

Authentication

User Accounts

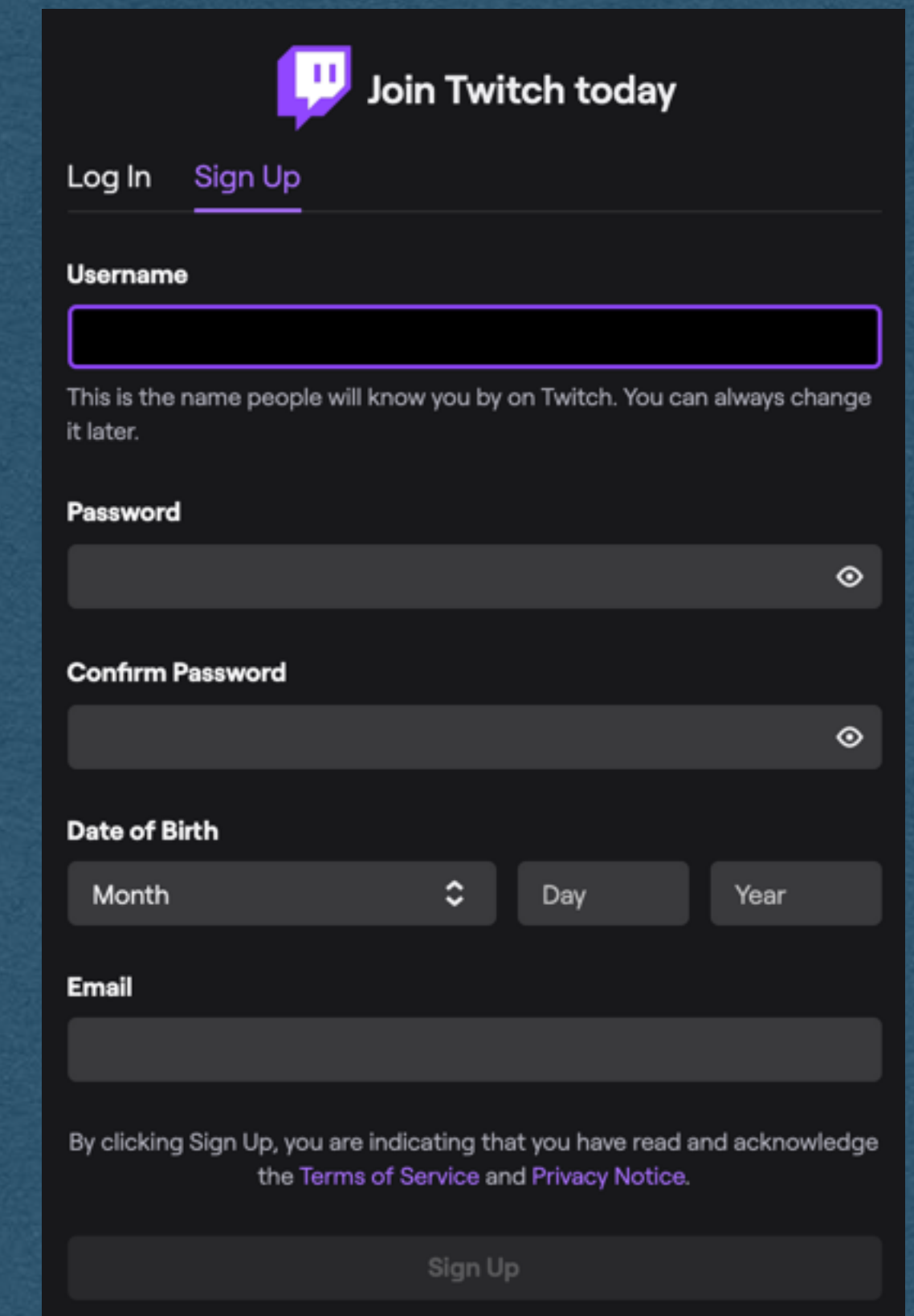
- Everything we've built so far treats every user the same and delivers the same content to all visitors
 - Only exception was setting a cookie to count visits
- For many features of a web app we want to remember a user across multiple visits and verify their identity

