File sharing with Samba

ComS 252 — Iowa State University

Barry Britt and Andrew Miner

Theoretical background

Sharing files — in general

Idea:

- Have a trusted LAN
  - Firewall to the outside
  - Everyone on this side is trusted
- Want ability to share files from a central location
  - I.e., a "shared drive" simultaneously connected to all machines
- With all the comforts of a modern, multi–user filesystem
  - Hierarchical directory structure
  - Files have owners and groups and permissions. . .

How can we make this happen?

Sharing by Remote Transfers

One solution:

- Have a central server machine with lots of disk space
- Users do the following cycle:
  1. "Download" file(s)
  2. View or edit file(s)
  3. "Upload" file(s)
- Choose some download/upload mechanism, e.g.,
  - `scp`, or `rsync`, or subversion, or git...
    (subversion and git actually work quite nicely for this)

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Problems with this solution:

- This does not act much like a "shared drive"
- What if the shared drive is huge with huge files?
  - E.g., filesystem in *terabytes*
  - E.g., files in *gigabytes*

What we really want

- Shared drive on server acts like a local drive on client
  - But clients interact with the server using some protocol
    - Not at the level of disk sectors
    - Details of file storage on the server are hidden
- Can open and edit files "directly"
- Call this "network file sharing" to stay generic

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Location transparency

A file's name does not reveal any hint of its physical storage location

Location independence

A file's name does not need to be changed when its physical storage location changes

Network File Sharing Issue: Performance

`head -n 1 file.txt` on a local disk

1. System call for "read first block of file.txt"
2. Wait for I/O request in disk scheduler
3. Perform I/O
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Network File Sharing Issue: Performance

`head -n 1 file.txt` on a remote disk

1. System call for "read first block of file.txt"
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How fast is data transfer on the network compared to disk?

- SATA revision 1.0 transfer rate: $\approx$ 1.5 Gbit/s
- USB 2.0: 480 Mbit/s in theory, 280 Mbit/s in practice
- 100 Mbit/s ethernet is 100 Mbit/s

Network File Sharing Issue: Caching

- Files (or parts of files) are cached on the client
  - This includes directories, also
  - Improves performance: reduces network traffic
  - Your web browser does this too, by the way
- But now we have the cache consistency problem
  - Need to keep cached file consistent with file on the server

  Client–initiated : client handles this
  Server–initiated : server handles this
- Cache update policy: when to send writes back to the server

  write through : writes sent to server immediately
  delayed write : writes not sent immediately
  write on close : send changes when file is closed
- Consider how choices here affect reliability
  - What if the client crashes?

Network File Sharing Issue: File Sharing Semantics

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  - Typically: all bets are off
- Fun realization: this is more likely to happen with directories

Network File Sharing Issue: Users

- Want files to have owners, groups, and permissions
- Need user and group information available over the network
  - E.g., what if different machines have different sets of users?
  - How will each machine know about the other users?
- This can be integrated into the file sharing system
- Or this can be handled separately by another protocol
  - Can "synchronize" users and groups on all machines
    - By hand — does not scale well
    - Using file transfers or custom software "hacks"
    - Using a protocol designed for this
  - Can move users and groups to a central server
    - Server provides "users, groups, passwords" service
    - Clients must support this
    - Part of a larger issue: "Network Identity"
    - We will discuss this some, in a few minutes

Network File Sharing Issues: Conclusion

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Take away lessons from this:

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Elegant and efficient file sharing solution that everyone uses

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Take away lessons from this:

- Sharing files is hard business
- DO NOT simultaneously edit files
  - That's what file locking is for
  - That's what subversion and git are for

Examples of Network File Sharing Systems

NFS (Network File System)

- By Sun Microsystems, 1985
- First widely–used IP–based network file sharing
- We will discuss this in another lecture

AFS (Andrew File System)

- Designed for WAN–scale sharing

AFP (Apple Filing Protocol)

SMB (Server Message Block)

