HOTP and TOTP

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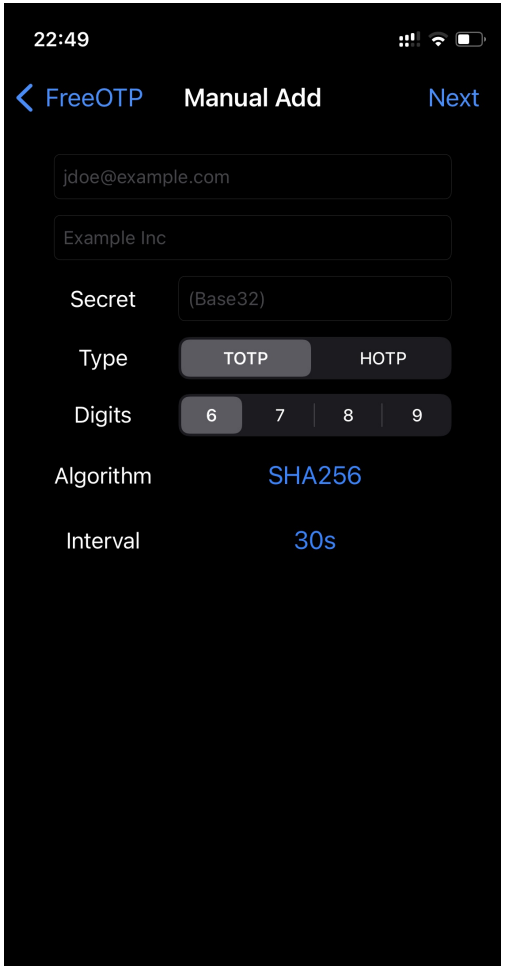
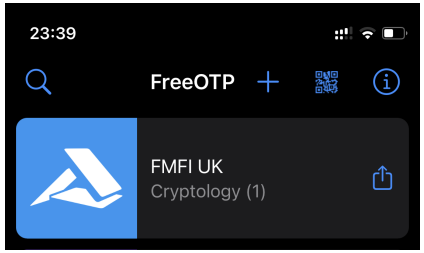
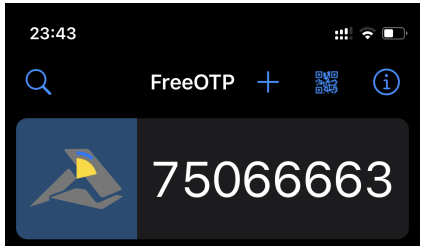
Introduction

- multifactor authentication, 2-step verification, …
  - something you know/have/are
  - often mobile phone: SMS, push notifications, authenticator app
- one-time passwords
- HOTP and TOTP
  - HOTP: HMAC-Based One-Time Password Algorithm (RFC 4226)
  - TOTP: Time-Based One-Time Password Algorithm (RFC 6238)

FreeOTP example







`otpauth://totp/FMFI%20UK:Cryptology%20(1)?secret=ONUG65LMMRRGKYTFOR2GK4TUNBQW45DINFZTCMRT&algorithm=SHA256&digits=8&period=30&lock=false`

HOTP

- actors: HOTP generator (client), HOTP validator (server)
- $\mathrm{HMAC}_K(\cdot)$, usually based on SHA-1 (default)
- parameters:
  - K – shared secret (static symmetric key, $\geq$ 128 bits)
  - C – counter value (8B, synchronized, starts with 0)
  - Digits – output length (≥ 6)

$$\mathrm{HOTP}(K, C) = \mathrm{Truncate}(\mathrm{HMAC}_K(C))$$

- Truncate – transform HMAC output to HOTP value
  - focus on uniformity and implementation clarity
- client increments C, and then calculates the next HOTP value
- server recalculates and compares received HOTP value
  - server increments C after a successful authentication

HOTP – remarks

- authentication protocol over a secure channel, e.g. TLS, IPsec
- security of shared secret is important (obviously)
- validation failure (HOTP values do not match)
  - resynch protocol (look-ahead window)
  - look-ahead parameter s – server validates against s consecutive values
  - if unsuccessful $\longrightarrow$ failed attempt
- brute-force attack prevention
  - brute-force attack is, in theory, the best attack possible
  - throttling parameter – the maximum number of failed attempts
- in some scenarios, server can request multiple HOTP values
- bidirectional authentication possible

TOTP

- extension of HOTP: counter value C replaced by time
  - short-lived OTP values (instead of “valid until next successful authentication”)
- HMAC based on SHA-1 (default), SHA-256, SHA-512
- parameters:
  - X – time step in seconds (usually $X = 30$ seconds)
  - time – current Unix time (seconds since 1.1.1970)
  - $T = \lfloor \text{time}/X \rfloor$ – number of time steps

$$\text{TOTP}(K, T) = \text{HOTP}(K, T)$$

TOTP – remarks

- time step size: security vs. usability
- “one-time only” requirement: the server must not accept the second attempt after the successful validation
- delay window – accept TOTP value from the previous time step
  - time when the value was entered vs. time when it is validated
  - recommended 1 time step
- resynchronization
  - clock drift
  - server can set limits on forward and backward time drifts
  - remember the drift and adjust for next validation