Tools for Breaking out of PRISM

Christian Grothoff

The GNUnet Project

“Never doubt your ability to change the world.” –Glenn Greenwald
Everybody Has Secrets

- Business & Trade Secrets
- Political opinions
- Illegal activities
Keeping Secrets

- Encryption: baseline
- Hide meta-data: state of the art
- Practice today?
Keeping Secrets

- Encryption: baseline
- Hide meta-data: state of the art
- Practice today?

Send everything to US in plaintext
Guardian: “The PRISM program allows the intelligence services direct access to the companies servers.”

Cooperating providers: Microsoft, Yahoo, Google, Facebook, PalTalk, YouTube, Skype, AOL, Apple
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PRISM enables real-time surveillance and access to stored content

Data collected: E-mails, instant messages, videos, photos, stored data (likely files), voice chats, file transfers, video conferences, log-in times, and social network profiles

Tiny part of NSA: $20 M budget
US discussion focuses on spying on US citizens and legality under US law.

Frank Church (D-Idaho):

“The NSA’s capability at any time could be turned around on the American people, and no American would have any privacy left, such is the capability to monitor everything: telephone conversations, telegrams, it doesn’t matter.”
NSA’s tool to track global surveillance data
2,392,343,446 records from the US
97,111,199,358 records worldwide
This is for March 2013 alone
- NSA’s tool to track global surveillance data
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- Germany most surveilled country in Europe
- NSA’s tool to track global surveillance data
- 2,392,343,446 records from the US
- 97,111,199,358 records worldwide
- This is for March 2013 alone
- Germany most surveilled country in Europe
- “leverages FOSS technology”
“Google for global tcpdump” – Jacob Appelbaum
History: Irak War

Katharine Gun leaked memo from NSA agent Frank Koza in 2003 about an American effort to monitor the communications of six delegations to the United Nations who were undecided on authorizing the Iraq War and who were being fiercely courted by both sides:

“As you’ve likely heard by now, the Agency is mounting a surge particularly directed at the UN Security Council (UNSC) members (minus US and GBR of course) for insights as to how to membership is reacting to the on-going debate RE: Iraq, plans to vote on any related resolutions, what related policies/negotiating positions they may be considering, alliances/dependencies, etc — the whole gamut of information that could give US policymakers an edge in obtaining results favorable to US goals or to head off surprises. In RT, that means a QRC surge effort to revive/create efforts against UNSC members Angola, Cameroon, Chile, Bulgaria and Guinea, as well as extra focus on Pakistan UN matters.”
Cyberwar

Presidential Policy Directive 20, issued October 2012 and released by Edward Snowden, outlines U.S. cyberwar policy:

“Offensive Cyber Effect Operations (OCEO) can offer unique and unconventional capabilities to advance U.S. national objectives around the world with little or no warning to the adversary or target and with potential effects ranging from subtle to severely damaging. (...)

The United States Government shall identify potential targets of national importance where OCEO can offer a favorable balance of effectiveness and risk as compared with other instruments of national power, establish and maintain OCEO capabilities integrated as appropriate with other U.S. offensive capabilities, and execute those capabilities in a manner consistent with the provisions of this directive.”
Technical Cooperation

Bloomberg reports:

- US companies provide internal information to US secret services
- Companies from software, banking, communications hardware providers, network security firms
- Including technical specifications and unpatched software vulnerabilities
- In return, these **US companies** are given access to intelligence information
- Partners include: Microsoft, Intel, McAfee
History: ECHELON

- SIGINT collection network of AU, CA, NZ, UK and US
- Baltimore Sun reported in 1995 that Airbus lost a $6 billion contract in 1994 after NSA reported that Airbus officials had been bribing officials to secure the contract.
- Used to facilitate Kenetech Windpower’s espionage against Enercon in 1994-1996.

Former US listening station at Teufelsberg, Berlin.
Does it matter?

MPI estimated losses due to industrial espionage damage in 1988 at DM 8 billion.

So how does the EU react to learning about PRISM?
Does it matter?

MPI estimated losses due to industrial espionage damage in 1988 at DM 8 billion.

So how does the EU react to learning about PRISM?

“Direct access of US law enforcement to the data of EU citizens on servers of US companies should be excluded unless in clearly defined, exceptional and judicially reviewable situations.”

–Viviane Reding, EC vice-president in response to PRISM
Not Just Monitoring

- **US controls** key Internet infrastructure:
  - Number resources (IANA)
  - Domain Name System (Root zone)
  - DNSSEC root certificate
  - X.509 CAs (HTTPS certificates)
  - Major browser vendors (CA root stores!)

- Encryption does not help if PKI is compromised!
Ron Wyden (US Senate intelligence committee) asked James Clapper, director of national intelligence in March 2013:

"Does the NSA collect any type of data at all on millions or hundreds of millions of Americans?"

