CSE 484 : Computer Security and Privacy

Software Security [Wrap-Up] Cryptography [Intro]

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Admin

- Lab 1: April 21
  - That is, sploits 1-3
  - When you are ‘done,’ stop changing those files.
  - Start early! You are encouraged to finish sploits 1-3 before April 21, and start on the other sploits before the final deadline
- Wednesday:
  - Gennie Gebhart, Acting Activism Director, Electronic Frontier Foundation (EFF)
  - https://www.eff.org/about/staff/gennie-gebhart
  - Title: Surveillance Self-Defense and Security Work in Civil Society

Attacker Model

```
PwdCheck(RealPwd, CandidatePwd)  // both 8 chars
    for i = 1 to 8 do
        if (RealPwd[i] != CandidatePwd[i]) then
            return FALSE
    return TRUE
```

- Attacker can guess CandidatePwds through some standard interface
- Naive: Try all 256^8 = 18,446,744,073,709,551,616 possibilities
- Is it possible to derive password more quickly?

Timing Attacks

- Assume there are no “typical” bugs in the software
  - No buffer overflow bugs
  - No format string vulnerabilities
  - Good choice of randomness
  - Good design
- The software may still be vulnerable to timing attacks
  - Software exhibits input-dependent timings
- Complex and hard to fully protect against

Other Examples

- Plenty of other examples of timings attacks
  - Timing cache misses
    - Extract cryptographic keys…
    - Recent Spectre/Meltdown attacks
  - Duration of a rendering operation
    - Extract webpage information
  - Duration of a *failed* decryption attempt
    - Different failures mean different thing (e.g., Padding oracles)

Side-channels

- Timing is only one possibility

- Consider:
  - Power usage
  - Audio
  - EM Outputs

General Principles

- Check inputs
- Check all return values
- Least privilege
- Securely clear memory (passwords, keys, etc.)
- Failsafe defaults
- Defense in depth
  - Also: prevent, detect, respond

- NOT: security through obscurity

General Principles

- Reduce size of trusted computing base (TCB)
- Simplicity, modularity
  - But: Be careful at interface boundaries!
- Minimize attack surface
- Use vetted components
- Security by design
  - But: tension between security and other goals
- Open design? Open source? Closed source?
  - Different perspectives

Does Open Source Help?

- Different perspectives…

- Positive example?
  - Linux kernel backdoor attempt thwarted (2003)
    (http://www.freedom-to-tinker.com/?p=472)

- Negative example?
  - Heartbleed (2014)
    - Vulnerability in OpenSSL that allowed attackers to read arbitrary memory from vulnerable servers (including private keys)

Vulnerability Analysis and Disclosure

- What do you do if you've found a security problem in a real system?
- Say
  - A commercial website?
  - UW grade database?
  - Boeing 787?
  - TSA procedures?

Breakout Groups:
What would you do? What ethical questions come up?

Vulnerability Analysis and Disclosure

- Suppose companies A, B, and C all have a vulnerability, but have not made the existence of that vulnerability public
- Company A has a software update prepared and ready to go that, once shipped, will fix the vulnerability; but B and C are still working on developing a patch for the vulnerability
- Company A learns that attackers are exploiting this vulnerability in the wild
- *Should Company A release their patch, even if doing so means that the vulnerability now becomes public and other actors can start exploiting Companies B and C?*
- *Or should Company A wait until Companies B and C have patches?*

Next Major Section of the Course: Cryptography

Terminology Note: “blockchain” and “crypto”

- Rising interest, mostly in the cryptocurrency space
- For this course: crypto means “cryptography”

