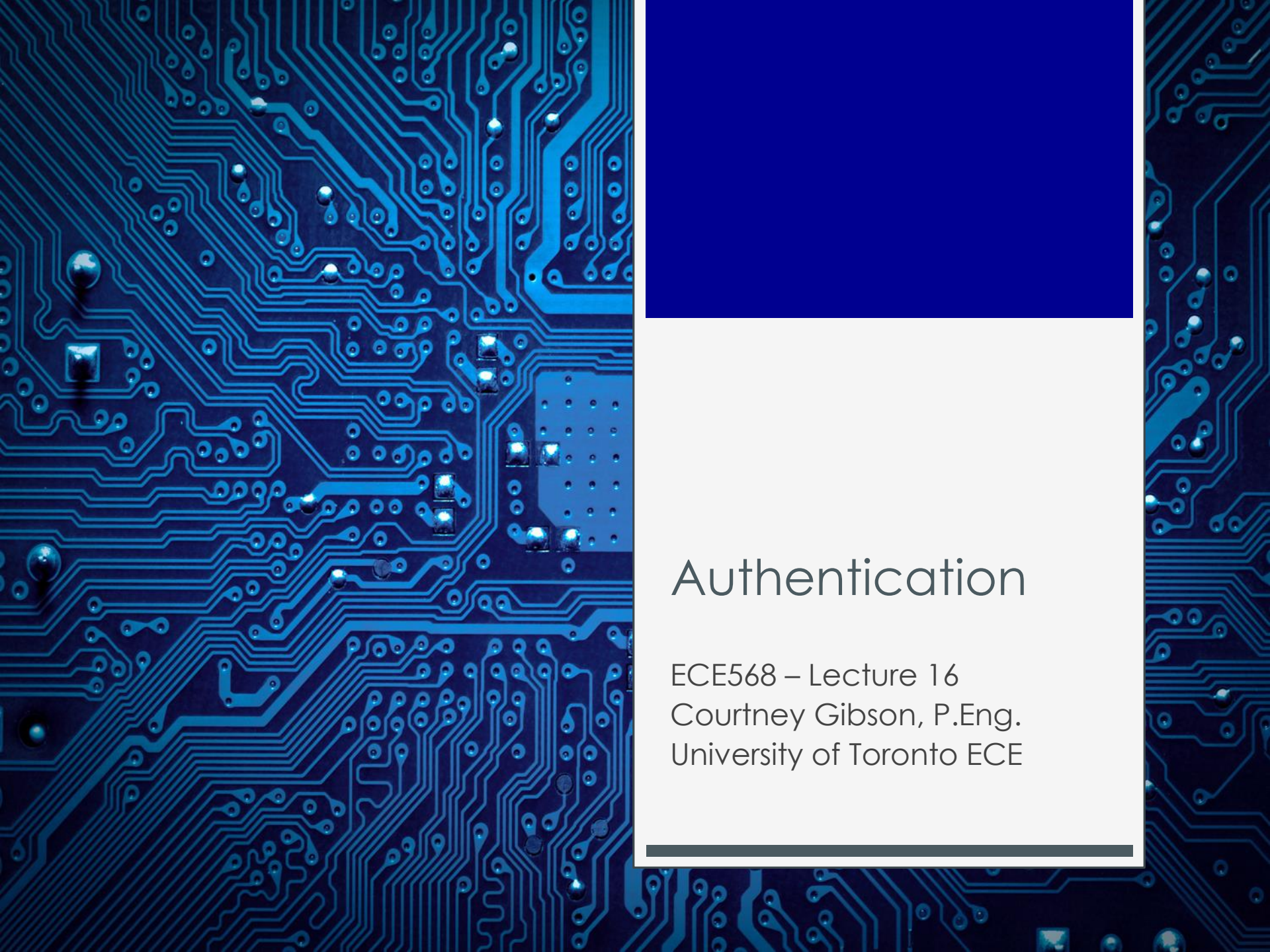

Authentication

ECE568 – Lecture 16

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Outline

Passwords

- Password Storage
- Salts
- One-Time Passwords

Multi-Factor Authentication

- Biometrics

Passwords

Passwords

Passwords are commonly used for user authentication, but have several problems

- People can't remember them, so they pick **easy** passwords or write them down where attackers can find them
  - Attacker has a list of commonly used passwords and tries them (**dictionary attack**)
- People tend to use the **same** passwords for many systems
  - A weak system that gets compromised can lead to a strong system getting compromised
- The authentication is **not mutual**
  - When a user enters a password, they usually don't know if they are sending their password to the right system
  - Examples of problems?