User Accounts

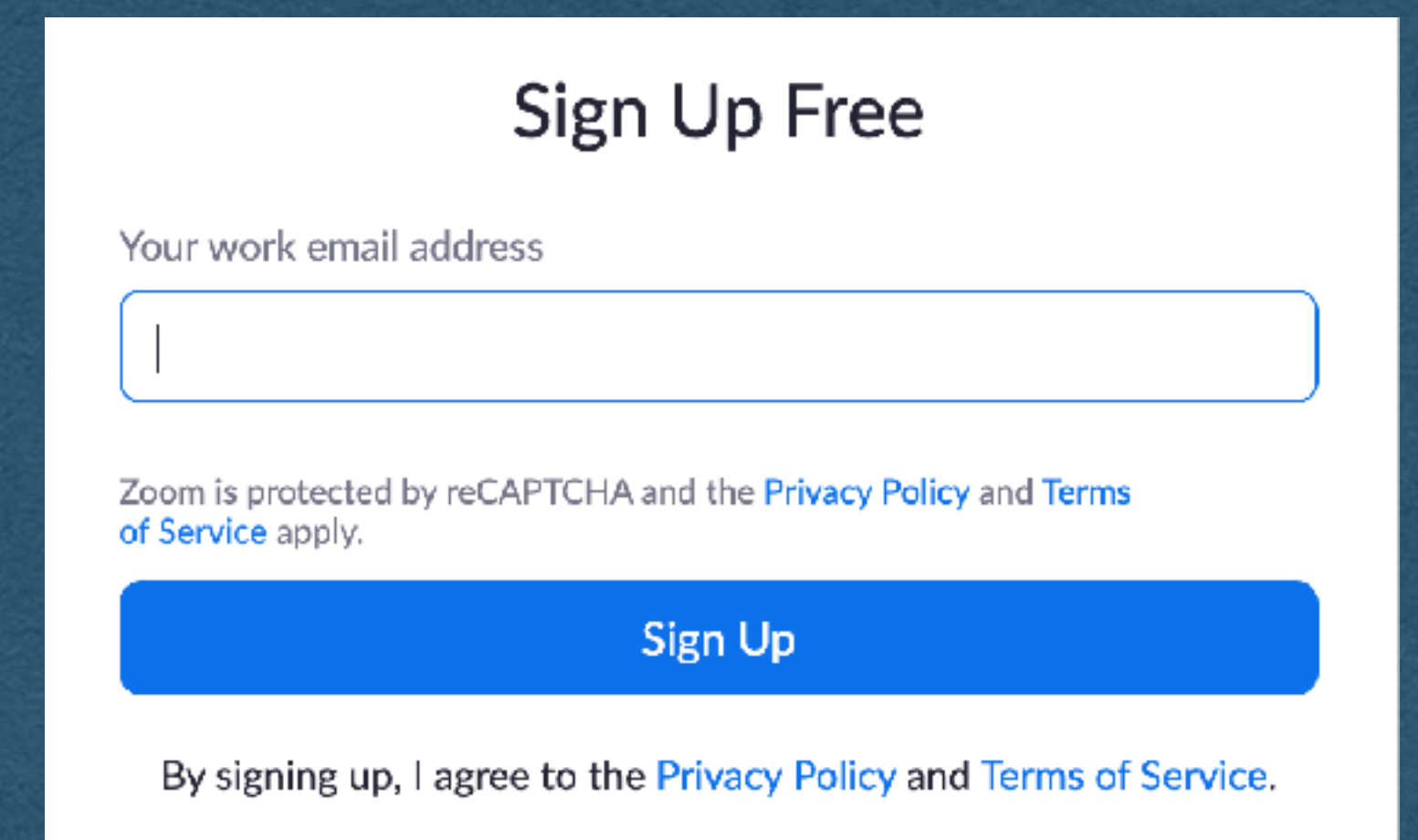
- Registration
 - Users can create an account on your app
 - Choose a username and password
- Authentication
 - Verify that a user is [likely] a registered account holder by providing their username/password
 - Log them into your app
 - Serve content specific to them

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



The image shows a dark-themed sign-up form for Twitch. At the top right, there is a Twitch logo and the text "Join Twitch today". Below this, there are two links: "Log In" and "Sign Up", with "Sign Up" being the active link. The form contains several input fields: "Username" with a text box and a note below it stating "This is the name people will know you by on Twitch. You can always change it later."; "Password" with a text box and an eye icon; "Confirm Password" with a text box and an eye icon; "Date of Birth" with three dropdown menus for "Month", "Day", and "Year"; and "Email" with a text box. At the bottom, there is a "Sign Up" button and a line of text: "By clicking Sign Up, you are indicating that you have read and acknowledge the [Terms of Service](#) and [Privacy Notice](#)."



The image shows a white-themed sign-up form for Zoom. At the top, it says "Sign Up Free". Below that, there is a label "Your work email address" and a text input field. Underneath the input field, there is a line of text: "Zoom is protected by reCAPTCHA and the [Privacy Policy](#) and [Terms of Service](#) apply." Below this is a large blue button with the text "Sign Up". At the bottom, there is a line of text: "By signing up, I agree to the [Privacy Policy](#) and [Terms of Service](#)."

