Database Admin

Class 1 - Introduction

By Ian Robert Blair, M.Sc.

Agenda

- Introduction
- Class Rules, Grading, and Assignments
- MySQL Installation
- Server Hardware

Introduction

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- New York City
- Teaching at Universities in China for 4 years
- Worked as a Systems Administrator for Merrill Lynch's Global Technology Department for 5 Years

Class Rules

- Please try to come to class on time
- Put your cellphones on vibrate or silent
- Take your calls in the hall
- Please don’t talk during lectures
- Please do all homework, reading, and assignments
- You must come to all classes! Attendance will be taken every day.

Goals

- We will learn about:
- Installing and configuring MySQL
- Queries
- User management
- Backups and recovery
- Tuning and Optimization
- Replication, load balancing and high availability

Semester Plan

1. Introduction and Linux Admin Overview (Review)
2. Basic MySQL Server Admin
3. Data Modeling
4. SQL Language
5. Advanced MySQL Server Admin
6. Backups and Replication
7. Tuning/Optimization
8. Final Review

Grading

- Final Exam 60%
- Assignment 20%
- Attendance 20%

The Book and Tools

- **Learning MySQL** by Seyet M.M. Tahaghoght & Hugh E. Williams
- **High Performance** MySQL by Baron Schwartz, Peter Zaitsev & Vadim Tkachenko
- Download and install Mysql Database and Tools (Community Server and MySQL Admin)
- http://dev.mysql.com/downloads/

Benefits of MySQL

- As of 2013, it's the second most widely used RDMS in the world.
- MySQL can run on very modest hardware (small and fast)
- It can be installed without a lot of difficult and sophisticated configuration
- MySQL does a reasonable job of providing a standard environment (Supports Standards)
- Most major programming languages have libraries of functions for use with MySQL (these include C, PHP, Perl, Python, Ruby, and the Microsoft .NET)
- MySQL also supports the Open Database Connectivity (ODBC) standard

Who Uses MySQL?

- Baidu
- Sina.com
- Facebook
- Twitter
- Linkedin
- Cisco
- Apple
- Youtube
- Google
- Cisco
- Ebay
- Uber
- Seimens
- Intel
- Sony
- Wallmart
- Almost every government in the world…

Connectors
Native C API, JDBC, ODBC, .NET, PHP, Python, Perl. Ruby, Cobol

MySQL Server

Management Services & Utilities
Backup & Recovery, Security Replication, Cluster, Administration, Configuration, Migration, & Metadata

Connection Pool
Authentication -Thread Reuse - Connection Limits – Check Memory - Caches

SQL Interface
DML, DDL, Stored Procedures Views, Triggers, etc.

Parser
Query Translation, Object Privilege

Optimizer
Access Paths, Statistics

Caches & Buffers
Global and Engine Specific Caches & Buffers

Pluggable Storage Engines
Memory, Index & Storage Management

MyISAM | InnoDB | Archive | Federated | Memory | Merge | Cluster | BDB | Custom

File System
NTFS – NFS
SAN - NAS

Files & Logs
Redo, Undo, Data, Index, Binary, Error, Query, and Slow

IT Team Roles and Responsibilities, pt. 1

- Managers
  - IT Business Managers - responsible for the purchase, installation, coordination and support of the information technology used by a business or organization
  - IT Project Manager - responsible for accomplishing the stated project objectives, and managing cost, time, scope, and quality
  - Business Systems Analysts - employee who examines the needs and concerns of clients and stakeholders to determine where potential problems and opportunities lie

IT Team Roles and Responsibilities, pt. 2

- Software and Security
  - Software Engineer - apply the principles of engineering to the design, development, maintenance, testing, and evaluation of the software and systems
  - Developer (Programmer) - is a person concerned with facets of the software development process. Their work includes researching, designing, implementing, and testing software
  - Security Analysts/Specialists - are responsible for maintaining the security and integrity of data

IT Team Roles and Responsibilities, pt. 3

- IT Administrators
  - Network Engineer - is an individual that is responsible for the maintenance of the computer network including the maintenance and monitoring of active data network or converged infrastructure and related network equipment (LAN/WAN)
  - Systems Engineer/Administrator - is a person who is responsible for the upkeep, configuration, and reliable operation of computer systems; especially multi-user computers, such as servers
  - Help Desk/Desktop Support
  - Database Administrator - next...

DBA Responsibilities in Detail, pt. 1

- Installing and upgrading the database server and application tools
- Allocating system storage and planning future storage requirements for the database system
- Modifying the database structure, as necessary, from information given by application developers
- Enrolling users and maintaining system security
- Ensuring compliance with database vendor license agreement
- Monitoring user access to the database

DBA Responsibilities in Detail, pt. 2

- Monitoring and optimizing the performance of the database
- Planning for backup and recovery of database information
- Maintaining archived data
- Backing up and restoring databases
- Contacting database vendors for technical support
- Generating various reports by querying from database as per need

Hardware

- Server failures directly impact a company's revenues, financial performance, productivity, and reputation
- The severity of a failure can range from not being able to back up data for a couple of days, to being out of business while the server is down
- The ultimate impact of server failure depends on how critical the application is to the organization

Oracle
SPARC T4-4 Server
4 x 8-Core, 3Ghz Sparc CPUs

High Availability and Fault Tolerance

- **Back-end** servers must have a high level of redundancy
- Use of more costly technologies, including hardware items such as:
  - Multiple power supplies
  - An Uninterruptible Power Supply (UPS)
  - Hot-swappable PCI slots
  - Hot-swappable hard disks
  - Multiple network cards
- **Fault tolerance** involves a server system's capability to successfully respond to a sudden software or hardware failure

