Networking and Package Management

CS 2043: Unix Tools and Scripting, Spring 2019 [1]

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The image above is a link. Click it.
welcome back to THE INTERNET
Command we forgot from last time

**ping** a packet off a remote host

**ping** [flags...] <host>

- Simple echo back-and-forth
- tests connections
- uses **ICMP** protocol – same as **traceroute**
- runs forever by default

```
$ ping -c 4 google.com
PING google.com (172.217.9.238) 56(84) bytes of data.
64 bytes from lga34s11-in-f14.1e100.net (172.217.9.238): icmp_seq=1 ttl=55 time=8.24 ms
64 bytes from lga34s11-in-f14.1e100.net (172.217.9.238): icmp_seq=2 ttl=55 time=8.51 ms
64 bytes from lga34s11-in-f14.1e100.net (172.217.9.238): icmp_seq=3 ttl=55 time=8.56 ms
64 bytes from lga34s11-in-f14.1e100.net (172.217.9.238): icmp_seq=4 ttl=55 time=8.56 ms

--- google.com ping statistics ---
4 packets transmitted, 4 received, 0% packet loss, time 8ms
rtt min/avg/max/mdev = 8.237/8.468/8.563/0.163 ms
```
Last time

- Computers communicate by sending **packets** through the network
- Packets are addressed to a local **MAC** and a potentially-remote **IP**
- **Switches** connect computers into a *local network* and forward packets by **MAC**
- **Routers** connect local networks into an *intranet* and forward packets by **IP**
Protocols from last time

- The **DHCP** protocol gives computers an IP address
- The **ARP** protocol associates an IP address with a MAC address
- The **DNS** protocol associates a domain name (google.com) with a MAC address
What is a protocol?

- an agreement on what sort of packets to exchange to achieve a particular goal
- Can be multi-step
- we distinguish between transport layer and application layer
More about protocols: transport layer

- *transport-layer* protocols correspond to different “kinds” of packets
  - examples: ARP, ICMP
- Operating system sees the different packets, handles them accordingly
- **operating system’s job** to handle transport-layer packets
application-layer protocols use the same kind of packet
  - examples: DHCP, DNS, HTTPS, SSH, most others you know

Operating system passes them to applications

How do applications find their packets?
Introducing: TCP and UDP

- transport-layer protocols for communicating with applications
- differentiate applications with “ports”
  - just a 16-bit integer
  - like apartment numbers
- applications listen at a specific port
  - registers with the OS
  - OS only forwards port-destined traffic
- contains “return addresses” for easy reply to client
TCP

- Most popular transport protocol
  - examples: HTTP, SSH
- *connection-oriented* protocol
  - “connect” to a port on a remote stream
  - receive a private channel on which to keep communicating
  - like a phone call ... or SSH session
- Hides common failures
  - ensures packets are reasonably ordered
  - retransmits packets if they get lost
  - cool algorithm to avoid congestion
UDP

- Second-most popular transport protocol
  - examples: DHCP, DNS, VoIP, Steam (as in video games), internet radio
  - **not** Netflix
- **only gives you the port**
  - no connection: works like physical mail.
- All common failures exposed to application
  - packet order may vary
  - packets may not arrive
  - no indication whether transmitted packet got there
- Mostly used in either very-old, high-assurance or real-time applications
- more resilient to DOS attacks than TCP
Application protocols

- Still defines pattern of communication
- specific messages expected at specific times
- messages sent via (usually) TCP/UDP
- Example: HTTP, SSH, etc.
Exploring application protocols: netcat

**netcat**: so much more than *cat* over the *network*

- `nc [flags] [host]`
- `nc -l -p <port>`
- `nc <host> <port>`

- Raw TCP protocol tool
- sends *stdin* over the network
- receives *stdout* from the network
- `nc -l “listens”, behaves like a server`
- `nc <host> “connects”, behaves like a client`
HTTP: a protocol to explore

- HTTP messages are raw text!
- Strings sent via TCP to port 80
- GET request: access a page

```
GET /people/mpmilano/ HTTP/1.1
Host: cs.brown.edu
```

- Let’s send this via `netcat`! (demo)
- Can explore more protocols this way; try it!
Some common ports

