Multi-Factor Authentication
How it works and why you need to be using it yesterday

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The What

What is this talk?

Multi-Factor Authentication and some applications to Django

Who is this talk for?

Curious programmery people

Slides available on GitHub

`https://github.com/swenson/mfa-talk-pycon-au-2018`

The Who

Christopher Swenson, Ph.D

Currently at Twilio (prev. Google, Simple, US Government).

Live and work in Portland, OR, USA.

Occasional BeeWare core contributor and PyDX organizer.

I love programming languages and stuff.

I worte a book on cryptanalysis.

Goal

Multi-factor authentication (MFA) and two-factor auth (2FA) are becoming popular, but how do they work?

What are the options, how secure are they, and how do you use them in your own applications?

We'll answer all these and more, covering everything from Django integration to cryptography.

Outline

We will cover:

- Brief history
- Authentication apps, like Google Authenticator, Authy, Duo
- SMS-based authentication
- Biometrics
- Problems with MFA
- Cryptography behind some of these algorithms
- New developments like U2F, TPMs, secure chips

Motivation

More specifically, when Google Authenticator gives you some six-digit number like `119505`, where does that number come from?

Is it secure?

How does the server verify that it is correct?

Does someone else seeing the number compromise me?

How do other factors work?

The Beginning

The first password-like thing we have is **pronounciation**.

Shibboleth

Penguins

The Three Factors

What is a factor?

- Something you know
- Something you have
- Something you are

Things you know

- A password
- Random facts about you (e.g., credit checks)
- Pop culture trivia (e.g., age verification)
- Secret handshake

Things you have

- USB device (token, thumb drive with data on it)
- driver's license
- passport
- cell phone with a certain number
- computer already logged into your account
- pre-determined shared secret
- challenge coins
- credit cards
- a copy of a book

Things you are

- biometrics
  - fingerprints
  - face
  - retina
  - signature
- you are alive (blood flow, temperature)
- reasoning (CAPTCHA, Contact)

2FA and MFA

"MFA" means multi-factor authentication.

2FA means $M = 2$.

When you "add 2FA," it almost universally means that you already have a password established and you are adding a "thing you have" factor, generally a phone number or a TOTP shared secret.

SMS and Email

SMS and email-based 2-factor auth are common, but not very secure.

SMS and email are easily compromised and insecurely transmitted.

Certainly **better than nothing**.

But really try to do better.

Apps

Google Authenticator, Authy, Duo, and friends are more secure.

Apps for iOS, Android, Blackberry.

HOTP and TOTP are open protocols.

HOTP

HMAC-based one-time password (RFC 4226).

HMAC means hash-based message authentication code (RFC 2104).
HMAC-SHA1 means we use SHA1 as our hashing algorithm.

$\oplus$ means XOR.
$||$ means concatenation.
C is an 8-byte counter (starts at 0).
K is some shared secret.

$$\text{HMAC}(K, m) = \text{SHA1}((K \oplus \texttt{0x5c5c}) \ldots || \text{SHA1}((K \oplus \texttt{0x3636} \ldots)||m))$$

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

HOTP in Python

HOTP

```
xor_5c = "".join(chr(x ^ 0x5c) for x in xrange(256))
xor_36 = "".join(chr(x ^ 0x36) for x in xrange(256))
blocksize = hashlib.sha1().block_size

def hmac_sha1(key, msg):
    if len(key) > blocksize:
        key = hashlib.sha1(key).digest()
    key += chr(0) * (blocksize - len(key))
    o_key_pad = key.translate(xor_5c)
    i_key_pad = key.translate(xor_36)
    return hashlib.sha1(o_key_pad + hashlib.sha1(i_key_pad +
        msg).digest()).digest()
```

Truncate

Truncate the HMAC-SHA1 result into a 6–8-digit number.

6 is the most common number of digits.

HOTP

```
def truncate(result, digits):
    offset = ord(hmac_result[19]) & 0xf
    num = ((ord(hmac_result[offset]) & 0x7f) << 24) \\
         | (ord(hmac_result[offset+1])        << 16) \\
         | (ord(hmac_result[offset+2])        <<  8) \\
         |  ord(hmac_result[offset+3])
    return num % (10**digits)
```

TOTP

TOTP (RFC 6238) is the same as HOTP, except the counter C is based on time.

$$C = T = \lfloor (\texttt{time.time()} - T_0)/X \rfloor$$

`time.time()` is the number of seconds since the UNIX epoch.