RAID

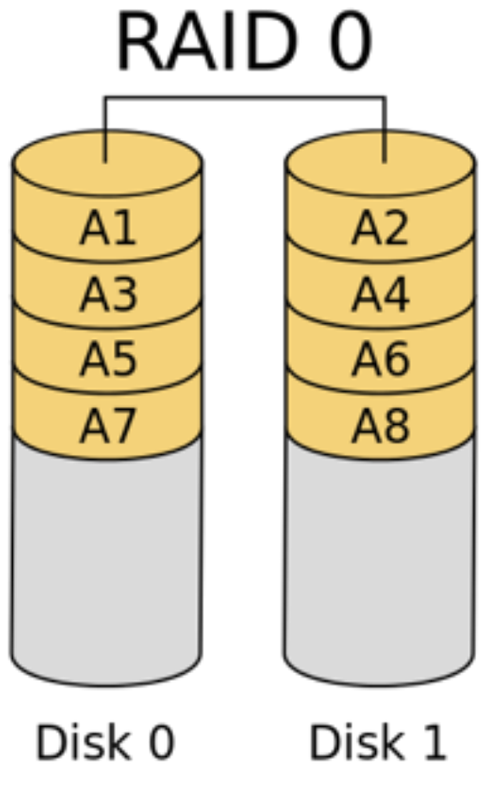
- Statistics about server component failures indicate that **50%** of server down-time can be attributed to **disk drive** failures
- RAID systems can simultaneously protect data and provide immediate online access to it, even when disks fail

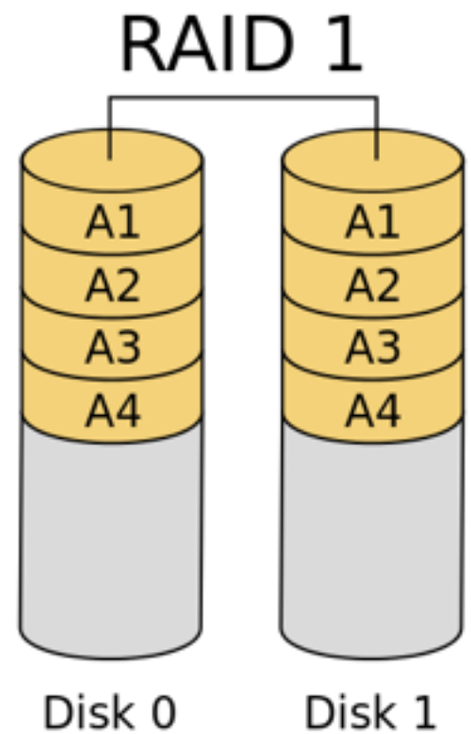
RAID, pt. 1

- **RAID level 0** (striping)—Improves performance but offers no redundancy

- **RAID level 1** (mirroring)—Provides simple redundancy, improving data reliability

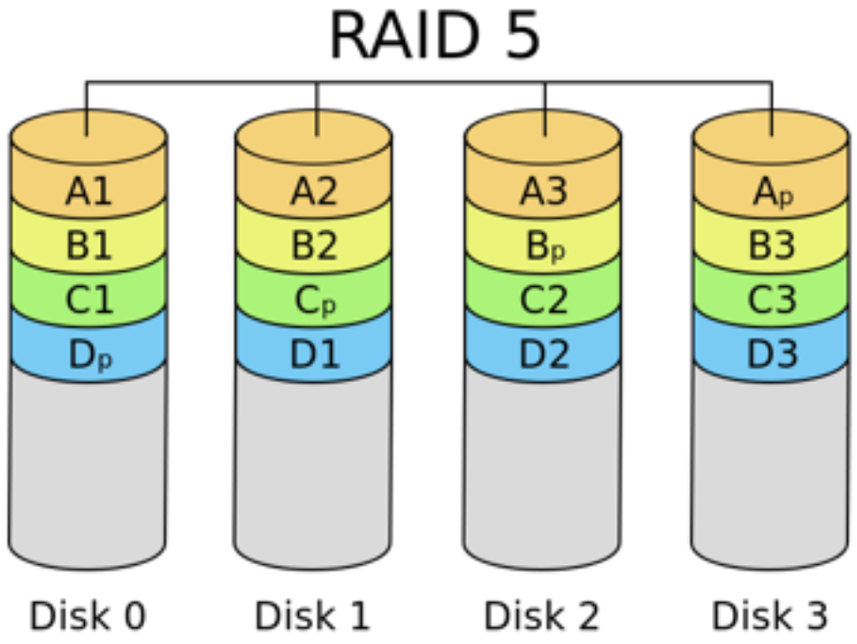
- **RAID level 10** (mirroring and striping)—A combination of RAID 1 and RAID 0 (also called RAID 1+0)