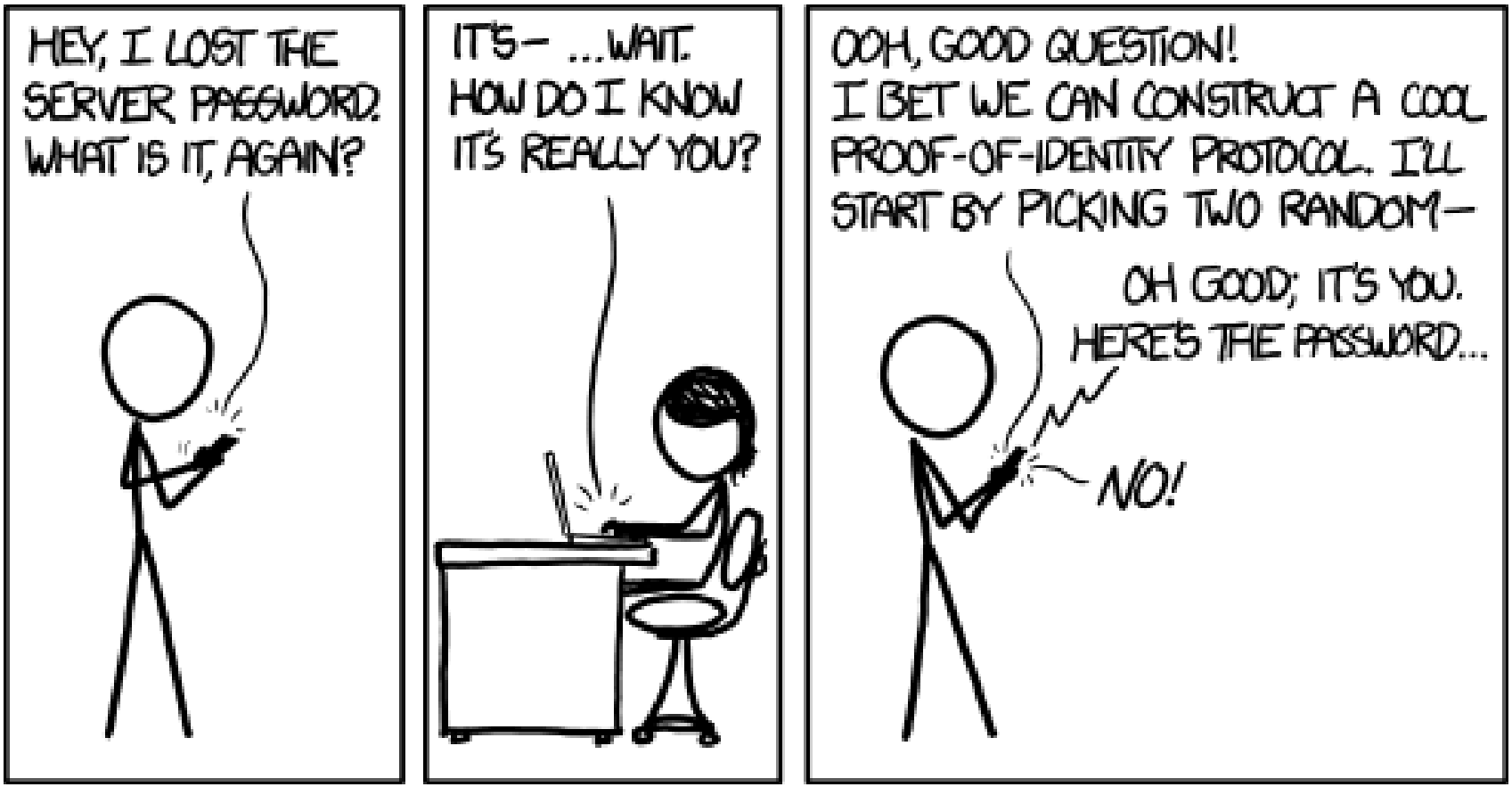
- Also known as CIFS
  (Common Internet File System)
- Will be discussed in this lecture

Network Identity — in general

What is this all about?