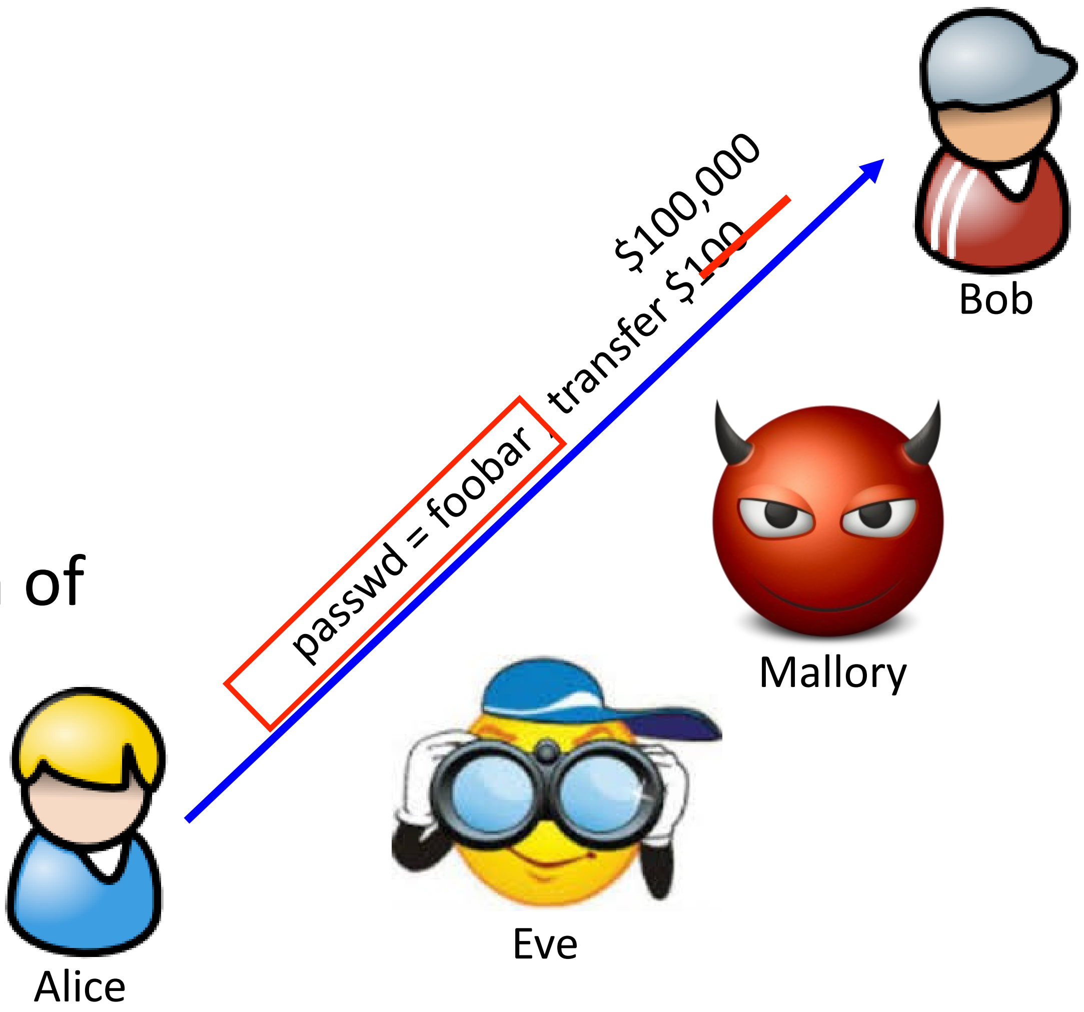
Common Communication Security Goals

Privacy of data:

Prevent exposure of information

Integrity of data:

Prevent modification of information



Recall Bigger Picture

- Cryptography only one small piece of a larger system
- Must protect entire system
  - Physical security
  - Operating system security
  - Network security
  - Users
  - Cryptography (following slides)
- Recall the weakest link

- Still, cryptography is a crucial part of our toolbox

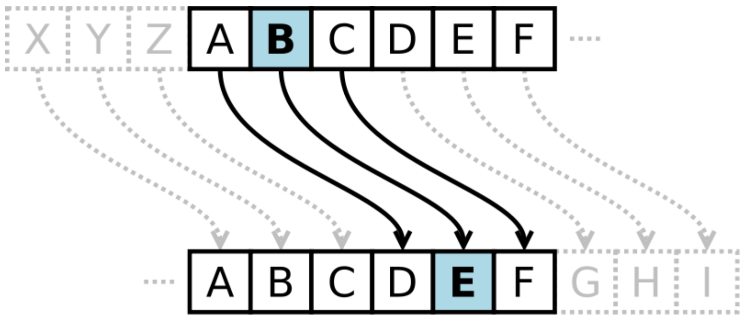
History

- Substitution Ciphers
  - Caesar Cipher
- Transposition Ciphers
- Codebooks
- Machines

- Recommended Reading: **The Codebreakers** by David Kahn and **The Code Book** by Simon Singh.

