GnuPG: Open Encryption, Signing and Authentication

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What is GnuPG?

GnuPG is the GNU project's complete and free implementation of the OpenPGP standard as defined by RFC4880 . GnuPG allows to encrypt and sign your data and communication, features a versatile key management system as well as access modules for all kinds of public key directories. GnuPG, also known as GPG, is a command line tool with features for easy integration with other applications. A wealth of frontend applications and libraries are available. Version 2 of GnuPG also provides support for S/MIME.

OK. What is GnuPG?

- Implementation of public-key cryptography
- Conforms to an open standard (OpenPGP)
- Allows for:
  - Encryption of Data & Communication
  - Signing of Data & Communication
  - Authentication

About this presentation

- Not a ”cookbook” for GPG
- Overview of what you can do
- Some technical points simplified
- GPG has excellent man pages and documentation

Outline

- Background
  - Terminology
  - Motivations
  - General Theory
- Getting Started
  - Key Generation
  - Choices
  - Key Signing
- Best Practices
  - Threat Modeling
  - Key Separation
- Integration & UIs
  - UIs
  - E-mail
- Advanced Topics
  - Smart Cards
  - Authentication

Terminology

- PGP – Pretty Good Privacy
  - Original implementation, 1991, by Phil Zimmerman
  - Source Available until 2000
- OpenPGP – Standard for implementations
  - RFC 4880 (Replaced RFC 2440) (Message format)
  - RFC 3156 (e-mail format, PGP/MIME)
- GnuPG – GNU-Project, GPL Implementation
  - Mostly PGP Compatible
  - Implements all of RFC 4880

Motivations: Encryption

- Protect messages against being read except by intended recipient(s).
- Intended recipient could be yourself.
- Can exchange secret communications without needing any pre-shared secrets.

Motivations: Signing

- Digital signatures prove that you wrote/signed a given chunk of data. (Non-repudiation)
- Used heavily for code signing, signed packages, etc.
- Message integrity (unmodified)

Shortcomings

- Encryption
  - Anyone with the private key can decrypt message
  - Have to know what key to encrypt to (anyone can generate a key with any UID)

- Signing
  - Anyone with the private key can sign a message
  - No proof of WHEN it was signed
  - No way to prove that you did NOT write a message

How it Works (Simplified)

- Public Key Encryption
  - Pair of Keys (Public, Private)
  - A message encrypted to one key can only be decrypted by the other key
  - Computationally infeasible to reverse calculation
- Encryption
  - Sender uses public key to encrypt
  - Recipient uses private key to decrypt
- Signing
  - Signer uses private key to sign (encrypt)
  - Recipient uses public key to verify (decrypt)

Some Technical Details

- Messages are not really encrypted with public key cryptography
  - Encrypted with symmetric cryptography
  - Key then encrypted with public-key cryptography
- Likewise, messages not signed across the entire message
  - Hash is calculated
  - Signed with public-key cryptography
- Signing + encryption
  - Signed first
  - Only recipient verifies

OpenPGP Algorithms

- Public-key (Asymmetrical)
  - RSA(*)
  - DSA
  - ElGamal
  - (Future) ECC

- Symmetrical
  - IDEA
  - 3DES
  - CAST5
  - AES (*)
  - Blowfish
  - Twofish

(*) Most often used

OpenPGP Algorithms

- Compression
  - ZIP
  - ZLIB (*)
  - BZIP2

- Hashing
  - MD-5
  - SHA-1 (*)
  - RIPE-MD/160
  - SHA-2 (Family)
    - SHA-256
    - SHA-384
    - SHA-512
    - SHA-224

(*) Most often used

Getting Started: Key Generation

```
$ gpg --gen-key
Please select what kind of key you want:
   (1) RSA and RSA (default)
   (2) DSA and Elgamal
   (3) DSA (sign only)
   (4) RSA (sign only)
Your selection? 1
RSA keys may be between 1024 and 4096 bits long.
What keysize do you want? (2048)
Requested keysize is 2048 bits
```

