

Decentralized Public Key Infrastructures

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Learning Objectives

Introduction to GnuPG

Secure Multiparty Computation example: Fog of Trust

The GNU Name System

Comparisson of Name Systems

Introduction to GNUnet

Part I: Introduction to GnuPG

PGP

- ▶ PGP can be used to encrypt and digitally sign files and e-mails.
- ▶ Data is at rest or transmitted unidirectionally. \Rightarrow No secure channel!
- ▶ PGP was published by Philip R. Zimmermann¹ in the early 1990s.
- ▶ Got immediate NSA attention and encountered legal issues on its use of RSA cryptography patents.
- ▶ PGP certificates are public key certificates with one or more identity labels tied to it.

¹<http://www.philzimmermann.com/>

GnuPG

- ▶ Free version of PGP, with library (libgcrypt)
- ▶ Provides common cryptographic primitives
- ▶ Provides implementation of OpenPGP ([3, 4, 2])
- ▶ Commonly used for:
 - ▶ secure E-mail (authentication, encryption)
 - ▶ encrypt files
 - ▶ sign files — i.e. sources and binaries in Free Software distributions

PGP Certificate Overview

PGP Version identifies which version of PGP was used to create the key associated with the certificate

Holder's public key the public portion of your key pair, together with the algorithm of the key: RSA or DSA (Digital Signature Algorithm)

Holder information this consists of "identity" information about the user, such as their name, user ID, photograph, and so on. . .

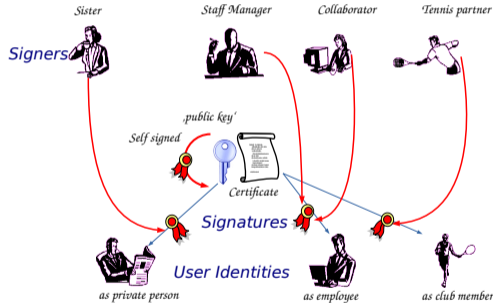
Holder digital signature also called a self-signature, this is the signature using the corresponding private key of the public key associated with the certificate

Validity period the certificate's start date/ time and expiration date/ time; indicates when the certificate will expire

Preferred symmetric encryption algorithm indicates the encryption algorithm to which the certificate owner prefers to have information encrypted. The supported algorithms are CAST, IDEA, Triple-DES, AES, ...

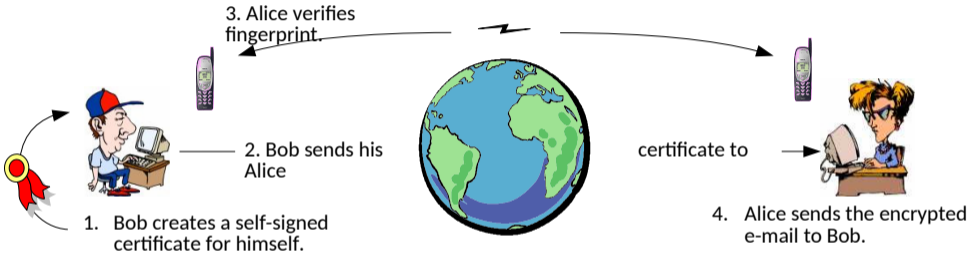
PGP Certification

- ▶ One certificate may be signed by multiple entities (persons).
- ▶ Digital signatures may bind different user attributes to a certificate when verifying the authenticity of that user.



Different people apply different methods to check authenticity before signing a key!

PGP Key Signing



Trust on First Use (TOFU)

Another kind of direct trust security model:

- ▶ Client creates a trust relationship with a not-yet-trusted and unknown endpoint.
- ▶ The public key of the endpoint is not verified, but *subsequent* connections to the same peer require the public key paired with other information of the service to remain the same.

TOFU is typically used in SSH and in HTTP Public Key Pinning (HPKP).

The Web of Trust

Problem:

- ▶ Alice has certified many of her contacts and *flagged* some as *trusted* to check keys well.
- ▶ Bob has been certified by many of his contacts.
- ▶ Alice has **not** yet certified Bob, but wants to securely communicate with him.

²Simplified, details later.

The Web of Trust

Problem:

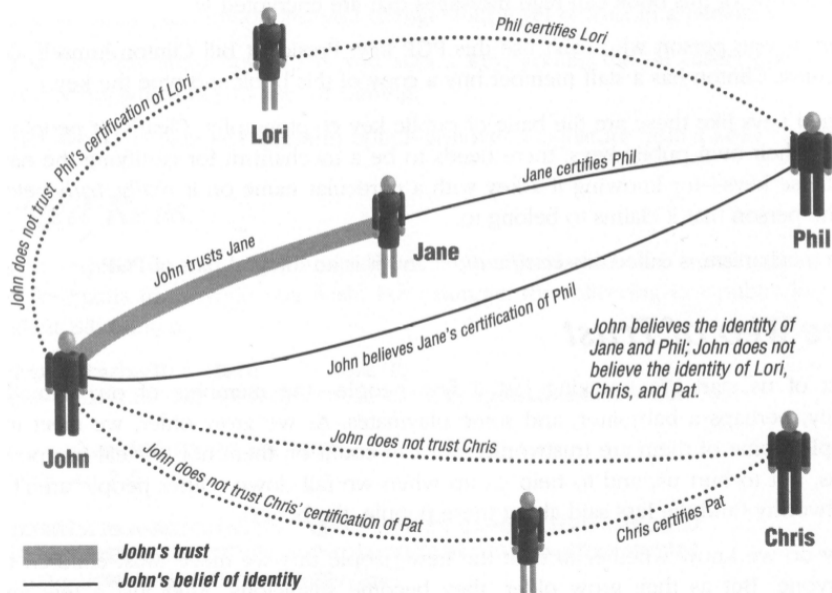
- ▶ Alice has certified many of her contacts and *flagged* some as *trusted* to check keys well.
- ▶ Bob has been certified by many of his contacts.
- ▶ Alice has **not** yet certified Bob, but wants to securely communicate with him.