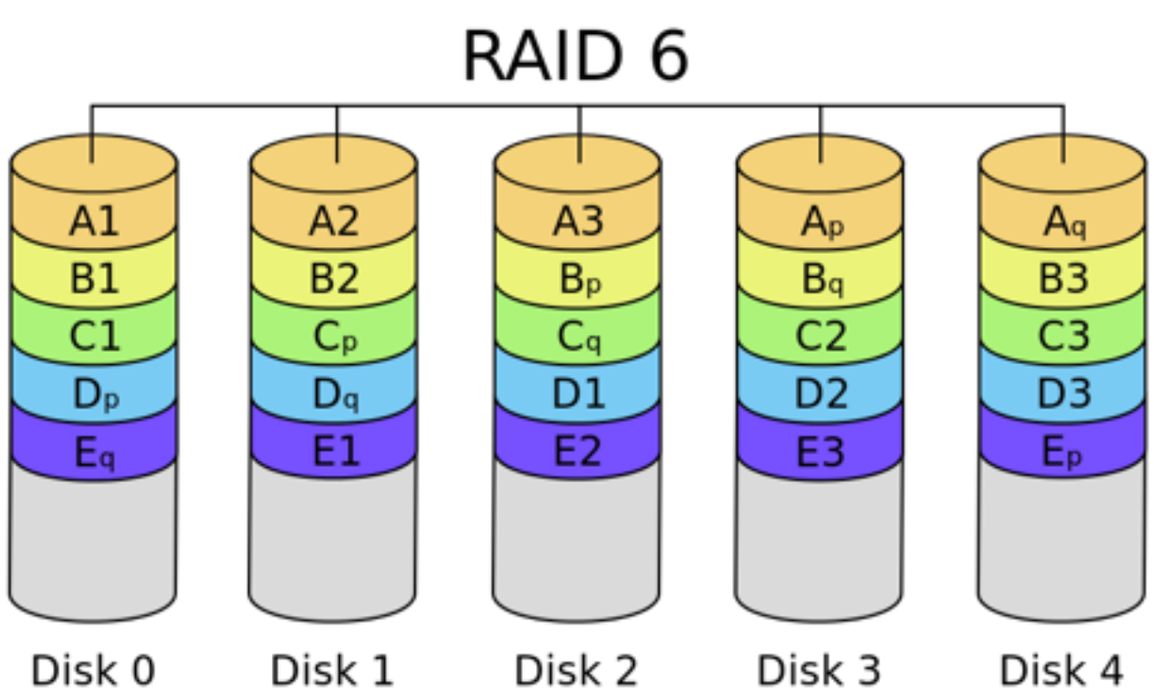


RAID, pt 2

- **RAID level 5** (disk striping with parity)—Provides redundancy and improves performance (most notably, read performance)



- **RAID level 6** (disk striping with double parity)—Improves upon level 5 RAID by protecting data when two disks fail at once



Scale Up/Out

- Two common methods are used to upgrade servers
- They are referred to as either scale up or scale out:
  - In a **scale-up** operation, components are added to the server computer, making it more powerful (CPU, Memory, Storage, etc.)
  - In **scale-out** operations, additional servers are installed, load-balancing techniques are implemented, and increased out-of-chassis redundancy is also employed
- Three primary factors that server system administrators take into account when deciding between scale-up or scale-out scenarios are capacity, reliability, and cost

Database Server Hardware

HP DL580 G7 Server
2 or 4 Intel Xeon 10-core or 8-core CPUs 2.40 GHz
2TB Maximum Memory
Quad Port 1Gb Ethernet Network Adaptor or Dual 10Gb Ethernet
HP Smart Array Controller w/ 1GB Cache
8 Hot plug SAS/SSD Drives (1TB SAS/800GB SSD)
Price Range $9000-40,000+USD
*Price w/ 4x10-core, 128GB RAM, 6x8GB SAS = $32,000USD

Datacenter

- A **data center** is a facility used to house computer systems and associated components, such as telecommunications and storage systems
- It generally includes redundant or backup power supplies, redundant data communications connections, environmental controls (e.g., air conditioning, fire suppression) and security devices

Microsoft

Google

SAN, pt. 1

- A **Storage Area Network (SAN)** is a high-speed subnetwork of shared storage devices, often nothing more complicated than a system unit containing a disk drive, or a number of disk drives, for storing data
- The SAN is connected through a server, or a cluster of servers, acting as access points for the clients
- **Block data** transfers over a SAN enjoy inherent performance advantages, and many commercial enterprises use SAN-attached disks for their mass storage requirements

HP EVA P6550 Dual Controller Fibre Channel Array (720TB)

SAN, pt. 2

- Usually uses **Fiber-channel** or **iSCSI (Ethernet)** network technology

- Out-of-band

- Centralized tape and disk backup systems

HP StoreEver MSL6480
500TB Capacity/80 Slot
8Gb Fiber-channel

Install

- A MySQL installation has two components:
  - A server that manages the data
  - Clients that ask the server to do things with the data
- Clients “MySQL Monitor” and “MySQL Administrator or Workbench”
- Integral part of the “LAMP” software stack
- You can get a performance increase of up to 30 percent and get the most recent updates if you compile the code with the ideal settings for your environment
- However, for this class class we’ll be using the packaged versions

MySQL Install on Centos/Fedora Linux

- yum install mariadb mariadb-server
- systemctl start mysqld.service
- systemctl enable mysqld.service
- mysql -u root

MySQL Client

- The most common way to access mysqld is through the command-line client tool mysql
- -u *username* or --user=user_name: *user_name*
- -p *password* or --password=*password*
- -h *hostname or ip_address* or --host= *hostname or ip_address*
- --protocol=*protocol* (most likely TCP)
- --compress
- --version or -V (Displays version info)

MySQL Client 2

- One common use of mysql is to execute a non-interactive batch file of SQL queries.