Clapper replied:

"No, sir."
“In February, the UK based research publication Statewatch reported that the EU had secretly agreed to set up an international telephone tapping network via a secret network of committees established under the “third pillar” of the Maastricht Treaty covering cooperation on law and order. (...) EU countries (...) should agree on international interception standards (...) to co-operate closely with the FBI (...). Network and service providers in the EU will be obliged to install tappable systems and to place under surveillance any person or group when served an interception order. These plans have never been referred to any European government for scrutiny (...) despite the clear civil liberties issues raised by such an unaccountable system. (...) The German government estimates that the mobile phone part of the package alone will cost 4 billion D-marks.”

Can we develop technologies to solve problems created by technology?
Can we develop technologies to solve problems created by technology?

- Hack back?
Technical Solutions

Can we develop technologies to solve problems created by technology?

- Hack back?
- Move data to European cloud?
Can we develop technologies to solve problems created by technology?

- Hack back?
- Move data to European cloud?
- Decentralize data and trust!
Decentralize Everything

- Encrypt everything end-to-end
- Decentralized PKI
- Decentralized data storage
- No servers
- No authorities
Decentralize Everything

- Encrypt everything end-to-end
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⇒ No juicy targets for APTs
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My Research and Development Agenda

Make decentralized systems:

- Faster, more scalable
- Easier to develop, deploy and use
- Easier to evolve and extend
- Secure (privacy-preserving, censorship-resistant, available, ...)
## Our Vision

**Internet**

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|  | Mesh (ECDHE＋AES) |
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Decentralized Naming Systems

Zooko’s Triangle

1 Joint work with Martin Schanzenbach and Matthias Wachs
The GNU Alternative Domain System (GADS)

Decentralized PKI that can also replace DNS/DNSSEC:

- Signed Resource Records (RRs)
- Secure delegation provides **transitivity** (SDSI)
- Decentralized resolution \( (R^5N \text{ DHT}) \)
- Every user manages his own zone
Zone Management: like in DNS

![Zone Management Interface](image)

<table>
<thead>
<tr>
<th>Name</th>
<th>Type</th>
<th>Value</th>
<th>Expiration</th>
<th>Public</th>
</tr>
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<tbody>
<tr>
<td>+</td>
<td>&lt;new record&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MX</td>
<td>5.mail.+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>priv</td>
<td>&lt;new record&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PKEY</td>
<td>3QT1G601GUBVOS5C0J0870EF88N3DBJ4L9SB8PFLR8UKCVGHG</td>
<td>end of time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>heise</td>
<td>&lt;new record&gt;</td>
<td></td>
<td>end of time</td>
<td></td>
</tr>
<tr>
<td>LEHO</td>
<td>heise.de</td>
<td></td>
<td>end of time</td>
<td></td>
</tr>
<tr>
<td>AAAA</td>
<td>2a02:2e0:3fe:100::8</td>
<td>end of time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>193.99.144.80</td>
<td></td>
<td>end of time</td>
<td></td>
</tr>
<tr>
<td>home</td>
<td>&lt;new record&gt;</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>大学</td>
<td>&lt;new record&gt;</td>
<td></td>
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<td>short</td>
<td>&lt;new record&gt;</td>
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<tr>
<td>fcfs</td>
<td>&lt;new record&gt;</td>
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<td></td>
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<tr>
<td>www</td>
<td>&lt;new record&gt;</td>
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Name resolution in GADS

Bob wants to be called **bob**
Bob can reach his webserver via **www.gads**
Secure introduction

Bob Builder, Ph.D.
Address: Country, Street Name 23
Phone: 555-12345
Mobile: 666-54321
Mail: bob@H2R84L4JIL3G5C.zkey

- Bob gives his public key to his **friends** via QR code
- Bob’s friends can resolve his records via *.petname.gads
Delegation

- Alice learns Bob’s public key
- Alice creates delegation to zone `bob`
- Alice can reach Bob’s webserver via `www.bob.gads`
Name Resolution

1. www.bob.gnu?
2. 'bob'
3. PKEY, $K_{pub}^{Bob}$

Local Zone

bob PKEY $K_{pub}^{Bob}$

A: 5.6.7.8

DHT

4. GET www, $K_{pub}^{Bob}$

5.
GADS as PKI (via DANE/TLSA)
Query Privacy: Terminology

$G$ generator in ECC curve, a point
$n$ size of ECC group, $n := |G|$, $n$ prime
$x$ private ECC key of zone ($\in \mathbb{Z}_n$)
$P$ public key of zone, a point $P := xG$
$l$ label for record in a zone ($\in \mathbb{Z}_n$)
$R_{P,l}$ set of records for label $l$ in zone $P$
$q_{P,l}$ query hash (hash code for DHT lookup)
$B_{P,l}$ block with information for label $l$ in zone $P$ published in the DHT under $q_{P,l}$
Publishing $B$ under $q_{P,l} := H(dG)$

\[ h := H(l, P) \]  \hspace{1cm} (1) \\
\[ d := h \cdot x \mod n \]  \hspace{1cm} (2) \\
\[ B_{P,l} := S_d(E_{HKDF(l,P)}(R_{P,l})), dG \]  \hspace{1cm} (3)
Query Privacy: Cryptography

