information technology & management

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INTRO TO OPEN SOURCE OPERATING SYSTEMS

ILLINOIS INSTITUTE OF TECHNOLOGY

ITMO456

Configuring & Using Network Services

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ITMO/IT-O 456 Fall 2017

Information Technology & Management Programs

School of Applied Technology

Objectives

At the end of this lesson students should be able to:

- Describe Linux infrastructure network services, including DHCP, DNS, NTP, and NIS
- Describe Web services using the Apache Web server
- Describe files sharing services, including Samba, NFS, and FTP

Objectives

At the end of this lesson students should be able to:

- Describe basics of e-mail services such as Sendmail and Postfix
- Recall & describe database services associated with Linux

Infrastructure Services

- Infrastructure services: provide network configuration and support for other computers on a network
- Include:
  - DHCP
  - DNS
  - NTP
  - NIS

DHCP

- Dynamic Host Configuration Protocol
  - Automatically configures a network interface
- Send DHCP broadcast on network
  - Request IP configuration information
- DHCP server leases IP address to client computer for a period of time
  - Ensures each client has unique IP address
  - After expiration, must send another DHCP request

The DHCP Lease Process

- Involves several stages:
  - Client sends request to all hosts on network
  - DHCP server sends offer containing potential IP configuration
  - Client selects (accepts) offer
  - DHCP server sends acknowledgement indicating the amount of time client can use IP configuration
  - Client configures itself with IP configuration

The DHCP Lease Process

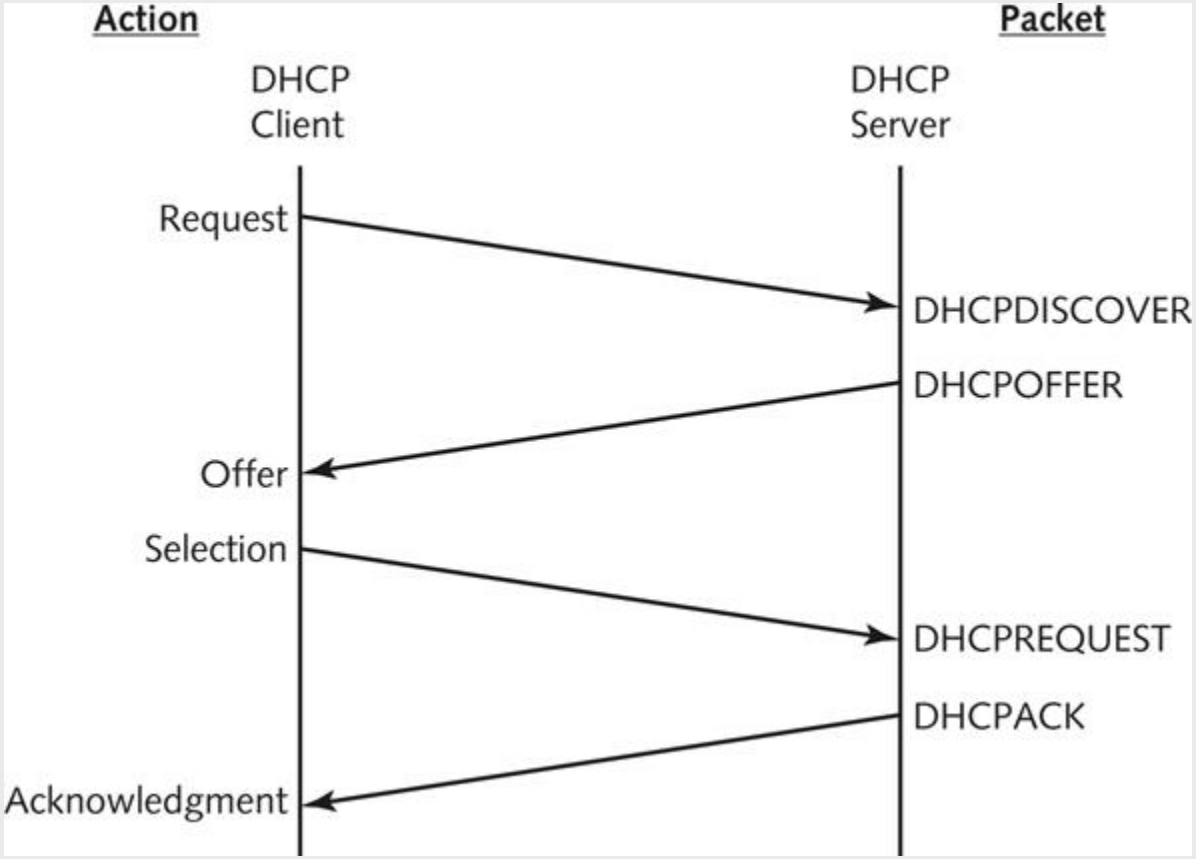


Figure 13-1: The DHCP lease process

Configuring a Linux DHCP Server

- Install DHCP daemon
  - Use **`yum install dhcp`** command
- The two most common DHCP daemons:
  - DHCP daemon (dhcpd)
  - BusyBox DHCP daemon (udhcpd)

Configuring a Linux DHCP Server

- Edit DHCP daemon configuration file to list appropriate IP address range for the network and lease information
  - **`/etc/dhcp/dhcpd.conf`** IPv4 config
  - **`/etc/dhcp/dhcpd6.conf`** IPv6 config
- **`systemctl start dhcp`**

  command: starts the DHCP daemon
- **`systemctl enable dhcp`**

Configuring a Linux DHCP Server

- Some Linux systems, including Ubuntu Server 14.04 use the udhcpd daemon
- To configure an Ubuntu Server 14.04:
  - Change the **DHCP_ENABLED="no"** line within the **/etc/default/udhcpd** file to read **"yes"** and save changes
  - Specify the appropriate IP address range and other IP configuration within the **/etc/udhcpd.conf**
  - Start **udhcpd**
    - Configure it to start at boot time

DNS

- Hierarchical namespace to identify computers on large TCP/IP networks
- Zone
  - Portion of DNS administered by one or more DNS servers
- Forward lookup
  - FQDN resolved to IP address
- Reverse lookup
  - IP address resolved to FQDN

The DNS Lookup Process

- When contacting a Web server using a web browser
  - Web browser performs forward lookup of FQDN to contact IP of Web server
  - Forward lookup performed by DNS servers
- Iterative query
  - Does not use top-level DNS servers
- Recursive query resolved with use of top-level DNS servers

Configuring DNS

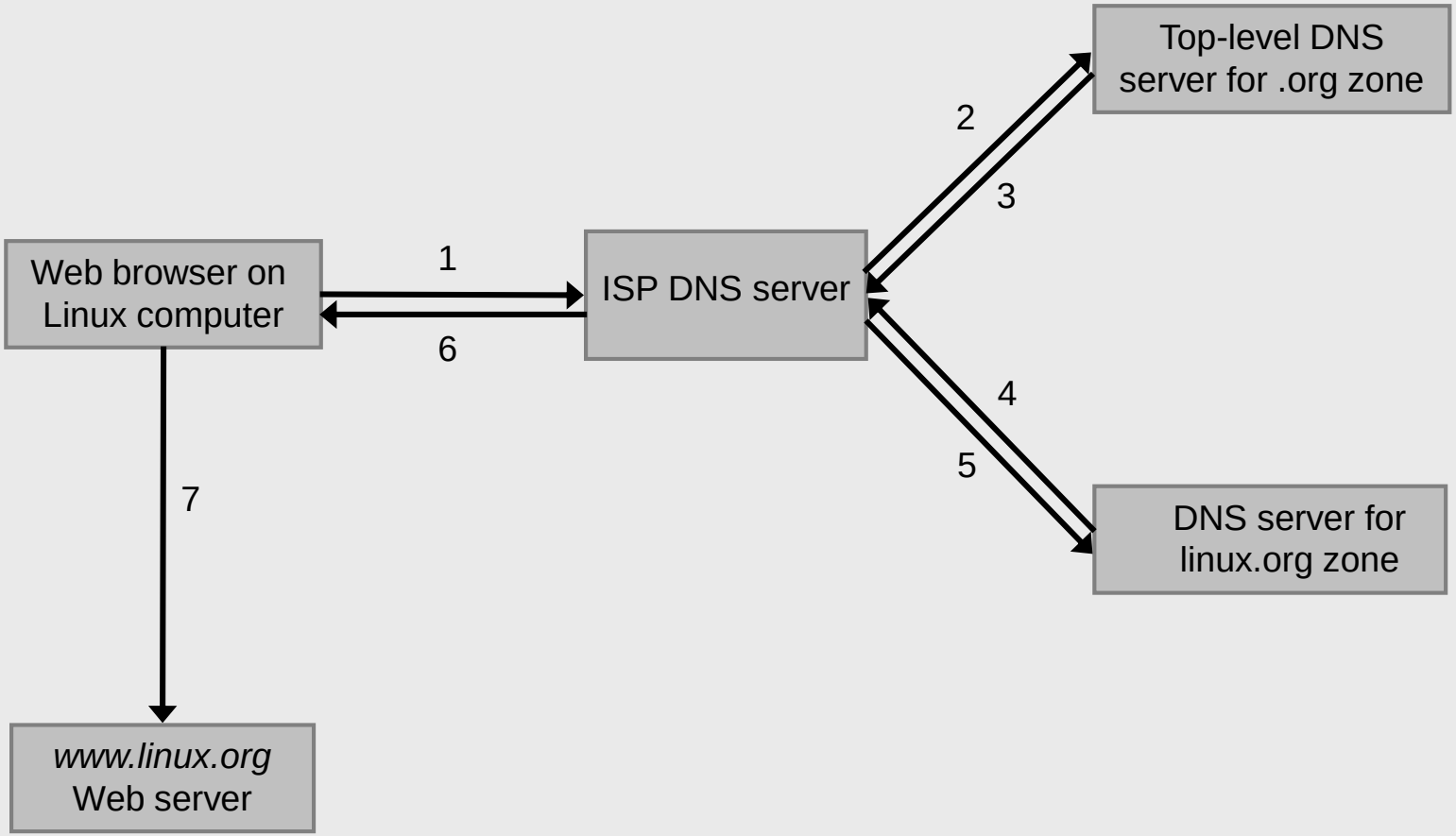


Figure 13-2: The DNS Lookup Process

Configuring DNS

- Master or primary DNS server
  - Contains read/write copy of zone
- Slave or secondary DNS server
  - Contains read-only copy of zone
- Zone transfer
  - Copying zone resource records from master to slave DNS server

Configuring a Linux DNS Server

- Configure DNS name daemon for a specific zone
  - Add resource records that list FQDNs and associated IP addresses for computers in that zone
- Configuration files have BIND format
  - Difficult to create manually
    - A graphical utility such as BIND configuration can aid in configuration

Configuring a Linux DNS Server

- Typically use Berkeley Internet Name Domain (BIND) server
- Implemented via the following packages:
  - **bind**
  - **bind-utils**
  - **bind-libs**
  - **bind-chroot** (for security)
- To configure:
  - Edit the **named.conf** file
  - Include Hostname-to-IP address mappings in **/var/named** zone files

Configuring a Linux DNS Server

- Start the DNS name daemon
  - Use **`systemctl start named`** command
- **`dig`**
  - Used to query records that exist on a specific DNS server

Configuring a Linux DNS Server


```
[root@itmo456 ~ ]# dig iit.edu

; <<>> DiG 9.9.4-P2-RedHat-9.9.4-18.P2.fc20 <<>> iit.edu
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 37870
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;iit.edu.                       IN      A

;; ANSWER SECTION:
iit.edu.                7200    IN      A       216.47.143.249

;; Query time: 119 msec
;; SERVER: 192.168.2.100#53(192.168.2.100)
;; WHEN: Mon Nov 16 13:48:04 CST 2015
;; MSG SIZE  rcvd: 52
```

Configuring DNS

Table 13-1: Common zone configuration files

File	Description
`/etc/named.conf`	Contains the list of DNS zones and their type (master/slave) that the name daemon will manage
`/var/named/zone_name.db` or `/var/named/zone_name.zone`	Contains resource records used to perform forward lookups for a particular zone_name. Lines in the file have a type that determines the type of resource record: • A (add host) records map FQDNs to IPv4 addresses. • AAAA (add host) records map FQDNs to IPv6 addresses. • CNAME (canonical name) records provide additional aliases for A records. • NS (name server) records provide the names of DNS servers for the zone. • MX (mail exchange) records provide the IP address of the e-mail server for a zone.