Algorithm Choice

- RSA
  - ”Safe bet” – very commonly used in a variety of applications
  - Based on Integer Factorization Problem
- DSA/ElGamal
  - A few cryptographers suggest it is SLIGHTLY stronger
  - Less researched
  - Based on Discrete Logarithm Problem
- Both are believed to be secure

Key Length

- Do not generate new 1024 bit keys!
- NIST suggests 2048 is secure until 2030.
  - 3072 secure until ~2040.
  - 4096 secure until ~2050.
- Quantum computing **could** change everything.
  - Topic for another day, and probably another group.
- Estimates against enterprise/government level attackers.
- Keylength.com

Getting Started: Key Generation

```
Please specify how long the key should be valid.
         0 = key does not expire
      <n>  = key expires in n days
      <n>w = key expires in n weeks
      <n>m = key expires in n months
      <n>y = key expires in n years
Key is valid for? (0) 1d
Key expires at Thu 17 Mar 2011 11:06:24 PM EDT
Is this correct? (y/N) y
```

Key Expiration

- Expires
  - Key will fall out of use if you lose private key
  - Update key periodically
  - Regenerate key and get new signatures

- Never expires
  - No need to update date or regenerate
  - May never fall out of use if you lose your key or compromised

Getting Started: Key Generation

```
You need a user ID to identify your key; the software constructs
the user ID
from the Real Name, Comment and Email Address in this form:
    "Heinrich Heine (Der Dichter) <heinrichh@duesseldorf.de>"

Real name: David Tomaschik
Email address: david@example.com
Comment: Demo Key Only
You selected this USER-ID:
    "David Tomaschik (Demo Key Only) <david@example.com>"

Change (N)ame, (C)omment, (E)mail or (O)kay/(Q)uit? o
```

Your Key

```
gpg: key 36D884AA marked as ultimately trusted
public and secret key created and signed.

gpg: checking the trustdb
gpg: 3 marginal(s) needed, 1 complete(s) needed, PGP trust model
gpg: depth: 0  valid:   1 signed: 0  trust: 0-, 0q, 0n, 0m, 0f, 1u
gpg: next trustdb check due at 2011-03-18
pub   2048R/36D884AA 2011-03-17 [expires: 2011-03-18]
Key fingerprint = 5C2E 2066 FB73 5DDC 3E0F
                  E0D7 1D4C 7FE2 36D8 84AA
uid                  David Tomaschik (Demo Key Only)
<david@example.com>
sub   2048R/AB130331 2011-03-17 [expires: 2011-03-18]
```

Demo: Key Generation

```
gpg --gen-key
```

Getting Started: Finding Keys

- gpg --recv-keys <keyid>
  - gpg --recv-keys 5DEA789B
- gpg --search-keys <UID substring>
  - gpg --search-keys david@systemoverlord.com
- Keyserver
  - pool.sks-keyservers.net
  - pgp.mit.edu
- gpg --refresh-keys

Getting Started: Sending Keys

- gpg --send-key
- Make sure you really want the key out there
  - Don't publish test keys
- Use again after signing keys
  - Only if the original key was on the keyserver
  - Considered rude to publish someone's key

Keysigning

- Why sign keys?
- Alice wants to e-mail Carol, but doesn't have her key
- Alice downloads Carol's key from a keyserver
- But wait! Anyone could generate a key for carol@example.com
    - Never forget who might have access to e-mail

Keysigning

- Alice knows Bob who knows Carol
- Alice has met Bob, verified Bob's key, signed Bob's key
- Bob has met Carol, verified Carol's key, signed Carol's key
- If Alice trusts Bob, Alice can believe this key really belongs to Carol

Demo: Key Signing

```
gpg --sign-key
```

Web of Trust

- Connections of signatures between users/keys
- gpg –list-sigs
- OpenPGP model instead of PKI (Certificate Authorities)
  - Some CAs may not be trustworthy, so some consider Web of Trust superior
  - Certainly individuals I trust more than many CAs

Keysigning Parties/Events

- Help expand your Web of Trust
  - Helps verify not only those at party, but also those just past that point
- Most effective in cases where you want to communicate within that ”social circle”

