The Open Crypto Audit Project: Our Story

Kenneth White & Matthew Green

DEF CON 22 | 2014.08.08

Open Crypto Audit Project

Everyone has a story. This is ours.

Agenda

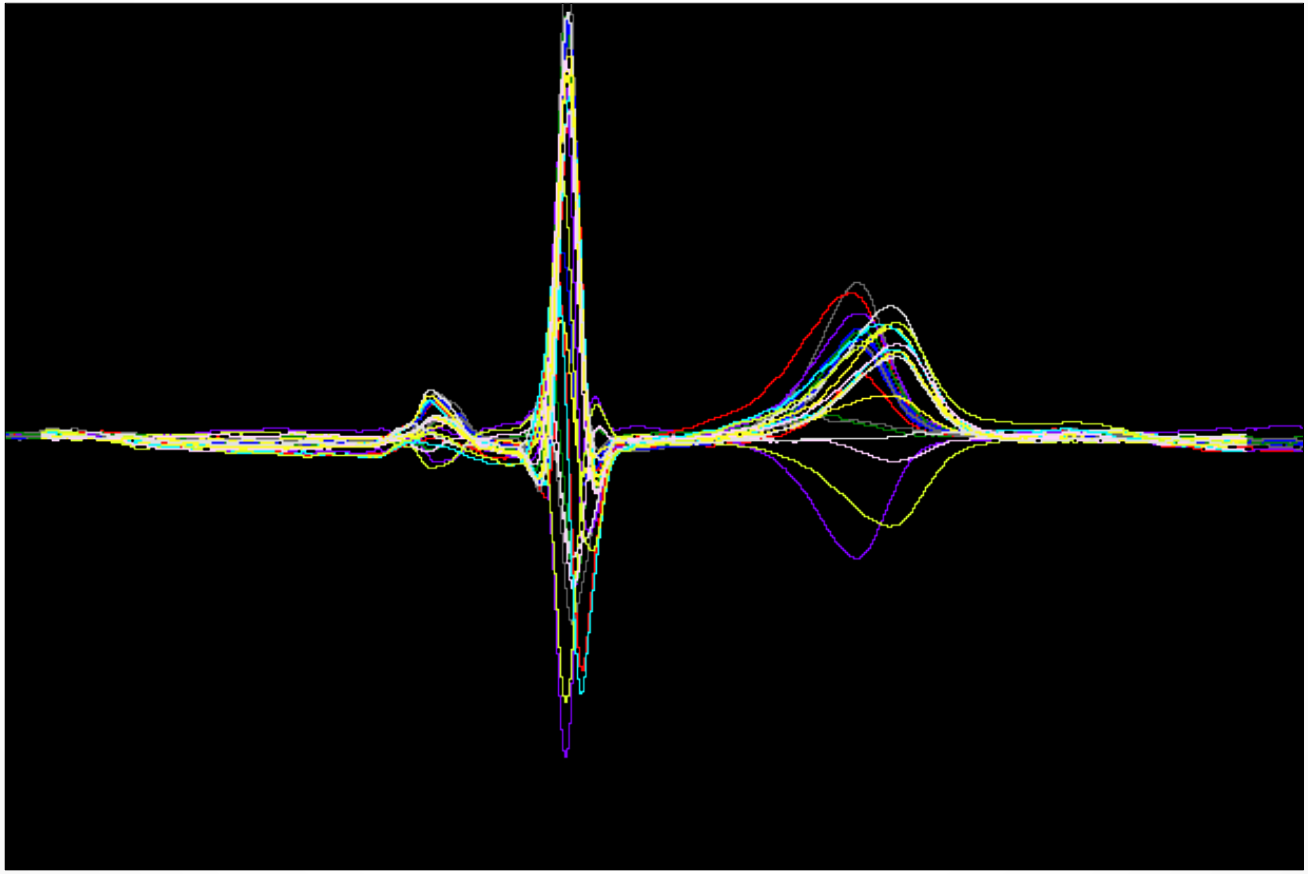
- First Principles
- Post-Snowden Era
- The TrueCrypt Story
- Open Crypto Audit Project
- Secure Coding & Trust
- Looking Ahead
- Open Discussion (and swag!)

About Us

Kenneth White

- Interests: RT signals, embedded systems, analytics
- First DEFCON: DC10
- Formal training: bio-signals (EEG/ERP, MRI, PET, EKG, EOG)
- Early career: databases, *nix, RTOS, h/w drivers
- Lifecycle: FDA (cardiac safety), SEI SEPG, IA
- Defense: network security, API endpoints
- Recently: public cloud security, ML/classification, safety-critical systems, breaking crypto/networks/websites/OS'
- Now: OCAP, Linux Foundation CII, NGO security
- *@kennwhite*

I like to work on interesting problems



Matthew Green

- Johns Hopkins University: Computer Science
- Teaches applied cryptography
- Builds secure systems
- Trained under Susan Hohenberger &Avi Rubin
- Former senior research staff: AT&T Labs
- On-going Research includes:
  - Techniques for privacy-enhanced information storage
  - Anonymous payment systems (including ZeroCoin)
  - Bilinear map-based cryptography
- *@matthew_d_green*

Matthew Green

(not his actual Dachshunds)

Long journey to DEFCON (no, really)

(my actual Shepherds, semi-medicated)

"*I'm here to share what I know, and learn with and from you.*"

— Jack Daniel

First Principles

"If a bad guy can persuade you to run his program on your computer, it's not your computer anymore."

— Scott Culp

First Principles

"If a bad guy can persuade you to run his program on your computer, it's not your computer anymore."

— Scott Culp

"Even if it has disk encryption."

— Kenn White

Crypto 101: First Principles

Thompson: Reflections on Trusting Trust
cm.bell-labs.com/who/ken/trust.html

Culp: 10 Immutable Laws of Security
technet.microsoft.com/library/cc722487

Zimmerman: Beware of Snake Oil
www.philzimmermann.com/EN/essays/SnakeOil

Post-Snowden Era

- NYT, Propublica, Guardian: NSA spends $250M/yr to counter & undermine "the use of ubiquitous encryption across the internet"
- NIST technical standards "intentionally weakened"
- BULLRUN: NSA actively working to *"Insert vulnerabilities into commercial encryption systems, IT systems, networks, and endpoint communications devices used by targets" The New York Times, 2013/09/05*

See: www.eff.org/nsa-spying/timeline

Post-Snowden Era

"Furthermore, we will be reviewing our existing body of cryptographic work"

— National Institute of Standards and Technology, Nov 2013

Recommends that the US government "fully support and not undermine efforts to create encryption standards"

— Presidential Advisory Committee, Jan 2014

"[C]lassified [reports] have heightened concern over the possibility of a backdoor… after conducting its own review, NIST [has] removed DRBG"