- HTTP: TCP/80
- SSH: TCP/22
- FTP: TCP/20 and TCP/21
- HTTPS: TCP/443
- SMTP (mail): TCP/25
Firewalls

- In a perfect world, we wouldn’t need a firewall.
- Lives in the network, or in the kernel
- inspects traffic *before* it reaches its destination
- Two primary uses: filter legitimate services, block unwanted ones
Firewalls: the good uses

• Legit: *Filters* certain ports to prevent regions of the internet from accessing them
  • Cornell firewall drops all traffic destined to on-campus servers originating from off-campus IPs
  • *wash* firewall does the same
  • mail relay firewall would only allow known senders to connect
• prevents server from being overloaded by random external griefers
• prevents aggressive server scans from the darkweb
  • which, by the way, exists. ask me later.
Firewalls: the lazy uses.

- Block insecure / old apps
- cover up for weird/bad OS/system design
  - Example: print server on a mac at port 631
  - Example: just a lot of windows
- Block **all** uninvited remote connections
  - if your laptop isn’t a server, shouldn’t have exposed ports
  - if it does have exposed ports, some application is doing a bad.
- Fundamentally lazy: right answer is to secure the applications, not hide them.
- lots of legacy apps (that we’re stuck with) can’t be fixed, so also fundamentally necessary
Package Management
Package Management Overview

- If I had to give only one reason why Unix systems are superior to Windows: Package Management.
- Can install almost anything with ease of from your terminal.
- Update to the latest version with one command.
  - No more download the latest installer nonsense!
- Various tools can be installed by installing a package.
  - A package contains the files and other instructions to setup a piece of software.
  - Many packages depend on each other.
  - High-level package managers download packages, figure out the dependencies for you, and deal with groups of packages.
  - Low-level managers unpack individual packages, run scripts, and get the software installed correctly.
- In general, these are “pre-compiled binaries”: no compilation necessary. It’s already packaged nice and neat just for you!
Package Managers in the Wild

• GNU/Linux:
  • Low-level: two general families of packages exist: deb, and rpm.
  • High-level package managers you are likely to encounter:
    • Debian/Ubuntu: apt-get.
    • Some claim that aptitude is superior, but I will only cover apt-get. They are roughly interchangeable.
    • SUSE/OpenSUSE: zypper.
    • Fedora: dnf (Fedora 22+).
    • zypper and dnf use SAT-based dependency solvers, which many argue is fundamentally superior. The dependency resolution phase is usually not the slowest part though...installing the packages is. See [3] for more info.
    • RHEL/CentOS: yum (until they adopt dnf).

• Mac OSX:
  • Others exist, but the only one you should ever use is brew.
  • Don’t user others (e.g. port), they are outdated / EOSL.
Using Package Managers

• Though the syntax for each package manager is different, the concepts are all the same.
  • This lecture will focus on \texttt{apt-get}, \texttt{dnf}, and \texttt{brew}.
  • The \texttt{dnf} commands are almost entirely interchangeable with \texttt{yum}, by design.
  • Note that \texttt{brew} is a “special snowflake”, more on this later.

• What does your package manager give you? The ability to
  • \texttt{install} new packages you do not have.
  • \texttt{remove} packages you have installed.
  • \texttt{update} installed packages.
  • update the lists to search for files / updates from.
  • view \texttt{dependencies} of a given package.
  • a whole lot more!!!
A Note on update

- The **update** command has importantly different meanings in different package managers.
- Some **do**, and some do **not** default to system (read linux kernel) updates.
  - Ubuntu: default is **no**.
  - Fedora: default is **yes**.
  - RHEL: default is **no**.
- It depends on your operating system, and package manager.
  - Know your operating system, and look up what the default behavior is.
- If your program needs a specific version of the linux kernel, you need to be very careful!
A Note on Names and their Meanings

- You may see packages of the form:
  - `<package>.i[3456]86` (e.g. `.i386` or `.i686`):
    - These are the **32-bit** packages.
  - `<package>.x86_64`: these are the **64-bit** packages.
  - `<package>.noarch`: these are independent of the architecture.