Solution:

- ▶ Find paths in the certification graph from Alice to Bob.
- ▶ If sufficient number of short paths exist certifying the same key, trust it.²

²Simplified, details later.

The Web of Trust



The PGP Private Keyring

Stores private/public key pairs:

- ▶ timestamp
- ▶ key ID (indexed)
- ▶ public key
- ▶ encrypted private key (with passphrase)
- ▶ user ID (indexed)

The PGP Public Keyring

Stores public key pairs, certificate and trust status:

- ▶ timestamp
- ▶ key ID (indexed)
- ▶ public key
- ▶ user ID (indexed)
- ▶ owner trust:
 - ▶ unknown user
 - ▶ usually not trusted to sign
 - ▶ usually trusted to sign
 - ▶ always trusted to sign
 - ▶ ultimately trusted (own key, only present in private key ring)
- ▶ signature(s)
- ▶ signature trust(s); copy of owner trust of the signer
- ▶ validity of public key

Key validity calculation

- ▶ if at least one signature trust is ultimate, then the validity of the key is 1 (complete)
- ▶ otherwise, a weighted sum of the signature trust values is computed:
 - ▶ always trusted signatures has a weight of $1/x$
 - ▶ usually trusted signatures has a weight of $1/y$

x, y are user-configurable parameters, default $x = 1, y = 2$.

Certificate Trust Models (Summary)

Direct Trust One trusts in a relationship between “public key” and “identity”, which it has verified by itself only. The identity of the subject (owner) is proven directly (personally).

Web of Trust One accepts/applies “public keys”, where the identity binding is validated by others (persons or agents). One accepts other entities as trustworthy authorities (indirect trust or recommended trust).

Hierarchical Trust One accepts/applies “public keys”, where the identity binding is validated by a trustworthy authority.

See also: **individualism, anarchism, authoritarianism.**

Certificate Trust Models (Summary)

- Direct Trust**
 - ▶ Zero-solution: public key must be exchanged over 2nd/private channel or remain non-verifiable.
 - ▶ Usable in limited scope. Key management is complex, legal validity/liability not possible.
- Web of Trust**
 - ▶ Flexible solution: One applies public keys validated by other entities.
 - ▶ Usable in bigger scope (e.g. community). Key management less complex using online key server. Legal validity/liability not possible.
- Hierarchical Trust**
 - ▶ Strict solution: One applies public keys only if validated by a “trustworthy” authority.
 - ▶ Usable in national or even global scope. Key management still complex but mostly done by experts. Legal validity/liability possible.

See also: **individualism, anarchism, authoritarianism.**

Using GnuPG

```
$ gpg --gen-key  
$ gpg --export  
$ gpg --import FILENAME  
$ gpg --edit-key EMAIL  
(gpg) fpr  
(gpg) sign  
(gpg) trust  
$ gpg --clearsign FILENAME
```

Excercise: Explore

`https://pgp.mit.edu`

Break

Part II: Fog of Trust

The Fog of Trust

Problem:

- ▶ Publishing who certified whom exposes the social graph.
- ▶ The “NSA kills based on meta data”.

Reminder: The Web of Trust

Problem:

- ▶ Alice has certified many of her contacts and *flagged* some as *trusted* to check keys well.
- ▶ Bob has been certified by many of his contacts.
- ▶ Alice has **not** yet certified Bob, but wants to securely communicate with him.

Solution:

- ▶ Find paths in the certification graph from Alice to Bob.
- ▶ If sufficient number of **short** paths exist certifying the same key, trust it.

The Fog of Trust

Problem:

- ▶ Publishing who certified whom exposes the social graph.
- ▶ The “NSA kills based on meta data”.

Solution:

- ▶ Do not publish the graph.
- ▶ Have Alice and Bob collect their certificates locally.
- ▶ Use SMC protocol for
private set intersection cardinality with signatures!

We will only consider paths with **one** intermediary.

Straw-man version of protocol 1

Problem: Alice wants to compute $n := |\mathcal{L}_A \cap \mathcal{L}_B|$

Suppose each user has a private key c_i and the corresponding public key is $C_i := g^{c_i}$ where g is the generator

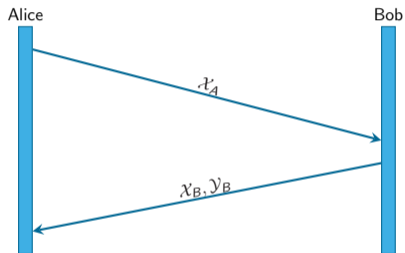
The setup is as follows:

- ▶ \mathcal{L}_A : set of public keys representing Alice trusted verifiers
- ▶ \mathcal{L}_B : set of public keys representing Bob's signers
- ▶ Alice picks an ephemeral private scalar $t_A \in \mathbb{F}_p$
- ▶ Bob picks an ephemeral private scalar $t_B \in \mathbb{F}_p$

Straw-man version of protocol 1

$$\mathcal{X}_A := \{ C^{t_A} \mid C \in \mathcal{L}_A \}$$

$$\begin{aligned} \mathcal{Y}_A &:= \{ \hat{C}^{t_A} \mid \hat{C} \in \mathcal{X}_B \} \\ &= \{ C^{t_A \cdot t_B} \mid C \in \mathcal{L}_A \} \end{aligned}$$



$$\begin{aligned} \mathcal{X}_B &:= \{ C^{t_B} \mid C \in \mathcal{L}_B \} \\ \mathcal{Y}_B &:= \{ \bar{C}^{t_B} \mid \bar{C} \in \mathcal{X}_A \} \\ &= \{ C^{t_B \cdot t_A} \mid C \in \mathcal{L}_B \} \end{aligned}$$

Alice can get $|\mathcal{Y}_A \cap \mathcal{Y}_B|$ at linear cost.

Attack against the Straw-man

If Bob controls two trusted verifiers $C_1, C_2 \in \mathcal{L}_A$, he can:

- ▶ Detect relationship between $C_1^{t_A}$ and $C_2^{t_A}$
- ▶ Choose $K \subset \mathbb{F}_p$ and substitute with fakes:

$$\mathcal{X}_B := \bigcup_{k \in K} \{C_1^k\}$$

$$\mathcal{Y}_B := \bigcup_{k \in K} \{(C_1^{t_A})^k\}$$

so that Alice computes $n = |K|$.

