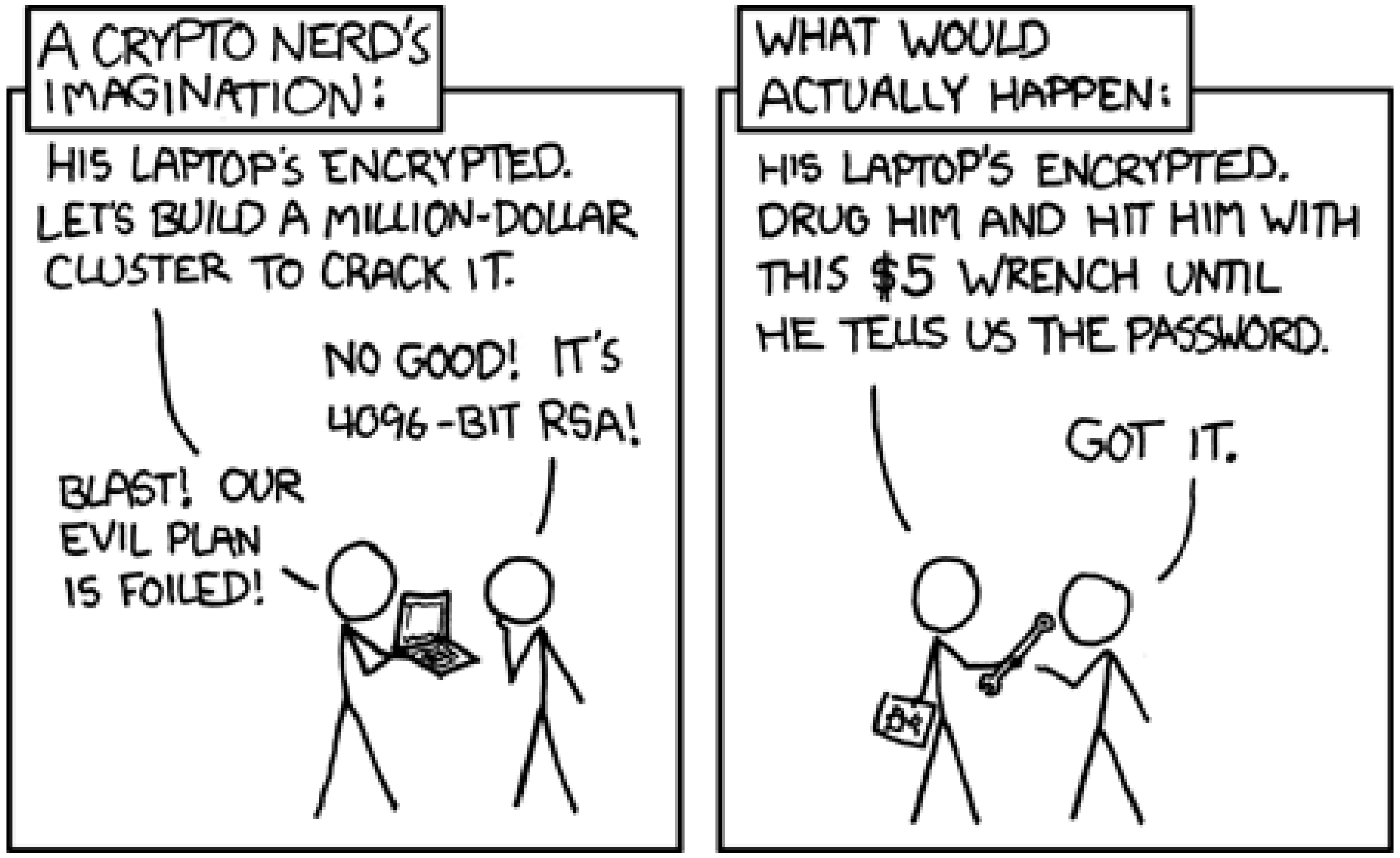
The security impact of a new cryptographic library

D. J. Bernstein, U. Illinois Chicago
& T. U. Eindhoven
Tanja Lange, T. U. Eindhoven

Joint work with:
Peter Schwabe, R. U. Nijmegen



http://xkcd.com/538/

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Obviously infeasible to break by best attacks in literature.

Implementations are available in public cryptographic libraries such as OpenSSL.

Common security practice is to use those implementations.

