How does Google Authenticator (or other types of 2-factor authenticators) work?

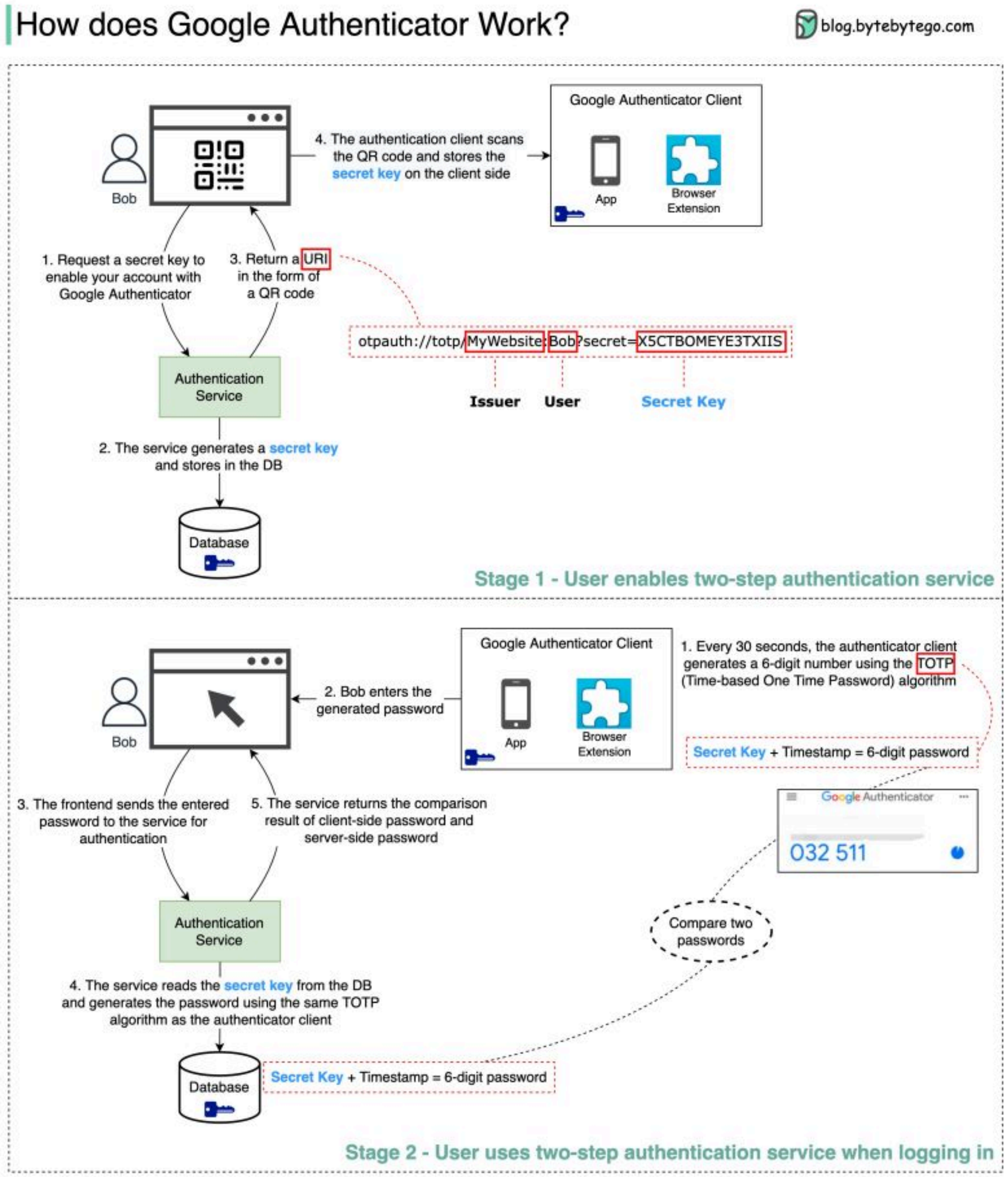
Google authenticator is commonly used for logging into our accounts when 2-factor authentication is enabled. How does it guarantee security?

Google Authenticator is a software-based authenticator that implements a two-step verification service. The diagram below provides detail.

There are two stages involved:

- Stage 1 - The user enables Google two-step verification
- Stage 2 - The user uses the authenticator for logging in, etc.

Let’s look at these stages.


How does Google Authenticator Work?
blog.bytebytego.com
Bob
4. The authentication client scans the QR code and stores the secret key on the client side
Google Authenticator Client
App
Browser Extension
1. Request a secret key to enable your account with Google Authenticator
3. Return a URI in the form of a QR code
otpauth://totp/MyWebsite:Bob?secret=X5CTBOMEYE3TXIIS
Issuer
User
Secret Key
Authentication Service
2. The service generates a secret key and stores in the DB
Database
Stage 1 - User enables two-step authentication service
Bob
2. Bob enters the generated password
Google Authenticator Client
App
Browser Extension
1. Every 30 seconds, the authenticator client generates a 6-digit number using the TOTP (Time-based One Time Password) algorithm
Secret Key + Timestamp = 6-digit password
Google Authenticator
032 511
3. The frontend sends the entered password to the service for authentication
5. The service returns the comparison result of client-side password and server-side password
Authentication Service
Compare two passwords
4. The service reads the secret key from the DB and generates the password using the same TOTP algorithm as the authenticator client
Database
Secret Key + Timestamp = 6-digit password
Stage 2 - User uses two-step authentication service when logging in

Stage 1

Steps 1 and 2: Bob opens the web page to enable two-step verification. The front end requests a secret key. The authentication service generates the secret key for Bob and stores it in the database.

Step 3: The authentication service returns a URI to the front end. The URI is composed of a key issuer, username, and secret key. The URI is displayed in the form of a QR code on the web page.

Step 4: Bob then uses Google Authenticator to scan the generated QR code. The secret key is stored in the authenticator.

Stage 2
Steps 1 and 2: Bob wants to log into a website with Google two-step verification. For this, he needs the password. Every 30 seconds, Google Authenticator generates a 6-digit password using TOTP (Time-based One Time Password) algorithm. Bob uses the password to enter the website.

Steps 3 and 4: The front end sends Bob's password to the backend for authentication. The authentication service reads the secret key from the database and generates a 6-digit password using the same TOTP algorithm as the client.

Step 5: The authentication service compares the two passwords generated by the client and the server, and returns the comparison result to the front. Bob can proceed with the login process only if the two passwords match.

Is this authentication mechanism **safe**?

- Can the secret key be obtained by others?

  We need to make sure the secret key is transmitted using HTTPS. The authenticator client and the database store the secret key, and we need to ensure the secret keys are encrypted.

- Can the 6-digit password be guessed by hackers?
- No. The password has 6 digits, so the generated password has 1 million potential combinations. Plus, the password changes every 30 seconds. If hackers want to guess the password in 30 seconds, they need to enter 30,000 combinations per second.

Over to you: What are some of the other 2-factor authentication devices you used?