Configuring DNS

Table 13-1: Common zone configuration files

File	Description
/var/named/reverse-network-ID.in-addr-arpa or **/var/named/network-ID.db** or **/var/named/network-ID.zone**	Contains resource records of type PTR (pointer), which list names used for reverse lookups for a particular network. The network is incorporated into the filename itself; for example, the filename that contains PTR records for the 192.168.1.0 network could be called 192.168.1.db or 1.168.192.in-addr-arpa.
/var/named/named.local & /var/named/named.ip6.local or **/var/named/named.localhost** or **/var/named/named.loopback**	Contains a PTR records used to identify the loopback adapter (127.0.0.1 IPv4 or ::1 IPv6)
/var/named/named.ca or **/var/named/named.root**	Contains the IP addresses of top-level DNS servers; commonly called the DNS cache file.

Configuring a Linux DNS Server

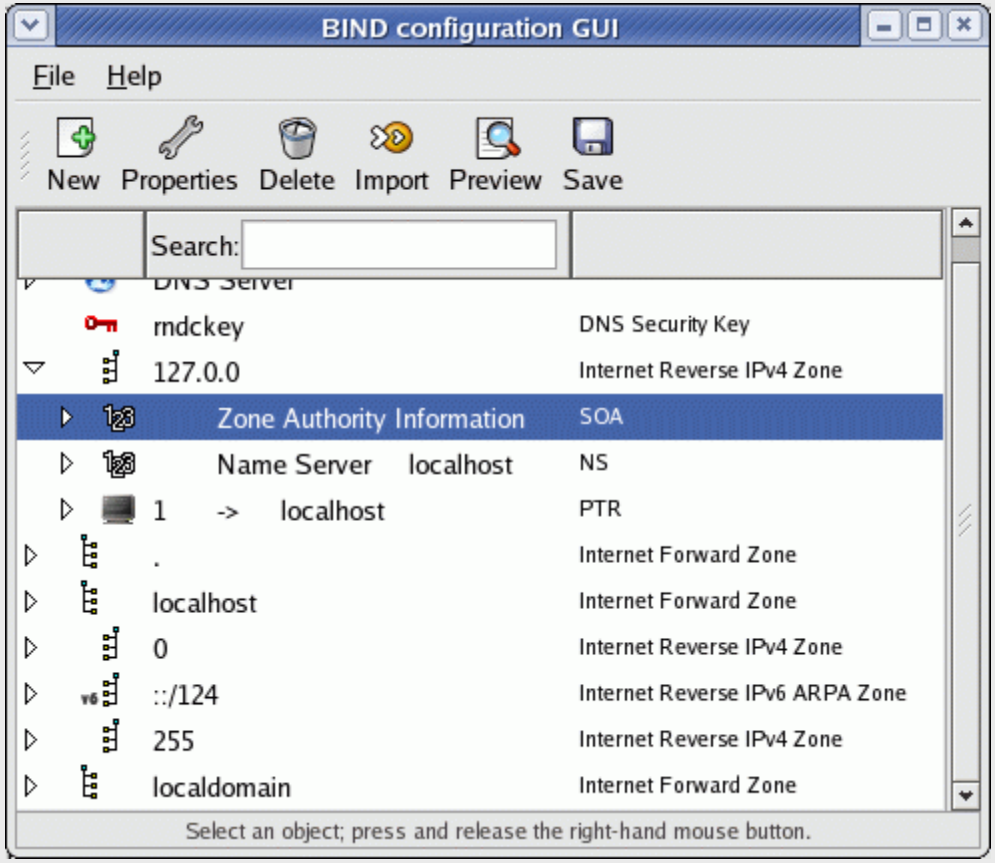


Figure 13-3: The BIND configuration utility

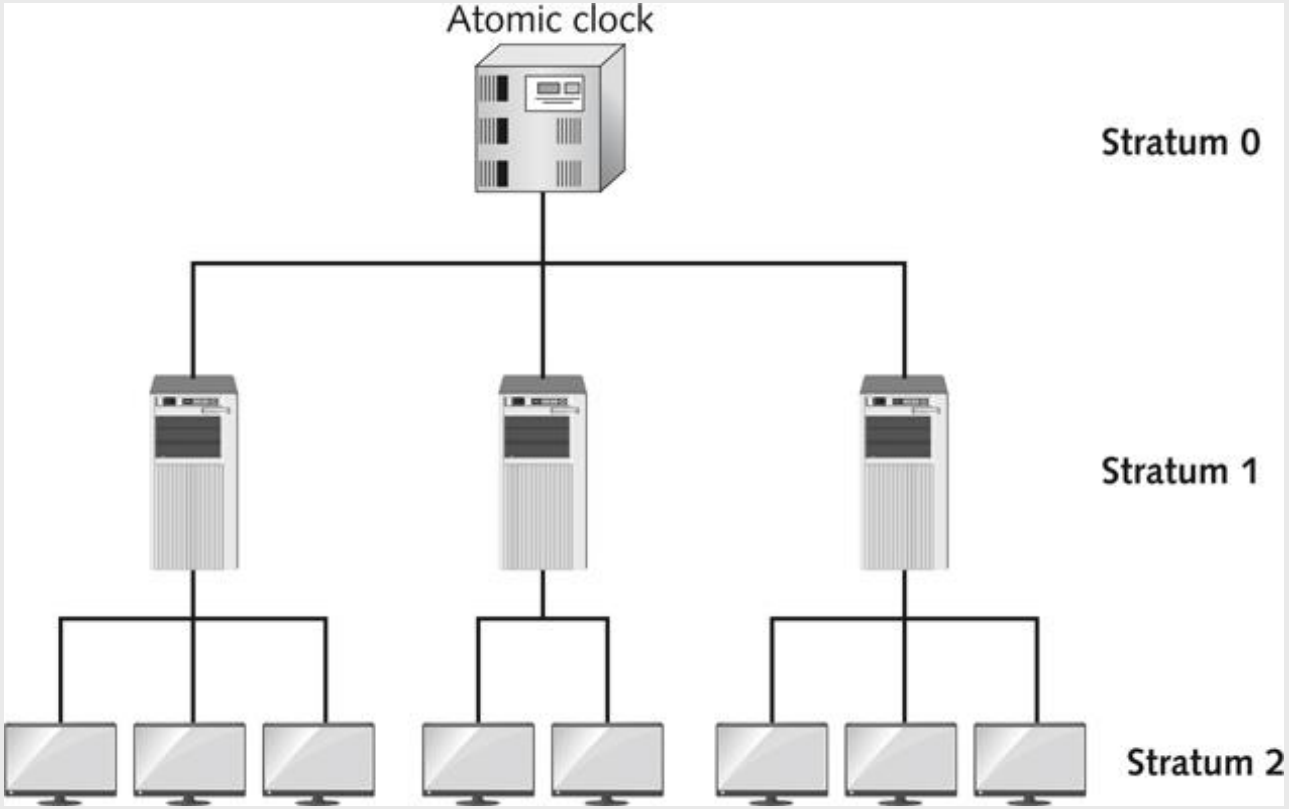
NTP

- Network Time Protocol (NTP)
  - Used by OS to obtain time information BIOS system clock or from network servers
  - Uses UDP port 123
- **`hwclock`**
  - Modifies BIOS date and time
- Two NTP daemons commonly used on Linux systems:
  - NTP daemon (**`ntpd`**)
  - Chrony NTP daemon (**`chronyd`**)

Understanding NTP Strata

- Strata
  - Hierarchical series of time resources used by NTP
  - Stratum 0: Atomic clock or GPS clock
  - Stratum 1: Obtain time directly from stratum 0 device
  - Stratum 2: Obtain time directly from stratum 1 device

Understanding NTP Strata



Understanding NTP Strata

- Stratum not an indication of quality or reliability
  - NTP servers obtain time information from multiple sources and use algorithm to determine most reliable time information

Configuring a Linux NTP Client

- **`ntpdate`**
  - Manually synchronize the time
- Offset
  - Time difference between time on local computer and time on time server
- **`ntpq`**
  - See what actual time servers system is synchronizing with

Configuring a Linux NTP Client

- Jitter Buffer
  - Stores the difference between the same time measurements from different NTP servers
  - Used by NTP when determining the most reliable time
  - `-p` option displays the offset and jitter
- **`tzselect`**
  - Change the time zone

Configuring a Linux NTP Client

- NTP – Network Time Protocol – allows clocks to be set to a distributed standard
  - Fedora 20 runs **`chronyd`** instead of **`ntpd`**
  - Use **`timedatectl`** to view time/date settings. NTP Settings in **`/etc/chrony.conf`**
  - Use the **`chronyc`** command to provide functionality that the **`ntpdate`** and **`ntpq`** commands do with **`ntpd`**