— National Institute of Standards and Technology, Apr 2014

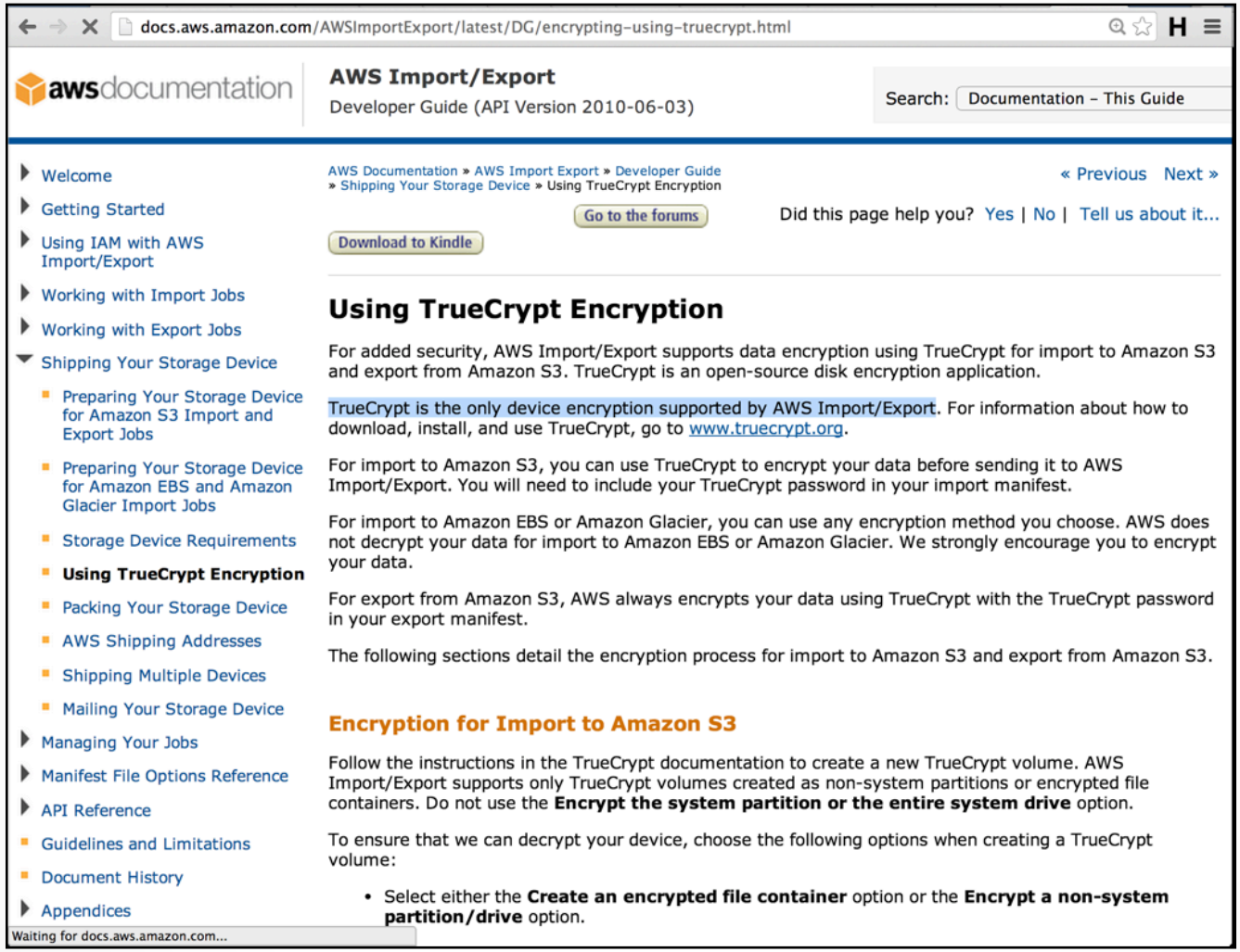
Which bring us to TrueCrypt

TrueCrypt

- File, volume, full disk encryption (FDE)
- 30M+ downloads
- Created Feb 2004 by anonymous development team
- Controversial license (Debian, Fedora, "forbidden items")

TrueCrypt

- Tool of choice for human rights workers, activists, attorneys, thousands of organizations, investigative/national security journalists, security professionals, and...?



Aug 2014: docs.aws.amazon.com/AWSImportExport/latest/DG/encrypting-using-truecrypt.html

TrueCrypt

- Never thoroughly audited on Windows
- Differences reported in volume headers
- Small differences in distributed binaries vs. source
- Windows vs. Mac & Linux
- With exception of deniability volume, no formal cryptanalysis
- Deterministic build? (Xavier de Carné de Carnavalet)
- Last license review in 2008 by RedHat/Fedora/OSSI concluded "we would not be protected from a lawsuit" and "this license is non-free"

By many measures, relatively strong*

descrypt, DES(Unix), Traditional DES	952,300,000
SHA512	797,417,300
MS-SQL 2012	770,212,200
OSX v10.7	743,689,500
HMAC-SHA512 (key = $salt)	371,098,600
Whirlpool	363,711,900
HMAC-SHA512 (key = $pass)	194,800,700
Kerberos 5 AS-REQ Pre-Auth etype 23	120,452,800
AIX SHA1	48,099,200
md5crypt, MD5(Unix), FreeBSD MD5, Cisco-IOS MD5	26,699,500
phpass, MD5(Wordpress), MD5(phpBB3)	13,736,900
1Password	9,249,000
TrueCrypt 5.0+ PBKDF2-HMAC-RipeMD160 boot-mode + AES	7,071,300
Samsung Android PIN	5,068,800
TrueCrypt 5.0+ PBKDF2-HMAC-RipeMD160 + AES	4,008,400
Password Safe	2,570,800
WPA/WPA2	1,304,800
TrueCrypt 5.0+ PBKDF2-HMAC-SHA512 + AES	310,323
sha256crypt, SHA256(Unix)	184,887
sha512crypt, SHA512(Unix)	98,285
bcrypt, Blowfish(OpenBSD)	36,141
GRUB 2	19,286
TrueCrypt 5.0+ PBKDF2-HMAC-Whirlpool + AES	17,036
OSX v10.8	5,571

*Hashes/sec on Sagitta Brutalis 290X: oclHashcat 1.00, AMD Catalyst 13.12
Accelerator: 8 x AMD Radeon R9 290X, stock clocks. Benchmark: Incremental brute force, alphanumcharset

Anonymous Dev Team

The information is out there

- Follow the money
- Follow the attorneys
- What we can share
- What we won't share

Public Record

- State of Nevada Corporate Records
- US Trademark Office
- International Trademark Filings (UK, France, China, Russia, Czech Republic)
- Public IRS filings
- Usenet/mailing list forums
- Published academic papers
- Student theses

Public Record

Some things we chose not to share.

Why?

Remember this doxing?

Let's not forget this:

And this:

Bitcoin Creator Returns To Internet To Say, 'I Am Not Dorian Nakamoto'

+ Comment Now + Follow Comments

support the company make micropayments impractical.

Bitcoin's solution is to use a peer-to-peer network to check for double-spending. In a nutshell, the network works like a distributed timestamp server, stamping the first transaction to spend a coin. It takes advantage of the nature of information being easy to spread but hard to stifle. For details on how it works, see the design paper at http://www.bitcoin.org/bitcoin.pdf

The result is a distributed system with no single point of failure. Users hold the crypto keys to their own money and transact directly with each other, with the help of the P2P network to check for double-spending.

Satoshi Nakamoto
http://www.bitcoin.org

Share Twitter Facebook

Views: 51425

▸ Reply to This

Replies to This Discussion

Reply by Satoshi Nakamoto 2 hours ago

I am not Dorian Nakamoto.

▸ Reply

And, crucially, this:

ARTHUR NAKAMOTO: Newsweek Reporter 'Is Destroying My Eldest Brother'

ROB WILE

MAR. 7, 2014, 4:18 PM | 9,699 | 20

FACEBOOK LINKEDIN TWITTER GOOGLE+ PRINT EMAIL

Newsweek is standing by Leah McGrath Goodman's assertion that Dorian Prentice Satoshi Nakamoto invented Bitcoin.

