments
    - Kubernetes management
    - Network infrastructure
    - Virtual machine images
    - Policy as code enforcement

- **SaltStack (Salt)**
  - A configuration management and orchestration tool commonly used with IaC deployments
  - SaltStack eliminates the manual processes used by legacy IT operations