Cut & choose version of protocol 1: Preliminaries

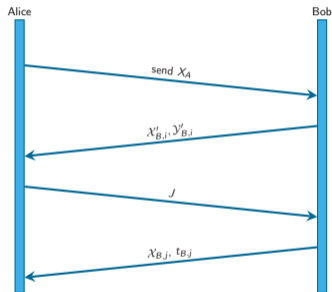
Assume a fixed system security parameter $\kappa \geq 1$.

Let Bob use secrets $t_{B,i}$ for $i \in \{1, \dots, \kappa\}$, and let $\mathcal{X}_{B,i}$ and $\mathcal{Y}_{B,i}$ be blinded sets over the different $t_{B,i}$ as in the straw-man version.

For any list or set Z , define

$$Z' := \{h(x) | x \in Z\} \tag{1}$$

Cut & choose version of protocol 1



Protocol messages:

1. Alice sends:
$$\mathcal{X}_A := \text{sort} [C^{t_A} \mid C \in \mathcal{A}]$$
2. Bob responds with commitments:
$$\mathcal{X}'_{B,i}, \mathcal{Y}'_{B,i} \text{ for } i \in 1, \dots, \kappa$$
3. Alice picks a non-empty random subset $J \subseteq \{1, \dots, \kappa\}$ and sends it to Bob.
4. Bob replies with $\mathcal{X}_{B,j}$ for $j \in J$, and $t_{B,j}$ for $j \notin J$.

Cut & choose version of protocol 1: Verification

For $j \notin J$, Alice checks the $t_{B,j}$ matches the commitment $\mathcal{Y}'_{B,j}$.

For $j \in J$, she verifies the commitment to $\mathcal{X}_{B,j}$ and computes:

$$\mathcal{Y}_{A,j} := \left\{ \hat{C}^{t_A} \mid \hat{C} \in \mathcal{X}_{B,j} \right\} \quad (2)$$

To get the result, Alice computes:

$$n = |\mathcal{Y}'_{A,j} \cap \mathcal{Y}'_{B,j}| \quad (3)$$

Alice checks that the n values for all $j \in J$ agree.

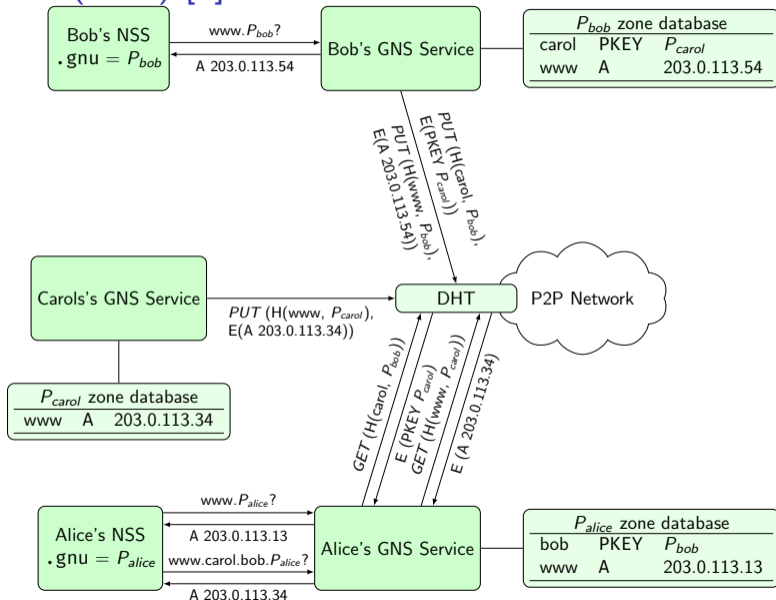
Protocol 2: Private Set Intersection with Subscriber Signatures

- ▶ Naturally, signers are willing to *sign* that Bob's key is Bob's key.
- ▶ We still want the identities of the signers to be private!
- ▶ BLS (Boneh et. al) signatures are compatible with our blinding.
- ⇒ Integrate them with our cut & choose version of the protocol.

Costs are linear in set size. Unlike prior work this needs no CA.

Part III: The GNU Name System

The GNU Name System (GNS) [5]



The GNU Name System³

Properties of GNS

- ▶ Decentralized name system with secure memorable names
- ▶ Delegation used to achieve transitivity
- ▶ Also supports globally unique, secure identifiers
- ▶ Achieves query and response privacy
- ▶ Provides alternative public key infrastructure
- ▶ Interoperable with DNS


³Joint work with Martin Schanzenbach and Matthias Wachs

Zone Management: like in DNS

The screenshot shows the 'gnunet-setup' application window. The 'GNS' tab is active, displaying the configuration for editing a zone named 'API5QDP7A126P06VV60535PDT50B9L12NK6QP64IE8KNC6E807G0'. The preferred zone name is 'schanzen'. The 'Master Zone' radio button is selected. A table lists DNS records for various subdomains, including MX, PKEY, LEHO, AAAA, and A records. A QR code and a 'Save As' button are visible in the top right. A 'Welcome to gnutet-setup.' message is at the bottom.



gnunet-setup

General Network Transports File Sharing Namestore **GNS**

Editing zone API5QDP7A126P06VV60535PDT50B9L12NK6QP64IE8KNC6E807G0 

Preferred zone name (PSEU):

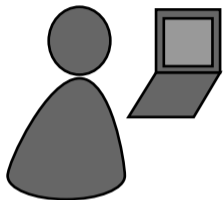
Master Zone Private Zone Shorten Zone

  Save As

Name	Type	Value	Expiration	Public
<new name>				
+ +	<new record>			
	MX	5,mail.+	end of time	<input checked="" type="checkbox"/>
priv	<new record>			
	PKEY	3IQT1G601GUBVOS5C0JO87OEFB8N3DBJQ4L9SBI8PFLR8UKCVGHG	end of time	<input type="checkbox"/>
heise	<new record>			
	LEHO	heise.de	end of time	<input checked="" type="checkbox"/>
	AAAA	2a02:2e0:3fe:100::8	end of time	<input checked="" type="checkbox"/>
	A	193.99.144.80	end of time	<input checked="" type="checkbox"/>
home	<new record>			
大学	<new record>			
short	<new record>			
mail	<new record>			
homepage	<new record>			
fdfs	<new record>			
www	<new record>			

[Welcome to gnutet-setup.](#)

Name resolution in GNS




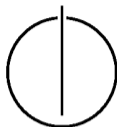
Bob



Bob's webserver

Local Zone: K_{pub}^{Bob}		
www	A	5.6.7.8





Bob Builder, Ph.D.