Configuring a Linux NTP Client

```
[root@itmo456 ~ ]# timedatectl status
      Local time: Sun 2015-10-25 20:23:46 CDT
  Universal time: Mon 2015-10-26 01:23:46 UTC
        RTC time: Mon 2015-10-26 01:23:46
        Timezone: America/Chicago (CDT, -0500)
     NTP enabled: yes
NTP synchronized: yes
 RTC in local TZ: no
      DST active: yes
 Last DST change: DST began at
                  Sun 2015-03-08 01:59:59 CST
                  Sun 2015-03-08 03:00:00 CDT
 Next DST change: DST ends (the clock jumps one hour backwards) at
                  Sun 2015-11-01 01:59:59 CDT
                  Sun 2015-11-01 01:00:00 CST
[root@itmo456 ~ ]# systemctl status chronyd
chronyd.service - NTP client/server
   Loaded: loaded (/usr/lib/systemd/system/chronyd.service; enabled)
   Active: active (running) since Sat 2015-10-24 15:07:20 CDT; 1 day 5h ago
  Process: 704 ExecStartPost=/usr/libexec/chrony-helper add-dhclient-servers (code=exited, status=0/SUCCESS)
  Process: 668 ExecStart=/usr/sbin/chronyd $OPTIONS (code=exited, status=0/SUCCESS)
 Main PID: 683 (chronyd)
   CGroup: /system.slice/chronyd.service
           └─683 /usr/sbin/chronyd

Oct 24 15:07:17 itmo456.iit.edu chronyd[683]: chronyd version 1.31.1 starting
Oct 24 15:07:19 itmo456.iit.edu chronyd[683]: Frequency -17.538 +/- 0.015 ppm read from /var/lib/chrony/drift
Oct 24 15:07:20 itmo456.iit.edu systemd[1]: Started NTP client/server.
Oct 24 15:07:43 itmo456.iit.edu chronyd[683]: Selected source 38.229.71.1
Oct 24 15:07:43 itmo456.iit.edu chronyd[683]: System clock wrong by 1.402094 seconds, adjustment started
Oct 24 15:07:45 itmo456.iit.edu chronyd[683]: Selected source 132.163.4.101
```

Configuring a Linux NTP Client

- NTP – Network Time Protocol – allows clocks to be set to a distributed standard
  - Ubuntu 14.04 comes with **`ntpdate`**
    - Ran once at boot to sync system clock
  - To install **`ntpd`**:
    - **`sudo apt-get install ntp`**
  - Configuration located in **`/etc/ntp.conf`**
  - Use **`ntpq`** to query more time information

Configuring a Linux NTP Client

```
root@itmo456-server:~# grep ^server /etc/ntp.conf
server 0.ubuntu.pool.ntp.org
server 1.ubuntu.pool.ntp.org
server 2.ubuntu.pool.ntp.org
server 3.ubuntu.pool.ntp.org
server ntp.ubuntu.com
root@itmo456-server:~# service ntp reload
root@itmo456-server:~# service ntp status
 * NTP server is running
root@itmo456-server:~# ntpq -p
     remote           refid      st t when poll reach   delay   offset  jitter
==============================================================================
 nisttime.carson .ACTS.           1 u    6   64    7   20.951  -10.290   1.634
 gopher.fart.web 106.61.18.129    3 u    5   64    7   76.068  -10.883  13.591
 clock.trit.net  69.36.224.15     2 u   10   64    7   74.980  -16.046   4.439
 leeloo.scurvyne 173.162.192.156  2 u   10   64    7   75.977   -8.491   3.316
 golem.canonical 193.79.237.14    2 u   13   64    7  103.466   -9.459   1.658
root@itmo456-server:~# _
```

NIS

- Network Information Service (NIS)
  - Coordinate common configuration files across several computers
  - Computers belong to an NIS domain, use NIS map to access configuration information
  - Commonly used to coordinate database files

NIS

- NIS master server
  - Sends all NIS map configuration to NIS slave servers
- NIS slave servers
  - Distribute maps to NIS clients

Configuring a NIS Server

- Install NIS server daemons via **`yum install ypserv rpcbind`** commands
- Define the NIS domain name via **`ypdomainname NIS_domain_name`** command
- Add **`NISDOMAIN="NIS_domain"`** to **`/etc/sysconfig/network`** file
  - Configure NIS domain at boot time

Configuring a NIS Server

- In the **`/var/yp/Makefile`** file, edit list of files to be made into maps
  - If no slave servers, ensure **`NOPUSH=true`**
- Add identification of allowed clients to **`/var/yp/securenets`** file
- Allow the allowed clients to access appropriate maps in **`/etc/ypserv.conf`**
- Generate configuration file maps by the **`/usr/lib/yp/ypinit –m`** command

Configuring an NIS Client

- Install **ypbind** and **rpcbind**
- Define the NIS domain name via **ypdomainname NIS_ domain_name**
- Edit **/etc/sysconfig/authconfig** to read **USENIS=yes**
- In **/etc/yp.conf** file, add, for each specific NIS server: **domain NIS_domain server NIS_server**
  - Alternatively add **domain NIS_domain broadcast**

Configuring an NIS Client

- Start the **`ypbind`** & **`rpcbind`** daemons
  - Set them to start at boot time
- Locate the NIS server with **`ypwhich`**
- Edit **`/etc/nsswitch.conf`** and add the keyword **`nis`** before other methods for user, group, and host name lookup
- Ensure all users on NIS clients use **`yppasswd`** to change their NIS password

Apache Web Server

- Most popular web server
  - Almost 55% of active websites use Apache
  - Serves more than 100 million websites
- Named out of respect for the Native American tribe Apache
  - Superior skills in warfare and strategy
- Apache is the name of the server
  - **`Httpd`** is the name of the Apache daemon

Apache Software Foundation

- Not-for-profit corporation formed in June 1999
- ASF grew out of the Apache Group, which was established in 1995 to develop the Apache server

Apache Features

- Server-side programming language support
  - Perl, Python, PHP and more
- Supports Modules
  - mod_ssl SSL/TLS Support
  - mod_secure Web Application Firewall
  - mod_gzip Reduce Content Size
- Virtual Hosts
  - Allows 1 Apache install to serve multiple sites

Installing Apache

- You can group install the Web Server group
  - **`yum groupinstall “Web Server”`**
  - Installs **`httpd, PHP, Perl, Python, Apache docs, SSL support, and mysql`**
- Minimal install would just be httpd
  - **`yum install httpd`**
- You will want to use a static IP for the server

Installing Apache

```
[root@itm456 ~]# yum group info "Web Server"
Loaded plugins: langpacks, refresh-packagekit

Environment Group: Web Server
 Environment-Id: web-server-environment
 Description: Server for serving static and dynamic internet content.
 Mandatory Groups:
   +core
   +hardware-support
   +standard
   +web-server
 Optional Groups:
   +guest-agents
   +haproxy
   +jbossas
   +mongodb
   +mysql
   +perl-web
   +php
   +python-web
   +rubyonrails
   +sql-server
   +tomcat
```

Allowing Access to Web Server

```
[root@itm456 ~]# firewall-cmd --add-port=80/tcp
success
[root@itm456 ~]# firewall-cmd --permanent --add-port=80/tcp
success
[root@itm456 ~]# firewall-cmd --add-port=443/tcp
success
[root@itm456 ~]# firewall-cmd --permanent --add-port=443/tcp
success
```

Starting Apache

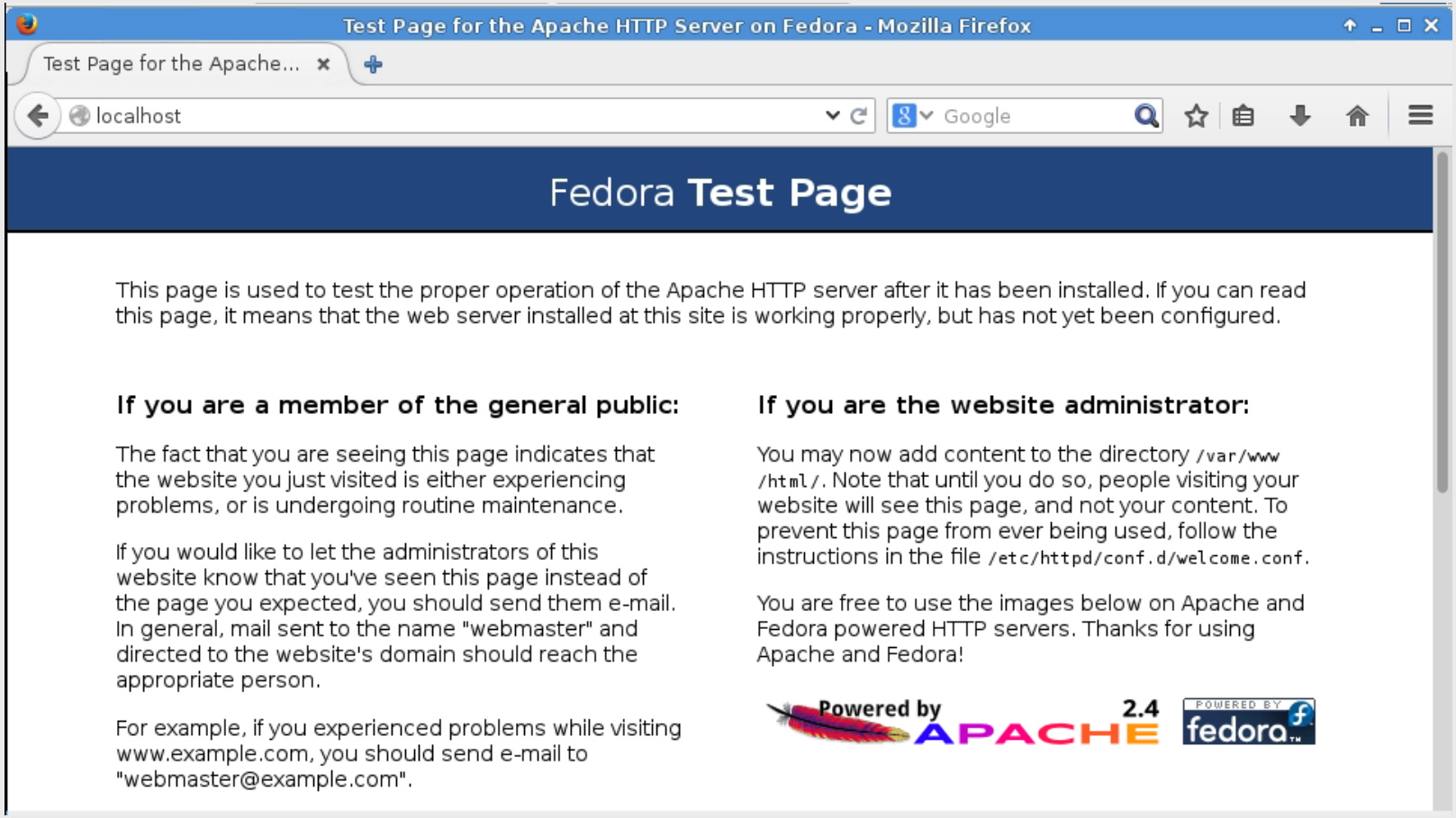
```
[root@itm456 ~]# systemctl status httpd
httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; disabled)
   Active: inactive (dead)

[root@itm456 ~]# systemctl enable httpd
ln -s '/usr/lib/systemd/system/httpd.service' '/etc/systemd/system/multi-user.target.wants/httpd.service'
[root@itm456 ~]# systemctl start httpd
[root@itm456 ~]# systemctl status httpd
httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; enabled)
   Active: active (running) since Wed 2014-11-05 11:19:47 CST; 2s ago
 Main PID: 12351 (/usr/sbin/httpd)
   Status: "Processing requests..."
   CGroup: /system.slice/httpd.service
           ├─12351 /usr/sbin/httpd -DFOREGROUND
           ├─12352 /usr/sbin/httpd -DFOREGROUND
           ├─12353 /usr/sbin/httpd -DFOREGROUND
           ├─12354 /usr/sbin/httpd -DFOREGROUND
           ├─12355 /usr/sbin/httpd -DFOREGROUND
           └─12356 /usr/sbin/httpd -DFOREGROUND

Nov 05 11:19:47 itm456.iit.edu systemd[1]: Started The Apache HTTP Server.
```