- Development tools can have as many as three packages:
  - The header files are usually called something like:
    - `deb`: usually `<package>-dev`
    - `rpm`: usually `<package>-devel`
  - The library you will need to link against:
    - If applicable, `lib<package>` or something similar.
  - The binaries (executables), often provided by just `<package>`.
  - Most relevant for **C** and **C++**, but also **Python** and others.
  - Use the **search** functionality of your package manager.
Example Development Tool Installation

• If I needed to compile and link against Xrandr (X.Org X11 libXrandr runtime library) on Fedora, I would have to install
  • libXrandr: the library.
  • libXrandr-devel: the header files.
  • Not including .x86_64 is OK / encouraged, your package manager knows which one to install.
  • Though in certain special cases you may need to get the 32-bit library as well.
    • In this case, if I were compiling a program that links against libXrandr, but I want to release a pre-compiled 32bit library, it must be installed in order for me to link against it.

• The deb versions should be similarly named, but just use the search functionality of find the right names.
• This concept has no meaning for brew, since it compiles everything.
System Specific Package Managers
Debian / Ubuntu Package Management (apt-get)

- Installing and uninstalling:
  - Install a package:
    ```
    apt-get install <pkg1> <pkg2> ... <pkgN>
    ```
  - Remove a package:
    ```
    apt-get remove <pkg1> <pkg2> ... <pkgN>
    ```
  - Only one pkg required, but can specify many.
  - “Group” packages are available, but still the same command.

- Updating components:
  - Update lists of packages available: **apt-get update**.
    - No arguments, it updates the whole list (even if you give args).
  - Updating currently installed packages: **apt-get upgrade**.
    - Specify a package name to only update / upgrade that package.
  - Update core (incl. kernel): **apt-get dist-upgrade**.

- Searching for packages:
  - Different command: **apt-cache search <pkg>**
RHEL / Fedora Package Managers (yum and dnf)

- Installing and uninstalling:
  - Install a package:
    \texttt{dnf install <pkg1> <pkg2> \ldots <pkgN>}
  - Remove a package:
    \texttt{dnf remove <pkg1> <pkg2> \ldots <pkgN>}
  - Only one \texttt{pkg} required, but can specify many.
  - “Group” packages are available, but different command:
    - \texttt{dnf groupinstall 'Package Group Name'}

- Updating components:
  - Update EVERYTHING: \texttt{dnf upgrade}.
  - \texttt{update} exists, but is essentially \texttt{upgrade}.
    - Specify a \texttt{package} name to only upgrade that package.
  - Updating repository lists: \texttt{dnf check-update}

- Searching for packages:
  - Same command: \texttt{dnf search <pkg>}

- \texttt{yum} and \texttt{dnf} (Dandified Yum) nearly interchangeable: [3].
**dnf: Cautionary Tales**

- **WARNING**: if you install package Y, which installs X as a dependency, and later **remove** Y
  - By default, X will be removed!
  - Generally, won’t know you needed to **mark** until it is too late.

- **Solution?**
  - Basically, **pay attention to your package manager**.
  - It gets removed because nothing *explicitly* depends on it.
  - So one day you may realize “OH NO! I’m missing package X”...
  - ...so just **dnf install X**.
    - So while **mark** is available, personally I don’t use it.
  - Sad face, I know. Just the way of the world.
OSX Package Management: Install `brew` on your own

- Sitting in class right now with a Mac?
- **DON’T DO THIS IN CLASS.** You will want to make sure you do not have to interrupt the process.
  - Make sure you have the “Command Line Tools” installed.
    - Instructions are on the First Things First Config Page
  - Visit [http://brew.sh/](http://brew.sh/)
    - Copy-paste the given instructions in the terminal as a regular user (**not root**).  

- **VERY IMPORTANT:** READ WHAT THE OUTPUT IS!!!! It will tell you to do things, and you **have** to do them. Specifically You should run `brew doctor` BEFORE you install anything.
OSX Package Management (brew)

- Installing and uninstalling:
  - Install a formula:
    
    ```
    brew install <fmla1> <fmla2> ... <fmla2>
    ```
  - Remove a formula:
    
    ```
    brew uninstall <fmla1> <fmla2> ... <fmlaN>
    ```
  - Only one formula required, but can specify many.
  - “Group” packages have no meaning in brew.