- How does a computer know that you are who you claim?
  - In particular, over a network
- Need these two things (at least):
  1. A unique identifier
     - Will be how users are identified
     - E.g., username, email address, account number...
     - Sometimes is aggregation of several things;
       E.g., username + domain gives unique email address
  2. An authentication scheme
     - How we verify users' identities
     - Can be based on what you know
     - Can be based on what you have

A relevant xkcd comic http://xkcd.org/1121



Authentication schemes: typical examples

- Passwords — something you know
  - Simple to implement
  - "Easy" to crack
  - More on this when we discuss security
- Tickets / certificates — something you have
  - Can be tricky to implement
  - Much harder to crack
  - Need "Authoritative broker" to assign certificates
    - A Trusted third party
- Host based
  - Simple, but easy to fake
- Host + port
  - Simple, but still possible to fake
- Two–factor authentication
  - E.g., ATM card + PIN

Network Identity Protocols

- NIS (Network Information Service)
  - Protocol for synchronizing information among hosts
  - Fairly easy to set up
- LDAP (Lightweight Directory Access Protocol)
  - Similar idea to NIS but more secure
    - . . . and more complex to set up
  - Version 3 is current: RFC 4511
  - Builds on dozens of other LDAP RFC's
- Active Directory. . .
- Kerberos
  - Developed at MIT
  - Uses "tickets" (provided by a trusted third party)
  - Allows machines to prove their identity to one another
  - Version 5 is current: RFC 4120
    - But there are several related RFC's

Protocols used for Windows Networking

Server Message Block

- Is a proprietary protocol — no RFC's
- Provides shared access to files, printers, and other devices
- Originally designed at IBM for a networked file system
- Originally designed to run on top of NetBIOS/NetBEUI
  - PC networking API used in 1980's
- 1996: Microsoft tried renaming it CIFS
  - Common Internet File System
  - Also added features (symbolic and hard links, . . .)
- Since Windows 2000: SMB can run directly on top of TCP/IP
- SMB 2.0 introduced with Windows Vista in 2006
- SMB 2.1 introduced with Windows 7
- SMB 3.0 introduced with Windows 8

SMB/CIFS services

1. File and print services
2. Authentication and Authorization
   - In a minute...
3. Name resolution
   - Originally: broadcast
     - Client broadcasts "where is machine Gamera?"
     - Gamera replies with an IP address
   - Later: machines send their name and IP address to a server
     - A NetBIOS Name Service (NBNS) server
     - Windows Internet Name Service (WINS): Microsoft's implementation of NBNS
   - Since Windows 2000: DNS can be used
4. Service announcement
   - So other users can browse a list of services (i.e., available shared folders and printers)

Active Directory

- A directory service created by Microsoft
  - Again, as in "telephone directory"
  - In use since 2000
- Uses LDAP versions 2 and 3
- Uses Kerberos
- Can use DNS
- What does it do, and why?
  - Need some terminology first...

Some Terminology

principal : an entity that can be authenticated

- Can be users, machines, services, processes
- Or groups of users, machines, services, processes
- Microsoft uses term security principal
- Are usually given a unique identifier for life
  - Microsoft: Security Identifier (SID)

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Windows domain : a collection of security principals

- Share a central directory (a database)
- Idea:
  - Authenticate once when connecting to the domain (usually, when you login)
  - Then the SID is used to determine permissions within the domain

More Terminology

Active Directory : directory service for a Windows domain

- I.e., protocols to manage the central directory

Domain Controller : a server that "controls" a Windows domain

- I.e., a server for the Active Directory service
- Responds to authentication requests

Active Directory Domain Services (since 2008)

- The software that the Domain Controller runs
- From Microsoft:

. . . you configure the server with the role of domain controller by installing AD DS.