History: Caesar Cipher (Shift Cipher)

- Plaintext letters are replaced with letters a fixed shift away in the alphabet.



- Example:
  - Plaintext: `The quick brown fox jumps over the lazy dog`
  - Key: Shift 3

    `ABCDEFGHIJKLMNOPQRSTUVWXYZ`

    `DEFGHIJKLMNOPQRSTUVWXYZABC`
  - Ciphertext: `WKHTX LFNEU RZQIR AMXPS VRYHU WKHOD CBGRJ`

History: Caesar Cipher (Shift Cipher)

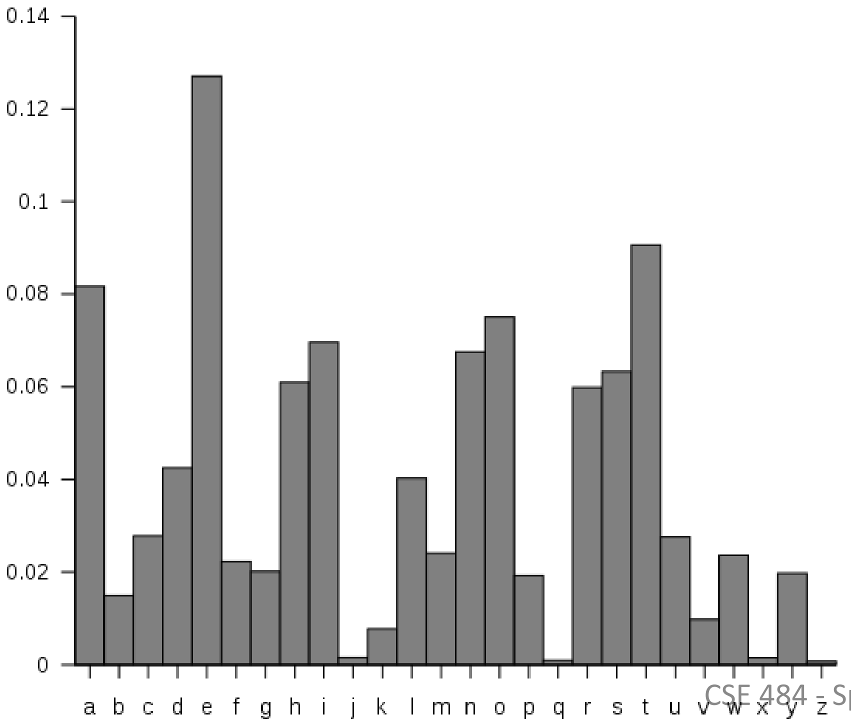
- ROT13: shift 13 (encryption and decryption are symmetric)
- What is the key space?
  - 26 possible shifts.
- How to attack shift ciphers?
  - Brute force.

History: Substitution Cipher

- Superset of shift ciphers: each letter is substituted for another one.
- One way to implement: Add a secret key
- Example:
  - Plaintext: `ABCDEFGHIJKLMNOPQRSTUVWXYZ`
  - Cipher: `ZEBRASCDFGHIJKLMNOPQTUVWXY`
- “State of the art” for thousands of years

History: Substitution Cipher

- What is the key space?
- How to attack?
  - Frequency analysis.



26! ~= 2^88

Bigrams:

th 1.52%	en 0.55%	ng 0.18%
he 1.28%	ed 0.53%	of 0.16%
in 0.94%	to 0.52%	al 0.09%
er 0.94%	it 0.50%	de 0.09%
an 0.82%	ou 0.50%	se 0.08%
re 0.68%	ea 0.47%	le 0.08%
nd 0.63%	hi 0.46%	sa 0.06%
at 0.59%	is 0.46%	si 0.05%
on 0.57%	or 0.43%	ar 0.04%
nt 0.56%	ti 0.34%	ve 0.04%
ha 0.56%	as 0.33%	ra 0.04%
es 0.56%	te 0.27%	ld 0.02%
st 0.55%	et 0.19%	ur 0.02%

Trigrams:

1. the	6. ion	11. nce
2. and	7. tio	12. edt
3. tha	8. for	13. tis
4. ent	9. nde	14. oft
5. ing	10.has	15. sth