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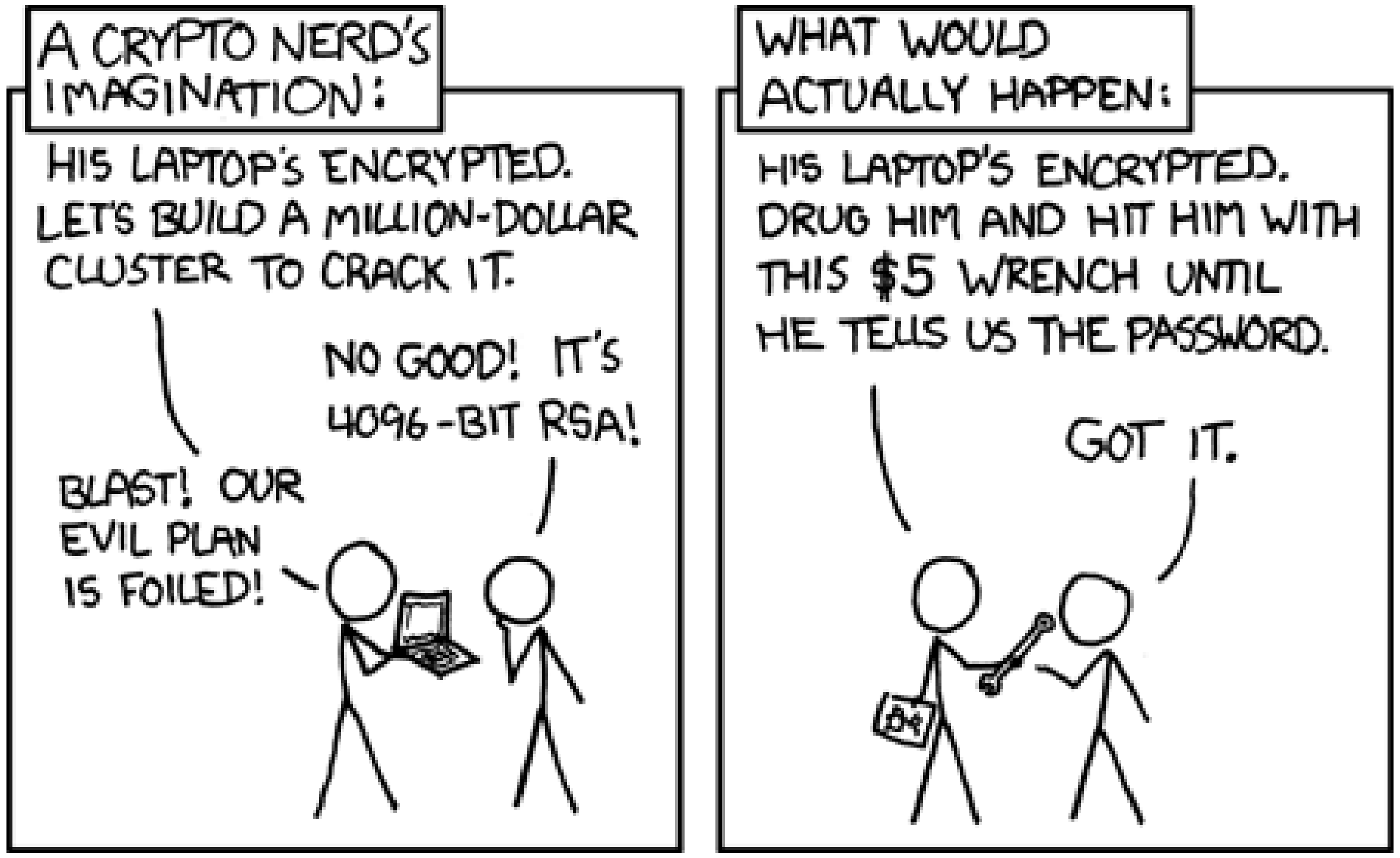

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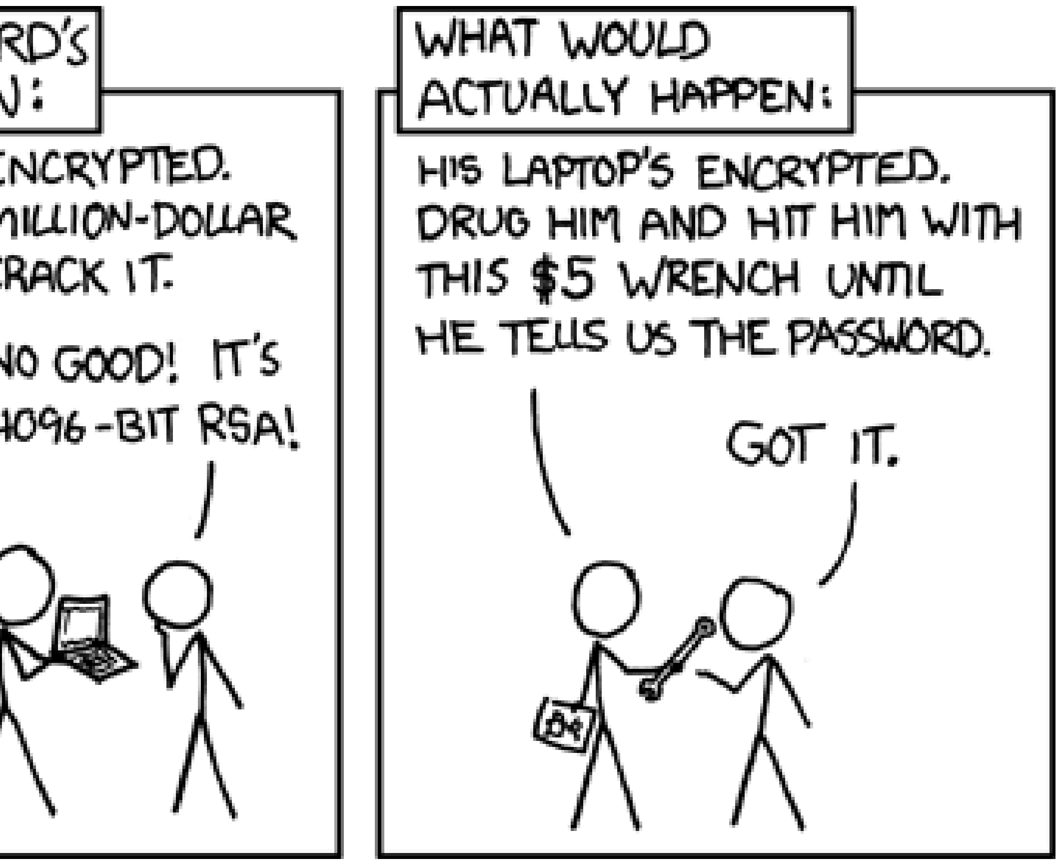