Some features of Active Directory

- Resources and security principals may be grouped into units
  - Makes administration easier
- Auditing
- Load balancing of Domain Controllers
- Support for MS Exchange
- Support for white page services

Active Directory: Summary

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Good news:

- You will only use a tiny fraction of this for homework
- Not even close to setting up a full–fledged domain controller

Protocol Implementations

Samba

`http://www.samba.org`

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- Allows Linux machines to be servers in a "Windows Network"
- You will do this for homework

Samba History

1992 Andrew Tridgell (Australian)

- Wanted to connect DOS PC to UNIX server
- AND needed PC to run NetBIOS
  - Choice 1: use NFS (UNIX protocol)
    and get IP and NetBIOS to run together under DOS
  - Choice 2: write a server that works with NetBIOS
    and have it run on the UNIX machine
- Went with Choice 2
  - Wrote a packet sniffer
  - Reverse engineered the SMB protocol
  - Implemented it on UNIX machine
- UNIX machine behaved like PC file server
- Published code
  - No formal name, Tridgell called it
    "UNIX file server for DOS Pathworks"
  - Eventually renamed it "NetBIOS for UNIX"
- After a few updates, set it aside and ignored it

Samba History (2)

1994 Tridgell again

- Wanted to connect his wife's Windows machine to his Linux machine
- Dusted off his old code and tried it out . . .

1

Samba History (2)

1994 Tridgell again

- Wanted to connect his wife's Windows machine to his Linux machine
- Dusted off his old code and tried it out . . . it worked!
- Discovered NetBIOS and SMB documentation
  - Renamed it "SMBServer"
- Was contacted by a company about the software name
  - They held the trademark
- Tridgell checked the dictionary file[1] for words with "`smb`"
  - "Samba" was the first match

[1] Typically, `/usr/share/dict/words`

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—Eric Raymond, "The Cathedral and the Bazaar"

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Samba History (3)

1999 Samba 2.0 released

2003 Samba 3.0 released

- IT Week Labs:
  Samba 3 is 2.5x faster than Windows 2003 Server
- Veritest (hired by Microsoft):
  Windows 2003 Server is 1.6x faster than "Linux"
- See `http://www.kegel.com/nt-linux-benchmarks.html`

2012 Samba 4.0 released

- Complete reworking of the Samba code
- Samba can be an Active Directory Domain Controller

Samba project: summary

- Is large and active
  - Around 50 developers on the team
  - Including Andrew Tridgell
- License: GPL
- Goal: do anything a Windows Server can do
  - Windows Servers can do lots of things
  - That means things can get complicated
- Has an lots of documentation

- Good news — setup for homework is "simple"
  - Far from a full–fledged Domain Controller

Samba client (1)

How to access SMB/CIFS shared folders in Linux?

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`smbtree`

- Command–line tool
- Displays a hierarchical diagram of available shares

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`smbtree`

- Command–line tool
- Displays a hierarchical diagram of available shares

`smbclient`

- Command–line tool
- Works like old–style `ftp`
- Can `get` and `put` files

Samba client (2)

For the ultimate in transparency:

Samba client (2)

For the ultimate in transparency:

```
mount
```

Samba client (2)

For the ultimate in transparency:

`mount`

- Filesystem type is "`cifs`"
- Will mount a SMB/CIFS shared folder
  - The shared folder is specified as the "device"
  - Use the syntax: `//server/share`
    - `server` can be an IP address
      or a hostname that we can find an IP address for
- After it is mounted, shared files act just like local ones
- Check `man mount.cifs` for more information
  - Lots of CIFS–specific options
    - E.g., setting the user (and password) for the connection