Starting Apache

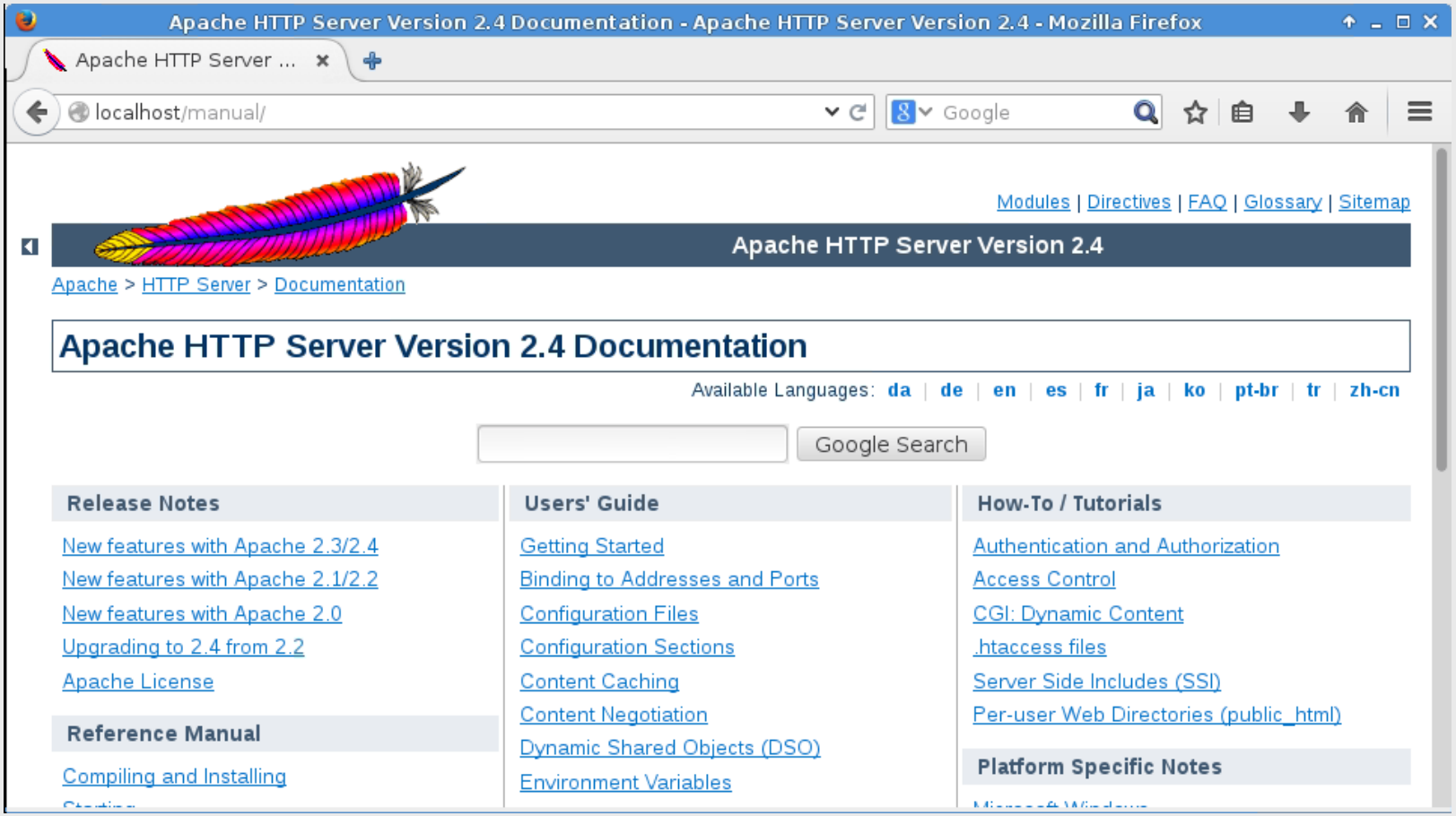
- Apache needs to start as root user to bind 80/443/Alt_Port
  - Apache then spawns processes as user/group Apache

```
[root@itm456 ~]# ps -ef | grep http
root      12351     1  0 11:19 ?        00:00:00 /usr/sbin/httpd -DFOREGROUND
apache    12352 12351  0 11:19 ?        00:00:00 /usr/sbin/httpd -DFOREGROUND
apache    12353 12351  0 11:19 ?        00:00:00 /usr/sbin/httpd -DFOREGROUND
apache    12354 12351  0 11:19 ?        00:00:00 /usr/sbin/httpd -DFOREGROUND
apache    12355 12351  0 11:19 ?        00:00:00 /usr/sbin/httpd -DFOREGROUND
apache    12356 12351  0 11:19 ?        00:00:00 /usr/sbin/httpd -DFOREGROUND
apache    12479 12351  0 11:36 ?        00:00:00 /usr/sbin/httpd -DFOREGROUND
apache    12487 12351  0 11:37 ?        00:00:00 /usr/sbin/httpd -DFOREGROUND
[root@itm456 ~]# netstat -lnp | egrep ":80|:443"
tcp6       0      0 :::80                   :::*                    LISTEN      12351/httpd
tcp6       0      0 :::443                  :::*                    LISTEN      12351/httpd
```

Testing Apache



Apache Manuals



Also located in **`/usr/share/httpd/manual`**

Apache Filesystem Layout

Binaries, scripts, and modules

The Apache server and related binary files are kept in several directories:

/usr/sbin/httpd—The Apache server (daemon).

/usr/sbin/apachectl—Starts and stops Apache.

/usr/bin/htpasswd—Creates and maintains the password files used by the Apache authentication module (page 972).

/usr/sbin/rotatelogs—Rotates Apache log files so that these files do not get too large. See logrotate (page 618) for more information.

/etc/httpd/modules—Holds module binaries. Two of the most frequently used module binary files are **mod_perl.so** (**mod_perl** package) and **mod_wsgi.so** (**mod_wsgi** package). This directory is a symbolic link to **/usr/lib64/httpd/modules** (page 968).

Configuration files

By default, **/etc/httpd** is the ServerRoot (page 955); all Apache configuration files are kept in this directory hierarchy, specifically in the **/etc/httpd/conf** and **/etc/httpd/conf.d** directories:

/etc/httpd/conf/httpd.conf—Holds configuration directives. This file is the main Apache configuration file. The discussion of configuration directives starts on the next page.

/etc/httpd/conf/magic—Provides *MIME* (page 1261) file type identification (the MIME hints file). It is not normally changed. See *magic number* (page 1259) for more information.

/etc/httpd/conf.d—Holds configuration files.

/etc/pki/tls/certs—Holds files and directories used by **mod_ssl** (page 970).

Apache Filesystem Layout

Logs Log files are kept in **/var/log/httpd** (there is a symbolic link at **/etc/httpd/logs**):

/var/log/httpd/access_log—Logs requests made to the server.

/var/log/httpd/error_log—Logs request and runtime server errors.

/var/log/httpd/ssl_*_log—Holds **mod_ssl** logs.

Web documents Web documents (including the Web pages displayed by client browsers), custom error messages, and CGI scripts are kept in **/var/www** by default:

/usr/share/httpd/error—Holds error documents in several languages. By default, Fedora/RHEL displays hardcoded error messages. See ErrorDocument (page 953).

/usr/share/httpd/icons—Holds icons used to display directory entries. This directory is aliased to **/icons/** in the **autoindex.conf** file.

/usr/share/httpd/manual—Holds the Apache Server Manual. Present only if the **httpd-manual** package is installed. This directory is aliased to **/manual/**.

/var/www/cgi-bin—Holds CGI scripts (page 969).

Document root By default, the document root (page 934) is **/var/www/html**. You can change this location using the DocumentRoot directive (page 942).

.htaccess files A **.htaccess** file contains configuration directives and can appear in any directory in the document root hierarchy. The location of a **.htaccess** file is critical: The directives in a **.htaccess** file apply to all files in the hierarchy rooted at the directory that holds the **.htaccess** file. You must use an AllowOverride directive to cause Apache to examine **.htaccess** files and process directives in those files. This protection is duplicated and enhanced in the **httpd.conf** file distributed by Fedora/RHEL, where a directive instructs Apache not to serve files whose names start with **.ht**. Because of this directive, Apache does not serve **.htaccess** files (nor does it serve **.htpassword** files).

Creating Group

- You may want to change the default group that is allowed to write to the **/var/www/html** directory