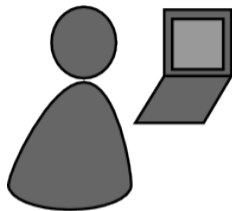
Address: Country, Street Name 23

Phone: 555-12345

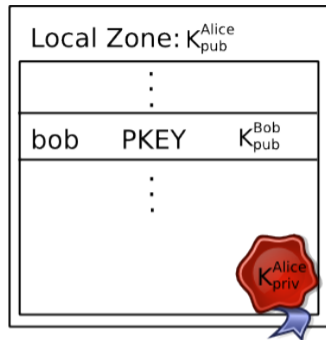
Mobile: 666-54321

Mail: bob@H2R84L4JIL3G5C.zkey

Delegation

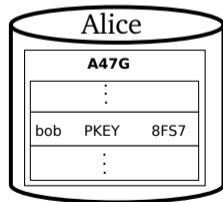
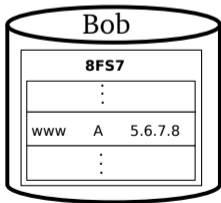
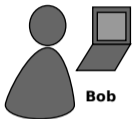


Alice

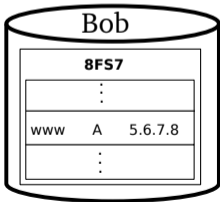


- ▶ Alice learns Bob's public key
- ▶ Alice creates delegation to zone K_{pub}^{Bob} under label **bob**
- ▶ Alice can reach Bob's webserver via **www.bob.gnu**

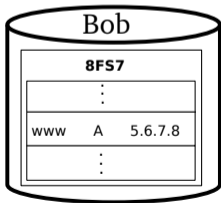
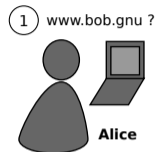
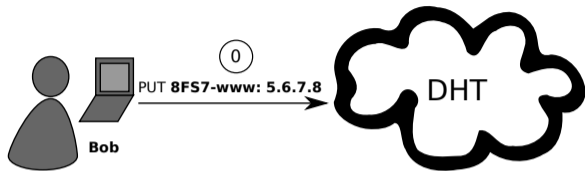
Name Resolution