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```
prompt$  mount -t cifs //10.9.8.7/SharedDocs /mnt/winshares
```

Samba server

- Requires 2 or 3 daemons
  - Described on the next slide . . .
  - Can be started and stopped as usual
  - Can be set to start at boot time as usual
- Can be configured using SWAT
  - Samba Web Administration Tool
  - Uses a Web–based Interface (WUI?)
- Can be configured by hand
  - Put the "magic text" in the configuration file
  - Usually the config file is `/etc/samba/smb.conf`
    - May vary by distribution
  - What you should do for homework
  - This lecture covers basic settings only

Samba server daemons

`nmbd` "`nmb.service`"

- Handles name registration and resolution
- Is involved in network browsing

`smbd` "`smb.service`"

- Handles file sharing
- Handles printer sharing
- Manages local authentication

`winbindd` "`winbind.service`"

- Optional daemon
- Required for Windows NT4 or ADS domains
- Needed for "trust relationships"

Samba configuration file: format

- Lines starting with "#" or ";" are ignored
  - Used for comments
  - Do not put comments after non-comments on the same line
- Configuration file is divided into sections
  - Start of a section is indicated by text: `[sectionname]`
  - A section ends when the next section starts, or at end of file
- Remaining lines are configuration options
  - Apply to the section containing them
  - Indented for readability (not required)
  - Format is: `option name = value`

Example configuration file

/etc/samba/smb.conf

```
[global]
;    These options are part of section "global"
     workgroup = HOMEGROUP
     wins support = yes
[printers]
;    These options are part of section "printers"
     path = /var/tmp
     printable = yes
     min print space = 2000
[myshare]
#    These options are part of section "myshare"
     browsable = yes
     read only = yes
     path = /usr/local/samba/tmp
```

Sections in the configuration file

`[global]`

- Server-wide settings
- Default settings for everything else

`[printers]`

- Settings for sharing printers

`[homes]`

- Settings for sharing home directories
- Creates a share for each user's home directory
- Share name matches username

other sections

- Define shares (shared directories)
- Share name matches the section name

Some useful options

Global options

`workgroup`:	the workgroup name
`netbios name`:	server name (15 characters max)
`hosts allow`:	the hosts allowed to connect

Share options

`path`:	Directory that will be shared (for a disk share)
`read only`:	Should the share be read-only?
`writable`:	Should the share be writable (not read-only)?
`force user`:	Pretend specified user is accessing share
`force group`:	Pretend specified group is accessing share

See `/etc/samba/smb.conf.example` for more information

Samba authentication

- Need to specify users and their passwords to Samba server
  - For the authentication and authorization part of SMB
- These are stored securely in a password database (usually)

- Use `smbpasswd` utility to update this database
  - As ordinary user: to change their SMB password
    - Requires that `smbd` is running
  - As root: to add SMB users

```
prompt$ smbpasswd -a chuck
```

  - As root: to remove SMB users

```
prompt$ smbpasswd -x chuck
```

  - Other changes are possible — check your `man` pages

And now for something completely different

Automatically mounting SMB shares in Linux

Suppose we want to set up a Linux (client) machine as follows

- Mount SMB share `//server/share` to `/mnt/server`
- Have this happen "automatically at boot time"
- Have this "fail cleanly"
  - E.g., if the server is down, the client can still function but of course cannot access files under `/mnt/server`

How can we do this?

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- From an earlier lecture:
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- Ugh, so do we need to `mount` these by hand every time?

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  - Not a clean solution
  - What if we have two servers?
  - And each server is a client of the other?
- From an earlier lecture:
  - `/etc/fstab` is for devices that are always connected
- Ugh, so do we need to `mount` these by hand every time?
  - Fortunately, no ...

Automounting

What is automounting?

- Filesystems are automatically mounted on demand
  - As compared to automatically mounted *at boot time*
- Filesystems are automatically unmounted after inactivity
- This can repeat
  - A filesystem may be re-mounted and unmounted several times

Automounting

What is automounting?

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  - As compared to automatically mounted *at boot time*
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- This can repeat
  - A filesystem may be re-mounted and unmounted several times

How does this happen?

- An automounter daemon
- Two systems available
  - amd : Berkeley Automounter
    - Implemented in user space
  - autofs : used in homeworks
    - Requires kernel support
    - Also uses a user–space daemon

Configuring autofs

- The autofs daemon can be managed as usual
  - Service name is autofs.service
  - E.g., systemctl is-enabled autofs.service
- Configuration:
  - Put "magic text" in the appropriate file(s)
  - auto.master
    - Normally in /etc
    - The "main" configuration file
  - Also: lots of map files
    - These will make more sense after we discuss the main configuration file

Format of `auto.master`

Example `auto.master`