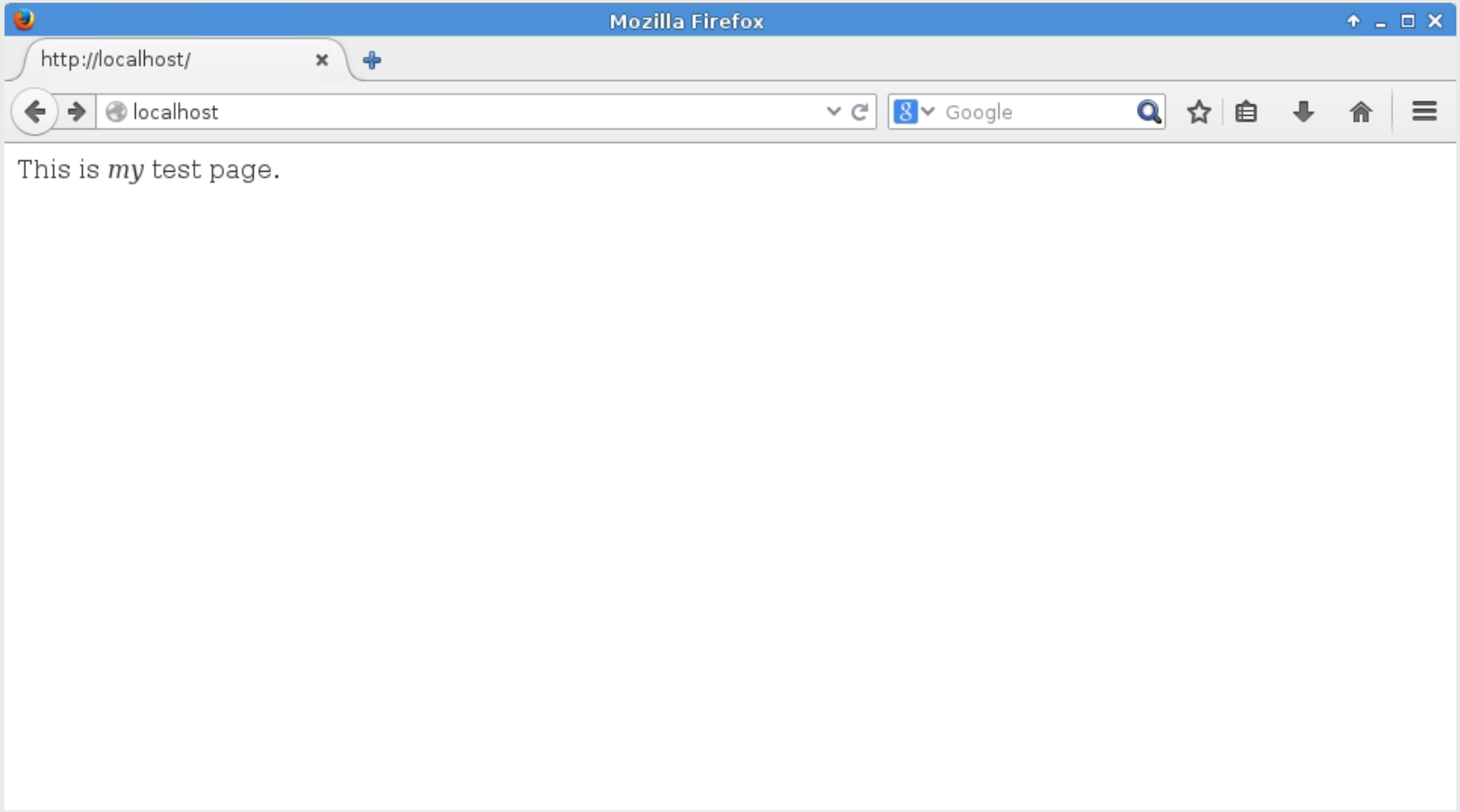
```
[root@itm456 ~]# ll -d /var/www/html/
drwxr-xr-x. 2 root root 4096 Sep  4 02:03 /var/www/html/
[root@itm456 ~]# groupadd webwork
[root@itm456 ~]# chmod 2775 /var/www/html/
[root@itm456 ~]# chown :webwork /var/www/html/
[root@itm456 ~]# ll -d /var/www/html/
drwxrwsr-x. 2 root webwork 4096 Sep  4 02:03 /var/www/html/
[root@itm456 ~]# usermod -aG webwork student
```

Creating Index.html

- By default in Fedora, there is no index.html located in **/var/www/html** directory
  - **/etc/httpd/conf.d/welcome.conf** contains redirect to **/usr/share/httpd/noindex/index.html**
- We will want to make our own index.html and place it in **/var/www/html**

```
[root@itm456 ~]# vi /var/www/html/index.html
[root@itm456 ~]# cat /var/www/html/index.html
<html><body><p>This is <i>my</i> test page.</p></body></html>
```

Creating Index.html



Configuration Directives

- Simply called, directives are lines in a config file that control some aspect of how Apache functions
  - Composed of keyword followed by one or more argument
  - Can be located in **`/etc/http/conf/ or /etc/http/conf.d/`**
  - **`Listen 80`**
  - **`Listen 443`**

Location of Config Files

```
[root@itm456 ~]# ll /etc/httpd/conf/
total 28
-rw-r--r--. 1 root root 11748 Nov  5 12:46 httpd.conf
-rw-r--r--. 1 root root 13077 Jul 23 05:36 magic
[root@itm456 ~]# ll /etc/httpd/conf.d/
total 48
-rw-r--r--. 1 root root 2893 Jul 23 05:35 autoindex.conf
-rw-r--r--. 1 root root  295 Jul 23 05:24 manual.conf
-rw-r--r--. 1 root root 1752 Aug  3  2013 perl.conf
-rw-r--r--. 1 root root  747 Oct 16 08:39 php.conf
-rw-r--r--. 1 root root  366 Jul 23 05:36 README
-rw-r--r--. 1 root root  296 Sep 12 06:00 squid.conf
-rw-r--r--. 1 root root 9426 Jul 23 05:24 ssl.conf
-rw-r--r--. 1 root root 1252 Jul 23 05:24 userdir.conf
-rw-r--r--. 1 root root  302 Aug 21 05:22 webalizer.conf
-rw-r--r--. 1 root root  516 Jul 23 05:24 welcome.conf
```

Configuring Apache

Directive	Description
`Listen 80`	Specifies that the Apache daemon will listen listen for HTTP requests on port 80
`ServerName server1.class.com`	Specifies that the name of the local server is server is server1.class.com
`DocumentRoot "/var/www/html"`	Specifies that the document root directory is directory is var/www/html on the local computer
`DirectoryIndex index.html`	Specifies that the index.html file in the document root directory will be sent to clients who request an HTML document
`ErrorLog /var/log/httpd/error_log`	Specifies that all Apache daemon messages messages will be written to the /var/log/httpd/error_log file

Table 13-2: Common httpd.conf directives

Configuring Apache

Directive	Description
`MaxClients 150`	Sets the maximum number of simultaneous requests to 150
`User apache`	Specifies that the Apache daemon will run as the “apache” local user account
`Group apache`	Specifies that the Apache daemon will run as the “apache” local group account

`<Directory /var/www/html>`
`Order allow,deny`
`Allow from all`
`Deny from 192.168.1.51`
`<Directory>`
	Specifies that all hosts are allowed to access HTML files and all other Web content from the /var/www/html directory except for the computer with the IP address 192.168.1.51

Table 13-2: Common httpd.conf directives

Contexts and Containers

- Contexts define where a config directive can appear

Table 26-1 Contexts

Context	Location(s) directives can appear
server config	In the **httpd.conf** file or included files only, but not inside <VirtualHost> or <Directory> containers (next section) unless so marked
virtual host	Inside <VirtualHost> containers in the **httpd.conf** file or included files only
directory	Inside <Directory>, <Location>, and <Files> containers in the **httpd.conf** file or included files only
.htaccess	In **.htaccess** files (page 939) only

- .htaccess can override settings configured in httpd.conf (unless **`AllowOverride None`** is set)

Contexts and Containers

- Containers are special directives that group other directives
  - **<Directory> . . . </Directory>**
  - **<Location> . . . </Location>**
  - **<VirtualHost> . . . </VirtualHost>**

Contexts and Containers Examples

- The below container does not allow .htaccess to override settings and denies all users from access to /

```
# Deny access to the entirety of your server's filesystem. You must
# explicitly permit access to web content directories in other
# <Directory> blocks below.
#
<Directory />
    AllowOverride none
    Require all denied
</Directory>
```

- The below container allows access the HTML dir

```
# Relax access to content within /var/www.
#
<Directory "/var/www">
    AllowOverride None
    # Allow open access:
    Require all granted
</Directory>
```

Context: server config, virtual host

Virtual Hosts

- Allows 1 instance of Apache to serve multiple websites

```
[root@itm456 ~]# cat /var/www/example.com/html/index.html
<html>
  <head>
    <title>Welcome to Example.com!</title>
  </head>
  <body>
    <h1>Success!  The example.com virtual host is working!</h1>
  </body>
</html>
[root@itm456 ~]# cat /var/www/test.com/html/index.html
<html>
  <head>
    <title>Welcome to Test.com!</title>
  </head>
  <body>
    <h1>Success!  The test.com virtual host is working!</h1>
  </body>
</html>
```

Virtual Hosts

- Now we modify **`httpd.conf`**

```
<VirtualHost *:80>
    ServerAdmin admin@example.com
    ServerName example.com
    ServerAlias www.example.com
    DocumentRoot /var/www/example.com/html
</VirtualHost>

<VirtualHost *:80>
    ServerAdmin admin@test.com
    ServerName test.com
    ServerAlias www.test.com
    DocumentRoot /var/www/test.com/html
</VirtualHost>
```

Virtual Hosts

- Add the following entries to **`/etc/hosts`**

```
[root@itm456 ~]# vi /etc/httpd/conf/httpd.conf
[root@itm456 ~]# cat /etc/hosts
127.0.0.1   localhost localhost.localdomain localhost4 localhost4.localdomain4
::1         localhost localhost.localdomain localhost6 localhost6.localdomain6
192.168.75.132 example.com
192.168.75.132 test.com
```

Virtual Hosts

Troubleshooting

- **`apachectl`** Command
  - Can be used to test config syntax
  - A front end to the **`httpd`** server
- Check status of httpd
  - **`systemctl status httpd`**
- Telnet to the port
  - **`telnet www.test.com 80`**

Troubleshooting

```
[root@itm456 ~]# apachectl configtest
Syntax OK
[root@itm456 ~]# systemctl status httpd
httpd.service - The Apache HTTP Server
   Loaded: loaded (/usr/lib/systemd/system/httpd.service; enabled)
   Active: active (running) since Wed 2014-11-05 13:49:21 CST; 11min ago
  Process: 13956 ExecStop=/bin/kill -WINCH ${MAINPID} (code=exited, status=0/SUCCESS)
 Main PID: 13962 (/usr/sbin/httpd)
   Status: "Total requests: 4; Current requests/sec: 0; Current traffic:   0 B/sec"
   CGroup: /system.slice/httpd.service
           ├─13962 /usr/sbin/httpd -DFOREGROUND
           ├─13963 /usr/sbin/httpd -DFOREGROUND
           ├─13964 /usr/sbin/httpd -DFOREGROUND
           ├─13965 /usr/sbin/httpd -DFOREGROUND
           ├─13966 /usr/sbin/httpd -DFOREGROUND
           ├─13967 /usr/sbin/httpd -DFOREGROUND
           └─13972 /usr/sbin/httpd -DFOREGROUND

Nov 05 13:49:21 itm456.iit.edu systemd[1]: Started The Apache HTTP Server.
[root@itm456 ~]# telnet www.test.com 80
Trying 208.64.121.188...
Connected to www.test.com.
Escape character is '^]'.
^]

telnet> quit
Connection closed.
```

Troubleshooting

- **`netstat -ln`**
  - Shows the ports that are listening
- **`tcpdump`**
  - Watch network traffic to ensure firewall is configured properly and traffic is coming to webserver
- **`ngrep`**
  - Similar to **`tcpdump`** but shows packet contents

