System Security, part 1

ComS 252 — Iowa State University

Andrew Miner and Barry Britt

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- This class cannot make you a security expert
  - Two lectures are not nearly enough
  - The prereqs for this class are not enough

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- I will teach you
  - What you are up against (i.e., why this is hard)
  - General principles to make your system safer
  - Utilities that can help you

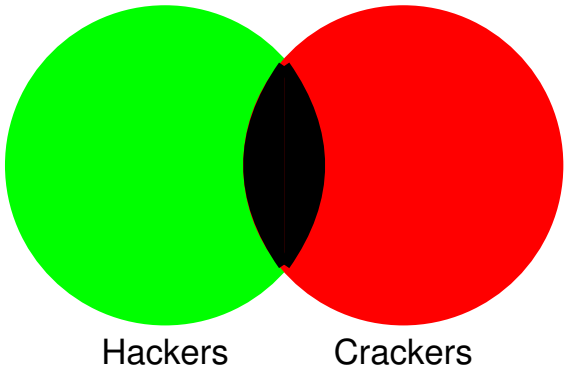
Some Terminology

hacker : someone who knows a lot about systems

- In particular, how they work
- Usually are programmers

cracker : someone who wants to crack a system

- I.e., break into a system
- Usually with malicious intent



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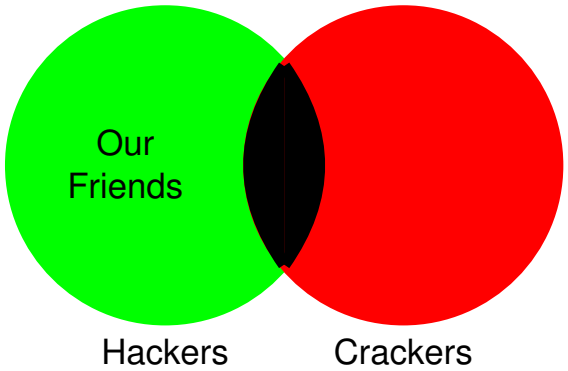

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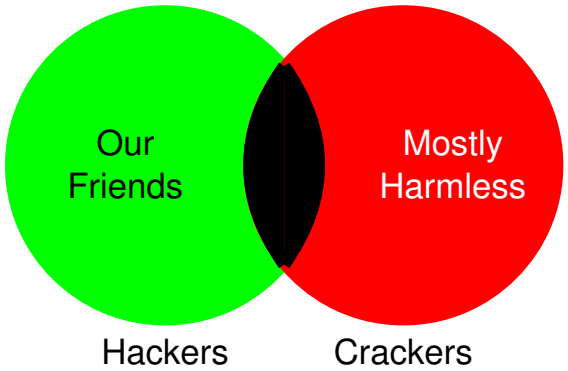

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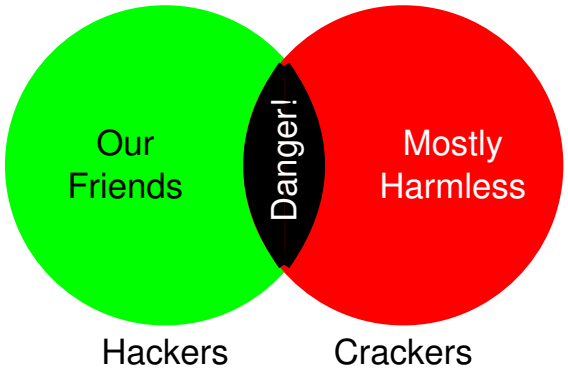

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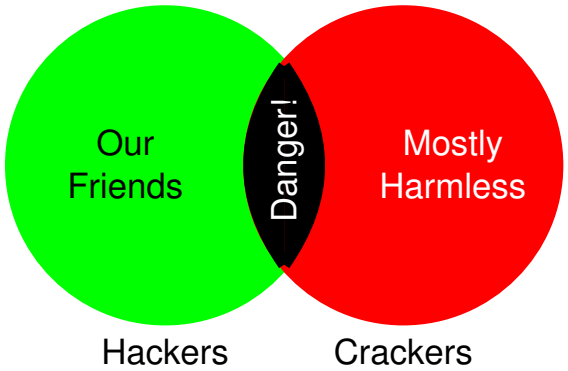

- Reality is not so clear–cut
- Let's examine the "Crackersphere" . . .