- mysql < sakila-schema.sql

- mysql < sakila-data.sql

- f or --force

- Another way to run a batch file of SQL queries is to use the **source** command within the mysql interactive shell

MySQL Admin

- The mysqladmin program is used to perform administrative tasks

Options	Description
create	create database
debug	sends debugging information to the error log
drop	drop database
flush-hosts, logs, privileges, tables, threads, and status	flushes cached data and writes to disk
kill	Kills client threads
password	Changes password
ping	Pings instance
start-slave, stop-slave	Starts and stops replication
processlist	Displays active threads
variables	Shows global variables and values

Options File

- Contains the configuration options for the mysql server, client, and other mysql programs
- The configuration for the server is in the [mysqld] section, client [mysql], etc…
- The system option file is **/etc/my.cnf** (Linux/Mac), <Windows_Directory>\my.ini (Win)
- The user option file is in your home directory (**~/.my.cnf**)
- To secure this file run chmod u=rw,g=,o= ~/.my.cnf
- So for example, to configure client to auto login for a user account
- [mysql]
  user=root password=the_mysql_root_password

MySQL Show Commands

- SHOW DATABASES;
- SHOW CREATE DATABASE *database_name*;
- SHOW COLUMNS FROM .... (table);

MySQL Storage Engines

Storage Engine	Transactional Support	Locking Level	Online Non-blocking Backup	Server Version(s) Available
MyISAM / Merge	No	Table	No	5.1, 6.0
InnoDB	Yes	Row	Yes	5.1, 6.0
MEMORY	No	Table	No	5.1, 6.0
Maria	Yes	Row	No	5.1, 6.0
Falcon	Yes	Row	Yes	6.0
PBXT	Yes	Row	Yes	5.1, 6.0
FEDERATED	No	Not applicable	Not applicable	5.1, 6.0
NDB	Yes	Row	Yes	5.1 up to 5.1.24; After that, available in MySQL Cluster
Archive	No	Row	No	5.1, 6.0
Blackhole	No	Not applicable	Not applicable	5.1, 6.0
CSV	No	Table	No	5.1, 6.0

InnoDB

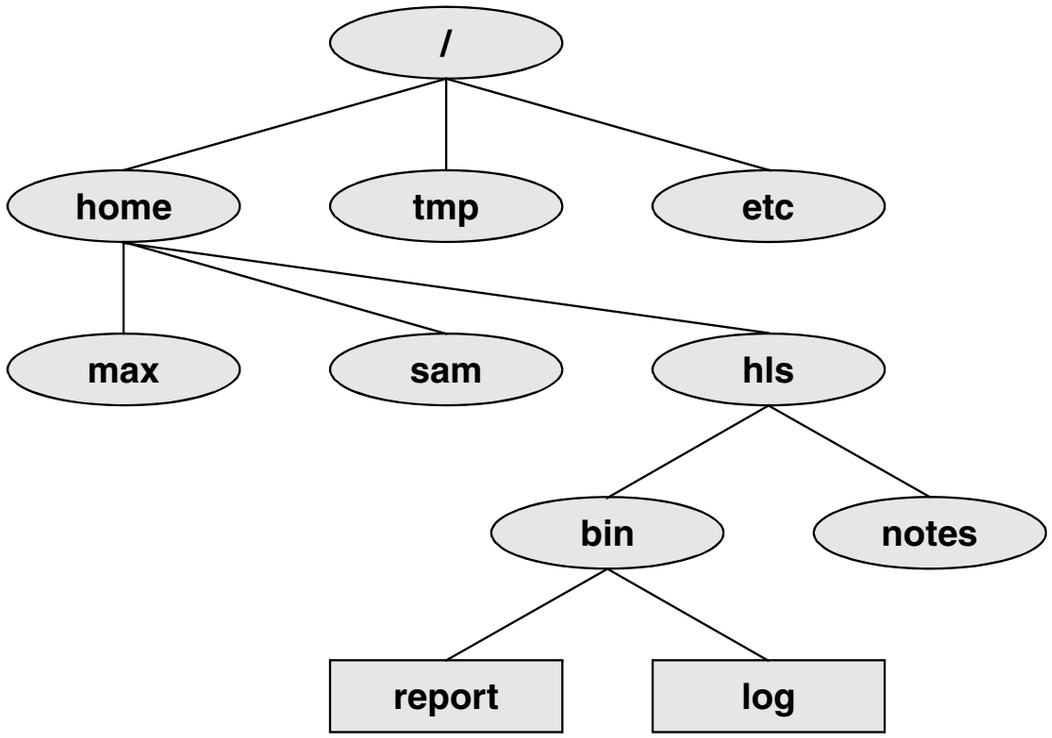
- The most widely used transactional storage engine is the InnoDB storage engine. InnoDB brought support for foreign keys to mysqld.
    - Transactional support provided by MVCC (Multi Version Concurrency Control)
    - Row-level locking
    - Foreign key support
    - Indexing using clustered B-tree indexes
    - Configurable buffer caching of both indexes and data
    - Online non-blocking backup through separate commercial backup program

InnoDB

- SHOW ENGINE InnoDB STATUS
    - used to provide detailed information about the workings of the InnoDB storage engine.
    - It shows information on Semaphores, Foreign key errors, Deadlocks, Transactions, File I/O, Insert buffer and adaptive hash index, Log, Buffer pool and memory, and Row operations