Nakamoto is denying it.

One source for McGrath Goodman's piece was Dorian's brother, Arthur.

In a very brief phone conversation with Business Insider Friday, Arthur Nakamoto indicated he'd been misquoted or misinterpreted

REUTERS/David McNew

Back to the Code

Conventional Wisdom: Given enough eyeballs, all bugs are shallow.

Meet Samuel Reshevsky, age 8 defeating 14 French chess masters at once, 1920

And so, it began...

The TrueCrypt Audit

- IsTrueCryptAuditedYet.com: Sept 24, 2013
- Announced on Twitter
- First contributions: Matthew & Me
- FundFill site set up


FundFill
FundFill
@FundFill
Follow
#istruecryptauditedyet ? Our first pledge of $100 comes from @kennwhite towards getting TrueCrypt audited!
fundfill.com/fund/TrueCrypt...
Reply
Retweet
Favorite
More
3
RETWEETS
7:14 PM - 24 Sep 13


E
0 1 0 1 0 1 0 1 ... 1 0 1

The TrueCrypt Audit

- Oct 9, 2014
  - Prof. Green blogs about it
  - Front page Hacker News

Why, hello there!

And so it went...

- No, we don't take Bitcoin.
- Yes, we take Bitcoin.
- Yes, the site is mobile-friendly.
- No, we don't take PayPal.
- /sets up IndieGoGo site.
- Yes! We take PayPal.

And so on…

"Hi, I'd like to buy 500 t-shirts, please."

"Do you ship to Thailand?"

Where does one purchase 150 DVDs of Sneakers?

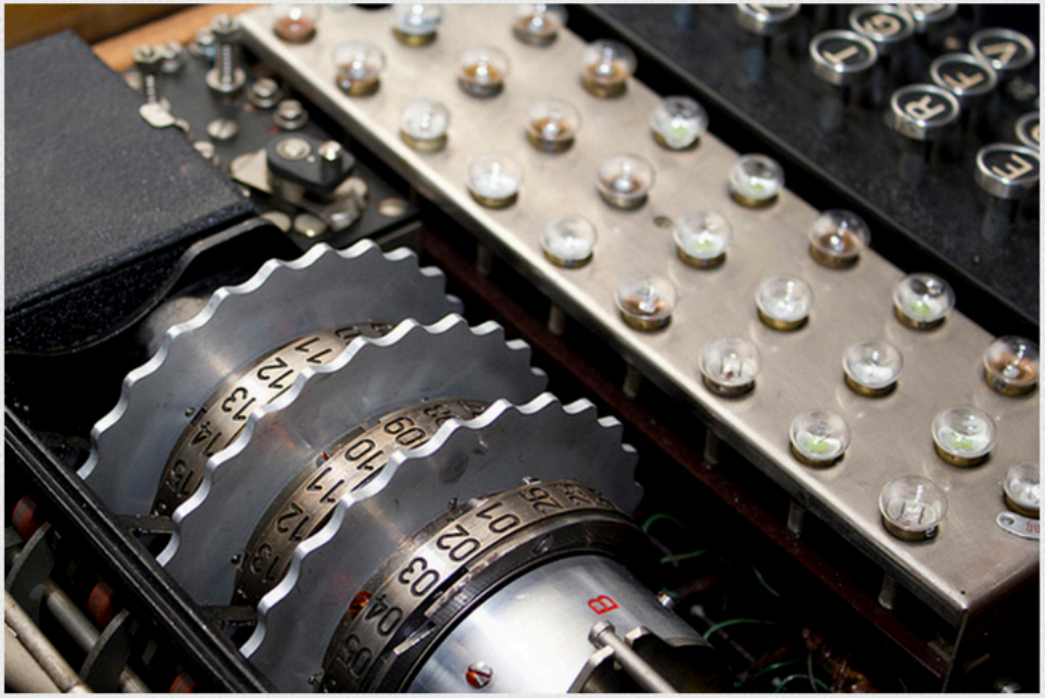
Incredible community

The TrueCrypt Audit

People, businesses, and governments all over the world use TrueCrypt to protect their privacy. We need help making it better and more secure.