Troubleshooting

```
[root@itm456 ~]# tcpdump -nni lo port 80 or port 443
tcpdump: verbose output suppressed, use -v or -vv for full protocol decode
listening on lo, link-type EN10MB (Ethernet), capture size 65535 bytes
14:09:57.387050 IP 192.168.75.132.46423 > 192.168.75.132.80: Flags [S], seq 2944464584, win 43690, options [mss 654
95,sackOK,TS val 13571435 ecr 0,nop,wscale 7], length 0
14:09:57.387085 IP 192.168.75.132.80 > 192.168.75.132.46423: Flags [S.], seq 2182070414, ack 2944464585, win 43690,
 options [mss 65495,sackOK,TS val 13571435 ecr 13571435,nop,wscale 7], length 0
14:09:57.387114 IP 192.168.75.132.46423 > 192.168.75.132.80: Flags [.], ack 1, win 342, options [nop,nop,TS val 135
71435 ecr 13571435], length 0
14:09:57.387192 IP 192.168.75.132.46423 > 192.168.75.132.80: Flags [P.], seq 1:365, ack 1, win 342, options [nop,no
p,TS val 13571435 ecr 13571435], length 364
14:09:57.387208 IP 192.168.75.132.80 > 192.168.75.132.46423: Flags [.], ack 365, win 350, options [nop,nop,TS val 1
3571435 ecr 13571435], length 0
14:09:57.387781 IP 192.168.75.132.80 > 192.168.75.132.46423: Flags [P.], seq 1:244, ack 365, win 350, options [nop,
nop,TS val 13571435 ecr 13571435], length 243
14:09:57.387792 IP 192.168.75.132.46423 > 192.168.75.132.80: Flags [.], ack 244, win 350, options [nop,nop,TS val 1
3571435 ecr 13571435], length 0
14:10:02.389347 IP 192.168.75.132.46423 > 192.168.75.132.80: Flags [F.], seq 365, ack 244, win 350, options [nop,no
p,TS val 13576437 ecr 13571435], length 0
14:10:02.389434 IP 192.168.75.132.80 > 192.168.75.132.46423: Flags [F.], seq 244, ack 366, win 350, options [nop,no
p,TS val 13576438 ecr 13576437], length 0
14:10:02.389448 IP 192.168.75.132.46423 > 192.168.75.132.80: Flags [.], ack 245, win 350, options [nop,nop,TS val 1
3576438 ecr 13576438], length 0
```

Troubleshooting

```
[root@itm456 ~]# ngrep -d lo port 80
interface: lo (127.0.0.0/255.0.0.0)
filter: ( port 80 ) and (ip or ip6)
####
T 192.168.75.132:46425 -> 192.168.75.132:80 [AP]
  GET / HTTP/1.1..Host: example.com..User-Agent: Mozilla/5.0 (X11; Linux i686; rv:32.0) Gecko/20100101 Firefox/3
  2.0..Accept: text/html,application/xhtml+xml,application/xml;q=0.9,*/*;q=0.8..Accept-Language: en-US,en;q=0.5.
  .Accept-Encoding: gzip, deflate..Connection: keep-alive..If-Modified-Since: Wed, 05 Nov 2014 19:37:56 GMT..If-
  None-Match: "a0-50721b76da6dc"..Cache-Control: max-age=0....
##
T 192.168.75.132:80 -> 192.168.75.132:46425 [AP]
  HTTP/1.1 304 Not Modified..Date: Wed, 05 Nov 2014 20:12:19 GMT..Server: Apache/2.4.10 (Fedora) OpenSSL/1.0.1e-
  fips PHP/5.5.18 mod_perl/2.0.9-dev Perl/v5.18.4..Connection: Keep-Alive..Keep-Alive: timeout=5, max=100..ETag:
   "a0-50721b76da6dc"....
```

Mod_ssl

- Enables SSL
  - Provides data encryption
  - Provides verification of identity
- You can use a self signed certificate to encrypt your traffic
  - Users can trust your identity but if this is a public site, you would want a signed certificate from VeriSign or similar

Mod_ssl

- **`/etc/httpd/conf.d/ssl.conf`**
  - This config file loads the mod_ssl module
  - Specifies public and private key files
- Generate certificates using the **`make`** command

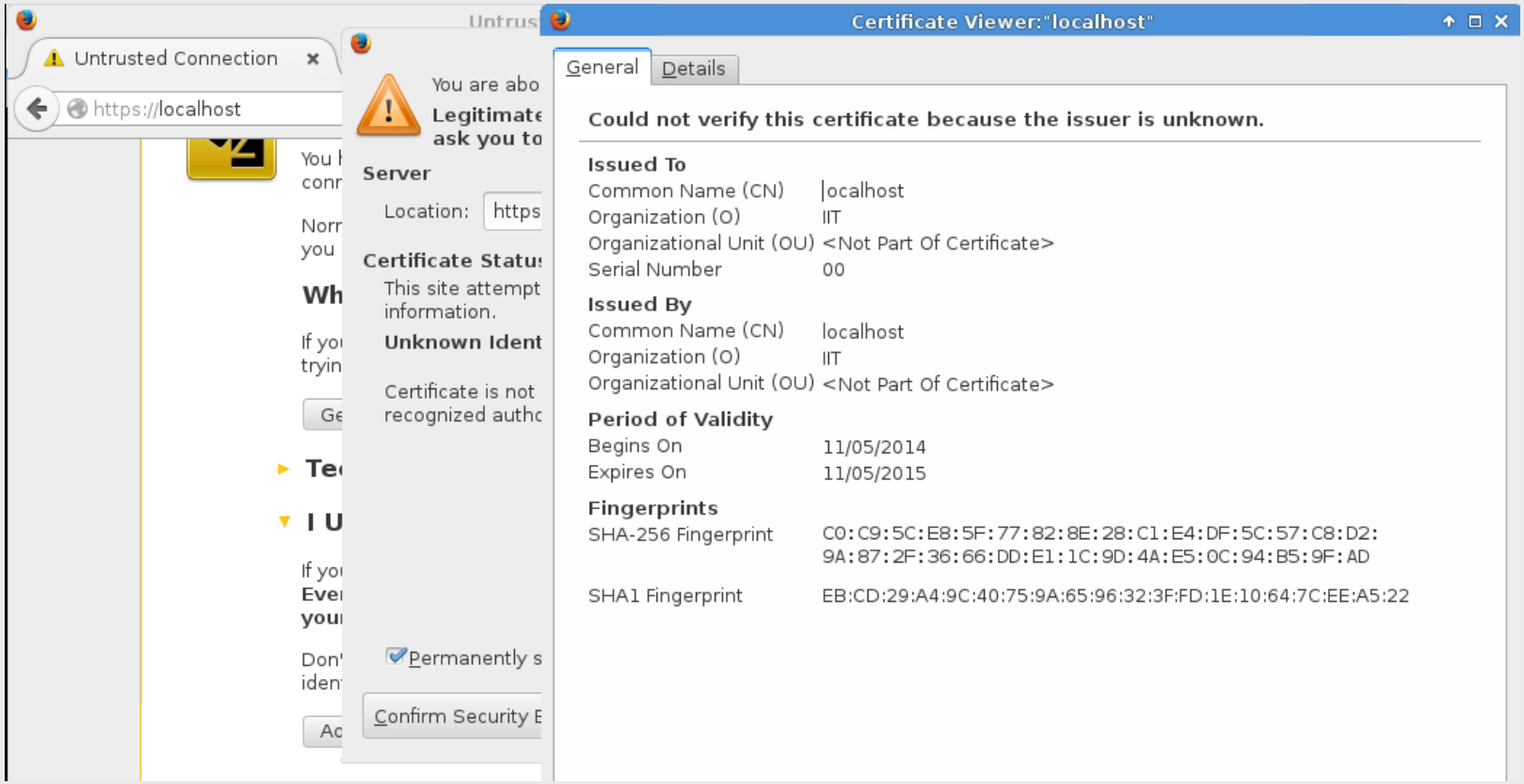
Mod_ssl

```
[root@itm456 ~]# grep -i '^sslcertificate' /etc/httpd/conf.d/ssl.conf
SSLCertificateFile /etc/pki/tls/certs/localhost.crt
SSLCertificateKeyFile /etc/pki/tls/private/localhost.key
[root@itm456 ~]# cd /etc/pki/tls/certs/
[root@itm456 certs]# make localhost.key
umask 77 ; \
/usr/bin/openssl genrsa -aes128 2048 > localhost.key
Generating RSA private key, 2048 bit long modulus
.................................+++
.....................................................+++
e is 65537 (0x10001)
Enter pass phrase:
Verifying - Enter pass phrase:
```

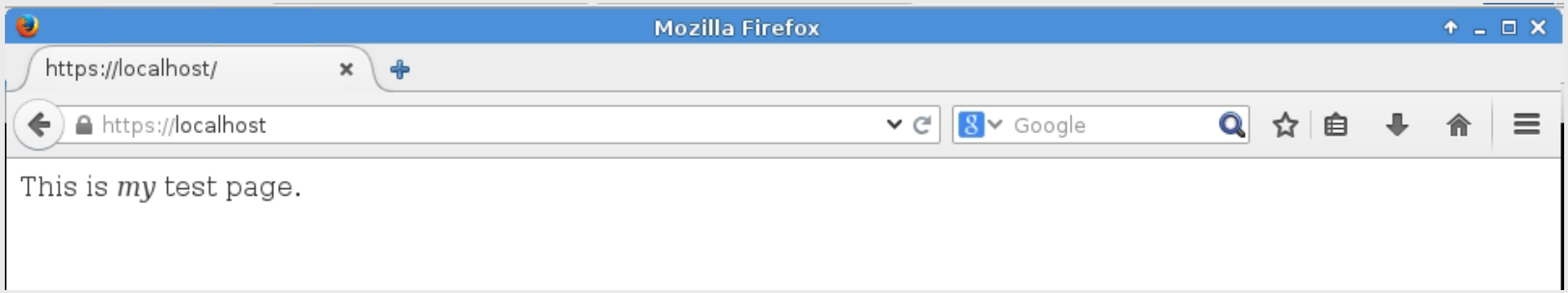
Mod_ssl

```
[root@itm456 certs]# make localhost.crt
umask 77 ; \
/usr/bin/openssl req -utf8 -new -key localhost.key -x509 -days 365 -out localhost.crt -set_serial 0
Enter pass phrase for localhost.key:
You are about to be asked to enter information that will be incorporated
into your certificate request.
What you are about to enter is what is called a Distinguished Name or a DN.
There are quite a few fields but you can leave some blank
For some fields there will be a default value,
If you enter '.', the field will be left blank.
-----
Country Name (2 letter code) [XX]:US
State or Province Name (full name) []:Illinis
Locality Name (eg, city) [Default City]:Chicago
Organization Name (eg, company) [Default Company Ltd]:Illinois Tech
Organizational Unit Name (eg, section) []:
Common Name (eg, your name or your server's hostname) []:localhost
Email Address []:root@localhost
```