Why Verify Email?

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
 - Among other applications
- 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



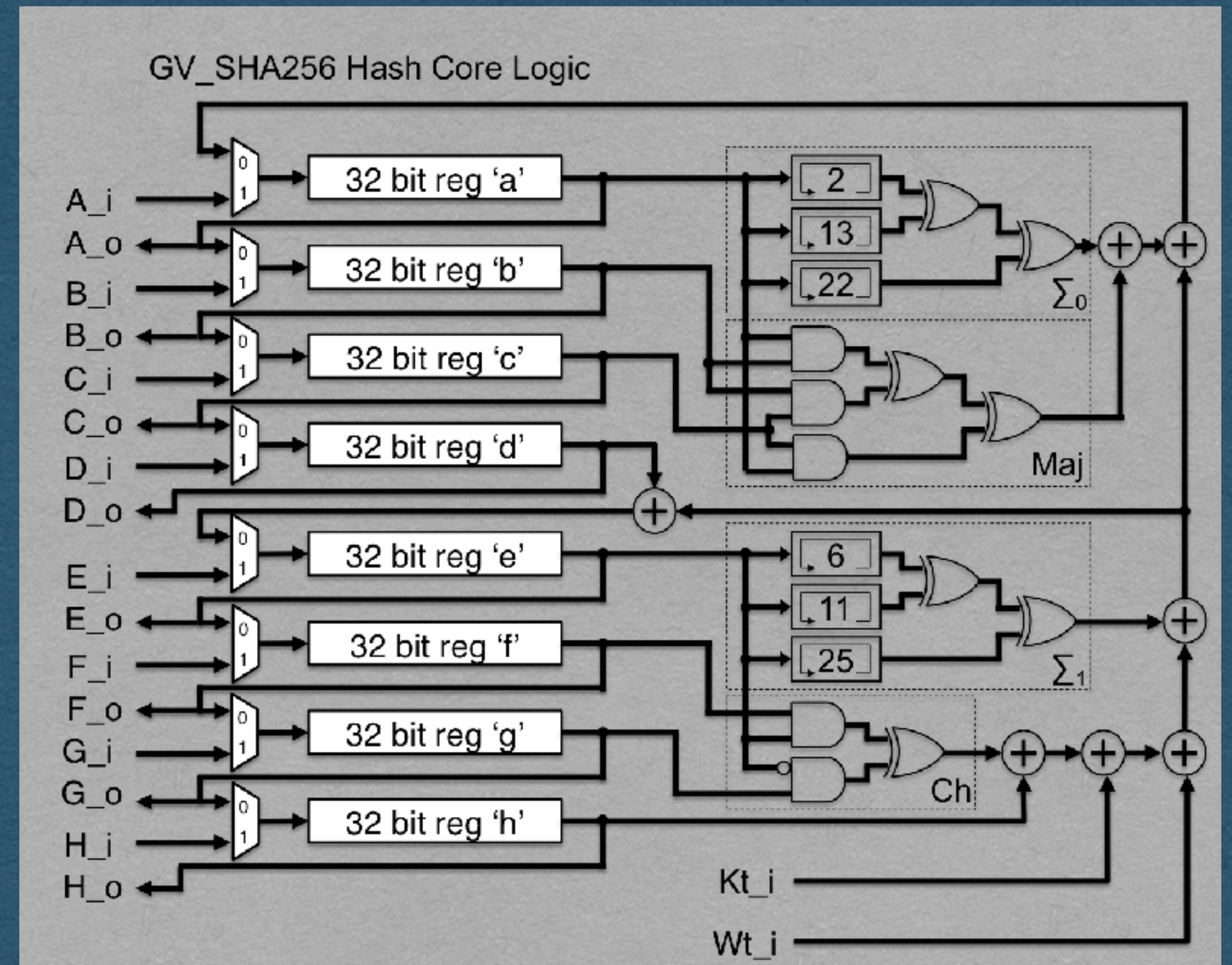
5e884898da28047151d0e56f8dc6292773603d0d6aabbdd62a11ef721d1542d8

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

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

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
- Typically consider ≥ 80 bits of entropy to be secure

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
 - Attackers take 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 attacks 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
- It is highly recommended that you use this library in your assignment

Authentication

- Registration
 - User provides username/password
 - Generate a random salt
 - Append the salt to the end of the password and compute the SHA256 hash
 - Store the username/salt/hash in your database

Authentication

- Authentication
 - User provides username/password
 - Lookup the salt/hash for the given username
 - Append the salt to the provided password and compute the SHA256 hash
 - If this hash matches the stored hash, the user is verified
 - If this hash does not match the stored hash, the user is not logged in