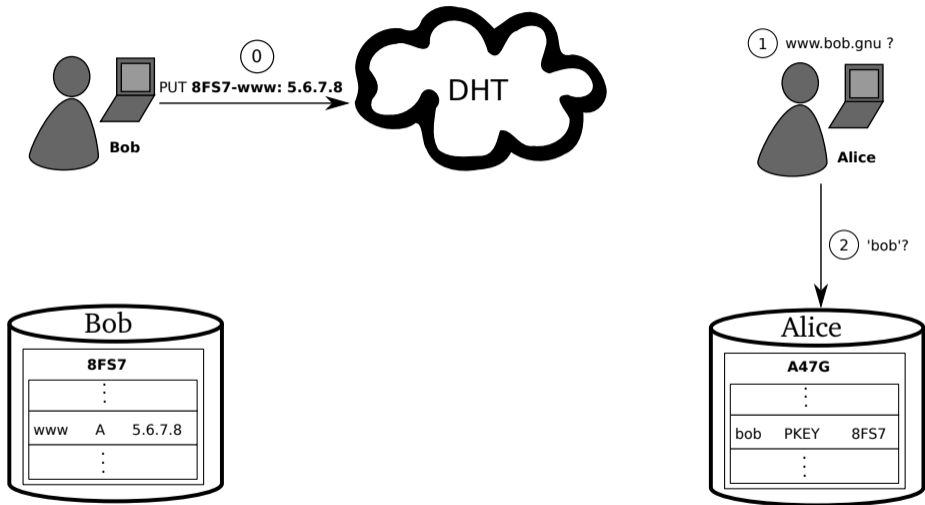
Name Resolution



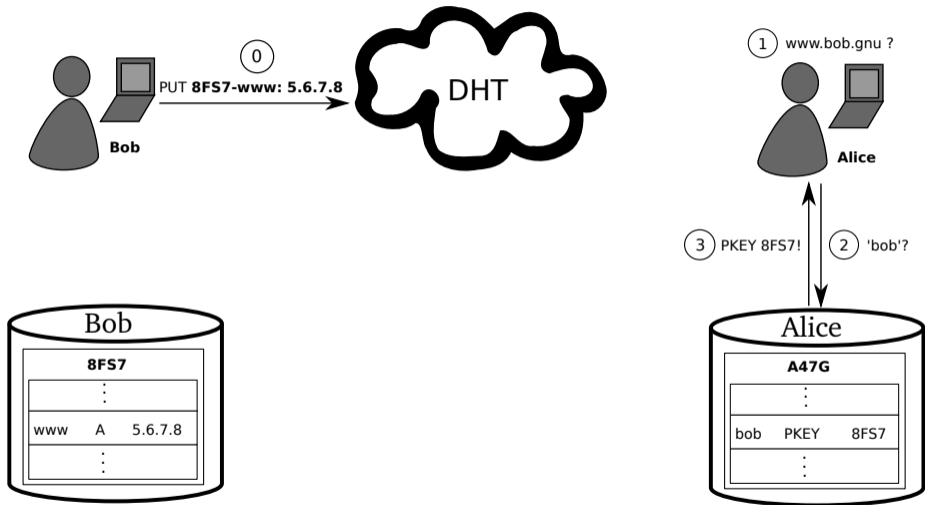
Name Resolution



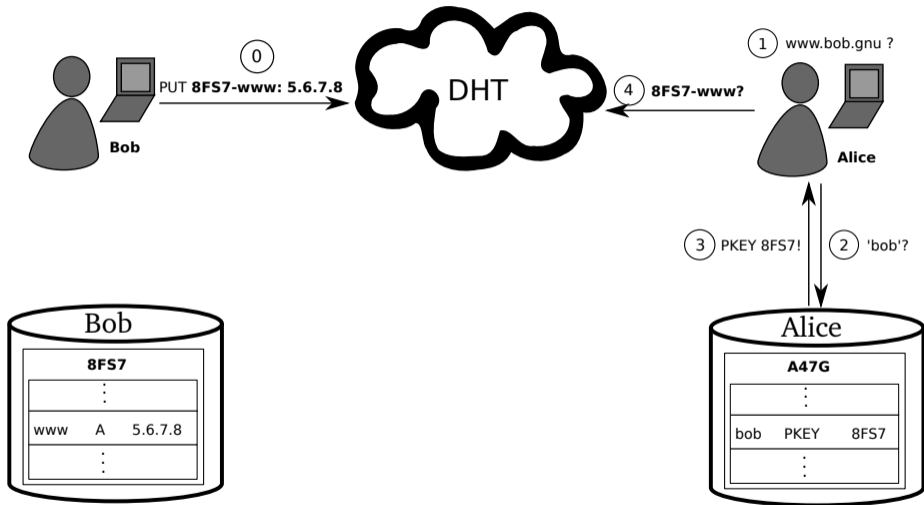
Name Resolution



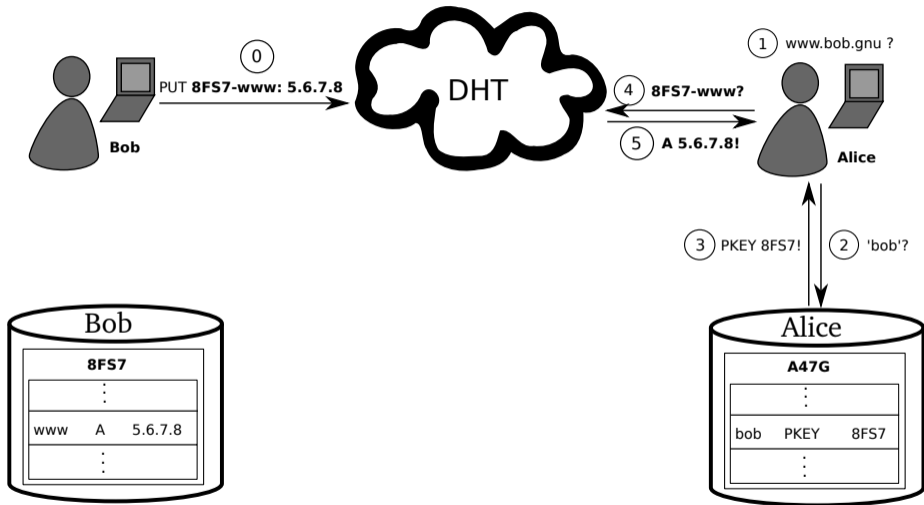
Name Resolution



Name Resolution



Name Resolution



GNS as PKI (via DANE/TLSA)

The screenshot shows a web browser window with the address bar displaying <https://freedom.gnu>. A security warning dialog box is open, showing the following information:

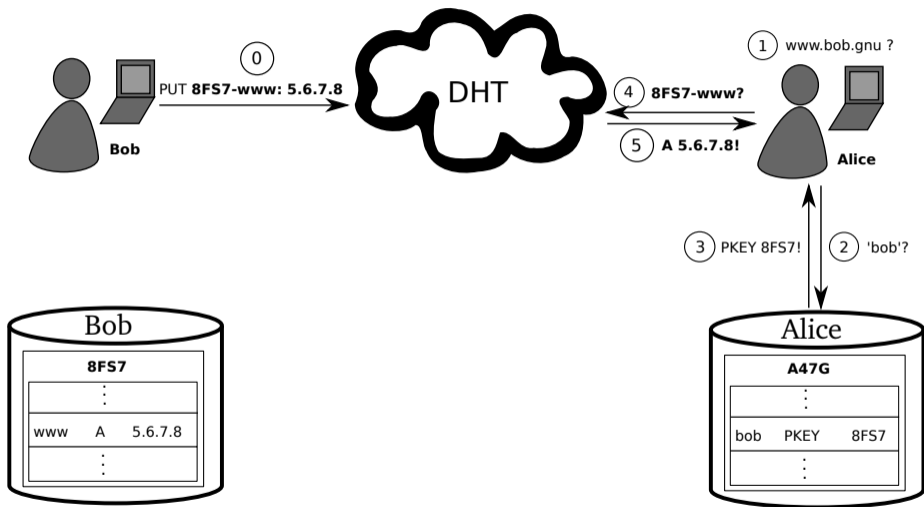
- freedom.gnu** Identity verified
- Permissions | Connection
- The identity of this website has been verified by GNS CA. [Certificate Information](#)
- Your connection to freedom.gnu is encrypted with 256-bit encryption. The connection uses TLS 1.2. The connection is encrypted using AES_256_CBC, with SHA1 for message authentication and ECDHE_RSA as the key exchange mechanism.
- Site information** You have never visited this site before today. [What do these mean?](#)

The background shows the Freedom GNU Operating System website. The navigation menu includes: [español \[es\]](#), [فارسی \[fa\]](#), [français \[fr\]](#), [hrvatski \[hr\]](#), [italiano \[it\]](#), [Why](#), [Licenses](#), [Education](#), [Software](#), [Documentation](#), and [Help](#). The main heading is **Operating System**. Below the navigation menu is a blue banner with the text **What is GNU?**. The text below the banner reads: "Operating system that is [free software](#)—it respects your freedom. [More of GNU](#) (more precisely, GNU/Linux systems) which are [what we provide](#)." Below this text is a small image of a computer screen displaying a document titled "What is free software? The Free Software Definition".