Technology – Research Triangle, North Carolina, United States

Campaign Home | Updates / 0 | Comments / 0 | Funders / 190



$8,154

Raised of $25,000 Goal

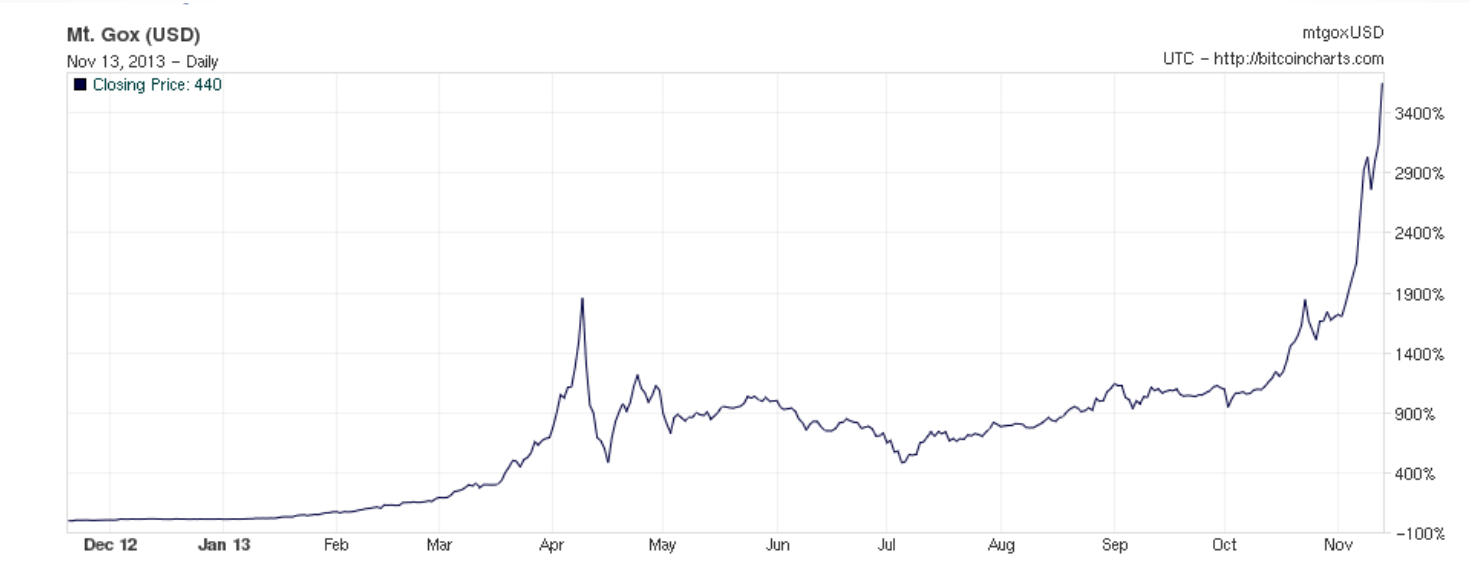
59 *days left*

CONTRIBUTE NOW ▶

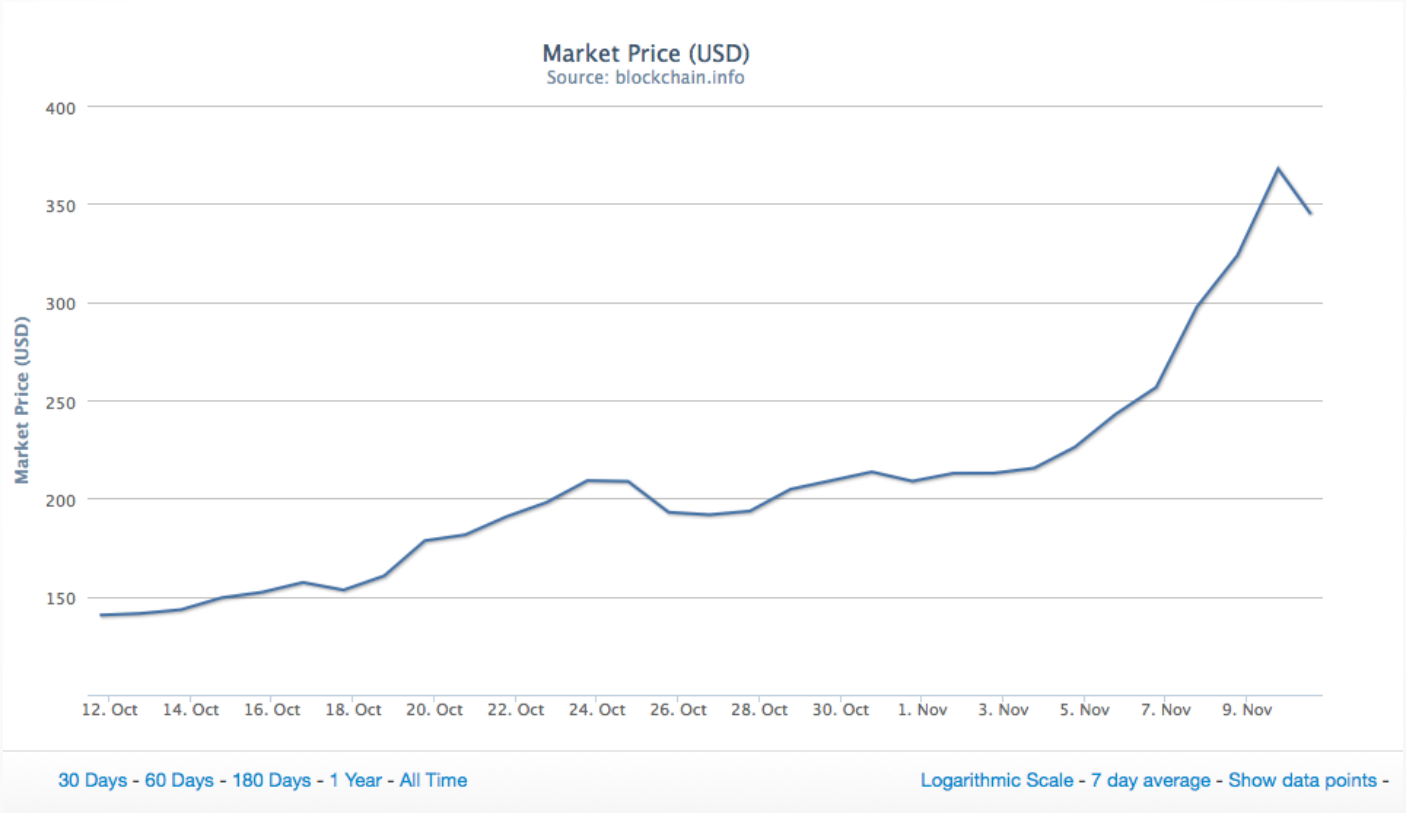
Flexible Funding

This campaign will receive all funds raised even if it does not reach its goal. Funding duration: October 14, 2013 - December 13, 2013 (11:59pm PT).

Fiducial responsibility is complicated



Fiducial responsibility is complicated



Then, a few days later

- Ars Technica, ThreatPost, The Economist, Nature, CIO, The Register, InfoWorld, PC World, Network World

  . . .

- What do you mean you there's $30,000 in PayPal?!

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- Ars Technica, ThreatPost, The Economist, Nature, CIO, The Register, InfoWorld, PC World, Network World

  . . .

- What do you mean you there's $30,000 in PayPal?!

And thus was born the Open Crypto Audit Project

A U.S. non-profit organization, incorporated in the state of North Carolina, currently seeking federal 501c(3) tax-exempt designation

Open Crypto Audit Project

Mission

- Provide technical assistance to free open source software ("FOSS") projects in the public interest
- Coordinate volunteer technical experts in security, software engineering, and cryptography
- Conduct analysis and research on FOSS and other widely software in the public interest

Open Crypto Audit Project

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Open Crypto Audit Project

Advisory Board

- Jean-Philippe Aumasson
- Nate Lawson
- Runa Sandvik
- Bruce Schneier
- Thomas Ptacek
- Jim Denaro
- Moxie Marlinspike
- Trevor Perrin
- Joseph Lorenzo Hall

And thus was born the Open Crypto Audit Project

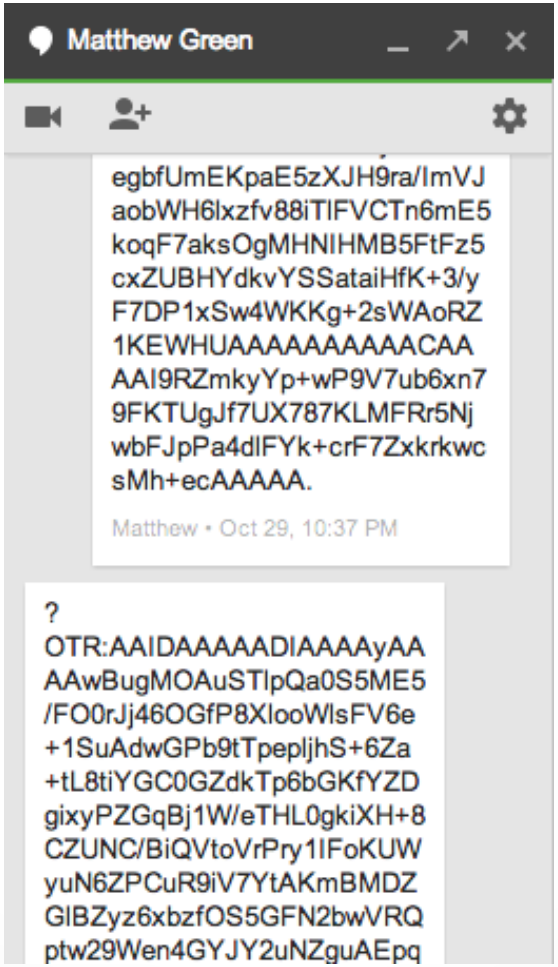
OpenCryptoAudit.org/people

Open Crypto Audit Project

Officers & Directors

- Matthew Green
- Marcia Hoffman
- Kenneth White

Our first Board meeting



Making the connections...

The work begins

- Reached out to a few of the small handful of organizations that are capable of doing this work
- Great response from iSec Labs
- Open Technology Fund matching grant

Fast-forward

Fast-forward

Open Crypto Audit Project

TrueCrypt

Security Assessment

iSECpartners
part of nccgroup

Prepared for:

Open Crypto Audit Project

Prepared by:

Andreas Junestam –Security Engineer

Nicolas Guigo – Security Engineer

Fast-forward

- iSec's final security assessment:
  - Weak volume header key derivation (low kdf iteration count)
  - Sensitive information could be paged out from kernel stacks
  - Issues in the boot loader decompressor
  - Use of memset() to clear sensitive data
- Overall findings: "no evidence of backdoors or intentional flaws"

What does that mean?

