Hardening PGP using GnuPG and Yubikey

hybrid multifactor authentication and cryptography

John Roman

Linux System Administrator
RAND Corporation

SCALE 2017

PGP 101

- public/private keyrings

PGP 101

- public/private keyrings
- public keys go to the world, generated on machine

PGP 101

- public/private keyrings
- public keys go to the world, generated on machine
- key types: signing, authentication, cryptography

pitfalls

- private keyring. . . but how private?

pitfalls

- private keyring. . . but how private?
- portability

pitfalls

- private keyring. . . but how private?
- portability
- standards compliance

conventional example, the CAC/PIV

- Common Access Card, in service since 2005

conventional example, the CAC/PIV

- Common Access Card, in service since 2005
- FIPS201 PIV Federal Information Processing Standard (FIPS) 201,Personal Identity Verification

OpenPGP: we we're JUST thinking that!

- OpenPGP Card: in service since 2004

OpenPGP: we we're JUST thinking that!

- OpenPGP Card: in service since 2004
- 9 different vendors, multiple form factors

OpenPGP: we we're JUST thinking that!

- OpenPGP Card: in service since 2004
- 9 different vendors, multiple form factors
- relatively unknown outside of FSF Europe.

Our focus: Yubikey

- supports hybrid mode

Our focus: Yubikey

- supports hybrid mode
- hermetic, crushproof, scaleable pricing

Our focus: Yubikey

- supports hybrid mode
- hermetic, crushproof, scaleable pricing
- NFC option.

general concepts

- card has a CPU, firmware.

general concepts

- card has a CPU, firmware.
- keys are loaded into slots, or generated by the card

general concepts

- card has a CPU, firmware.
- keys are loaded into slots, or generated by the card
- encryption, decryption, signature are all commands

general concepts

- card has a CPU, firmware.
- keys are loaded into slots, or generated by the card
- encryption, decryption, signature are all commands
- once loaded, private keys are sacrosanct.

general concepts

- card has a CPU, firmware.
- keys are loaded into slots, or generated by the card
- encryption, decryption, signature are all commands
- once loaded, private keys are sacrosanct.
- Yubikey only accepts commands, only returns data. NEVER KEYS.

HSM Specific concepts

- pin number similar to european credit cards

HSM Specific concepts

- pin number similar to european credit cards
- 3 strikes, your pin is locked

HSM Specific concepts

- pin number similar to european credit cards
- 3 strikes, your pin is locked
- pin can be unlocked with a security officer pin.

HSM Specific concepts

- pin number similar to european credit cards
- 3 strikes, your pin is locked
- pin can be unlocked with a security officer pin.
- 3 strikes against the SO pin? card is bricked. keys lost. game over.

HSM Specific concepts

- pin number similar to european credit cards
- 3 strikes, your pin is locked
- pin can be unlocked with a security officer pin.
- 3 strikes against the SO pin? card is bricked. keys lost. game over.
- pin length 6-8 characters, some implementations more than 128 char.

placing the card into 'hybrid' mode

```
ykpersonalize -d -m82
Firmware version 4.3.1 Touch level 527 Program sequence 3

The USB mode will be set to: 0x82

Commit? (y/n) [n]: n
```