The [GNU Project](#) was launched in 1984 to develop the GNU system. The name "GNU" is a recursive acronym for "GNU's Not Unix!". ["GNU" is pronounced g'noo](#), as one syllable, like saying "grew" but replacing the *r* with *n*.

A Unix-like operating system is a [software collection](#) of applications, libraries, and developer tools, plus a program to allocate resources and talk to the hardware, known

Privacy Issue: DHT



Query Privacy: Terminology

G generator in ECC curve, a point

o size of ECC group, $o := |G|$, o prime

x private ECC key of zone ($x \in \mathbb{Z}_o$)

P public key of zone, a point $P := xG$

l label for record in a zone ($l \in \mathbb{Z}_o$)

$R_{P,l}$ set of records for label l in zone P

$q_{P,l}$ query hash (hash code for DHT lookup)

$B_{P,l}$ block with encrypted information for label l
in zone P published in the DHT under $q_{P,l}$

Query Privacy: Cryptography

Publishing records $R_{P,I}$ as $B_{P,I}$ under key $q_{P,I}$

$$h := H(I, P) \tag{4}$$

$$d := h \cdot x \pmod{o} \tag{5}$$

$$B_{P,I} := S_d(E_{HKDF(I,P)}(R_{P,I})), dG \tag{6}$$

$$q_{P,I} := H(dG) \tag{7}$$

Query Privacy: Cryptography

Publishing records $R_{P,I}$ as $B_{P,I}$ under key $q_{P,I}$

$$h := H(I, P) \tag{4}$$

$$d := h \cdot x \pmod{o} \tag{5}$$

$$B_{P,I} := S_d(E_{HKDF(I,P)}(R_{P,I})), dG \tag{6}$$

$$q_{P,I} := H(dG) \tag{7}$$

Searching for records under label I in zone P

$$h := H(I, P) \tag{8}$$

$$q_{P,I} := H(hP) = H(hxG) = H(dG) \Rightarrow \text{obtain } B_{P,I} \tag{9}$$

$$R_{P,I} = D_{HKDF(I,P)}(B_{P,I}) \tag{10}$$

Using cryptographic identifiers

- ▶ Zone are identified by a public key
 - ▶ “alice.bob.*PUBLIC-KEY*” is perfectly legal in GNS!
- ⇒ Globally unique identifiers

GNS Summary

- ▶ Interoperable with DNS
- ▶ Globally unique identifiers with “.PUBLIC-KEY”
- ▶ Delegation allows using zones of other users
- ▶ Trust paths explicit, trust agility
- ▶ Simplified key exchange compared to Web-of-Trust
- ▶ Privacy-enhanced queries, censorship-resistant
- ▶ Reliable revocation using flooding with proof-of-work

Privacy summary

Method	Defense against MiTM	Zone privacy	Privacy vs. network	Privacy vs. operator	Traffic amplification resistance	Censorship resistance	Ease of migration
DNS	✗	✓	✗	✗	✗	✗	✓
DNSSEC	✓	✗	✗	✗	✗	✗	✗*
DNSCurve	✓	✓	✓	✗	✓	✗	✗
DNS-over-TLS	✓	n/a	✓	✗	✓	✗	✗
Namecoin	✓	✗	✓	✓	✓	✓	✗
RAINS	✓	✗	✓	✗	✓	✗	✗
GNS	✓	✓	✓	✓	✓	✓	✗

*EDNS0

Key management summary

	Suitable for personal use	Memorable	Decentralised	Modern cryptography	Understandable	Exposes metadata	Transitive
DNS	✗	✓	✗	✗	✗	✗	✓
DNSSEC	✗	✓	✗	✗	✗	✗	✓
DNSCurve	✗	✓	✗	✓	✗	✗	✓
DNS-over-TLS	✗	✓	✗	✗	✗	✗	✓
TLS-X.509	✗	✓	✗	✗	✗	✗	✓
Web of Trust	✓	✗	✓	✗	✗	✗	✓
TOFU	✓	✗	✓		✓	✓	✗
Namecoin	✗	✓	✗	✓	✓	✗	✓
RAINS	✗	✓	✗	✓	✓	✗	✓
GNS	✓	✓	✓	✓	✓	✓	✓

Case study: GNS

DNS is known to suffer from a lack of end-to-end integrity protections. As a result, Chinese "great firewall" DNS manipulation has been shown to impact name resolution even in Europe.

"The GNU Name System (GNS) establishes a new name system using cryptography where zone data, queries and replies are private. The use of a distributed hash table (DHT) implies that resolution costs are comparable to those of DNS. However, states and ISPs cannot monitor or block queries, limiting their ability to protect the public from malicious Web sites. Names are not globally unique, allowing multiple anonymous users to lay claim to the same name. However, the system includes some well-known mappings by default, which users are unlikely to change. Trademarks, copyrights anti-fraud or anti-terrorism judgements can only be enforced against those well-known mappings, which users are able to bypass."

Discuss virtues and vices affected.

Conclusion

DNS	globalist
DNSSEC	authoritarian
Namecoin	libertarian (US)
RAINS	nationalist
GNS	anarchist

In which world do you want to live?

Part IV: Introduction to GNUnet

Internet Design Goals, David Clark, 1988

1. **Internet communication must continue despite loss of networks or gateways.**
2. The Internet must support multiple types of communications service.
3. The Internet architecture must accommodate a variety of networks.
4. The Internet architecture must permit *distributed management* of its resources.
5. The Internet architecture must be cost effective.
6. The Internet architecture must permit host attachment with a low level of effort.
7. **The resources used in the internet architecture must be accountable.**

Where We Are



Source: esmont

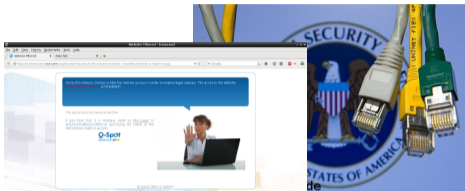


Source: gawand.org



Source: gawand.org

Where We Are



الموقع محظور

أسف إن الموقع الذي أردت تصفحه قد أجنب وذلك بسبب إحتواءه على نشاط مخالف للقيم الاجتماعية أو السياسية أو الثقافية أو الدينية لخدمة الإمارات العربية المتحدة.