Signing Philosophies

- ID-Based
  - Present ID (often 2)
  - Match Names to UIDs
  - Sign Key

- E-mail based
  - Signer sends encrypted email to signee
  - Signee responds with signed email
  - Proves control of e-mail address

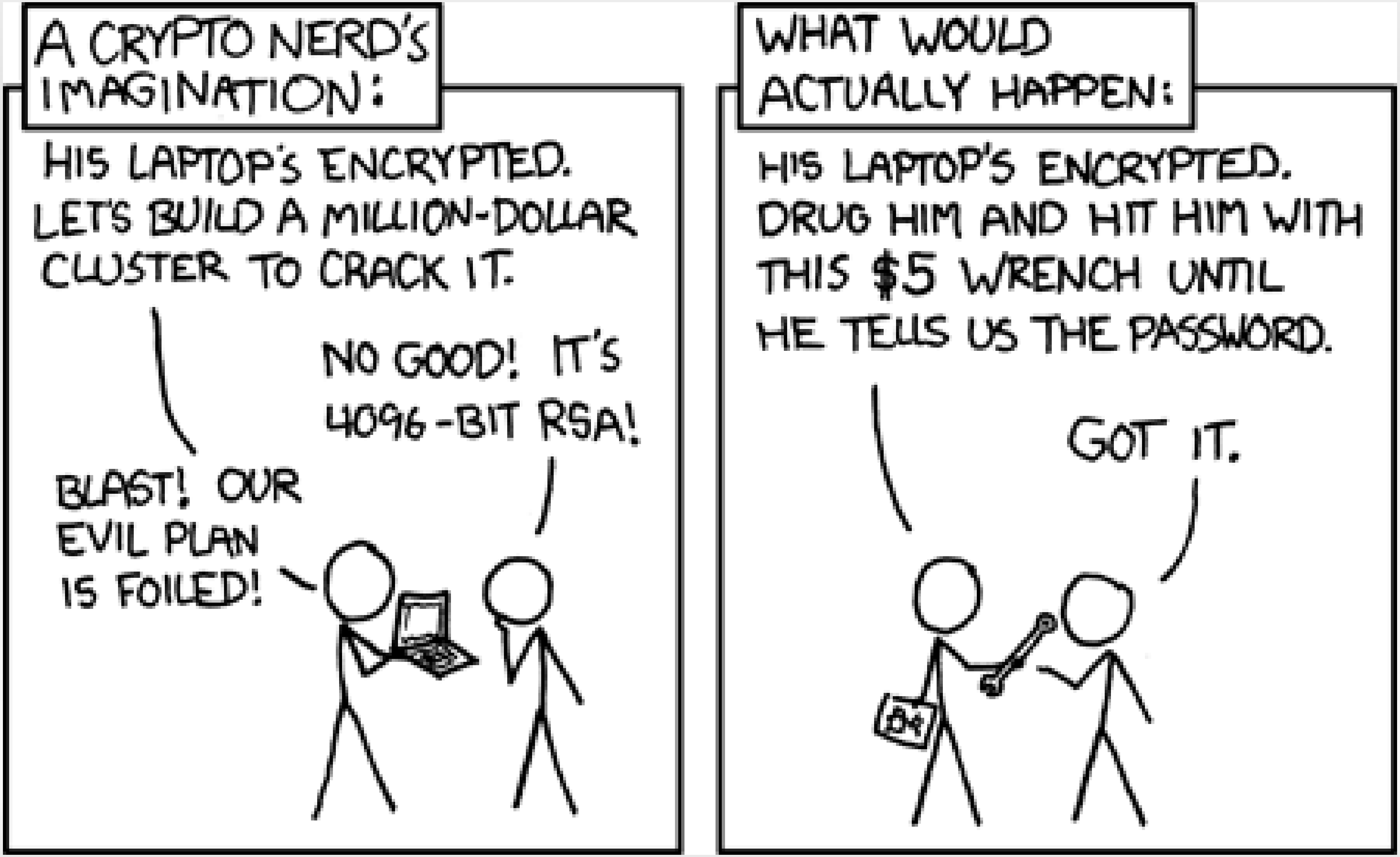
Best Practices: Key Security

- Keep a copy of your key in a secure location
- Use a strong passphrase
  - If the file that contains your key is compromised, it is encrypted with this passphrase
- Keep a pre-generated revocation certificate offline ”just in case”
  - This should be secured too

