Authentication

User Accounts

- Everything we've built so far treats every user the same and delivers the same content to all visitors
  - Only exception was setting a cookie after their first visit
- For many features of a web app we want to remember a user across multiple visits and verify their identity

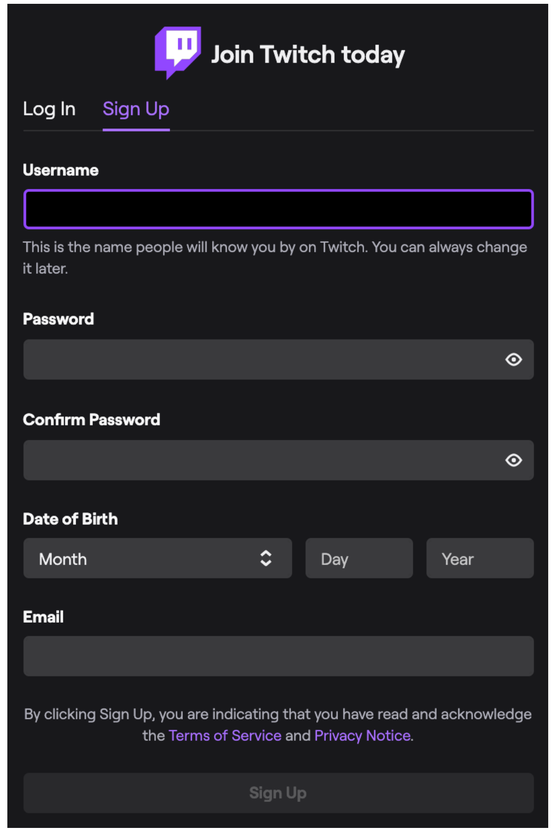
User Accounts

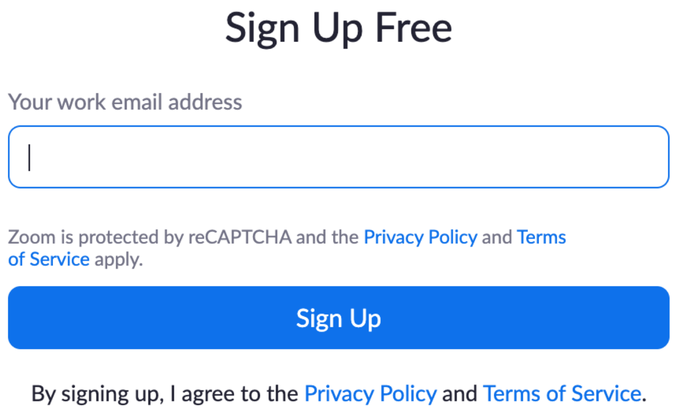
- Registration
  - Users can create an account on your app
  - Choose a username and password

- Authentication
  - Verify that a user is [likely] a registered account holder by providing their username/password
  - Log them into your app
  - Serve content specific to them

User Accounts

- Registration
  - Can be a simple web form
  - At a minimum, provide a username and password
- Common to affiliate an account with a valid email address
  - And verify that email
  - Limits the number of bots that register





Why Verify Email?

Example

Authentication

- On the server
  - Store each username/password in a database
  - This data must persist so the users can log in
  - What if this database is compromised?
    - Perhaps by a SQL injection attack

Authentication

- NEVER store passwords as plain text
- Not even the admins of a website should know the passwords of their users
- We do this by **hashing** the passwords and storing only the hashes

Hash Function

- A function that converts one value into another with certain properties
  - Typically a fixed length value
- Used to build hash tables
- Hash functions may not add any security!

Cryptographic Hash Function

- A hash function that is meant for secure purposes
- Goal of being a one-way function
  - Easy to compute a hash value from plain text
  - Very difficult to compute the plain text of a given hash
- Hashes can be shared without compromising the plain text