- Updating components:
  - Update brew, all taps, and installed formulae listings. This does not update the actual software you have installed with brew, just the definitions: **brew update**.
  - Update just installed formulae: **brew upgrade**.
    - Specify a formula name to only upgrade that formula.

- Searching for packages:
  - Same command: **brew search <formula>**
• Safe: confines itself (by default) in `/usr/local/Cellar`:
  • No `sudo`, plays nicely with OSX (e.g. Applications, `python3`).
  • Non-linking by default. If a conflict is detected, it will tell you.
  • **Really important to read what `brew` tells you!!!**
• `brew` is modular. Additional repositories ("taps") available:
  • Essentially what a `.rpm` or `.deb` would give you in linux.
  • These are 3rd party repos, not officially sanctioned by `brew`.
• Common taps people use:
  • `brew tap homebrew/science`
    • Various “scientific computing” tools, e.g. `opencv`.
  • `brew tap caskroom/cask`
    • Install `.app` applications! Safe: installs in the “Cellar”, symlinks to `~/Applications`, but **now these update with brew all on their own when you brew update!**
    • E.g. `brew cask install vlc`
**OSX: One of These Kids is Not Like the Others (Part II)**

- **`brew` installs formulas.**
  - A **ruby** script that provides rules for where to download something from / how to compile it.

- Sometimes the packager creates a “**Bottle**”:
  - If a bottle for your version of OSX exists, you don’t have to compile locally.
  - The bottle just gets *downloaded* and then “*poured***.

- Otherwise, **`brew`** downloads the source and compiles locally.
- Though more time consuming, can be quite convenient!
  - **`brew options opencv`**
  - **`brew install --with-cuda --c++11 opencv`**
  - It really really really is magical. No need to understand the **opencv** build flags, because the authors of the **`brew`** formula are kind and wonderful people.
  - **`brew reinstall --with-missed-option formula`**
Reiteration: **pay attention to brew and what it says.** Seriously.

Example: after installing **opencv**, it tells me:

```bash
mkdir -p /Users/sven/.local/lib/python2.7/site-packages
echo 'import site; site.addsitedir(
    ":/usr/local/lib/python2.7/site-packages")' >> 
/Users/sven/.local/lib/python2.7/site-packages/homebrew.pth
```

**brew** gives copy-paste format, above is just so you can read.

I want to use **opencv** in **Python**, so I do what **brew** tells me.
Sometimes when dependencies are installed behind the scenes, and you no longer need them, you will want to get rid of them.

- **apt-get autoremove**
- **dnf autoremove**
- **brew doctor**

View the list of repositories being checked:

- **apt-cache policy** (well, sort of... **apt** doesn’t have it)
- **dnf repolist [enabled|disabled|all]**
  
  - Some repositories for **dnf** are **disabled** by default (with good reason). Usually you want to just
  
    dnf --enablerepo=<name> install <thing>

  e.g. if you have **rawhide** (development branch for fedora).

- **brew tap**
Other Managers
Like What?

- There are so many package managers out there for different things, too many to list them all!
  - Ruby: `gem`
  - Anaconda Python: `conda`
  - Python: `pip`
  - Python: `easy_install` (but really, just use `pip`)
  - Python3: `pip3`
  - LaTeX: `tlmgr` (uses the CTAN database)
    - Must install TeX from source to get `tlmgr`
  - Perl: `cpan`
  - Sublime Text: Package Control
  - Many many others...
Some notes and warnings about Python package management.

Notes:
- If you want X in Python 2 and 3:
  - `pip install X` and `pip3 install X`
- OSX Specifically: advise only using `brew` or Anaconda Python. The system Python can get really damaged if you modify it, you are better off leaving it alone.
- So even if you want to use `python2` on Mac, I strongly encourage you to install it with `brew`.

Warnings:
- Don’t mix `easy_install` and `pip`. Choose one, stick with it.
  - But the internet told me if I want `pip` on Mac, I should `easy_install pip`
  - NO! Because this `pip` will modify your system python, USE BREW.
- Don’t mix `pip` with `conda`. If you have Anaconda python, just stick to using `conda`.
References

[1] Stephen McDowell, Bruno Abrahao, Hussam Abu-Libdeh, Nicolas Savva, David Slater, and others over the years. “Previous Cornell CS 2043 Course Slides”.