Best Practices: Threat Modeling

- U.S. Government
  - U.S. v. Boucher
  - Probably nothing will protect you
- Foreign Government
  - Might have law compelling you to disclose passphrase
  - Only if you are there or commit crime there
- Corporation
  - Unlikely to have resources
  - Termination for improper computer use
- Malicious Attacker
  - Theft of Key
  - Keylogger

Threat Modeling


A CRYPTO NERD'S IMAGINATION:
HIS LAPTOP'S ENCRYPTED. LET'S BUILD A MILLION-DOLLAR CLUSTER TO CRACK IT.
NO GOOD! IT'S 4096-BIT RSA!
BLAST! OUR EVIL PLAN IS FOILED!
WHAT WOULD ACTUALLY HAPPEN:
HIS LAPTOP'S ENCRYPTED. DRUG HIM AND HIT HIM WITH THIS $5 WRENCH UNTIL HE TELLS US THE PASSWORD.
GOT IT.

http://xkcd.com/538

Best Practices: Key Separation

- Key Capabilities
  - Sign
  - Certify
  - Encrypt
  - Authenticate

- Use --expert option to gpg
- Separate keys: if weakness found in one key, other keys may be fine

Best Practices: Key Separation

```
pub  4096R/5DEA789B  created: 2010-12-19  expires: never       usage: C
                     trust: unknown       validity: unknown
sub  3072R/3F0A7DEA  created: 2010-12-19  expires: 2012-12-18  usage: S
sub  3072R/63469263  created: 2010-12-19  expires: 2012-12-18  usage: E
sub  2048R/8D1C060E  created: 2011-02-23  expires: 2013-02-22  usage: A
[ unknown] (1). David Tomaschik <david@systemoverlord.com>
```

Best Practices: When to Sign E-Mail

- Always
  - Some suggest it builds history
  - Still doesn't prove an unsigned message didn't come from you
  - Be careful what you sign – only the body is signed
- Important e-mail
  - Signifies email as significant
  - My personal practice

Best Practices: Signing Files

- Be careful signing files you didn't create
  - Binary files (including doc, docx, odt, etc.) may have multiple data streams, hidden text, etc.
- Sign ”significant” files
  - Off-site backups (really!)
  - Code, packages, etc.
- Not currently in use for legal contracts
  - May change soon, but need ”legal” keyholder verification