The Crackersphere

- Crackers have different amounts of knowledge
- Crackers have different amounts of available resources
- Crackers have different motivations

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- Next: a breakdown into groups by "prevention difficulty"

An arbitrary discretization of crackers into groups

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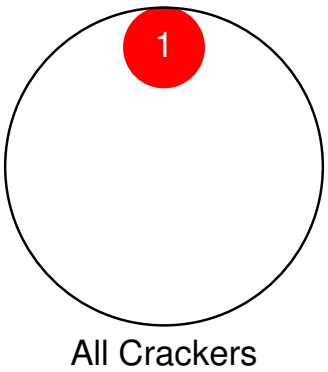

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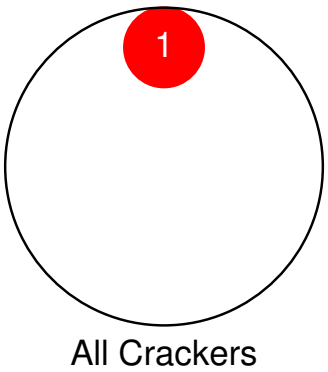

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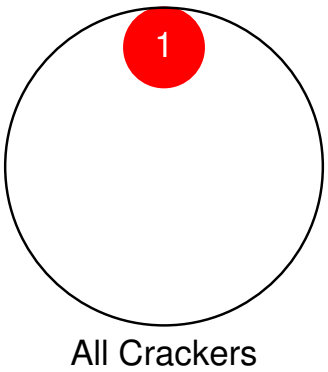

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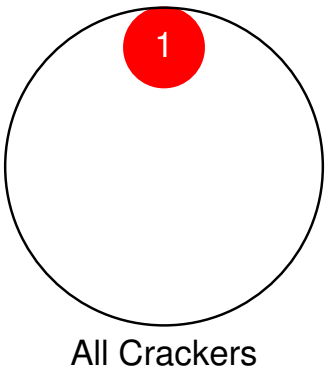

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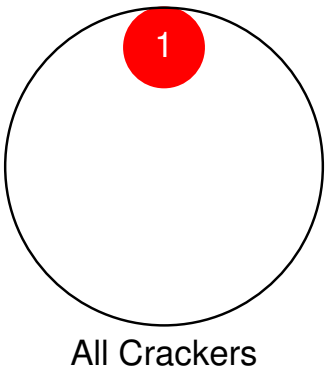

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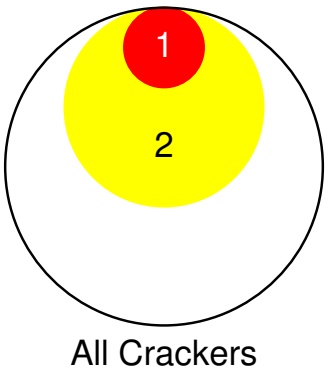

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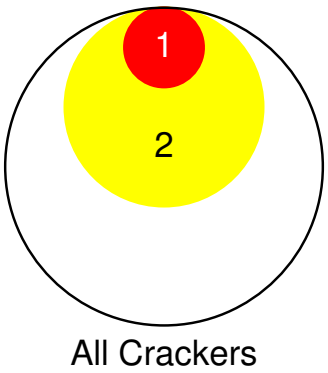

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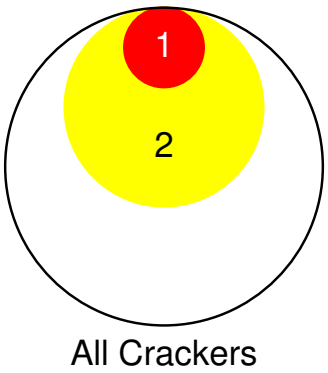

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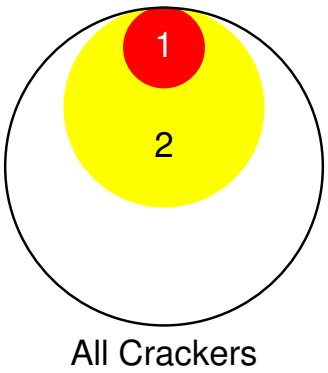

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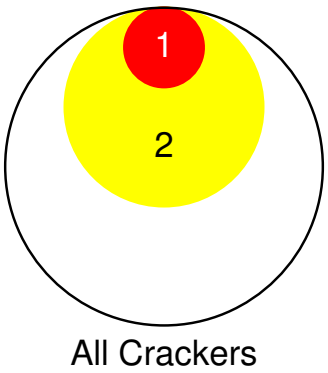