- Password strength is crucial (same as always)
- Vulnerabilities discovered would likely require physical access to a mounted volume to construct exploit chains (scape key material, page files, etc)
- This is *not* a part of the TrueCrypt security model
- If your machine is compromised, disk crypto will not help you (see Culp-White Law, earlier)
- PSA: *All* major FDEs, including Bitlocker, DM-Crypt, and FileVault have *identical* attack vectors
- So far, so good.

But then…

Life is what happens when you're busy making other plans

TrueCrypt.org goes dark

- v. 7.2 is released, signed with developer keys (updated cert)
- Now read-only
- Archive is taken offline
- Recommendations for alternatives non-optimal

TrueCrypt

TrueCrypt

truecrypt.sourceforge.net

Google

WARNING: Using TrueCrypt is not secure as it may contain unfixed security issues

This page exists only to help migrate existing data encrypted by TrueCrypt.

The development of TrueCrypt was ended in 5/2014 after Microsoft terminated support of Windows XP. Windows 8/7/Vista and later offer integrated support for encrypted disks and virtual disk images. Such integrated support is also available on other platforms (click here for more information). You should migrate any data encrypted by TrueCrypt to encrypted disks or virtual disk images supported on your platform.

Migrating from TrueCrypt to BitLocker:

If you have the system drive encrypted by TrueCrypt:

1. Encrypt the drive by BitLocker first. Open the Explorer:

Our Response

- OCAP is continuing through with the Phase II (formal cryptanalysis) of the code
- We have created a trusted repository of source and binaries for all platforms
- Thomas Ptacek and Nate Lawson organizing Phase II
- We are considering several post-audit scenarios,
- /possibly/ including financial support for a trusted fork
- *Many* challenges and questions remain

Secure Coding and Trust

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Crypto Engineering

"There is no difference, from the attacker's point of view, between gross and tiny errors. Both of them are equally exploitable...This lesson is very hard to internalize. In the real world, if you build a bookshelf and forget to tighten one of the screws all the way, it does not burn down your house."

— Maciej Cegłowski

(In)secure Coding:
Where static analysis might help

- Unintended compiler optimizations
- Primitive type transpositions
- Pointer assignment vs. array assignments/terminators

From: www.viva64.com/en/examples (*recommend preparing a tall glass of Scotch first)*

(In)secure Coding

"Source code is interesting. Everybody thinks if you have source code, you're going to be able to find everything wrong with [a system]. That's a misconception. It's nice to have source code so if you see something funny happening, you can check and see why – try to dig down… But for somebody to [manually] analyze millions of lines of source code, it's just not going to happen."

— Richard George
Former Technical Director
NSA Information Assurance Directorate
Retrospective Keynote, June, 2014
vimeo.com/97891042 *[35:50]*

Consider a hypothetical:

```
void Foo()
{
  char password[MAX_PASSWORD_LEN];
  InputPassword(password);
  ProcessPassword(password);
  memset(password, 0, sizeof(password));
}
```

Consider a hypothetical:

```
void Foo()
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}
```

In Action

Credits: Program Verification Systems

(http://www.viva64.com/en/d/0208/)

Visual Studio 2010

```
void F1()
{
  TCHAR buf[100];
  _stprintf(buf, _T("Test: %d"), 123);
  MessageBox(NULL, buf, NULL, MB_OK);
  memset(buf, 0, sizeof(buf));
}

void F2()
{
  TCHAR buf[100];
  _stprintf(buf, _T("Test: %d"), 123);
  MessageBox(NULL, buf, NULL, MB_OK);
  RtlSecureZeroMemory(buf, sizeof(buf));
}
```

memset() didn't

```
000000013F711143  mov         r8d,7Bh
000000013F71114B  call        qword ptr [__imp__swprintf
  MessageBox(NULL, buf, NULL, MB_OK);
000000013F711151  lea         rdx,[rsp+20h]
000000013F711156  xor         r9d,r9d
000000013F711159  xor         r8d,r8d
000000013F71115C  xor         ecx,ecx
000000013F71115E  call        qword ptr [__imp_MessageBo
  memset(buf, 0, sizeof(buf));
}
000000013F711164  mov         rcx,qword ptr [rsp+0F0h]
000000013F71116C  xor         rcx,rsp
000000013F71116F  call        __security_check_cookie (1
000000013F711174  add         rsp,108h
000000013F71117B  ret
```

Back to the source

```
void F1()
{
  TCHAR buf[100];
  _stprintf(buf, _T("Test: %d"), 123);
  MessageBox(NULL, buf, NULL, MB_OK);
  memset(buf, 0, sizeof(buf));
}

void F2()
{
  TCHAR buf[100];
  _stprintf(buf, _T("Test: %d"), 123);
  MessageBox(NULL, buf, NULL, MB_OK);
  RtlSecureZeroMemory(buf, sizeof(buf));
}
```

RtlSecureZeroMemory() does

```
000000013F2511AD  call          qword ptr [__imp__swprintf
  MessageBox(NULL, buf, NULL, MB_OK);
000000013F2511B3  lea           rdx,[rsp+20h]
000000013F2511B8  xor           r9d,r9d
000000013F2511BB  xor           r8d,r8d
000000013F2511BE  xor           ecx,ecx
000000013F2511C0  call          qword ptr [__imp_MessageBo
  RtlSecureZeroMemory(buf, sizeof(buf));
000000013F2511C6  lea           rdi,[rsp+20h]
000000013F2511CB  xor           eax,eax
000000013F2511CD  mov           ecx,0C8h
000000013F2511D2  rep stos      byte ptr [rdi]
}
000000013F2511D4  mov           rcx,qword ptr [rsp+0F0h]
000000013F2511DC  xor           rcx,rsp
000000013F2511DF  call          __security_check_cookie (1
000000013F2511E4  add           rsp,100h
000000013F2511EB  pop           rdi
000000013F2511EC  ret
```

Multiple options

- Prefer secure memory/copy functions of stdlib
- Review limitations of the language/framework
- Understand compiler optimization side-effects
- GCC 4.4+ (2009) offers a pragma for function-level optimization control or prevention

  (see: gcc.gnu.org/onlinedocs/gcc-4.4.0/gcc/Optimize-Options.html)
- Learn from others' experience

Multiple options

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  (see: gcc.gnu.org/onlinedocs/gcc-4.4.0/gcc/Optimize-Options.html)
- Learn from others' experience

The Onion Router (TOR)

crypto.c
tortls.c
connection_or.c
onion.c
rendclient.c
tor-gencert.c

```
int
crypto_pk_private_sign_digest(....)
{
  char digest[DIGEST_LEN];
  ....
  memset(digest, 0, sizeof(digest));
  return r;
}
```

The Onion Router (TOR)

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  ....
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  return r;
}
```

Network Security Services (NSS)

sha512.c

```
SECStatus
SHA384_HashBuf(unsigned char *dest, const unsigned char *src,
               PRUint32 src_length)
{
  SHA512Context ctx;
  unsigned int outLen;

  SHA384_Begin(&ctx);
  SHA512_Update(&ctx, src, src_length);
  SHA512_End(&ctx, dest, &outLen, SHA384_LENGTH);
  memset(&ctx, 0, sizeof ctx);

  return SECSuccess;
}
```

Network Security Services (NSS)

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{
  SHA512Context ctx;
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  SHA384_Begin(&ctx);
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  SHA512_End(&ctx, dest, &outLen, SHA384_LENGTH);
  memset(&ctx, 0, sizeof ctx);

  return SECSuccess;
}
```

OpenSSL

ec_mult.c

```
void usage(void)
{
  static unsigned char *buf=NULL,*obuf=NULL;
  ....
  OPENSSL_cleanse(buf,sizeof(buf));
  OPENSSL_cleanse(obuf,sizeof(obuf));
  ....
}
```

OpenSSL

ec_mult.c

```
void usage(void)
{
  static unsigned char *buf=NULL,*obuf=NULL;
  ....
  OPENSSL_cleanse(buf,sizeof(buf));
  OPENSSL_cleanse(obuf,sizeof(obuf));
  ....
}
```

On Trust

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Probably not your threat model

(TS//SI//NF) Such operations involving **supply-chain interdiction** are some of the most productive operations in TAO, because they pre-position access points into hard target networks around the world.