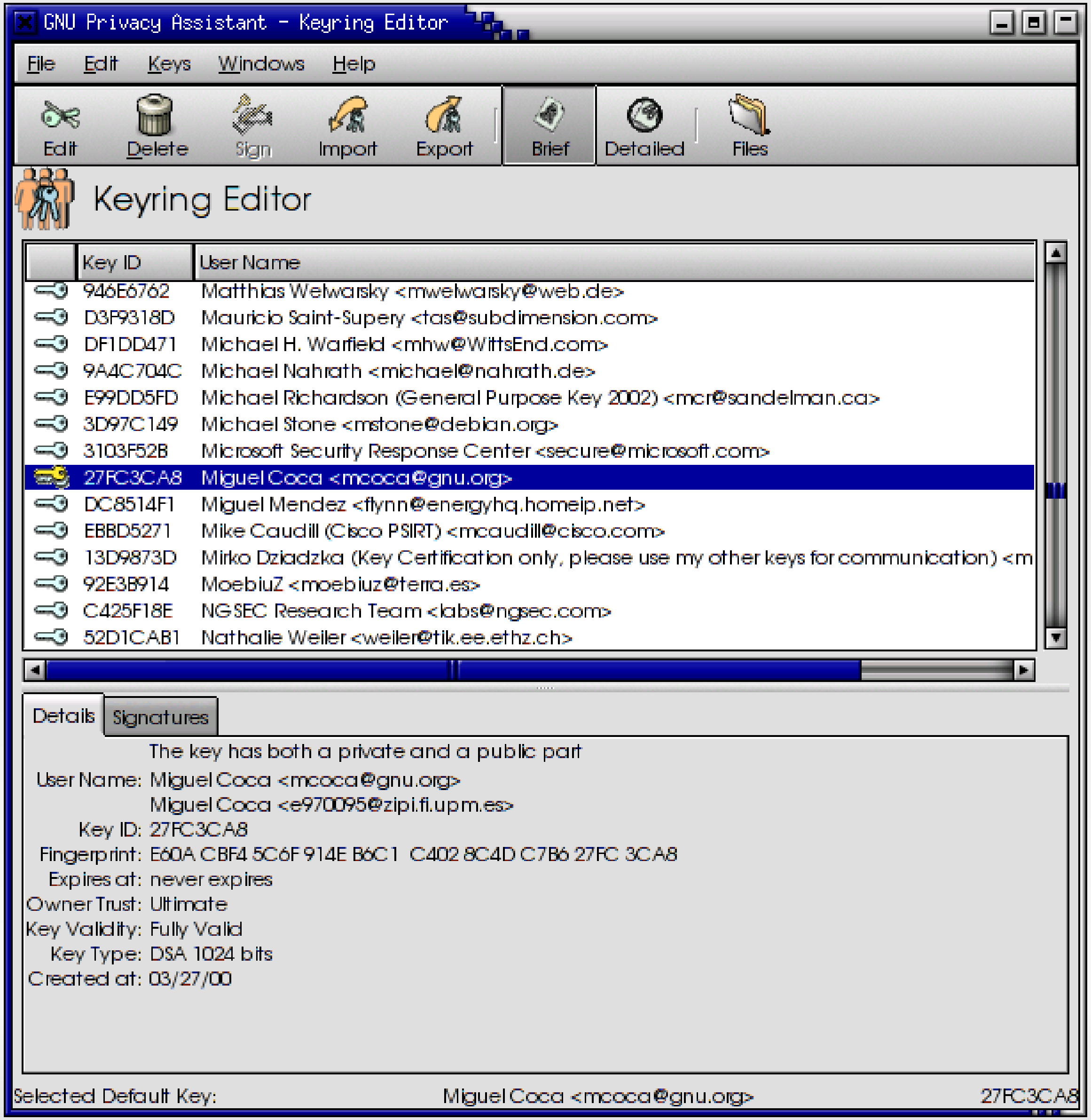
Best Practices: E-mail encryption

- Encrypt everything (to recipients with OpenPGP)
  - Some overhead
  - Many mobile devices don't support GPG or users don't use GPG on there
- Encrypt only the important
  - Tells an attacker which messages are important
  - Allows casual messages to be read everywhere

Integration: UIs

- GPA
  - Standard, Cross-Platform
  - GTK-based
- Seahorse
  - In most Gnome Installations
  - Highly Integrated
  - GPG/SSH/etc.
- KGPG
  - KDE based
  - GPG only
- (Non-Linux) GPGTools
  - OS X Suite
- (Non-Linux) Cryptophane
  - Windows