14589#
SCHLAGE
1 2 3
4 5 6
7 8 9
* 0 #

Storage of Passwords

Systems usually don't store passwords in the clear

- Why is this a good practice?
  - If an attacker somehow got the password file, they would know the passwords of all users
- The passwords are hashed using a one-way hash, and only the hash is stored

```
tom:$1$r4ySvmPT$uG3vAOKx9oe84UyaU6MEv0:13090:0:99999:7:::
```

  - If attacker gets the hash, she doesn't know the password without guessing or reversing the hash
- Login procedure
  - User provides input password
  - System calculates the hash of the input password, and compares this value with the one in the password file

Storage of Passwords

/etc/passwd

```
cgibson:x:507:100:Courtney Gibson:/home/cgibson:/bin/bash
```

/etc/shadow

```
cgibson:qDjGf7984zb3.:12975:0:99999:7:::
```

Interesting note: the Unix `crypt` function, used for traditional password hashing, ignores everything after the first eight characters.

Password Salts

Suppose an attacker steals the password file and breaks one password (*i.e.*, attacker finds a password **p**, given **H(p)**)

- Then the attacker has found the password for all users using the password **p**, since **H(p)** will match
- This problem can be prevented by adding a random value called a **salt** (different for every user) to the password, before hashing:
  - User 1: crypt("password" + "**aa**") = `jfMkNH1hTm2`
  - User 2: crypt("password" + "**bb**") = `v4NvUbQpMC2`
- Salt value is stored in the password file
  - Do salts make it harder to break a single password?

One-Time Passwords

Static passwords can be broken given enough time

- A **one-time password** changes every time it is used, reducing this risk greatly
- One-time passwords are often implemented using **challenge-response authentication**
  - One party presents a question (“challenge”)
  - Other party must provide a valid answer (“response”)
- Example:
  - Server encrypts ‘n’ using shared key, sends E(n) to client
  - Client decrypts ‘n’, adds 1, and send E(n+1) to server
  - Client is authenticated if server is able to decrypt the message and get ‘n+1’

Multi-Factor Authentication

Multi-factor Authentication

Authentication, in general, uses a piece of information about the user, called an **authentication factor**

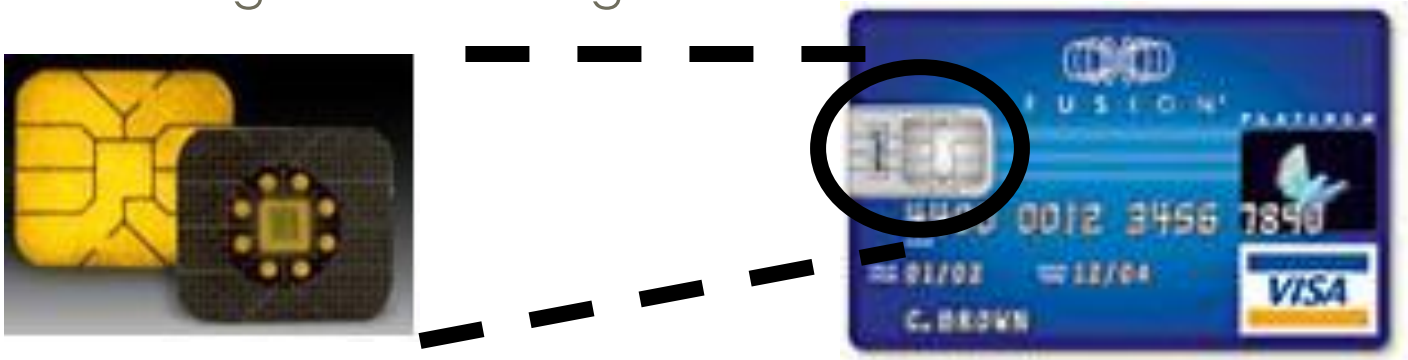
- An authentication factor can be
  - Something the user **knows** (*i.e.*, password)
  - Something the user **has**
  - Something the user **is**
  - Something the user **can do**
- **Multi-factor authentication** provides better security by using multiple authentication factors

Something the User Has: Smart Cards

Smart cards are a good option for a security token

- Smart card contains secure microcontroller that is hardened against tampering
- Contains keys and performs cryptographic operations

- How can the card be used for authentication?
- Have the card sign a randomly generated string
  - Why random?
  - Who generates string?