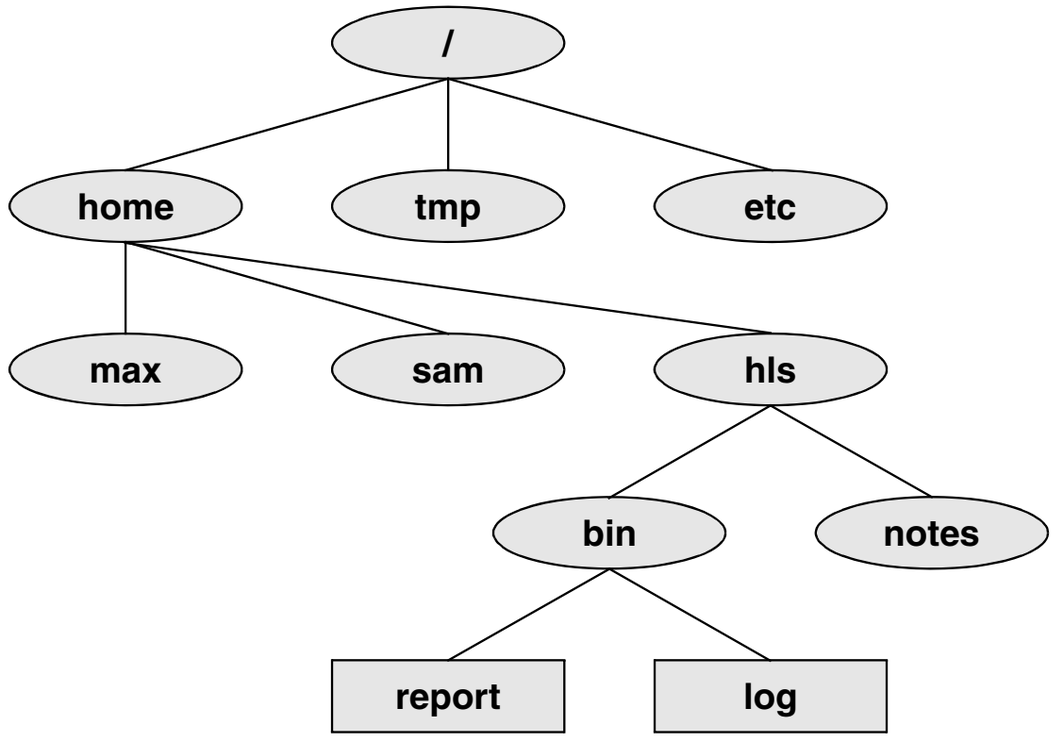
Linux File System, pt. 1

- The **Linux filesystem** provides a hierarchal structure whereby files are arranged under directories, which are like folders or boxes
- Each **directory** has a name and can hold other files and directories
- Security is provided by **file access permissions** (read, write, execute)
- **Access Control Lists** (ACL) give users and administrators finer-grained control over file access permissions



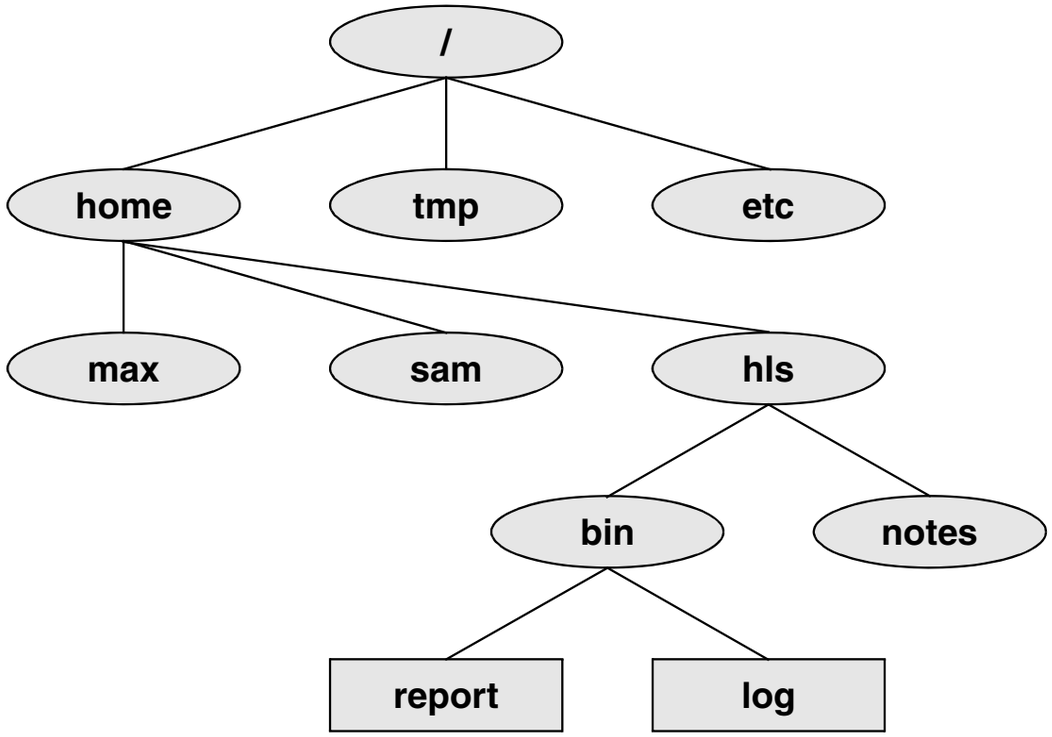
Linux File System, pt. 2

- In Linux, the single system namespace is rooted at /, which is the **root** directory
- Linux files can be a maximum of 255 characters long
- Can contain uppercase/lowercase letters (A-Z, a-z), numbers (0-9), underscore (_), period (.), or comma (,)
- No two files in same directory can have the same name
- Hidden files and directories begin with “.”, i.e. .ssh, .bash_profile
- Linux is case-sensitive