(TS//SI//NF) Left: Intercepted packages are opened carefully; Right: A "load station" implants a beacon

Trust is complicated

Peter Bowen
@pzb

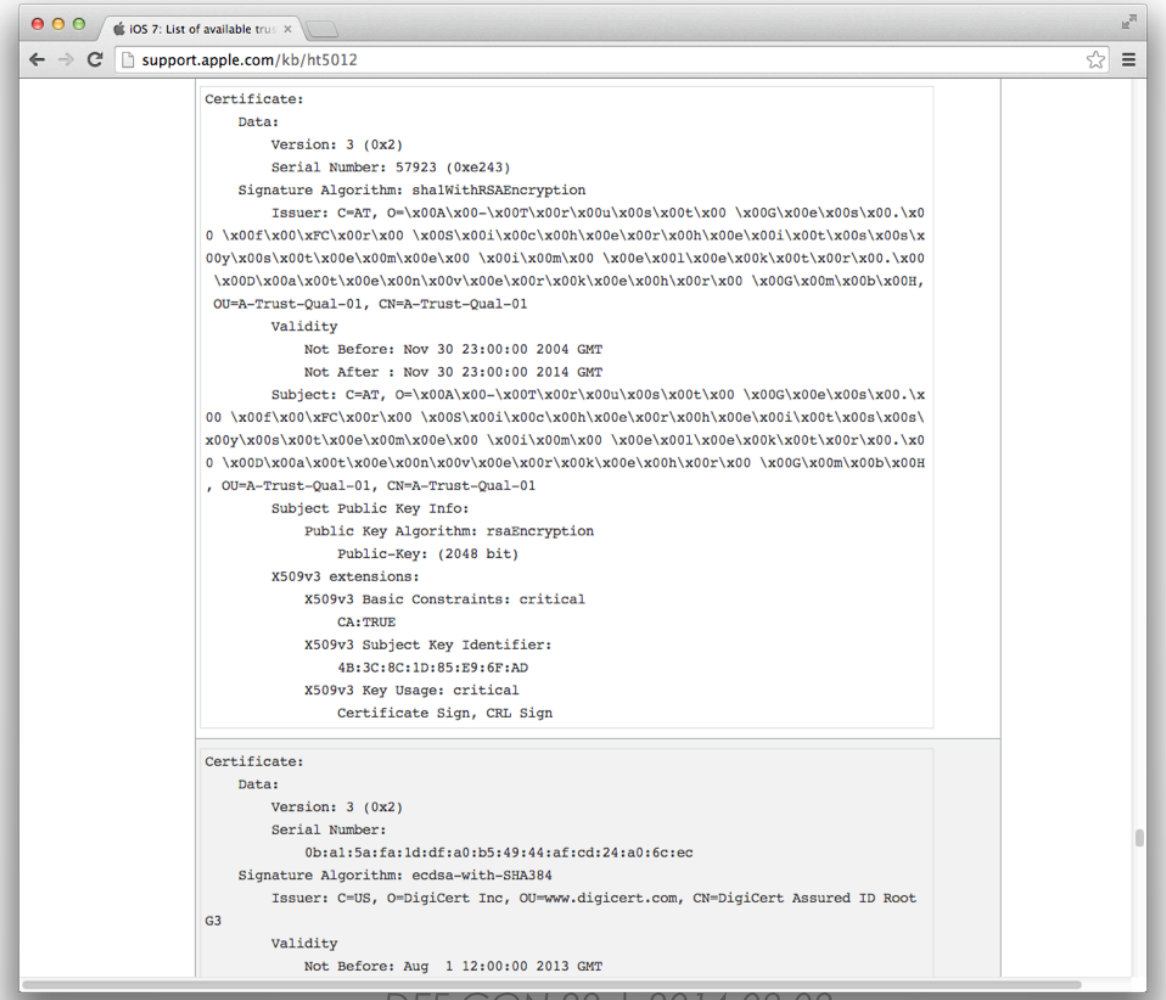
Following

Over 4900 unique CAs are or were transitively trusted by MSFT and/or Mozilla. That is just insane.