Something the User Is: Biometrics

Biometrics involves identifying a person by measuring some physical aspect of that person

- Common biometrics techniques are based on using:
  - **Fingerprints:** Every person's fingerprint is fairly unique, a product of genetics and environment
  - **Iris:** Scans the pattern of a person's iris (pretty accurate)
  - **Retina:** Scans the pattern of blood vessels at the back of the eye (pretty accurate)
  - **Hand Geometry:** Matches the shape of your hand
  - **Gait Recognition:** Recognize people by the way they walk (non-intrusive)
  - **Facial Recognition:** Recognize faces (non-intrusive)
  - **Speech Recognition:** Recognize people by their voices and the way the say things

Biometric Systems

What makes a good biometric system?

- Understanding that you are moving from a **binary** to a **probabilistic** security model
  - **FRR:** False Rejection Rate
  - **FAR:** False Acceptance Rate (1:50,000?)
    - "Birthday Attack" problem
  - Layered approaches, using multiple biometric measures, are needed for good security
- Management of the biometric templates
  - Good enrollment
  - Secure storage
  - Aging / updating of the templates

Something the User Can Do: Turing Test

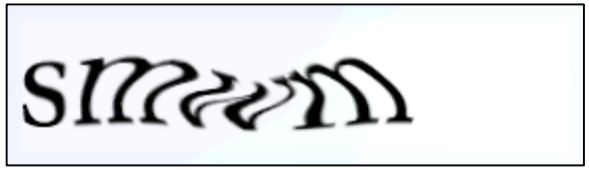
Often a remote site wants to check whether there is a human on the other end

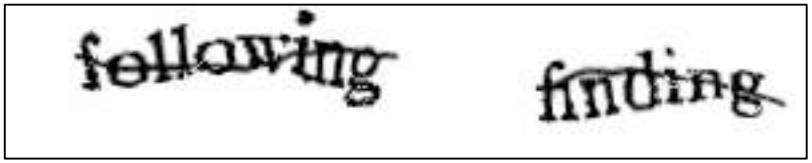
- In 1950, Alan Turing postulated a test that could differentiate between a machine and a human
  - Given a means of communicating only through written language (*i.e.*, a terminal, chat client, etc.), can a human tell if the other end is a human or a computer?
- This test was a way to decide whether machines can think…
- While Turing's paper had much larger implications, the concept of a **test** to tell if something is a human or a computer still applies

Something the User Can Do: Turing Test

Previously, setting up an account required a user to physically meet a sys admin

- Today, that is often not feasible
- Common solution is to use a **CAPTCHA** (**C**ompletely **A**utomated **P**ublic **T**uring Test to tell **C**omputers and **H**umans **A**part)





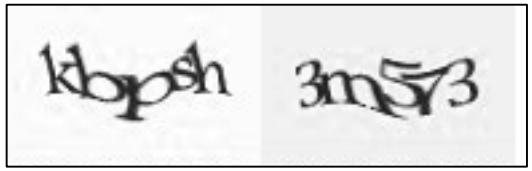


Image Source: Wikimedia Commons

reCAPTCHA

200 million CAPTCHAs are solved per day: equivalent to 150,000 hours of work

- The reCAPTCHA project provides a free CAPTCHA engine: aims to improve the accuracy of scanned historical texts
- Each new word that cannot be read correctly by OCR is given to a user in conjunction with another word for which the answer is already known. User is asked to read both words: if they solve the one for which the answer is known, the system assumes their answer is correct for the new one. The system gives the new image to a number of other people to determine, with higher confidence, whether the original answer was correct.