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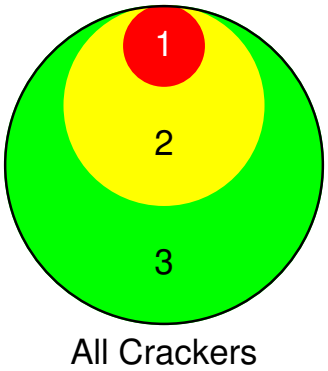

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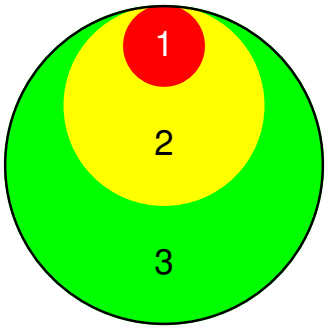

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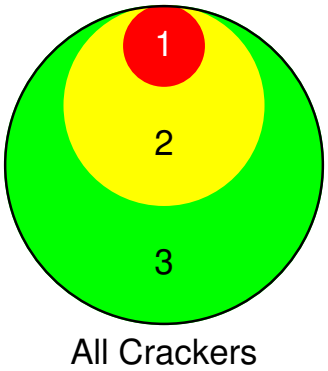

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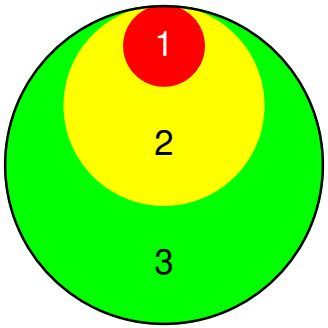

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   - Prevention difficulty: easy
     - Because the script is available online, the vulnerability is already well–known
     - (Except maybe within a few days of posting)
     - You should have patched your system by now

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- If you answered "yes" to all questions
  - You are living in the first generation of computing (1940's and 1950's)
  - You may proceed without ever thinking about security
- If you answered "no" to *any* question — start being paranoid

Broad security topics

For the next lectures, anyway

- Physical security
- Authentication
- Authorization
- Network security
- Detecting intrusions

But first — System backups

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If yes to both — you need to have a backup plan

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  - `/tmp`, `/proc`, `/dev`
- Grey area: other "system files"
  - E.g., kernel image, modules, libraries, applications?
  - Arguments for yes:
    - May be easier to rebuild the system
    - No danger of missing some critical file(s)
  - Arguments for no:
    - These things can be rebuilt "easily" by re-installing the OS
    - Backups will take more time and space if we include these

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The terms “differential” and “incremental” are often confused

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- Remote storage
  - Vendors provide secure and reliable storage
  - Performance depends on network

Backup utilities

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`rsync`

- Synchronizes data between two locations
- Can be used for hard disk and remote storage
- Smart — minimizes data transfer by only copying changes

Backup utilities: Macintosh

Time Machine

- Makes semi–regular full backups
- Makes regular incremental backups
- Can back up to any non–booting hard drive
- Easy to recover state of a file on any given date

Backup utilities: Windows

System Restore

- Only backs up certain system files
- Will create restore points
  - Does this before Windows updates and software installs, and at various other times
- Can roll back to earlier restore points

Windows backup

- Can create full and incremental backups
- Run the "backup wizard" to set this up

Backups — summary

- You should have some backup plan in place
- Can be a mixture of full and incremental backups; e.g.:
  - Full backups Sunday at 4am
  - Incremental backups Monday — Saturday at 4am
- Use automation to make this happen
  - Check out `cron` and `anacron` to do this yourself
- Check your backups occasionally
  - Make sure you can recover from them
- Consider off–site backups in your plan
  - Important for natural disasters
  - Remote storage is great for this
  - E.g., take an encrypted drive with a full backup of home machine to office every Monday

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- For sysadmins — also includes measures against crackers who have physical access
  - E.g., in public computer labs on campus

Single user mode

Must do all of the following to prevent crackers from booting in single user mode:

1. Use a GrUB password
   - Prevents editing of boot entries
2. Disable "boot from CD drive" in the BIOS
   - Prevents booting a live CD
3. Use a BIOS password
4. Lock machine(s) shut
   - Prevents crackers from resetting BIOS
   - Prevents crackers from changing drives

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- Is your machine locked shut? No?
  Then they can reset the BIOS and boot from a live CD...