```
/foo      /etc/auto.foo   --timeout 60
/bar      /etc/auto.bar
```

- First column: family of mount points
  - E.g., there can be several mount points under `/foo`
- Second column: where to obtain the map for those points
  - Generic entry is of the form "`type:name`"
  - Supported types include:

    `file, program, yp, nisplus, userdir`
  - `/etc/auto.foo` really means `file:/etc/auto.foo`
- Third column: options (optional)
- In this example:
  - File `/etc/auto.foo` explains how to mount things under `/foo`

Format of maps

- First column: key
  - Acts as a "relative mount point"
  - "Family" + "key" gives the complete mount point
- Second column: mount options
  - Same as for `/etc/fstab`, except...
  - Need to use `-fstype` to specify filesystem type (unless it is an NFS share)
- Third column: location to mount from
  - Add a ":" in front if location starts with "/"

- Pro tricks
  - Can use "*" in the key field
    - Matches all keys
  - Can use "&" in the location
    - Replaced by the key
    - Makes sense with "*"

Complete example (1)

/etc/auto.master

```
/foo      /etc/auto.foo   --timeout 60
/bar      /etc/auto.bar
```

/etc/auto.foo

```
cd        -fstype=iso9660,ro   :/dev/cdrom
floppy    -fstype=auto         :/dev/fd0
```

- Device `/dev/cdrom` will be automounted to `/foo/cd`
- Device `/dev/fd0` will be automounted to `/foo/floppy`

Complete example (2)

/etc/auto.master

```
/foo      /etc/auto.foo   --timeout 60
/bar      /etc/auto.bar
```

/etc/auto.bar

```
*         -fstype=cifs,<options>  ://server/&
```

- SMB share `//server/xyz` will be automounted to `/bar/xyz` for any string `xyz`

How this should work

```
prompt$
```

(Insert CD into drive)

How this should work

```
prompt$ ls -aF /foo
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$
```

Automounter mounts `/dev/cdrom` to `/foo/cd`

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
```

Will wait here for 90 seconds

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
prompt$
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
prompt$ ls -F
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$
```

Device is still busy so it is was not unmounted

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ cd ..
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ cd ..
prompt$
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ cd ..
prompt$ ls -aF
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ cd ..
prompt$ ls -aF
./   ../  cd/
prompt$
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ cd ..
prompt$ ls -aF
./   ../  cd/
prompt$ sleep 90
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ cd ..
prompt$ ls -aF
./   ../  cd/
prompt$ sleep 90
```