Mod_ssl


Untrusted Connection
https://localhost
You are abo
Legitimate
ask you to
Server
Location:
https
Certificate Status
This site attempt
information.
Unknown Ident
Certificate is not
recognized authc
Permanently s
Confirm Security E
Certificate Viewer:"localhost"
General
Details
Could not verify this certificate because the issuer is unknown.
Issued To
Common Name (CN) localhost
Organization (O) IIT
Organizational Unit (OU) <Not Part Of Certificate>
Serial Number 00
Issued By
Common Name (CN) localhost
Organization (O) IIT
Organizational Unit (OU) <Not Part Of Certificate>
Period of Validity
Begins On 11/05/2014
Expires On 11/05/2015
Fingerprints
SHA-256 Fingerprint C0:C9:5C:E8:5F:77:82:8E:28:C1:E4:DF:5C:57:C8:D2:
9A:87:2F:36:66:DD:E1:1C:9D:4A:E5:0C:94:B5:9F:AD
SHA1 Fingerprint EB:CD:29:A4:9C:40:75:9A:65:96:32:3F:FD:1E:10:64:7C:EE:A5:22

Mod_ssl

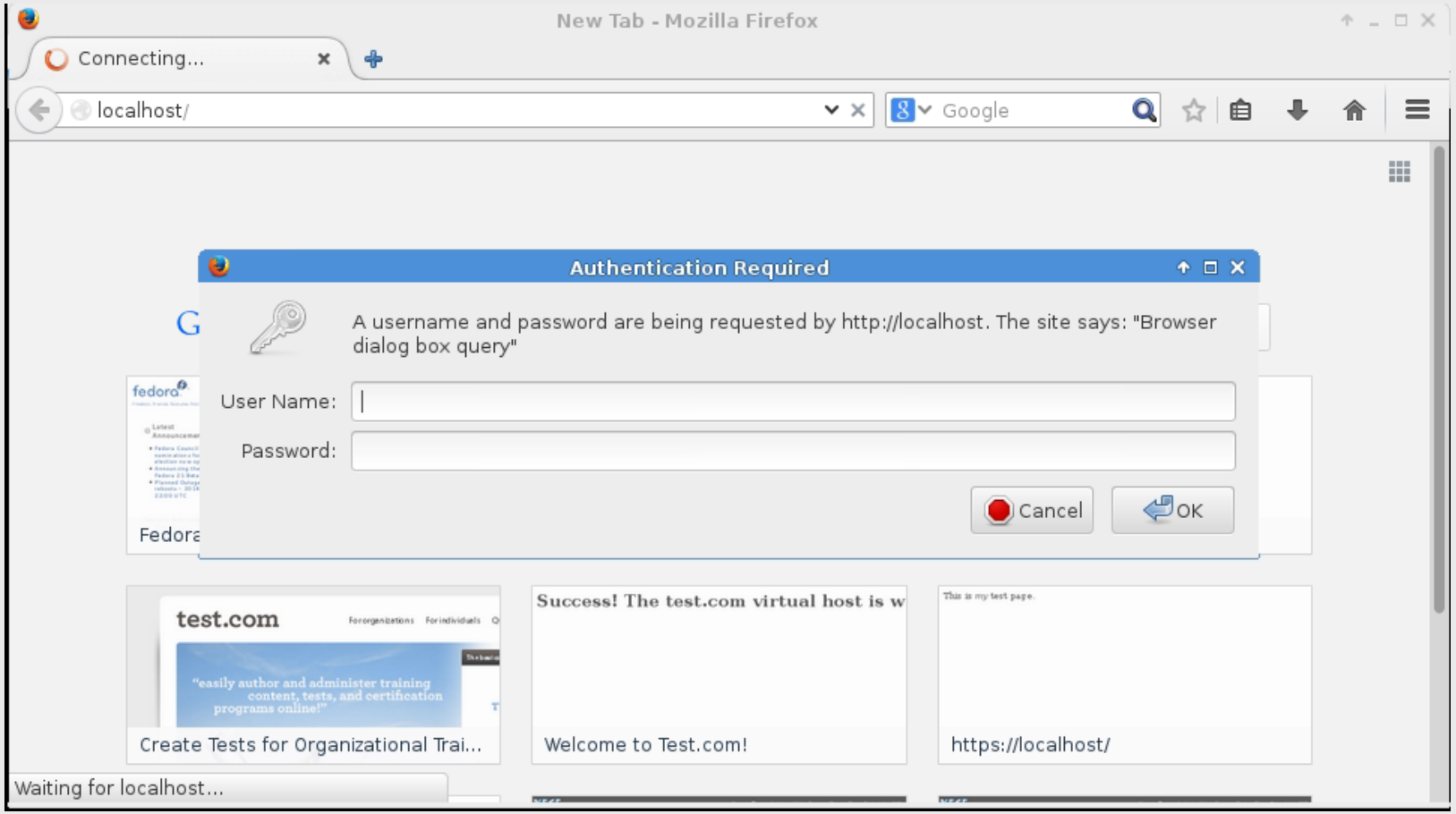

Mozilla Firefox
https://localhost/
https://localhost
Google
This is my test page.

Auth Module

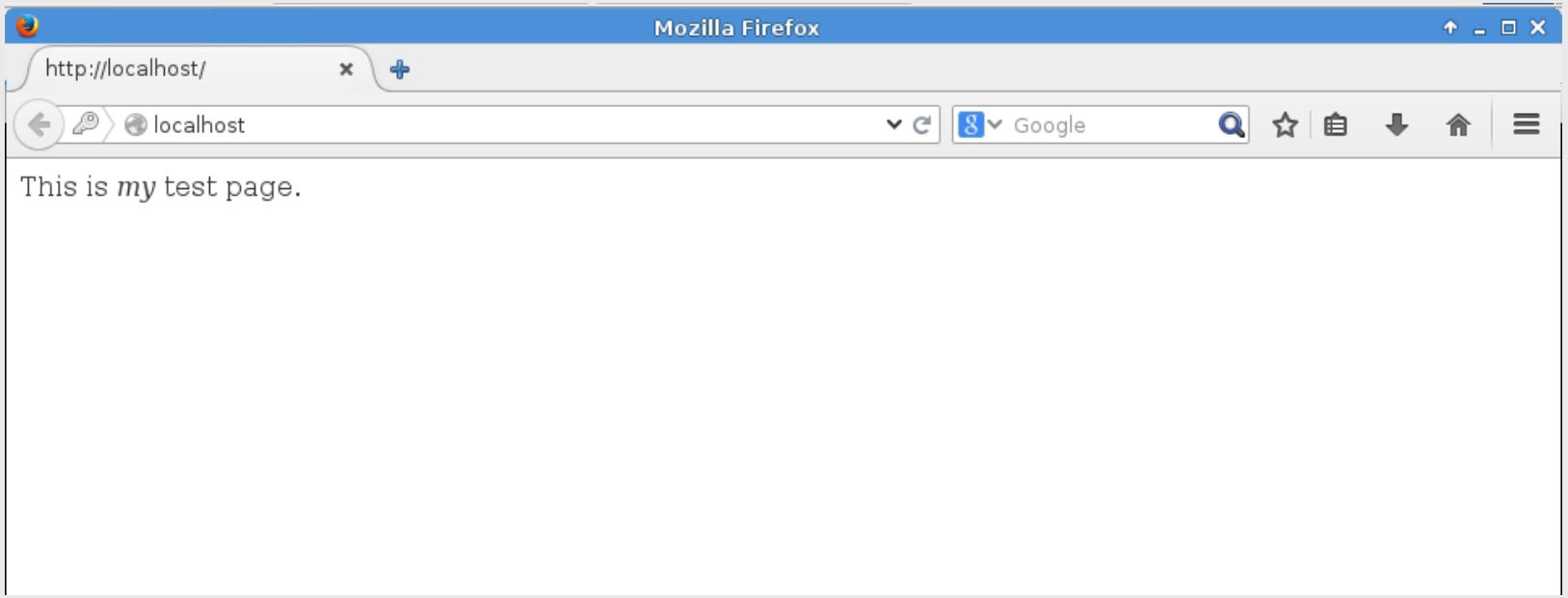
- You can use the **.htaccess** and **.htpasswd** to prompt users to authenticate before the site will be displayed
- Must modify **AllowOverride None** to **AllowOverride AuthConfig**

```
[root@itm456 ~]# cat /var/www/html/.htaccess
AuthUserFile /var/www/html/.htpasswd
AuthGroupFile /dev/null
AuthName "Browser dialog box query"
AuthType Basic
require valid-user
[root@itm456 ~]# htpasswd -c /var/www/html/.htpasswd student
New password:
Re-type new password:
Adding password for user student
```

Auth Module


New Tab - Mozilla Firefox
Connecting...
localhost/
Google
Authentication Required
A username and password are being requested by http://localhost. The site says: "Browser dialog box query"
User Name:
Password:
Cancel
OK
Fedora
test.com
"easily author and administer training content, tests, and certification programs online!"
Create Tests for Organizational Trai...
Success! The test.com virtual host is w
Welcome to Test.com!
This is my test page.
https://localhost/
Waiting for localhost...

Auth Module


Mozilla Firefox
http://localhost/
localhost
Google
This is my test page.

Web Site Tools

- **`curl`** and **`wget`**
  - Similar tools for retrieving all or part of a Web site
  - Many options
  - For details on use, see `http://www.gnu.org/software/wget/manual/wget.html` and `http://curl.haxx.se/docs/manpage.html`

File Sharing Services

- There are many file sharing services available on Linux systems
- The most common include:
  - Samba
  - NFS
  - FTP

Configuring Samba

- SaMBa daemon
  - Emulates SMB protocol; formats TCP/IP data like Windows computers
    - **`yum install samba`**
- NetBIOS name daemon
  - Creates and advertises NetBIOS name for Windows computers to connect to Linux server
- **`nmblookup`** command
  - Tests NetBIOS name resolution in Linux

Configuring Samba

- **`smbpasswd`** command
  - Generate Samba passwords
- **`/etc/samba/smb.conf`**
  - Default Samba configuration file
  - Edit to include NetBIOS name
  - **`testparam`** command checks syntax of **`/etc/samba/smb.conf`**
- Start Samba and NetBIOS name daemons by **`systemctl start smb`** && **`systemctl start nmb`** commands

Configuring Samba

- Test Samba functionality after configuration
  - From Windows client enter *Samba_server_name* in the Run dialog
- **`smbclient`**
  - Connect Linux computer to Samba server
  - Can also be used to display an FTP-like interface on Samba or Windows servers
- **`system-config-samba`**
  - GUI for Samba administration

NFS

- Network File System (NFS) allows Unix, Linux, & Mac OS X computers to share files transparently
- Export a directory by placing its name in the **`/etc/exports`** file
- **`mount`**
  - Used by another computer to access an exported directory across the network by mounting the remote directory on the local computer

Configuring a Linux NFS Server

- Create directory containing information to share
- Edit **`/etc/exports`** file:
  - Add line listing dir to be shared + options
- Run **`exportfs -a`** command
  - Update list of exported filesystems
- Restart the NFS processes
  - **`systemctl start nfs`**
  - **`systemctl start nfslock`**