Theft revisited

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Encrypt any sensitive files!

Keyboard access

- If you step away from your machine you should
  - Log out; or
  - Lock the screen; or
    - Most modern screen savers can be configured to do this
  - Lock the office door
- It only takes a few seconds to
  - Install an ssh key
  - Delete your files
  - Read (or send) mail
- Some companies will fire you for leaving an unsecured machine

Keystroke loggers

- Record all keystrokes
  - Cracker will search for usernames and passwords
- Can be software–based
  - We need to prevent crackers from installing "system" software
    - Not just for keyloggers
    - We will discuss this later
- Can be hardware–based
  - Small and inexpensive
  - Not hard to build
  - Sit between keyboard and machine
  - Might be inside the keyboard
  - Need physical access to install
  - Need physical access to retrieve

A keystroke logger

Recap of authentication

Authentication: mechanism to prove that you are who you claim

- Knowledge factor: something you know
  - E.g., password, city of birth, name of first pet
  - Have issues...
- Possession factor: something you have
  - E.g., ATM card, certificates
- Inherence factor: something you are
  - E.g., fingerprint, iris scan

- Multi–factor authentication: uses two or more factors

How to crack a password

Two ways to attempt this

1. Online cracking
   - Attempt to crack the password through the actual system
     - Sit at a terminal and repeatedly try to login
     - Write a script to do this via ssh
   - A system can have countermeasures for this attack
     - Artificial delay
       e.g., it always takes 5 seconds to login
     - Lockout after repeated unsuccessful attempts
       e.g., after 5 failed attempts, no login for an hour
2. Offline cracking
   - Attempt to crack the password without going through system
   - Cracker must obtain hashed password(s) first
   - Compute hashes for each guess, until a match is found
     - See function `crypt()`
     - Easy to parallelize: 3 years using 1 machine can be done in one day using 1000 machines

Salt

Issue: a cracker could generate a database of hashed passwords

- Each entry: password and its hash
- This might take a while to build
- Can then simply "`grep`" a hash to find its matching password
- Could be sold to script kids for fun and profit

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Solution: use random salt

- A number of randomly–generated characters
- Are hashed with the password
- Salt can be determined from the hash
- Does not prevent use of a password database
  - But, multiplies the required size of the database
  - E.g., 24 bits of salt gives 16 million possible salt values
  - This makes a reverse–lookup database infeasible

Password space

Password space: set of all possible passwords

- Different systems allow different characters
- Different systems allow different lengths
- Password space grows with length and allowed characters

Allowed	**5 chars**	**6 chars**	**8 chars**
lower	$26^5 \approx 11 \times 10^6$	$26^6 \approx 308 \times 10^6$	$26^8 \approx 208 \times 10^9$
+ upper	$52^5 \approx 380 \times 10^6$	$52^6 \approx 19 \times 10^9$	$52^8 \approx 52 \times 10^{12}$
+ digits	$62^5 \approx 916 \times 10^6$	$62^6 \approx 56 \times 10^9$	$62^8 \approx 218 \times 10^{12}$
+ 32 special	$94^5 \approx 7 \times 10^9$	$94^6 \approx 689 \times 10^9$	$94^8 \approx 6 \times 10^{15}$

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- Brute force attack will check the entire password space
- Necessary to find random passwords
- But what if my password is not "random"?

Entropy — what is it?

- Information theory concept
- Idea: measure of "information content"
  - Number of bits required to store something
- Related to compression

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Try a list of "likely" passwords

- Called a dictionary attack
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- Top 3 commonly–used passwords in 2012:
  1. password
  2. 123456
  3. 12345678

Strong passwords

- Are at least 8 characters
  - Use a passphrase if possible
- Contain a variety of character types
  - Upper, lower, digit, "special"
- Are not based on single words
- Are memorized
  - Or use a secure password manager
  - Are not written on a post it note stuck to your monitor
- Are changed regularly
- One way to select "more random" passwords:
  - Start with a sentence or phrase
  - Pull letters, symbols, and digits from it
  - Example:
    This semester, I will get 4 As produces `Ts,Iwg4A`
    Pretty good password and has a built–in expiration date