في حالة أردت فتح موقع قد أجنب، الرجاء قم بتسمية استشارة الملاحظات الموجودة على موقعنا.

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SITE BLOCKED Source: wikileaks.org



Source: enturebeat.com

What is HACIENDA?

- Data reconnaissance tool developed by the CITD team in JTRIG
- Port Scans entire countries
 - Uses nmap as port scanning tool
 - Uses GEOFUSION for IP Geolocation
 - Randomly scans every IP identified for that country



How is it used?

- CNE
 - ORB Detection
 - Vulnerability Assessments
- SD
 - Network Analysis
 - Target Discovery



Example 1: Collateral Damage



Communications Security
Establishment

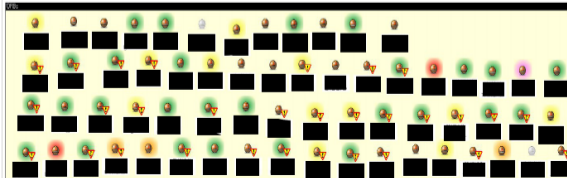
Centre de la sécurité
des télécommunications

TOP SECRET//COMINT



LANDMARK

- ✳ CSEC's Operational Relay Box (ORB) covert infrastructure used to provide an additional level of non-attribution; subsequently used for exploits and exfiltration
- ✳ 2-3 times/year, 1 day focused effort to acquire as many new ORBs as possible in as many non 5-Eyes countries as possible



Why should you care?

If you are ...

- ▶ ... of any importance in the world, or
- ▶ ... a system or network administrator, or
- ▶ ... a security researcher, or
- ▶ ... in this room, or
- ▶ ... mistaken for any of the above,

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then you are probably a target.

So what if they listen to my calls?

- ▶ Kompromat — and you do not get to decide what is bad!
- ▶ Self-censorship
- ▶ Loss of business
- ▶ No privacy \Rightarrow No free press \Rightarrow No liberal democracy

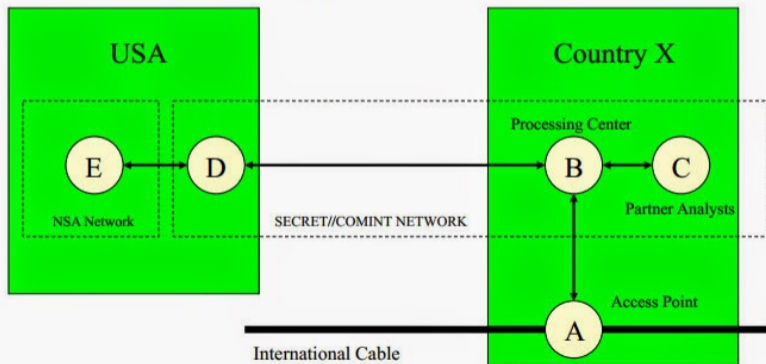
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- ▶ Security services also get you drunk, encourage you to drive, arrest you for drunken driving and then ask you for your customer data.

Example 2: Owning the Network





RAMPART-A Typical Operation



Example 2: Owning the Network

TS//SI//REL TO USA, FVEY



(U) What is TREASUREMAP?

(U//FOUO) Capability for building a near real-time, interactive map of the global internet.

Map the entire Internet – Any device*, anywhere, all the time

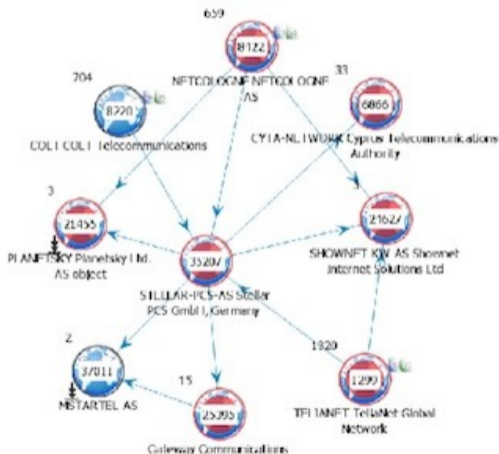
(U//FOUO) We enable a wide range of missions:

- Cyber Situational Awareness – *your own network plus adversaries'*
- Common Operation Pictures (COP)
- Computer Attack/Exploit Planning / Preparation of the Environment
- Network Reconnaissance
- Measures of Effectiveness (MOE)

(* limited only by available data)

Example 2: Owning the Network

TOP SECRET STRAP1



Generated via TeasureMap

The Internet is Broken

Administrators have power.

Power attracts Mexican drug cartels.

Adversary model: Mexican drug cartel

- ▶ They took your family, and will brutally kill them if you do not give them what they want.
- ▶ Under these circumstances, you must still not be able to assist, and the public system design must make that clear.
- ▶ Thus, the cartel has nothing to gain from abducting your family and will not bother with it.

System administrators are targets of such an adversary.

Design Choices for a Civil Network!

Internet Design Goals (David Clark, 1988)

1. **Internet communication must continue despite loss of networks or gateways.**
2. The Internet must support multiple types of communications service.
3. The Internet architecture must accommodate a variety of networks.
4. The Internet architecture must permit *distributed management* of its resources.
5. The Internet architecture must be cost effective.
6. The Internet architecture must permit host attachment with a low level of effort.
7. **The resources used in the internet architecture must be accountable.**

GNUet Design Goals

1. GNUet must be implemented as free software.
2. **The GNUet must only disclose the minimal amount of information necessary.**
3. **The GNUet must be decentralised and survive Byzantine failures in any position in the network.**
4. **The GNUet must make it explicit to the user which entities must be trustworthy when establishing secured communications.**
5. **The GNUet must use compartmentalization to protect sensitive information.**
6. The GNUet must be open and permit new peers to join.
7. **The GNUet must be self-organizing and not depend on administrators.**
8. The GNUet must support a diverse range of applications and devices.
9. The GNUet architecture must be cost effective.
10. **The GNUet must provide incentives for peers to contribute more resources than they consume.**

Let's Implement It!