Connecting to a Linux NFS Server

- Use **`showmount`** to see a list of available NFS shared directories on a remote server
- Mount directory from remote NFS server to a directory on local system
  - Use mount command specifying nfs filesystem type, server name or IP address, remote directory, and local directory as arguments
- Use **`umount`** command to dismount remote directory

Connecting to a Linux NFS Server

- Client for NFS included in Windows 7 and Windows 8.1 Enterprise
  - Not on by default
  - To activate go to Control Panel →Programs and Features
    - Select link Turn Windows features on or off
    - In the resulting Windows Features list box, find Services for NFS and click the **+** box to display two sub-features, Administrative Tools and Client for NFS
    - Check all three boxes and click OK

Connecting to a Linux NFS Server

- Windows will install components and ask to reboot your system; once rebooted, Client for NFS will be installed
  - Once installed, go use it, go to Administrative Tool → Services for NFS to configure
  - Alternatively, use the command line program **`nfsadmin`** to configure

FTP

- Protocol most commonly used to transfer files on public networks
- Hosts files differently than NFS
- In anonymous access special directory is available to any user who wants to connect to FTP server
- User can log in, via an FTP client program, to a home directory on the FTP server

FTP

- FTP is very insecure
  - Recommend use of SFTP (secure FTP) whenever possible
  - SFTP is an included component of SSH
  - Microsoft is adding OpenSSH to Windows (announced June 2) so that presumably will also add SFTP support
    - Meanwhile use FreeFTPd for Windows or Bitvise WinSSHd server

Configuring a Linux FTP Server

- Very secure FTP daemon (vsftpd)
  - Used by most Linux systems
- To configure (assuming logon as user1)
  - Create directory below user1's home directory to host the files
    - Ensure user1 owns directory
  - Edit **`/etc/vsftpd/vsftpd.conf`** to modify appropriate commented options
  - Run **`systemctl start vsftpd`** to start vsftpd daemon

Downloading Files Using FTP

- Most web browsers have built-in FTP
  - Allows you to access files on remote system
  - To connect through Web browser, specify the location by typing **`ftp://servername`** in the browser
  - To log in as particular user, type **`ftp://user:password@servername`**

Downloading Files Using FTP

- Most OSs have command-line FTP utility
  - Use **`ftp`** command and specify host name as argument, log in as anonymous or as specific user
  - Receive prompt that accepts FTP commands

Downloading Files Using FTP

- **`sftp`** command
  - Invokes secure FTP (preferred)
  - Installed automatically with **`ssh`**; normally installed by default on Linux systems
  - ALWAYS use SFTP over FTP is available
- Current Linux file managers can do both FTP & SFTP natively in a graphical environment

Downloading Files Using FTP

Command	Description
pwd	Displays the current directory on the remote computer
dir **ls**	Displays a directory listing from the remote computer
cd *directory*	Changes the current directory to *directory* on the remote computer
lcd *directory*	Changes the current directory to *directory on* the local computer
get *filename*	Downloads *filename* to the current directory on the local computer
ascii	Used to specify text file downloads (default)
binary	Used to specify binary file downloads
mget *filename*	Downloads *filename* to the current directory on the local computer; also allows the use of wildcard metacharacters to specify *filename*

Table 13-3: Common FTP/SFTP commands

Downloading Files Using FTP

Command	Description
put *filename*	Uploads *filename* from the current directory on the local computer to the current directory on the remote computer
mput *filename*	Uploads *filename* from the current directory on the local computer to the current directory on the remote computer; also allows the use of wildcard metacharacters to specify *filename*
!	Runs a shell on the local computer
close	Closes the FTP connection to the remote computer
open *hostname* or *IP*	Opens an FTP connection to the *hostname* or *IP* address specified
help	Displays a list of commands
bye **quit**	Quits the FTP utility

Table 13-3: Common FTP/SFTP commands

Microsoft Windows SFTP Clients

- Filezilla – Open Source
  - **http://sourceforge.net/projects/filezilla/**
- WinSCP – Open Source
  - **http://winscp.net/**
- PSCP and PSFTP (from PuTTY)
  - **http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html**

E-mail Services

- Various e-mail protocols exist: SMTP, ESMTP, POP, and IMAP
- E-mail server looks up the name of target e-mail server in domain's MX records, stored on public DNS server
  - Resolves target e-mail server name to IP address using public DNS server
- Daemons and system components rely on e-mail to send important information to the root user

E-mail Services

- Common email packages for Linux include Sendmail and Postfix
  - Will be installed for internal messaging even if not used otherwise

Working with Postfix

- Postfix is easier to install and use
  - Install using **`yum install postfix`**
  - Edit config **`/etc/postfix/main.cf`**
  - Run **`systemctl start postfix`** to stop Sendmail daemon and activate Postfix daemon
    - To make the change permanent, run **`systemctl enable postfix`**

Working with Postfix

- Most common e-mail daemon used on modern Linux systems is Postfix
  - Configured by default to accept e-mail on TCP port 25 and route to appropriate user
  - To check e-mail, use the mail command
- **`/etc/aliases`** file
  - Contains other e-mail names used to identify the users on the system
  - **`newaliases`** command rebuilds the aliases database after modifications

Working with Postfix (continued)

Line	Changes
`mydomain=sample.com`	Sets the email domain; change to desired name
`myorigin=$mydomain`	Sets local access to the domain name
`inet_interfaces=all`	Configures Postfix toi listen for email on all interfaces
`mydestination=$myhostname, localhost. $mydomain, localhost, $mydomain.`	Configures destination domain for email
`mynetworks_style=class`	Trusts email from other computers on the local network

Table 13-4: Lines in **`/etc/postfix/main.cf`** to uncomment or add when configuring Postfix

Database Services

- Databases
  - Large files that store information in the form of tables
- DBMS
  - Database Management System
  - Software to manage a database system
- Table
  - Organizes information into a list

Database Services

- Record
  - Set of information about a particular item within a list
- Fields
  - Categories of information within a record
- Relational databases
  - Information within one table is related to information within other tables
  - Tables are usually linked by a common field, also known as the *key* field

Database Services (continued)

EmployeeID	FirstName	LastName	Address	ZIP	Home Phone	Mobile Phone
A518	Bob	Smith	14 Wallington St.	49288	555-123-1399	555-144-2039
A827	Jill	Sagan	51 York Ave. N.	49282	555-123-1039	
A988	Frank	Kertz	623 Queen St.	44922	555-209-1039	555-199-2938
A472	Bethany	Weber	82 Shepherd Ave.	49100	555-299-0199	555-203-1000
A381	John	Lauer	55 Rooshill Ave.	49288	555-123-2883	555-203-2811

Common field

EmployeeID	Week	Hours	MgroK
A518	08/20/10	37	Yes
A827	08/20/10	40	Yes
A988	08/20/10	40	Yes
A472	08/20/10	40	Yes
A381	08/20/10	22	Yes
A518	08/27/10	40	Yes
A827	08/27/10	35	Yes
A988	08/27/10	0	Yes
A472	08/27/10	40	Yes
A381	08/27/10	22	Yes

Field names

Record

Figure 13-8: A simple relational database structure

Database Services

- Structured Query Language (SQL)
  - Common language used to store and access data in databases
  - Server programs that allow use of SQL are called SQL servers
    - Offer advanced backup, repair, replication, and recovery utilities for data
    - Allow programs to access databases from across the network

Common Linux SQL DBMS

- Oracle
  - Commercial and very expensive
- MySQL
  - Open source and probably most popular
  - Owned by Oracle and dual-licensed
  - MySQL forks
    - GPL (free only): MariaDB
    - Drizzle: not backwards compatible; for Web use
- PostgreSQL
  - Open source; many front-end GUI tools

Configuring PostgreSQL

- Powerful SQL server that provides large number of features
  - To install: **`yum -y install postgresql-server postgresql-contrib`**
  - Assign user password: **`passwd postgres`**
  - Initialize internal databases: **`systemctl start postgresql`**
  - Modify PostgreSQL configuration files
  - Start the PostgreSQL engine

Configuring PostgreSQL Databases

- Log in as postgres user
- Use PostgreSQL command-line utilities to create and manage databases
  - Create tables and add records within the PostgreSQL utility using appropriate SQL statements
  - PostgreSQL utility has many built-in commands
    - Prefixed with a \ character
    - Can be used to obtain database information or perform functions within the utility

Configuring PostgreSQL Databases

Command	Description
clusterdb	Associates a PostgreSQL database with another database on a different server
createdb	Creates a PostgreSQL database
createlang	Allows a new programming language to be used with PostgreSQL
createuser	Creates a PostgreSQL user
dropdb	Deletes a PostgreSQL database
droplang	Removes support for a programming language within PostgreSQL
dropuser	Deletes a PostgreSQL user
pg_dump	Backs up PostgreSQL database settings
pg_dumpall	Backs up PostgreSQL database cluster settings
pg_restore	Restores PostgreSQL database settings
psql	The PostgreSQL utility
reindexdb	Reindexes a PostgreSQL database
vacuumdb	Analyzes and regenerates internal PostgreSQL database statistics

Table 13-6: PostgreSQL command-line utilities

Configuring PostgreSQL Databases

Command	Description
`\l`	Lists available databases
`\c database_name`	Connects to a different database
`\d`	Lists the tables within the current database
`\d table_name`	Lists the fields within a table
`\q`	Exits the PostgreSQL utility

Table 13-7: Common built-in PostgreSQL utility commands

Other Common Linux SQL DBMS

- Oracle
  - Commercial and very expensive
- MySQL
  - Open source and probably most popular
  - Owned by Oracle and dual-licensed
- MySQL forks
  - GPL (free only): MariaDB
  - Drizzle: not backwards compatible; intended for Web use

Summary

- DHCP, DNS, NTP, and NIS are infrastructure services since they provide network-related services to other computers
- DHCP servers lease other computers an IPv4 or IPv6 configuration
- DNS servers provide name resolution services for computers on the network

Summary

- Linux computers can use the system time stored within the computer BIOS or obtain time from an NTP server across the network
- NIS servers provide key configuration files to other Linux computers that are configured as NIS clients

Summary

- The Apache server shares Web pages from its document root directory to computers on the network using the HTTP protocol
- Samba can be used to share files to Linux, UNIX, Macintosh, & Windows computers using the SMB protocol
- NFS can be used to natively share files among Linux, UNIX, and Macintosh systems

Summary

- FTP can be used to share files to any computer that has an FTP client utility
  - SFTP should always be used as a preferred alternative to FTP as FTP is insecure
- Email servers deliver e-mails to users, accept new e-mails from users and relay the new emails to other e-mail servers on the Internet for delivery

Summary

- Applications that store data in databases on database servers use SQL statements to manipulate information within a database
- PostgreSQL provides advanced configuration and utilities

The End…

- Questions?