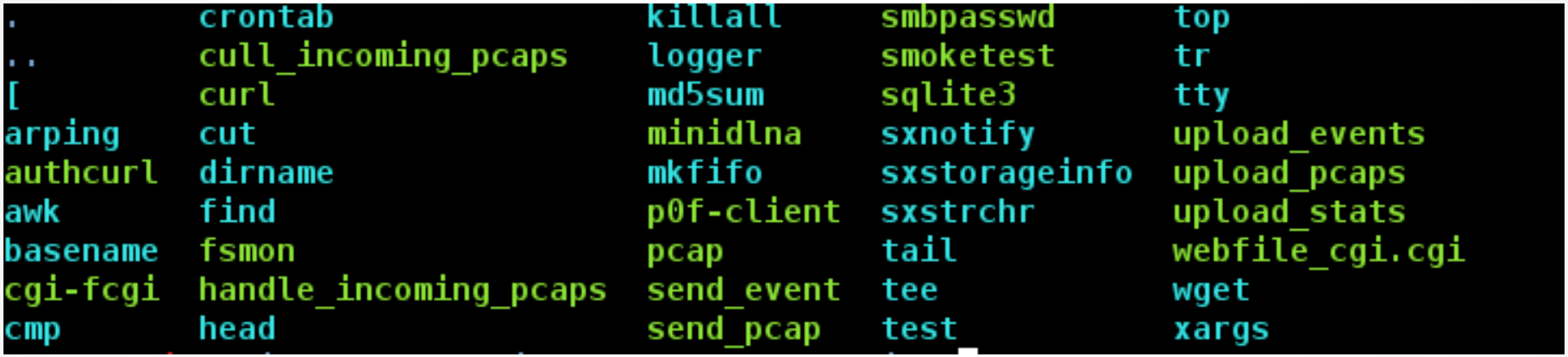
Reply Retweet Favorite ••• More

4:13 PM - 23 May 2014

Really complicated



On Trust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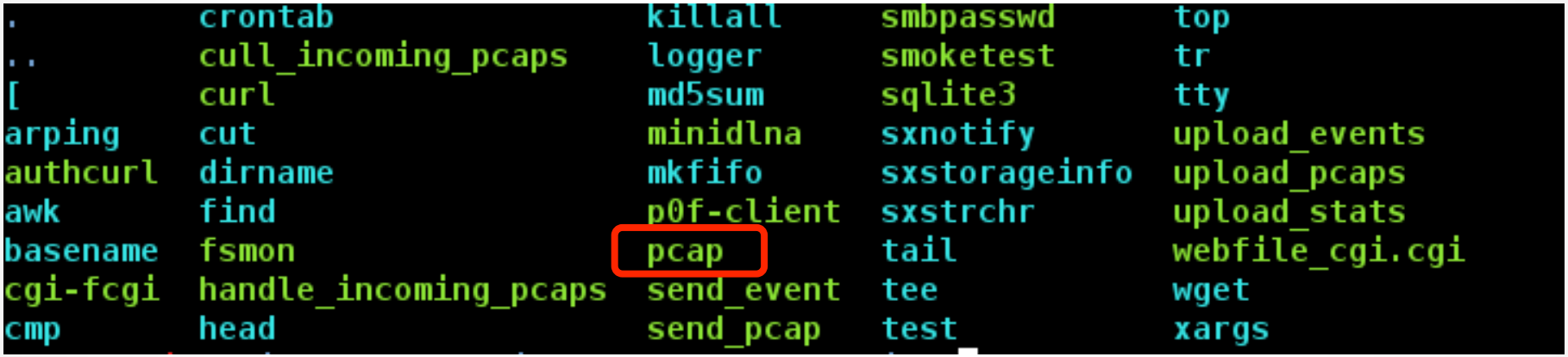
arping
authcurl
awk
basename
cgi-fcgi
cmp
crontab
cull_incoming_pcaps
curl
cut
dirname
find
fsmon
handle_incoming_pcaps
head
killall
logger
md5sum
minidlna
mkfifo
p0f-client
pcap
send_event
send_pcap
smbpasswd
smoketest
sqlite3
sxnotify
sxstorageinfo
sxstrchr
tail
tee
test
top
tr
tty
upload_events
upload_pcaps
upload_stats
webfile_cgi.cgi
wget
xargs

On Trust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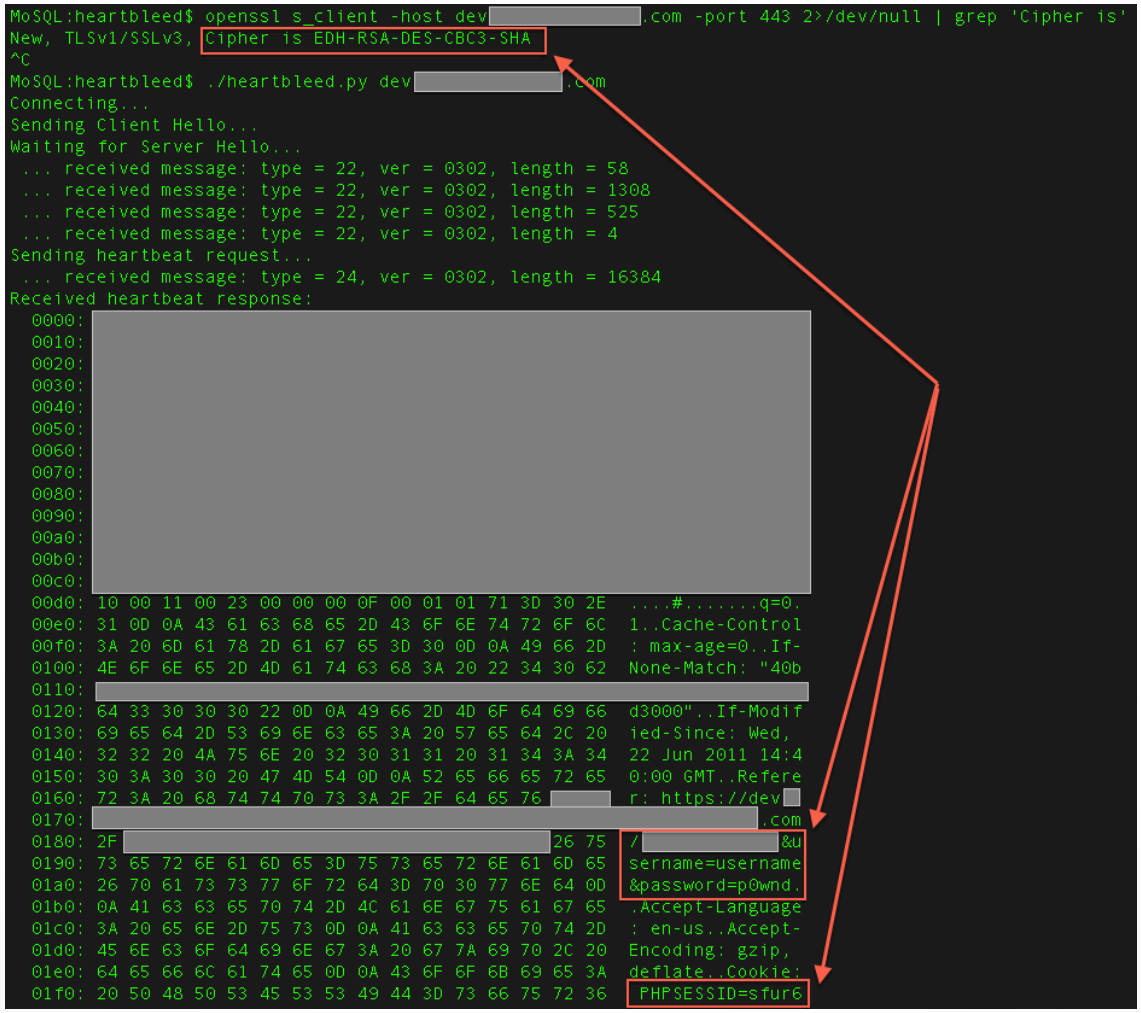
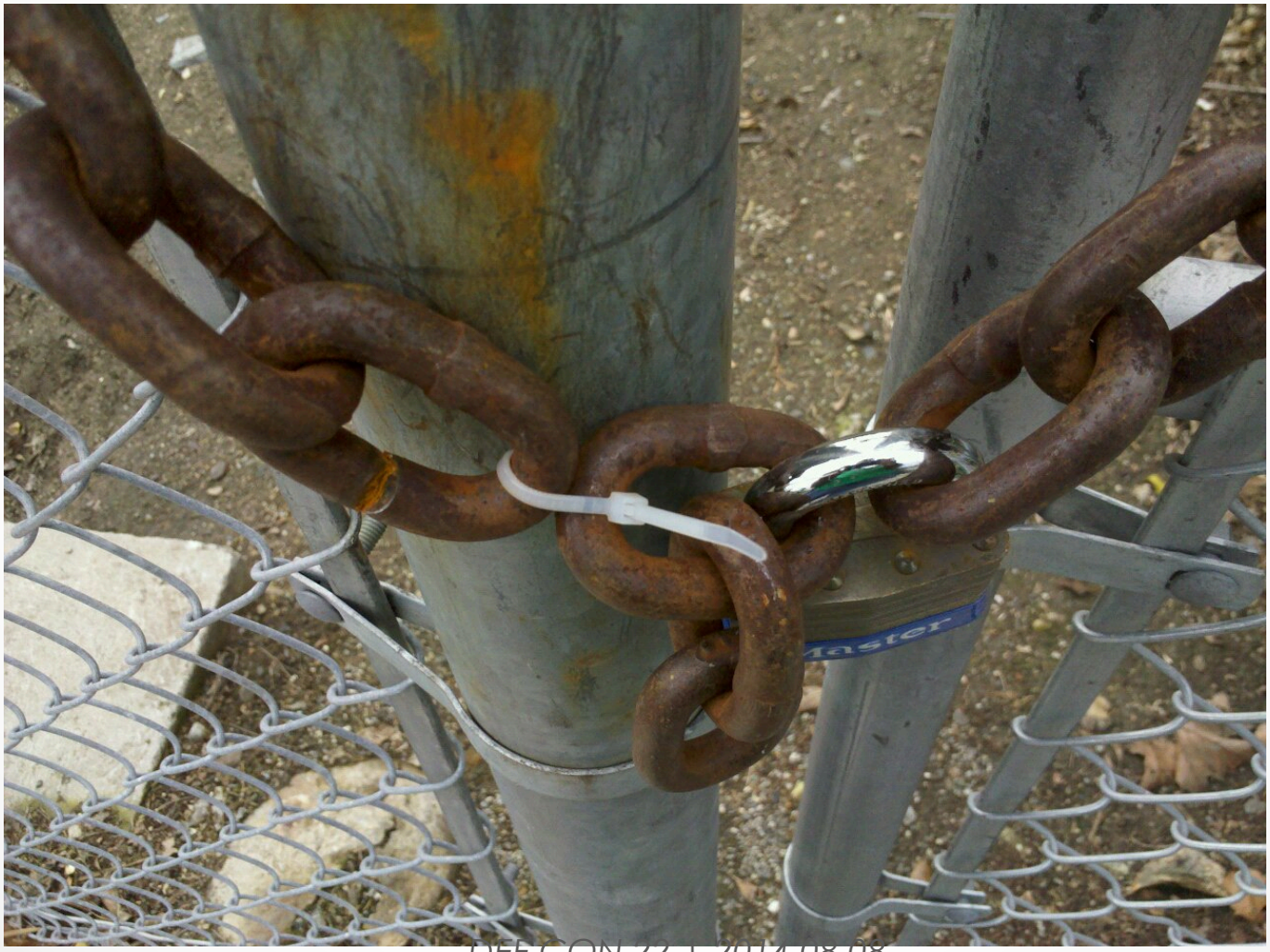
..
[
arping
authcurl
awk
basename
cgi-fcgi
cmp
crontab
cull_incoming_pcaps
curl
cut
dirname
find
fsmon
handle_incoming_pcaps
head
killall
logger
md5sum
minidlna
mkfifo
p0f-client
pcap
send_event
send_pcap
smbpasswd
smoketest
sqlite3
sxnotify
sxstorageinfo
sxstrchr
tail
tee
test
top
tr
tty
upload_events
upload_pcaps
upload_stats
webfile_cgi.cgi
wget
xargs