Internet

Google
DNS/X.509
TCP/UDP
IP/BGP
Ethernet
Phys. Layer

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CORE (OTR)
HTTPS/TCP/WLAN/...

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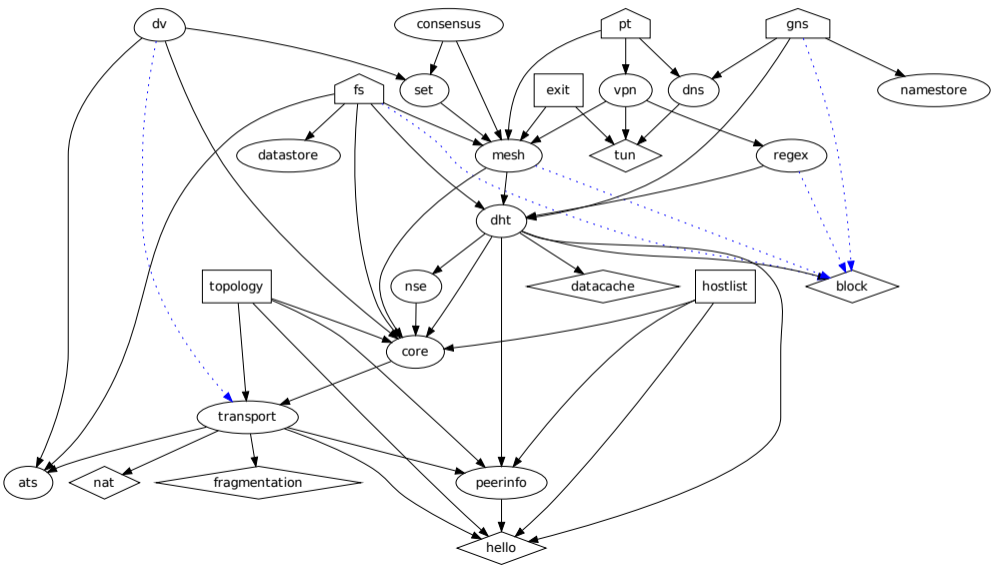
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A real peer: Dependencies



A GUNet Service is a Process

- ▶ If all subsystems are used, GUNet would currently use ≈ 40 processes (services and daemons)
 - ▶ user interfaces increase this number further
 - ▶ systemd-like `gnunet-service-arm` starts them
 - ▶ services are manipulated using the respective command-line tool
- ⇒ `gnunet-arm -s` starts GUNet

Applications (being) built using GUNet

- ▶ Anonymous and non-anonymous file-sharing
- ▶ IPv6–IPv4 protocol translator and tunnel
- ▶ GNU Name System: censorship-resistant replacement for DNS
- ▶ Conversation: secure, decentralised VoIP
- ▶ SecuShare, a social networking application
- ▶ GNU Taler: privacy-preserving payments
- ▶ ...

A Pattern of Hope

Spy Program	Target	Defense	Started
FTM/TRACFIN	SWIFT/VISA/etc.	DigiCash/GNU Taler	1990
TREASUREMAP	Internet (all)	Freenet/GNUnet/Tor	2000
HACIENDA	vuln. TCP service	Port Knocking	2000
BULLRUN/DUAL_EC_DRBG	PRNG (backdoor)	n/a	2004
BULLRUN/LONGHAUL	TLS/IPSEC (keys)	OTR/AXOLOTL	2004
MJOLNIR	Long-path in Tor	Tor 0.2.3.11	2007
PRISM	US big data corps	SecuShare	2009
MORECOWBELL	DNS	GNU Name System	2012
...




Exercise

```
# apt-get install git autoconf automake autopoint gettext
# apt-get install libunistring-dev libgnutls28-dev
# apt-get install openssl gnutls-bin libtool libltdl-dev
# apt-get install libcurl-gnutls-dev libidn11-dev
# apt-get install libsqlite3-dev libjansson-dev libpq-dev
$ git clone git://git.gnunet.org/libmicrohttpd
$ git clone git://git.gnunet.org/gnunet
$ git clone git://git.gnunet.org/gnunet-gtk
$ for n in libmicrohttpd gnunet gnunet-gtk do;
    cd $n ; ./bootstrap ; ./configure --prefix=$HOME ...
    make install
    cd ..
done
```

Exercise

```
$ gnunet-setup # enable TCP transport only
$ gnunet-arm -s # launch peer
$ gnunet-namestore-gtk # configure your GNS zone
$ gnunet-gns # command-line resolution
$ gnunet-gns-proxy # launch SOCKS proxy
$ firefox # configure browser to use proxy
```

References I

-  D. Atkins, W. Stallings, and P. Zimmermann.
PGP Message Exchange Formats.
RFC 1991 (Informational), August 1996.
Obsoleted by RFC 4880.
-  J. Callas, L. Donnerhacker, H. Finney, D. Shaw, and R. Thayer.
OpenPGP Message Format.
RFC 4880 (Proposed Standard), November 2007.
Updated by RFC 5581.
-  J. Callas, L. Donnerhacker, H. Finney, and R. Thayer.
OpenPGP Message Format.
RFC 2440 (Proposed Standard), November 1998.
Obsoleted by RFC 4880.

References II

-  M. Elkins, D. Del Torto, R. Levien, and T. Roessler.
MIME Security with OpenPGP.
RFC 3156 (Proposed Standard), August 2001.
-  Matthias Wachs, Martin Schanzenbach, and Christian Grothoff.
A censorship-resistant, privacy-enhancing and fully decentralized name system.
In *13th International Conference on Cryptology and Network Security (CANS 2014)*, pages 127–142, 2014.