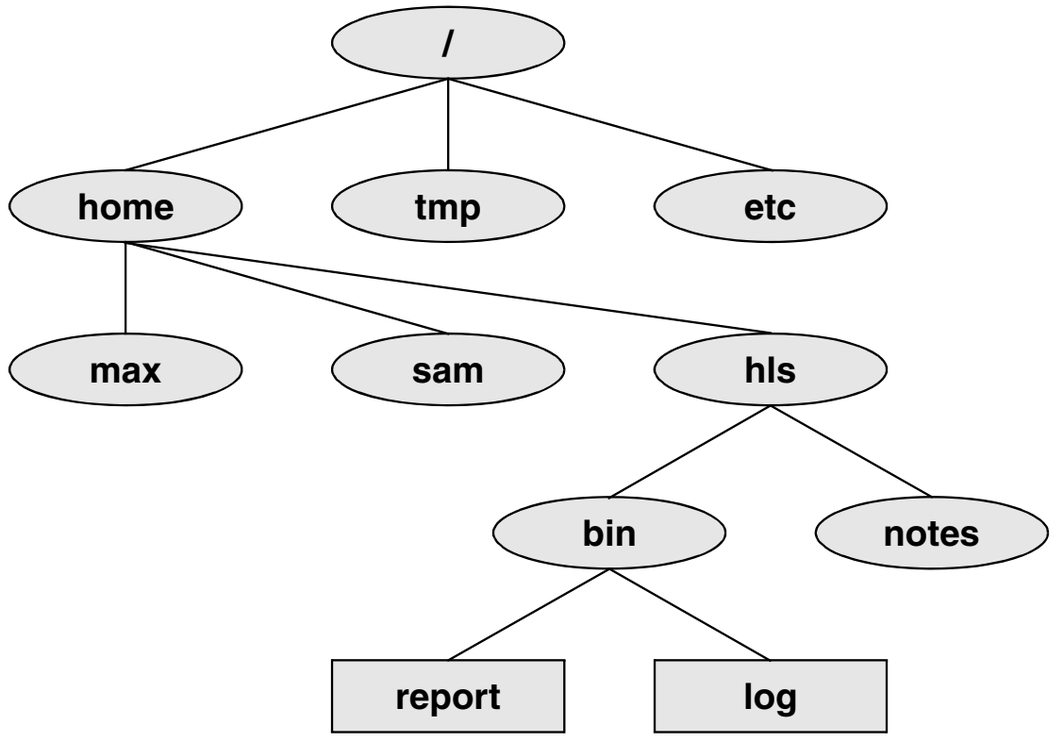
Linux File System, pt. 3

- The **pwd** command shows your current directory
- After logging in, users are placed into their home directory
- “~” with a path name refers to the current users home directory (ie. ~/notes is the same as /home/his/notes)
- Relative vs. Absolute path names
- “.” refers to current directory and “..” to the parent directory



Linux File System, pt. 4

- A **inode** data structure defines a file's existence and is identified by an inode number
- An **inode** contains critical information about a file, such as the UID of the owner, where it is physically located on the disk, and how many hard links point to it



Directory Commands

Usage	Description	Popular Options
pwd	Show the current working directory	
mkdir folder [folder 2..]	Create one or more directories	-p (create parents)
cd path	Change the current working directory	~ (home dir.), - (previous dir.)
rmdir directory	Remove empty directory	
touch file	Create and empty file, update access time	

File Commands

Command	Description	Popular Options
cp source destination	Copies one for more files Examples: cp -va /home/lisa /srv/nfs	-R (recursive), -a (archive), -v (verbose)
file filename	Displays information about the contents of a file	
rm file	Removes a file or folder	-i (interactive), -R (recursive), -f (force, no questions!)
less file	Pager to view the contents of text file	
mv source destination	Moves for renames files or directories	

Information and Location Commands

Usage	Description	Popular Options
man/info command	Command help	
apropos keyword	Searches for the keyword in the short description line of all man pages	
ls pathname	List files, ex. (ls -ltr)	-l (long listing), -a (hidden files), -R (recursive), -d (directories), -h (human readable), -t (sort by time), -r (reverse order) *ll same as ls -l
locate file	Searches for files on the local system via database	
find [path] file	Locate files	-name (search string), -iname
whereis/which command	Displays the full pathnames of a utility, source code, or man page	

Find

- find $HOME -name "*.html" -print
- find /bin -size +60 -type f -ls
- find /usr -type f -user $USER -perm +u=w
- find . -type f -exec file '{}' \;

Wildcards and Globbing

- The **question mark (?)** wildcard matches any single character in the name of an existing file
- The **asterisk (*)** wildcard matches any number of characters, including zero characters, in a filename
- A pair of **brackets[ ]** surrounding a list of characters causes the shell to match filenames containing the individual characters, A hyphen within brackets defines a range of characters within a character-class definition [a-z], [1-5]
- The process that the shell performs on these filenames is called **pathname expansion** or **globbing**, for example:

  ls -l a*

  ls report1?.txt

  ls report[123].txt or ls report[1-3].txt

Command Line Expansion

- The shell expands the comma-separated strings inside the **braces { }**

  $ cp /usr/local/src/C/{main,f1,f2,tmp}.c .

  mkdir backup_{1,2,3,4}

Archive and Compression Commands

Command	Description	Popular Options
tar	Creates or extracts files from an archive file Examples: tar jvcf all_etc.`date +%F`.tar.bz2 /etc	x (extract), c (create), j (bzip2), z (gzip), t (list), v (verbose), f (file)
cpio	Creates or extracts archives Examples: find /bin -print | cpio -o > bin.cpio.bak	-o (output), -i (input)
bzip2, bunzip2, bzcat	Returns a file compressed with bzip2 to its original size and format	-k (keep original)
gzip, gunzip, zcat	compress file	-c
zip, unzip	zip archives compatible with Windows	

Communication and Misc. Commands

Command	Description	Popular Options
date	Displays the current date and time	+%F, +%T

Command History

- The **history** mechanism maintains a list of recently issued command lines in a file (**~/.bash_history**)
- Enter the command **history** to display the events in the history list
- !!, !*num*, !-*num*, !string, !?string? will also run previous commands

User Management 1

- The **system-config-users** utility displays the User Manager window and enables you to add, delete, and modify system users and groups

- To display the User Manager window, enter **system-config-users** on a command line or select **Main menu: Applications->Other->Users and Groups** or **Main menu: System->Administration->Users and Groups** (RHEL)