Publishing $B$ under $q_{P,l} := H(dG)$

\[ h := H(l, P) \]  
\[ d := h \cdot x \mod n \]  
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Searching for $l$ in zone $P$

\[ h = H(l, P) \]  
\[ q_{P,l} = H(dG) = H(h \times G) = H(hP) \Rightarrow \text{obtain } B_{P,l} \]  
\[ R_{P,l} = D_{HKDF(l,Q)}(B_{P,l}) \]
GADS for GNUnet

Properties of GADS

➢ Decentralized name system with secure memorable names
➢ Decentralized name system with globally unique, secure identifiers
➢ QR codes for introduction, delegation used to achieve transitivity
➢ Achieves query and response privacy except against confirmation attack
➢ Can provide alternative PKI, validate TLS via TLSA records

Uses for GADS in GNUnet

➢ Pseudonymous file-sharing
➢ IP services in the P2P network (P2P-VPN) via “VPN” records
➢ Identities in social networking applications
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The Evolution Challenge\(^2\)

- Features are frequently added to social applications
- Some require changes ("extensions") to data formats and messages
- Centralized, browser-based networks can easily update to new version
- Decentralized systems must transition *gracefully*

\(^2\)Joint work with Carlo v. Loesch and Gabor Toth
Related Work: XML

- Extensible Markup Language
- Syntax is *extensible*
- Extensions have no *semantics*
We are working on PSYC2, the successor to PSYC:

- More compact, mostly human-readable, faster-to-parse relative of XML/JSON
- PSYC messages consist of a **state update** and a **method invocation**
- PSYC includes interesting ideas for social networking:
  - Stateful multicast
  - History
  - Difference-based updates
- PSYC addresses extensibility problem using **try-and-slice** pattern
PSYC State: Example

The PSYC state is a set of key-value pairs where the names of keys use underscores to create an inheritance relationship:

- _name
- _name_first
- _name_first_chinese
- _address
- _address_street
- _address_country

The data format for each state is fixed for each top-level label.
A PSYC method has a name which follows the same structure as keys:

- `_message`
- `_message_private`
- `_message_public`
- `_message_public_whisper`
- `_message_announcement`
- `_message_announcement_anonymous`

Methods have access to the current state and a per-message byte-stream.
The Try-and-Slice Pattern

```c
int msg (string method) {
    while (1) {
        switch (method) {
            case "_notice_update_news": // handle news update
                return 1;
            case "_notice": // handle generic notice
                return 1;
            case "_message": // handle generic message
                return 1;
            // ...
        }
        int glyph = strrpos (method, '_');
        if (glyph <= 1) break;
        truncate (method, glyph);
    }
}
```
Advantages of Try-and-Slice

- Extensible, can support many applications
- Can be applied to state and methods
- Defines what backwards-compatible extensibility means:
  - Can incrementally expand implementations by deepening coverage
  - Incompatible updates = introduce new top-level methods
PSYC2 for GNUnet

Properties of PSYC

- Compact encoding (much smaller than XML/JSON)
- Supports stateful multicast
- Supports message history (replay, see latest news, etc.)
- Extensible syntax and semantics

Uses for PSYC2 in GNUnet

- P2P social networking foundation (combine with GADS!)
- Pushes social profiles (state) to all recipients, no federation
- Replay from local database used as primary access method
- **My data is stored on my machine**
- Use secure multicast to support very large groups
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Distributed Search via Regular Expressions: Idea

1. Offerer creates regular expression describing service
2. Regular expression is compiled to a DFA
3. DFA is stored in the DHT
4. Patron matches using a string

---

Joint work with Max Szengel, Ralph Holz, Bart Polot and Heiko Niedermayer
Problem: Mapping of States to Keys

Regular expression \((ab|cd)e^*f\) and corresponding DFA
Evaluation

- Implementation in GNUnet
- Profiling of Internet-scale routing using regular expressions to describe AS address ranges
- CAIDA AS data set: Real AS data
Evaluation
Evaluation: Results of Emulation

Search duration averaged over five runs with randomly connected peers.

![Graph showing search duration averaged over five runs with randomly connected peers for 1,000, 2,000, and 4,000 peers. The x-axis represents search duration in seconds, and the y-axis represents the percentage of matched strings. The lines indicate the performance of searches as the number of peers increases.]
RegEx Search for GNUUnet

Properties of RegEx Search

▶ Capability discovery in DHT-based P2P networks using regular expressions
▶ Linear latency in the length of the search string
▶ Suitable for applications that can tolerate moderate latency

Uses for GADS in GNUUnet

▶ Network search
▶ Discovery of matching services
▶ Topic-based subscriptions in messaging
Conclusion

- Everybody has something to hide
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We must decentralize or risk to lose control over our lives.
Do you have any questions?

References:

Problem: Decentralizing the Start State

Regular expression: $abc^*defg^*h$ and $k = 4$. 
GNUnet: Envisioned Applications

- secushare
- gns
- fs
- reuters
- psyc
- voting
- multicast
- consensus
- mesh
- dotproduct
- core
- msg
- regex
- set
- dht
- ats
- vpn
- exit
- voting
- consensus