Integration: GPA

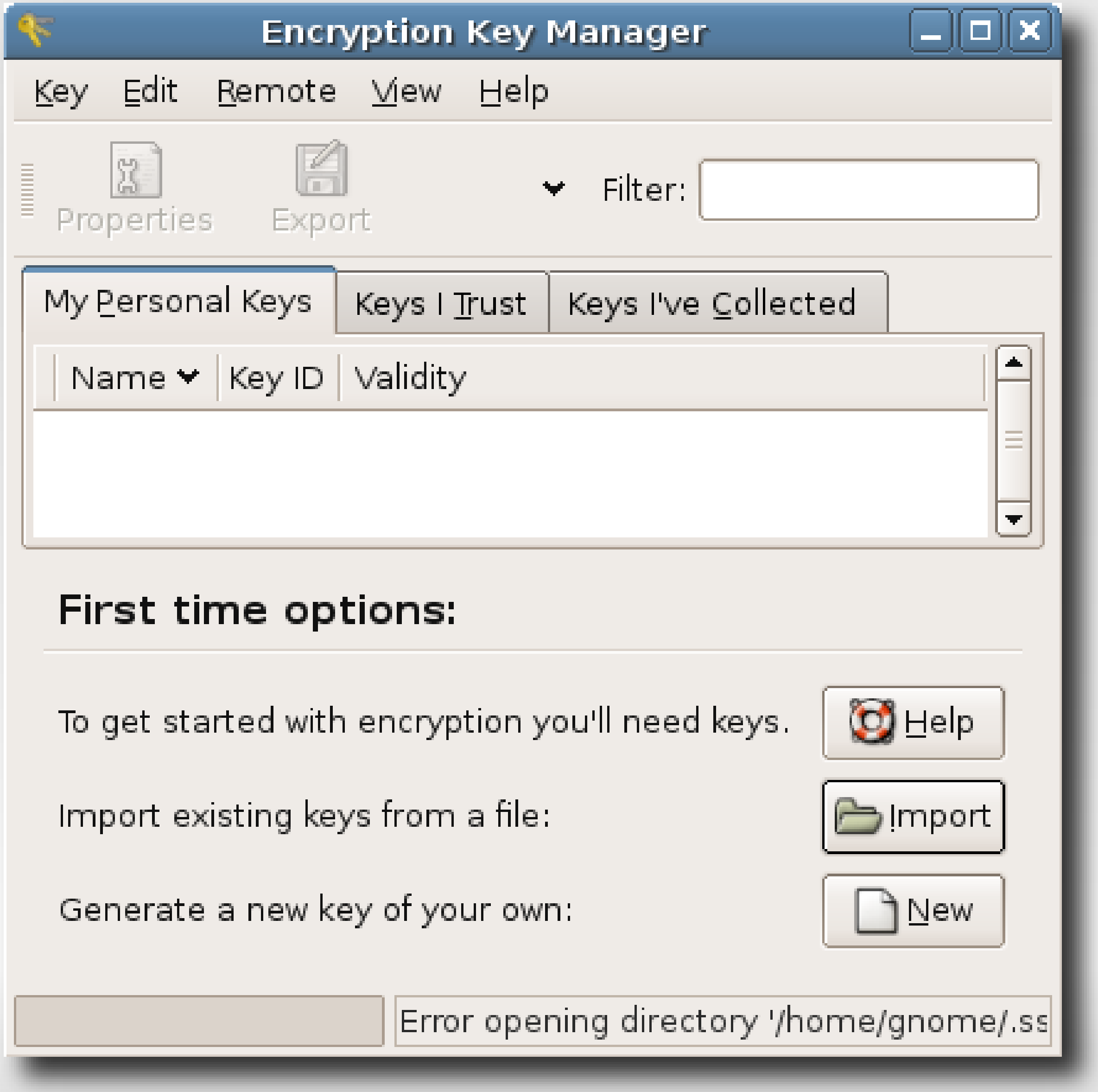


Key ID	User Name
946E6762	Matthias Welwarsky <mwelwarsky@web.de>
D3F9318D	Mauricio Saint-Supery <tas@subdimension.com>
DF1DD471	Michael H. Warfield <mhw@WittsEnd.com>
9A4C704C	Michael Nahrath <michael@nahrath.de>
E99DD5FD	Michael Richardson (General Purpose Key 2002) <mcr@sandelman.ca>
3D97C149	Michael Stone <mstone@debian.org>
3103F52B	Microsoft Security Response Center <secure@microsoft.com>
27FC3CA8	Miguel Coca <mcoca@gnu.org>
DC8514F1	Miguel Mendez <flynn@energyhq.homeip.net>
EBBD5271	Mike Caudill (Cisco PSIRT) <mcaudill@cisco.com>
13D9873D	Mirko Dziadzka (Key Certification only, please use my other keys for communication) <m
92E3B914	MoebiuZ <moebiuz@terra.es>
C425F18E	NGSEC Research Team <labs@ngsec.com>
52D1CAB1	Nathalie Weiler <weiler@tik.ee.ethz.ch>