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Alice using a
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Use key to sign ha
Read Bob's key fr
Use key to encryp
Convert to wire fo

Plus more code:
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handle errors, etc.

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Generate random AES key.
Use AES key to encrypt pac
Hash encrypted packet.
Read RSA key from wire for
Use key to sign hash.
Read Bob's key from wire fo
Use key to encrypt signature
Convert to wire format.

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Hash encrypted packet.
Read RSA key from wire format.
Use key to sign hash.
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Convert to wire format.

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Alice using NaCl:

`c = crypto_box(`

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Alice using NaCl:

```
c = crypto_box(m,n,pk,s
```

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Plus more code:
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handle errors, etc.

Alice using NaCl:
`c = crypto_box(m,n,pk,sk)`

32-byte secret key `sk`.
32-byte public key `pk`.
24-byte nonce `n`.
`c` is 16 bytes longer than `m`.

All objects are C++
`std::string` variables
represented in wire format,
ready for storage/transmission.

C NaCl: similar, using pointers;
no memory allocation, no failures.

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Bob veri

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m=crypt
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`m=crypto_box_op`

Initial key generati

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Bob verifying, decrypting:

`m=crypto_box_open(c,n,`

Initial key generation:

`pk = crypto_box_keypair`

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Can instead use **signatures** for public messages:

`pk = crypto_sign_keypair(&sk)`
64-byte secret key,
32-byte public key.

`sm = crypto_sign(m,sk)`
64 bytes overhead.

`m = crypto_sign_open(sm,pk)`

ng NaCl:

`pto_box(m,n,pk,sk)`

secret key `sk`.

public key `pk`.

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Examples of applications using NaCl's `crypto_box`:

DNSCurve and DNSCrypt, high-security authenticated encryption for DNS queries; deployed by OpenDNS.

QUIC, Google's TLS replacement.

MinimaLT in Ethos OS, faster TLS replacement.

Threema, encrypted-chat app.

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`to_box_open(c,n,pk,sk)`

ey generation:

`ypto_box_keypair(&sk)`

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c messages:

`ypto_sign_keypair(&sk)`
secret key,
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`ypto_sign(m,sk)`
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`pto_sign_open(sm,pk)`

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2005 Osvik–Shamir–Tromer: 65ms to steal Linux AES key used for hard-disk encryption. Attack process on same CPU but without privileges.

Almost all AES implementations use fast lookup tables. Kernel's secret AES key influences table-load addresses, influencing CPU cache state, influencing measurable timings of the attack process. 65ms to compute influence^{-1}.

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Not confidence-inspiring;
likely to be breakable.

NaCl systematically avoids
all loads from addresses
that depend on secret data.
Eliminates this type of disaster.

2010 Langley `ctgrind`:
verify this automatically.

et load addresses

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Most cryptographic libraries
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intended to obscure influence
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Not confidence-inspiring;
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NaCl systematically avoids
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Eliminates this type of disaster.

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Intel's RDRAND in applications.
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Crypto performance problems often lead users to reduce cryptographic security levels or give up on cryptography.

Example 1: Google SSL used RSA-1024 until 2013.

Security note:
Analyses in 2003 concluded that RSA-1024 was breakable; e.g., 2003 Shamir–Tromer estimated 1 year, $\approx 10^7$ USD.
RSA Labs and NIST response:
Move to RSA-2048 by 2010.

Example 2: Tor us
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Example 4: Open
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Example 2: Tor used RSA-1
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Example 3: DNSSEC uses R
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Example 4: OpenSSL continues to use secret AES load addresses.

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Processing 1,000 packets per second and processing each in 1 ms can hardly be met by current hardware. As discussed in [32], a Pentium D 3.4 GHz processor needs about 5 times as long for a verification . . . a dedicated cryptographic co-processor is likely to be necessary."

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Here q is standard prime,
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Signer generates A and R as secret powers of B; easily solves for S.

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A higher-security

OpenSSL `secp16`
security level only
least secure ECC
2.1 million cycles
on Cortex-A8.

Our new Curve41
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A higher-security curve

OpenSSL `secp160-r1`,
security level only 2^{80},
least secure ECC option:
2.1 million cycles
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Our new Curve41417,
security level above 2^{200}:
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