OpenPGP card overview

keys were loaded from an airgapped system using the keytocard command.

```
cicero@cypher ~ $ gpg --card-status
Application ID ...: D2760001240102010006049011200000
Version ..........: 2.1
Manufacturer .....: Yubico
Serial number ....: 04901120
Name of cardholder: John Roman
Language prefs ...: [not set]
Sex ..............: male
URL of public key : https://dev1ce.com/johnroman.gpg
Login data .......: nimbius
Signature PIN ....: not forced
Key attributes ...: 4096R 4096R 4096R
Max. PIN lengths .: 127 127 127
PIN retry counter : 3 0 3
Signature counter : 51
Signature key ....: 8402 B920 F553 B6A6 F903  55FB 4F6F 7F56 D7F7 774D
      created ....: 2016-12-27 04:27:41
Encryption key....: EA74 1AE9 152D 4C23 6A22  3FBC 63A1 BF2C AF90 8338
      created ....: 2016-12-27 04:20:40
Authentication key: E6CC 0785 C1AE D58E 22C2  C697 116A F523 D67B 445B
      created ....: 2016-12-27 04:33:13
General key info..: sub  4096R/D7F7774D 2016-12-27 John Roman (just another lonely soul on the
 internet) <john@dev1ce.com>
sec   4096R/7D238A21  created: 2016-12-27  expires: 2017-12-27
ssb>  4096R/AF908338  created: 2016-12-27  expires: 2017-12-27
                      card-no: 0006 04901120
ssb>  4096R/D7F7774D  created: 2016-12-27  expires: 2017-06-25
                      card-no: 0006 04901120
ssb>  4096R/D67B445B  created: 2016-12-27  expires: 2017-06-25
                      card-no: 0006 04901120
cicero@cypher ~ $ scdaemon[24952]: updating slot 0 status: 0x0000->0x0007 (0->1)
scdaemon[24952]: scdaemon (GnuPG) 2.0.30 stopped
```

OpenPGP card programming

gpg –card-edit mode, admin commands enabled

```
fetch      fetch the key specified in the card URL
passwd     menu to change or unblock the PIN
verify     verify the PIN and list all data
unblock    unblock the PIN using a Reset Code

gpg/card> admin
Admin commands are allowed

gpg/card> help
quit       quit this menu
admin      show admin commands
help       show this help
list       list all available data
name       change card holder's name
url        change URL to retrieve key
fetch      fetch the key specified in the card URL
login      change the login name
lang       change the language preferences
sex        change card holder's sex
cafpr      change a CA fingerprint
forcesig   toggle the signature force PIN flag
generate   generate new keys
passwd     menu to change or unblock the PIN
verify     verify the PIN and list all data
unblock    unblock the PIN using a Reset Code

gpg/card>
```

applications

- anything GPG enabled

applications

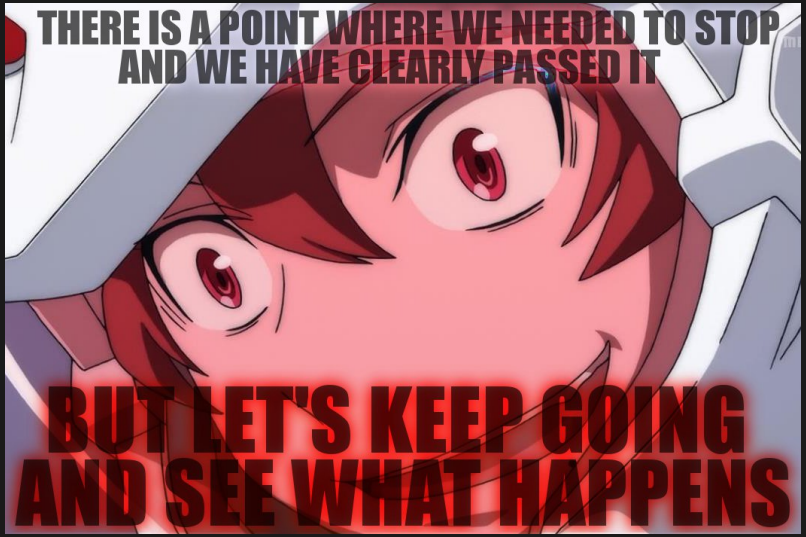
- anything GPG enabled
- anything PAM enabled

applications

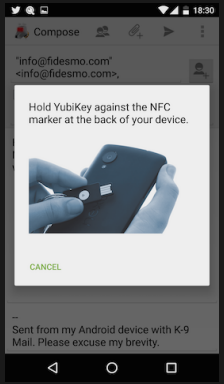
- anything GPG enabled
- anything PAM enabled
- defense in depth: OTP/Cert/PW? sure

applications

- anything GPG enabled
- anything PAM enabled
- defense in depth: OTP/Cert/PW? sure
- multiple cards per key, each has a unique subkey (code signing!)