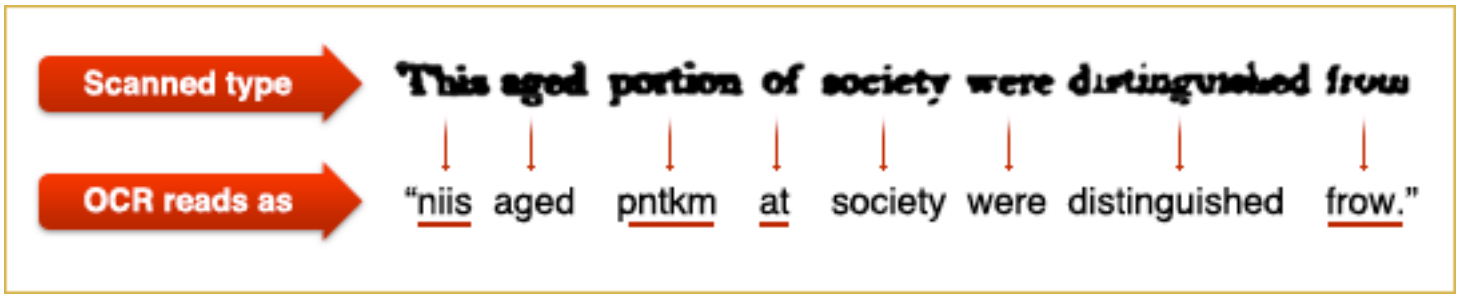
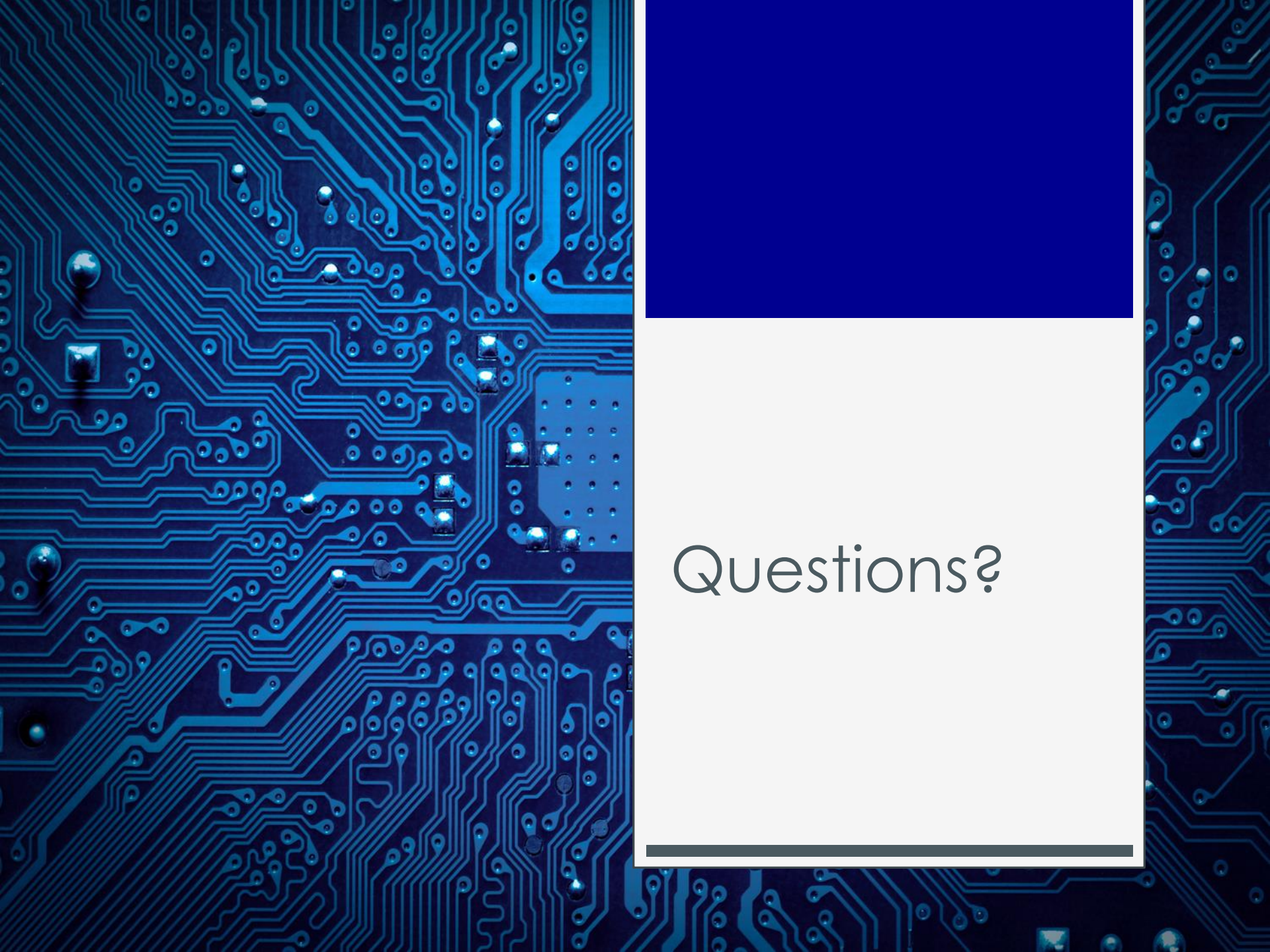


Image Source: Google.com

Strength of CAPTCHA's

- CAPTCHA's have many nice properties
  - No human tester is needed, since a computer can test if the other end is a computer or not quite reliably
  - Relatively easy to use (though getting worse)
- Unfortunately, CAPTCHA's have been getting weaker and alternatives will likely have to be found
  - Computer vision researchers have improved algorithms to the point that they are nearly on-par with humans
    - Analysis is slow, but is successful
  - One of the largest botnets tracked in 2008 consisted of 1.5 million infected computers being used to automate breaking CAPTCHAs
  - Can also trick humans into posting answers to CAPTCHA by copying the graphics to another page


Questions?