Avoiding weak passwords

- Some systems will not allow passwords based on a word
- Some systems will not allow short passwords
- For all VMs this semester
  - I had to set the password as `root`
  - Otherwise Linux complained that the passwords were too weak
- There are utilities
  - E.g., John the Ripper
    - Purpose is to detect weak passwords and notify users
    - Can also be used for evil

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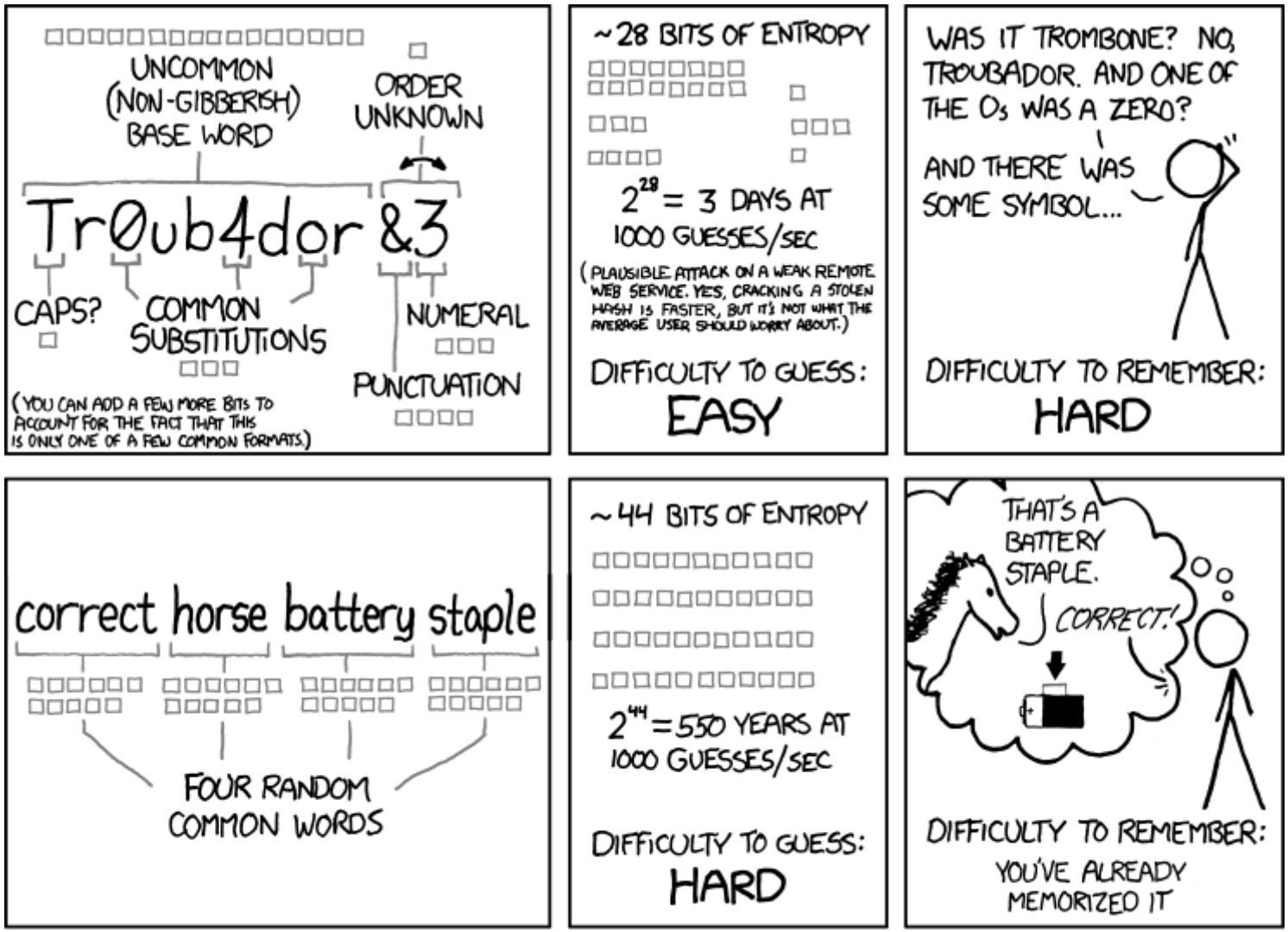
- Social engineering
  - Phishing is an example of this
  - Probably the most effective way to get passwords

Instructional xkcd comic: http://xkcd.com/936



End of lecture