User Management 2

- The **useradd** utility adds a user account to the system (adds entries to the /etc/passwd and /etc/shadow files)
  - useradd -g 1105 -c "Max R." max
- Based on the **/etc/login.defs** and **/etc/default/useradd** files, useradd creates a home directory for the new user
- When doing so, it copies the contents of **/etc/skel** to that directory.
- The **userdel** utility deletes a user account (—remove (–r) option removes the home directory)
  - userdel --remove max
- **usermod** to make changes to an account
  - usermod -G wheel user
- The **passwd** utility is used to change passwords
  - passwd lisa

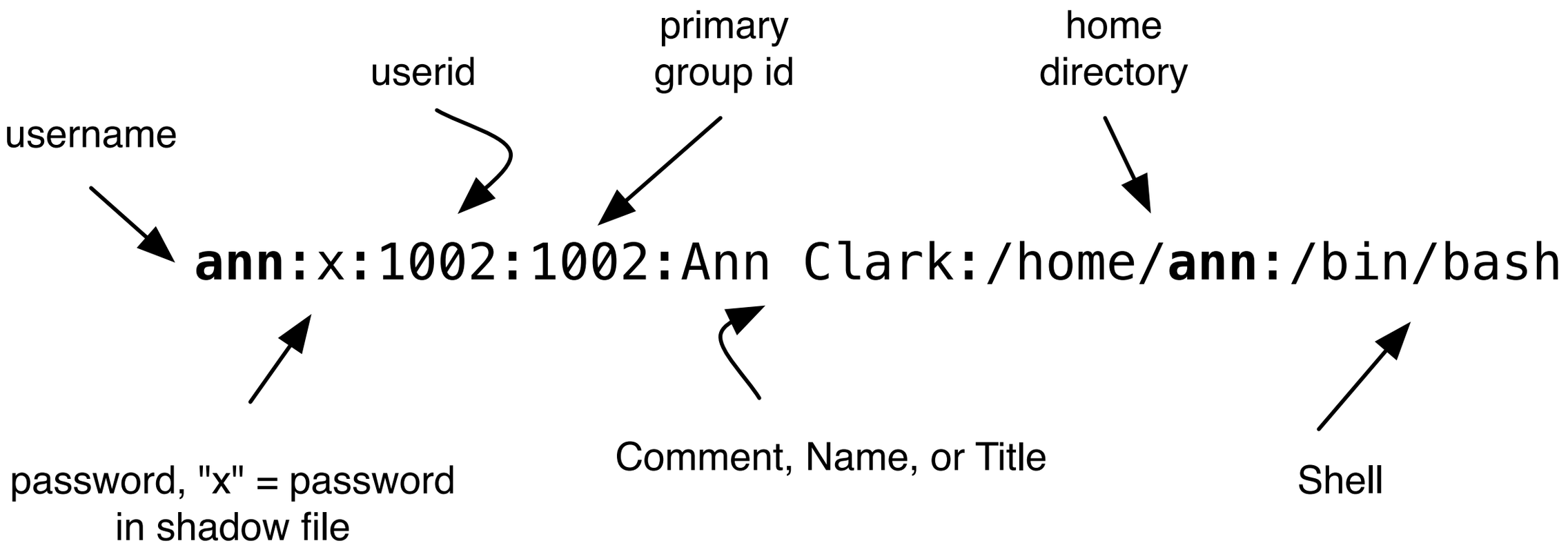
User Management 3

- Use **chage** to view and modify account expiry information; **–l** option displays information about password expiration and the **–E** option changes the date an account expires
  - chage -E "12/31/10" max
- **groupadd** adds a new group by adding an entry to /etc/group (use the –g option to assign a group ID)
  - groupadd -g 1024 pubs
- **groupdel** deletes groups and **groupmod** modifies groups
  - groupmod -g 1025 pubs
  - groupmod -n manuals pubs
- **gpasswd** allows you change membership of groups
  - gpasswd -a mary projects