Strong crypto does not equal secure code

Forward Secrecy won't help



Even with the best designs…



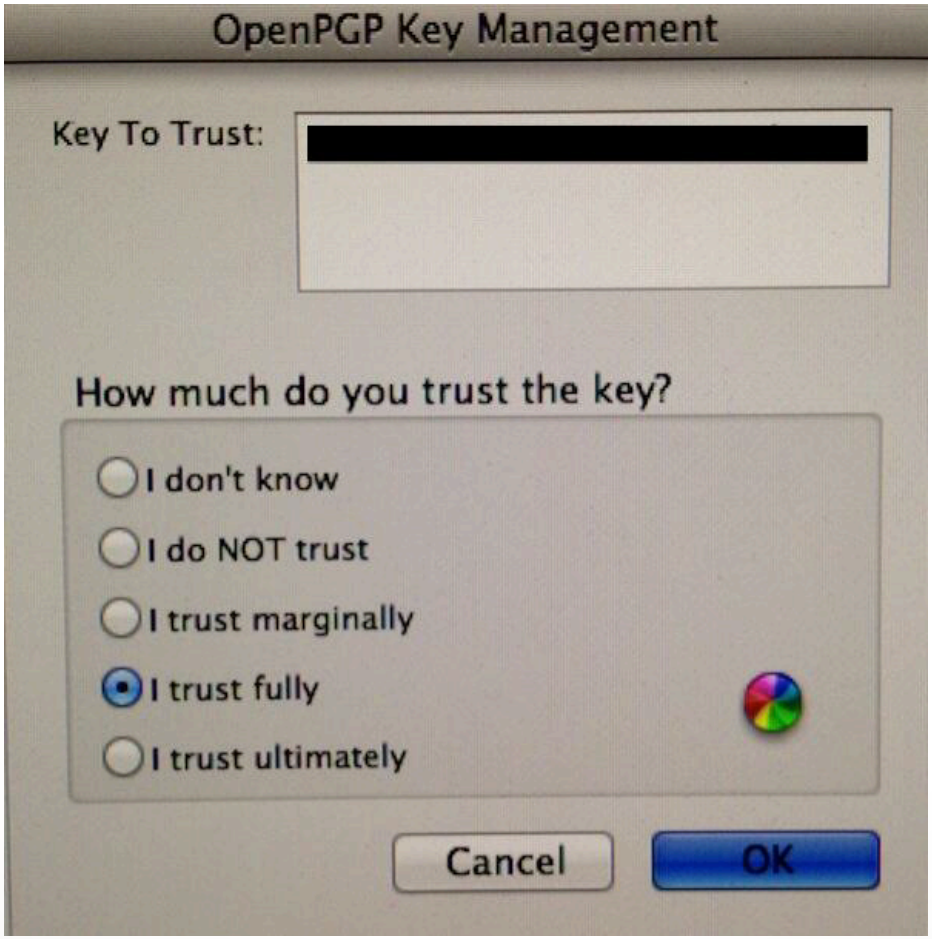
Things that make you go "hmmm"

```
ExclusiveArch: i686 x86_64

Summary: Utilities from the general purpose cryptography library with TLS implementation
Name: openssl
Version: 1.0.1e
Release: 4%{?_buildid}%{?dist}
Epoch: 1
# We have to remove certain patented algorithms from the openssl source
# tarball with the hobble-openssl script which is included below.
# The original openssl upstream tarball cannot be shipped in the .src.rpm.
Source: openssl-%{version}-usa.tar.xz
Source1: hobble-openssl
Source2: Makefile.certificate
Source6: make-dummy-cert
Source7: renew-dummy-cert
Source8: openssl-thread-test.c
Source9: opensslconf-new.h
Source10: opensslconf-new-warning.h
Source11: README.FIPS
# Build changes
```

It bears repeating…

Usable Crypto is HARD



Take-Aways

- Many recent catastrophic failures are secure coding errors, not crypto errors
- Static analyzers are not enough
- Manual inspection is not enough
- Source code can result in unexpected binary code
- Subject matter experts (protocols, crypto, network) may bring more perspective than "enough" eyes

If the game is rigged, strong crypto probably won't help you.

Looking forward

Recap: Where are we now?

- Phase I Report released April 23, 2014
- Beginning Phase II, to include:
  - Formal cryptanalysis
  - OSX & Linux review
  - Additional license work
- Partnering with Linux Foundation Core Infrastructure Initiative
- Auditing OpenSSL, possibly more
- Looking ahead!
- Trusted TC mirror: github.com/AuditProject/truecrypt-verified-mirror

Final Thoughts & Goals

- Unpaid volunteers are not enough
- One-off bug bounties are not enough
- Encourage secure coding practices
- Support & create smarter test harnesses
- Develop a workable model for public code review

Open Discussion

Talk to us

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IsTrueCryptAuditedYet.com (partly!)

OpenCryptoAudit.org

blog.cryptographyengineering.com

github.com/AuditProject/truecrypt-verified-mirror