The key has both a private and a public part
User Name: Miguel Coca <mcoca@gnu.org>
Miguel Coca <e970095@zipi.fi.upm.es>
Key ID: 27FC3CA8
Fingerprint: E60A CBF4 5C6F 914E B6C1 C402 8C4D C7B6 27FC 3CA8
Expires at: never expires
Owner Trust: Ultimate
Key Validity: Fully Valid
Key Type: DSA 1024 bits
Created at: 03/27/00

Selected Default Key: Miguel Coca <mcoca@gnu.org> 27FC3CA8

Integration: Seahorse



First time options:

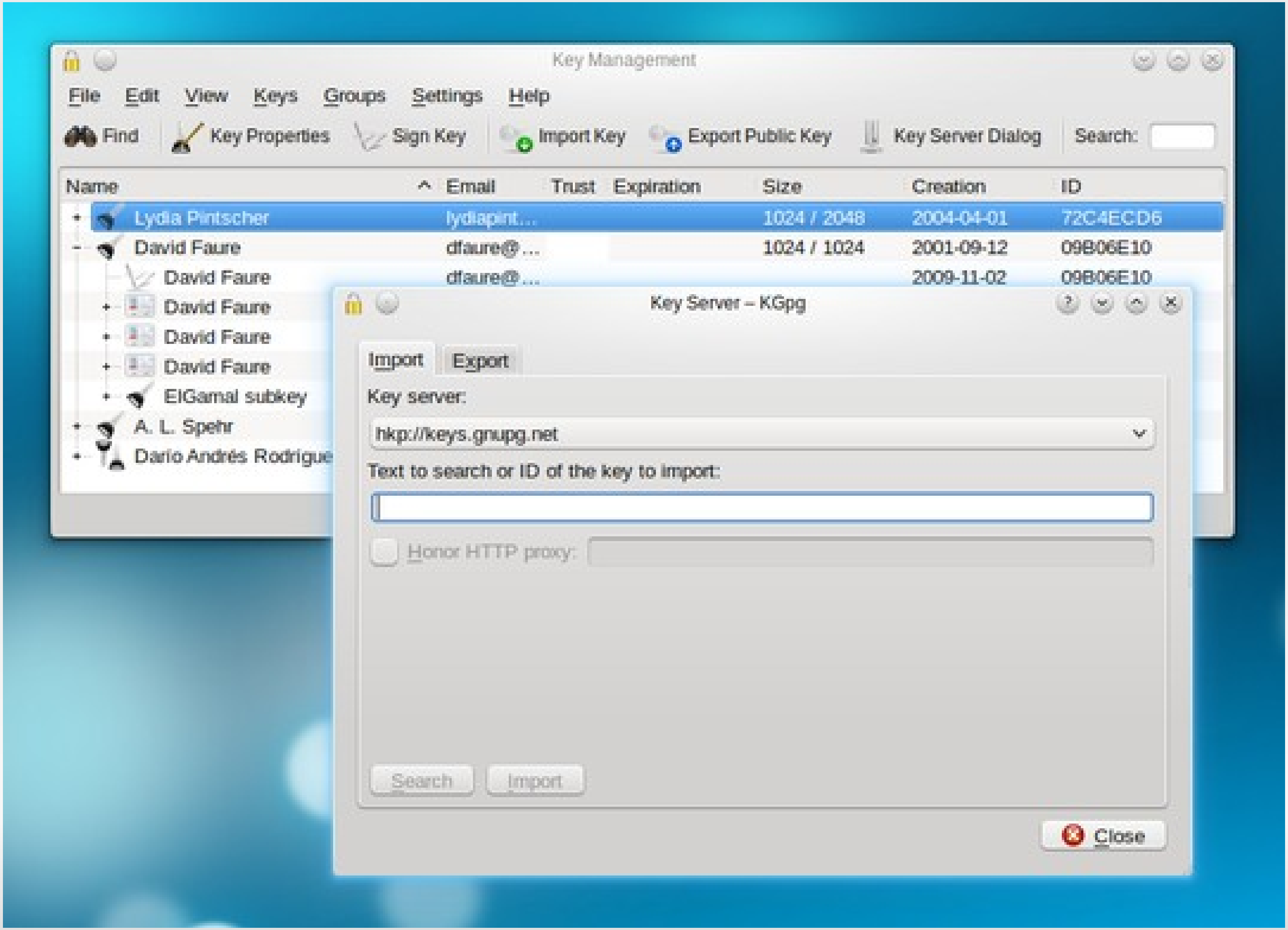
To get started with encryption you'll need keys.