password

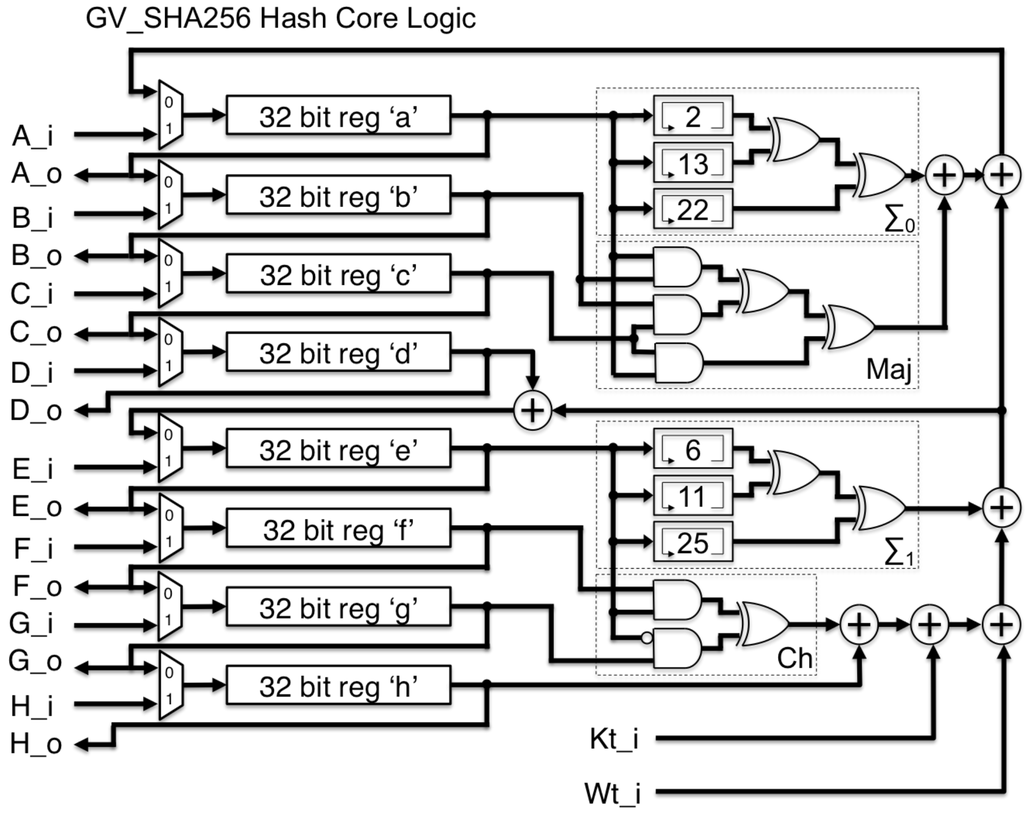
5e884898da28047151d0e56f8dc6292773603d0d6aabbdd62a11ef721d1542d8

Cryptographic Hash Function

- Only a cryptographic hash of your password is stored
- By only storing the hash of a password:
  - Even the admins of a site can’t read your password!
- SHA256 is a commonly used cryptographic hash function
  - https://www.xorbin.com/tools/sha256-hash-calculator

SHA256

- Runs input through multiple rounds of bit-level manipulation
- Easy (Fast) to compute
- Very difficult to compute in reverse



Ref: opencores.org

SHA256 Demo

Brute Force Attack

- Storing SHA256 hashes is not always secure!
  - Surprisingly common misconception
- Hashes are easy to compute, but hard to reverse
- To attack a hash:
  - Hash every possible password
  - If the hashes match, you know the password

Brute Force Demo

Entropy

- Entropy is a measure of uncertainty
  - Number of guesses required to guarantee a hash is matched
- Examples:
  - If you know the plain text is a single lowercase letter the entropy is 26
  - If it’s two lowercase letters, the entropy is 26^2 = 676
  - If it’s two letters that can be upper or lower case, 52^2 = 2704
- Tend to measure the “bits of entropy”
  - The log base 2 of these values

Entropy Demo

Dictionary Attack

- More advanced version of the brute force attack
- Use common words with common replacements
  - a -> @
  - O -> 0
  - i -> !
- Real words are easier to remember
  - Attacker takes advantage of this
- Lists of common passwords are freely available
  - Start with these

Rainbow Table

- A table containing the start and end of "chains" of hashes
- Repeatedly rehash the start to reach the end
- To attack a hash:
  - Rehash until you reach the end of a chain
  - Rehash the beginning of the chain to find the value before the hash
- Takes a long time to compute a large table
- Effectively trades space for time once the table is computed

Salting

- Salt hashes to prevent attack like rainbow tables
- A salt is a randomly generated string that is stored in plain text with the hash
- The salt is appended to the plain text before hashing
  - Nearly all hashes in the rainbow table will not use this salt
- The salt does not add entropy since it is stored in the clear

Authentication

- The bcrypt library implements hashing, salting, and other security related functions
- Available in many different languages