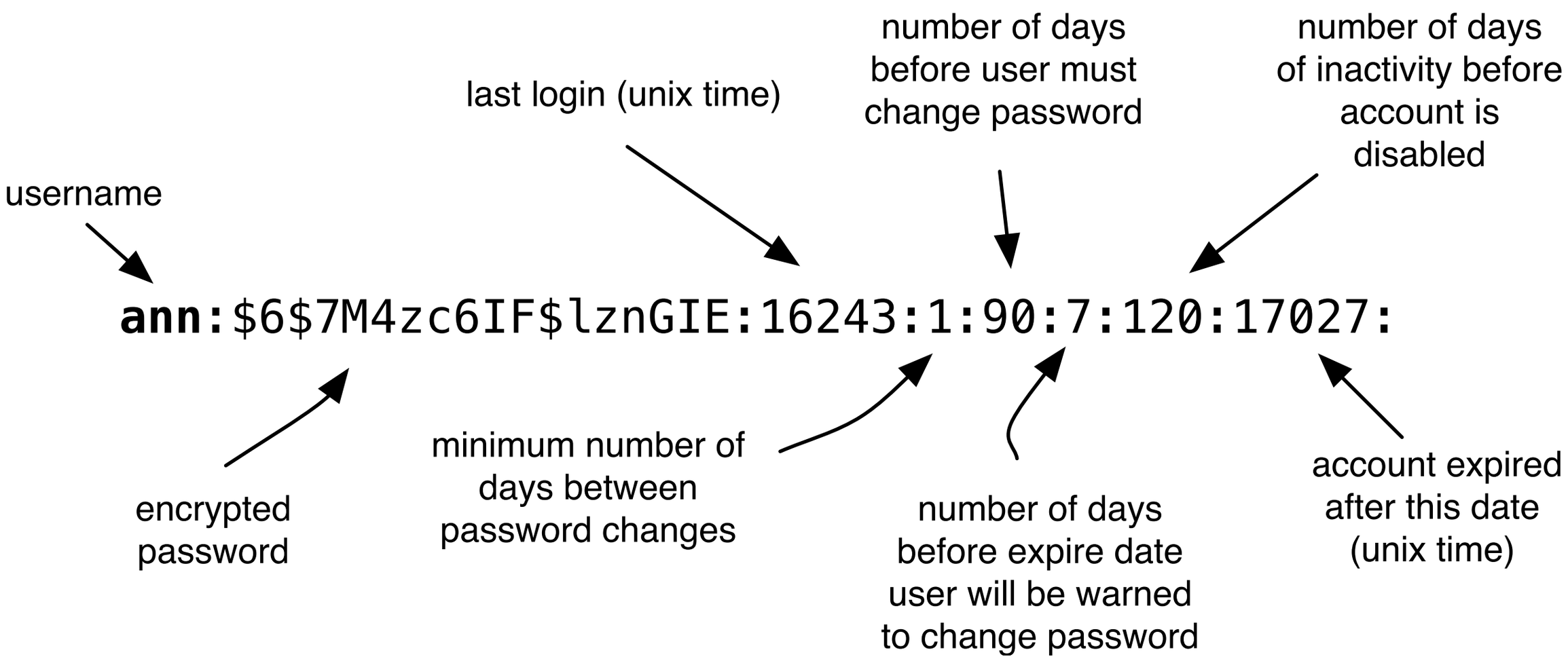
Important Files

- **/etc/passwd** - users on the system
- **/etc/group** - file associates one or more usernames with each group (number)
- **/etc/shadow** - hashed user passwords, depending on system configuration

/etc/passwd


username
userid
primary group id
home directory
ann:x:1002:1002:Ann Clark:/home/ann:/bin/bash
password, "x" = password in shadow file
Comment, Name, or Title
Shell

/etc/shadow


username
last login (unix time)
number of days before user must change password
number of days of inactivity before account is disabled
ann:$6$7M4zc6IF$lznGIE:16243:1:90:7:120:17027:
encrypted password
minimum number of days between password changes
number of days before expire date user will be warned to change password
account expired after this date (unix time)

Root User

- Linux restricts certain privileges that are powerful enough to cause damage to a **super user** or **root user**
- By default the root can:
  - Add new users and groups,
  - Partition hard drives and
  - Change system configuration files
  - Read, write, and execute all files
  - Examine and work in all directories
- Some distributions (including Fedora) lock the root account by not assigning a root password (unlock by running: sudo passwd root)

Basic Security

Command	Description	Popular Options
sudo	gain root or other users privileges using your password	-s, -i, -u user
su -	gain root or other users privileges using root or other users password	-c

Su

- **su (username) –c** “command”
- **su –** (**–l** or **—login**)
- Root is assumed if don’t specify user
- No auditing by default

Sudo 1

- The **sudo** utility logs all commands it executes and the username of a user who issues an **sudo** command in **/var/log/secure**
- The sudo utility allows implementation of a finer-grained security policy than does the use of su and the root account
- Privileges for sudo are set in the **/etc/sudoers** file

Sudo 2

- Only use the **visudo** command to edit this file
- Sudo asks for your password when you first use it (5 minutes of privileges)
  - –l option checks which commands sudo will allow a user to run
  - –i spawns a new root shell
  - –s spews a shell without modifying the current environment and variables

Sudoers File 1

- The format of a line in the **/etc/sudoers** file:
  - *user_list host_list = [(runas_list)] command_list*
- **user_list**: usernames, groups (prefixed with %), user aliases, or ALL (all users)
- **host_list**: one or more hostnames, IP addresses, host aliases, or ALL
- **runas_list**: usernames, groups (prefixed with %), user aliases, or ALL (when sudo is called with the –u option)
- **command_list:** specifies a comma-separated list of utilities, directories holding utilities, and command aliases

Sudoers File 2

- An **alias** in the sudoers file enables you to rename group users, hosts, or commands:
  - *alias_type alias_name = alias_list*
- **Alias_type** is the type of alias (User_Alias, Runas_Alias, Host_Alias, Cmnd_Alias), alias_name is the name of the alias (by convention in all uppercase letters)
- **Alias_list** is a comma-separated list of one or more elements that make up the alias

Sudoers File 3

- Preceding an element of an alias with an exclamation point (!) negates it
    - User_Alias OFFICE = zach, sam, sls
    - Runas_Alias SM = sam, sls
    - Host_Alias LCL = guava, plum
    - Cmnd_Alias BASIC = /bin/cat, /usr/bin/vi, /bin/df, /usr/local/safe/

Configure Network

- Configuration for each server system: IP address, network mask, gateway address, DNS server addresses, system hostname
- Right-click the **NetworkManager** applet to display a menu that allows you to configure networking (Graphical)
- Use **nmtui** to configure from the command line
- You can perform the same task by running **system-config-network** or by editing the appropriate configuration file in **/etc/sysconfig/network-scripts**
  - vi /etc/sysconfig/network-scripts/ifcfg-Auto_eth0

Lab

- Build a linux server using Virtual Box
- Connect to it using putty on windows or the terminal on Mac
- Install my MySQL Server rpm package

Homework

- Read Chapters 1-3 in “Learning MySQL”
- Do page 94, Exercises 1-4
- Do page 105, Exercises 1-4
- Read Chapter 1 in “High Performance MySQL”