Another wait for 90 seconds

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/         System/      mach_kernel
prompt$ sleep 90
prompt$ ls -F
EFI/         System/      mach_kernel
prompt$ cd ..
prompt$ ls -aF
./   ../  cd/
prompt$ sleep 90
prompt$
```

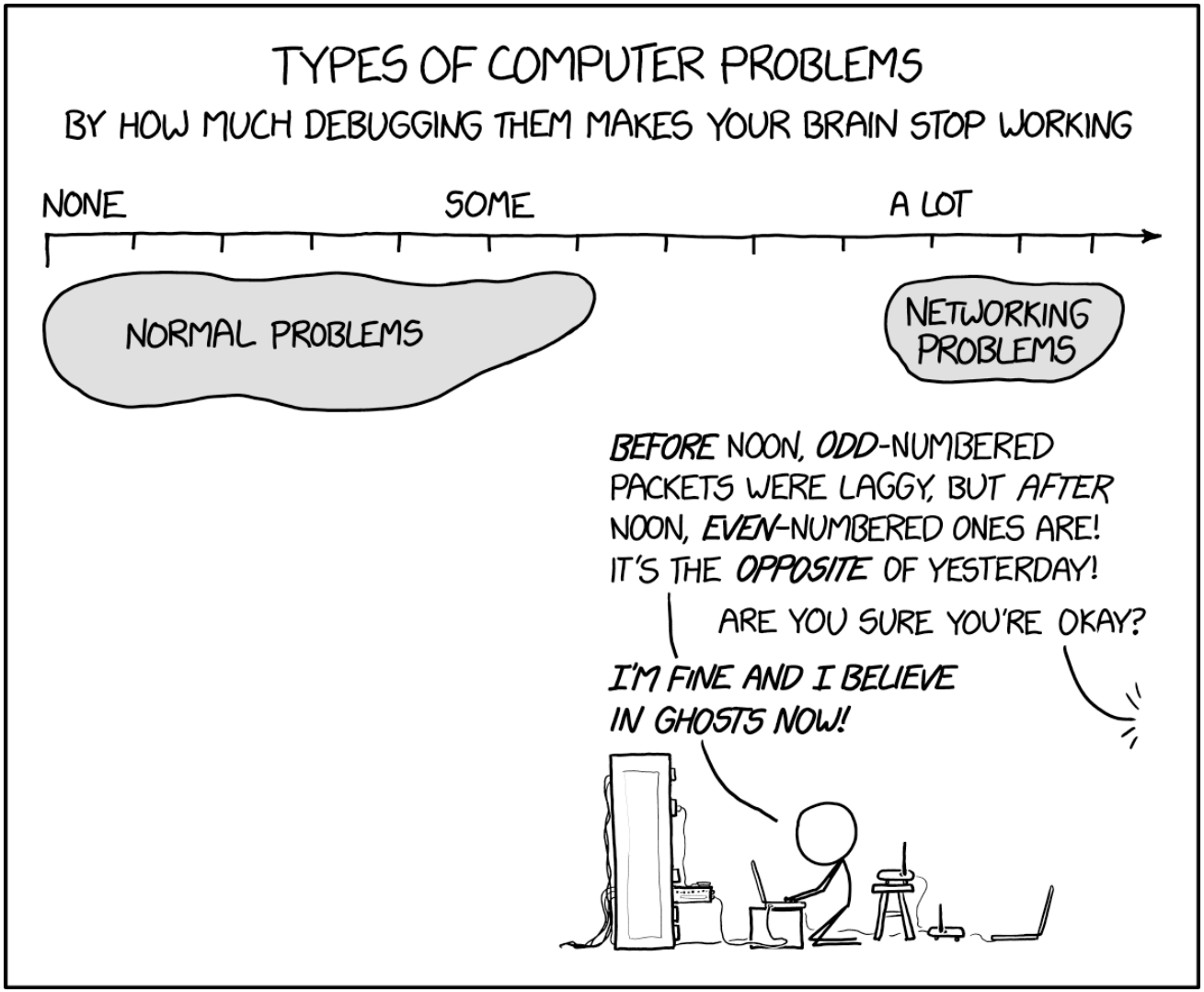
How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ sleep 90
prompt$ ls -F
EFI/          System/       mach_kernel
prompt$ cd ..
prompt$ ls -aF
./   ../  cd/
prompt$ sleep 90
prompt$ ls -aF
```

How this should work

```
prompt$ ls -aF /foo
./   ../
prompt$ cd /foo/cd
prompt$ ls -F
EFI/         System/      mach_kernel
prompt$ sleep 90
prompt$ ls -F
EFI/         System/      mach_kernel
prompt$ cd ..
prompt$ ls -aF
./   ../  cd/
prompt$ sleep 90
prompt$ ls -aF
./   ../
prompt$
```

An appropriate xkcd comic: http://xkcd.com/2259



End of lecture