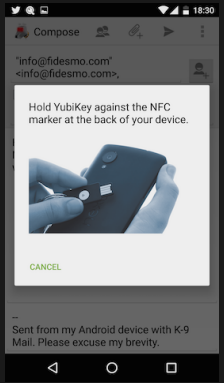

THERE IS A POINT WHERE WE NEEDED TO STOP
AND WE HAVE CLEARLY PASSED IT
BUT LET'S KEEP GOING
AND SEE WHAT HAPPENS

NFC option: here be dragons



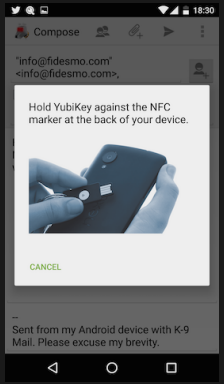
- easy integration with Openkeychain in Android/IPhone

NFC option: here be dragons



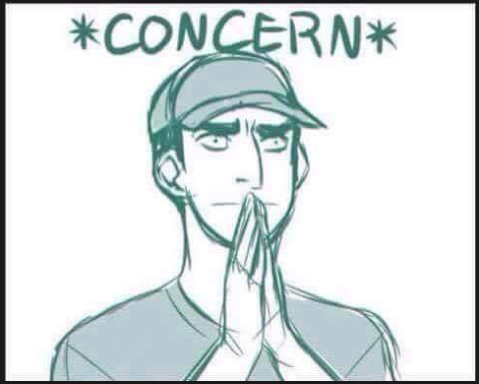
- easy integration with Openkeychain in Android/IPhone
- keys need to be generated by the user

NFC option: here be dragons



- easy integration with Openkeychain in Android/IPhone
- keys need to be generated by the user
- only supports a 2048 bit key

deploying 450 (thousand?) of these things.



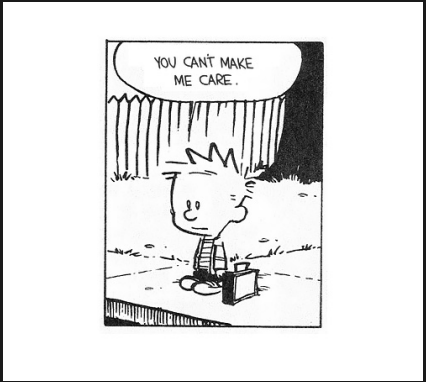
Entropy.

GPG relies on kernel, not userland entropy.
- Flying Stone FST01 from the FSF store!
- RTL digital TV dongle and a tractor paper copy of phrack

OpenPGP not included...

Red Hat Enterprise Linux 7 does not include opensc GnuPG

y tho...



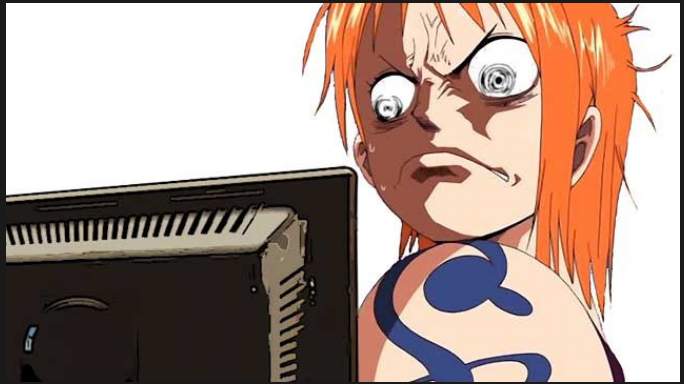
NFC user fatigue.
not all NFC devices are “great” at picking up NFC
lack of a yubikey might cause lack of communication.

“destroyed” cards...

– try not to trigger a SO/Reset pin lock!!

– to reissue or reset?

cardware considerations



processing rate is a function of USB IO and CPU. generating keys on the card = Entropy+CPU.

Questions?