T_0 is generally 0, meaning calculated relevant to the UNIX epoch.

(The UNIX epoch is 1970-01-01T00:00:00Z.)

Typically, $X = 30$ (so codes are valid for about 30 seconds).

Division is floor-division.

HOTP and TOTP Security

How secure are these 6-digit numbers?

Reasonably secure.

Six digits $= 1000000 \approx 2^{20}$.

A typical password has about 21 bits of entropy.

Most importantly, those 6 digits do not reveal anything meaningful about the underling secret. So you can leak as many of them as you like, and it will not help an attacker.

Weaknesses in SHA1 have not affected the security of HOTP / TOTP.

QR codes

How do you transmit the secret? QR codes.

How does a QR code work? That would be a whole extra talk.

```
otpauth://totp/swenson?secret=
26FXII6KEZWOJWIAEI2PZSOXDCZBQHMR&algorithm=SHA1&
digits=6&period=30
```

See `https://github.com/google/google-authenticator/wiki/Key-Uri-Format`

TPM

Trusted Platform Module — basically like a built-in yubikey into your device or computer.

Can store things as well as generate new keys in a way that no one can ever get the private key.

Generally, a "secure element" and a standard set of protocols for accessing it.

Django 2FA

```
pip install django-otp && pip install qrcode
```

- Supports TOTP, HOTP, Email, (optionally) SMS, Yubikey
- Can hook into a normal login flow or the admin login flow easily
- A bit rough around the edges
- Flow is awkward.
- Admin can see secrets.
- No easy enrollment or reset.

(Sprint anyone?)

Django 2FA (cont'd.)

site settings.py

```
INSTALLED_APPS = [
    'sampleapp.apps.OtpAdminConfig',  # replaces 'django.
        contrib.admin'
    'django_otp',
    'django_otp.plugins.otp_totp',
    'django_otp.plugins.otp_hotp',
    'django_otp.plugins.otp_static',
]
MIDDLEWARE = [
    'django_otp.middleware.OTPMiddleware',
]
```

Run migrations and all that jazz.

```
$ python manage.py migrate
```

Django 2FA (cont'd.)

app admin.py

```
from django.contrib import admin
from django_otp.admin import OTPAdminSite

class OtpAdminSite(OTPAdminSite):
    pass
```

Django 2FA (cont'd.)

app apps.py

```
from django.apps import AppConfig
from django.contrib.admin.apps import AdminConfig

class SampleappConfig(AppConfig):
    name = 'sampleapp'

class OtpAdminConfig(AdminConfig):
    default_site = 'sampleapp.admin.OtpAdminSite'
```

Django 2FA (cont'd.)

Can use it like:

app views.py

```
from django.shortcuts import render, redirect
from django.http import HttpResponse

def index(request):
    if not (request.user.is_authenticated and request.user.
        is_verified()):
        return redirect('/admin/?next=%s' % (request.path))
    return HttpResponse("Hello, world!")
```

Demo

Time for a demo?

Problems with MFA

Lose your device $\Rightarrow$ you can be out of luck.

Backup solutions (e.g., recover codes) are cumbersome.

Hope that *only* you can convince support to reset your account.

Annoying to type in codes from devices.

Bluetooth difficult to use with multiple accounts.

Hardware can often only hold 1–3 sets of keys.

HOTP and TOTP keys are symmetric — admin can impersonate you.

U2F

Universal 2-Factor, standardized by FIDO, jointly developed by Yubico and Google.

Different communications allowed: USB, BT, NFC

Based on ECDSA (RSA too in the latest spec).

Designed to be inexpensive, easy-to-use, and relatively secure.

Not well-supported outside of the largest websites.

Django support is nearly non-existant. (Sprint anyone?)

Take-aways:

- Use an app if you can
- A hardware token is better
- Even better if it is U2F
- Try to integrate it into your system (carefully)!

I'm happy to take questions!