Import existing keys from a file:

Generate a new key of your own:

Error opening directory '/home/gnome/.ss

Integration: KGPG



Name	Email	Trust	Expiration	Size	Creation	ID
Lydia Pintscher	lydiapint…			1024 / 2048	2004-04-01	72C4ECD6
David Faure	dfaure@…			1024 / 1024	2001-09-12	09B06E10
David Faure	dfaure@…				2009-11-02	09B06E10
David Faure						
David Faure						
David Faure						
ElGamal subkey						
A. L. Spehr						
Dario Andrés Rodrigue						

Key server: hkp://keys.gnupg.net

Text to search or ID of the key to import:

□ Honor HTTP proxy:

Integration: E-Mail

- Thunderbird
  - Enigmail
- KMail
  - Integrated
- Evolution
  - Integrated
- Mutt
  - Integrated
- Also transparent outgoing
  - GNU Anubis
  - Freenigma
- See Also
  - Vim integration
  - Emacs integration

Advanced Topic: Smartcards

- Physical device that generates and stores keys and performs signing and encryption operations
- OpenPGP Smartcard v2 allows for up to 3 RSA keys, each up to 3072 bits in size
  - Sign/Certify
  - Encryption
  - Authentication
- Sold by Kernel Concepts out of Germany

Smartcard-Specifc Terms

- PINs
  - Admin PIN
  - PIN
  - Similar to passphrase; cards limit length; use only digits if you intend to use a reader that has a PIN pad
  - 3 strikes rule

Card Readers

- Any CCID or PC/SC-compliant smart card reader should work
  - Very common (Amazon, eBay, etc.) with use of CAC cards for U.S. Military
  - Also available from Kernel Concepts
- Requires GPGSM on Debian-derivatives (S/MIME support for GPG)
- pcscd and pcsc-lite tools (required for PC/SC)
  - Provides more details if you run into issues

Caveats

- You must use gpg-agent
  - But you should anyway
- If you don't backup your key during the generation process, you can never retrieve it
  - Important for security reasons
- If you issue a smartcard command without a reader in place, scdaemon locks up
  - pkill -9 scdaemon
  - gpg-agent will restart scdaemon

Usage

- gpg –card-status
  - Use to get card ”recognized”
- gpg --card-edit
  - admin
  - passwd
  - url
  - fetch
  - Generate
- gpg --edit-key
  - keytocard

Authentication

- PAM
  - Poldi
- SSH
  - gpg-agent is a drop-in replacement for ssh-agent
  - enable-ssh-support
  - Must disable standard SSH agent, Seahorse, etc.
  - gpg --card-status
  - ssh-add -l, ssh-add -L (public key)

Tips

- Helpful gpg.conf options
  - default-key
  - keyserver
  - use-agent
- Helpful gpg-agent.conf options
  - enable-ssh-support
  - use-standard-socket

Really Advanced Topics

- Monkeysphere
  - Server Identification via GnuPG
  - Like PKI overlaid on Web of Trust
  - You define your CAs
- Key Distribution over DNS
  - PGP Record (”Long” Record)
  - IPGP Record (”Short” Record)
  - DNSSEC

Resources

- http://gnupg.org
- http://sks-keyservers.net
- RFC 4880
- RFC 3156
- http://keylength.com
- http://kernelconcepts.de/en