

The GNU Name System

A Public Key Infrastructure for Social Movements in the Age of
Universal Surveillance

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

A Matter of Life and Death

The Intercept reports in February 2014:

- ▶ NSA identifies targets based on meta data (social graph, location profiles, cell-phone tracking)
- ▶ Joint Special Operations Command (JSOC) uses geolocation of SIM card for assassinations using drone strikes
- ▶ No due process, no immanent threat, no consent of foreign government, no declaration of war

“F3: Find, Fix, Finish” is state terrorism facilitated by networks.

Not Just Monitoring

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- ▶ NSA uses NSLs to force companies to disclose private keys.
- ▶ Targets include:
 - ▶ Journalists
 - ▶ Environmental groups
 - ▶ UN Climate Change Conference in Copenhagen

Where We Are



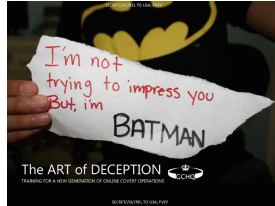
Source: esmont



Source: gaWand.org



Where We Are



Where We Are



Source: esmont



Source: gaWand.org



SECRET//SI//REL TO USA, FVEY



Do you  your brand?

SECRET//SI//REL TO USA, FVEY

Encryption to the Rescue?

- ▶ Centralized Internet infrastructure is easily controlled:
 - ▶ 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!

The GNU Name System¹

Properties of GNS


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

¹Joint work with Martin Schanzenbach and Matthias Wachs

Zone Management: like in DNS


gnunet-setup


General Network Transports File Sharing Namestore **GNS**

Editing zone API5QDP7A126P06VV60535PDT50B9L12NK6QP64IE8KNC6E807G0 

Preferred zone name (PSEU):

Master Zone Private Zone Shorten Zone

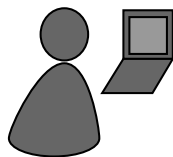


 Save As

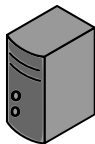
Name	Type	Value	Expiration	Public
<new name>				
+ >	<new record>			
	MX	5,mail.+	end of time	<input checked="" type="checkbox"/>
priv >	<new record>			
	PKEY	3IQ1TG601GUBVO55C0J087OEFB8N3DBJQ4L9SBI8PFLR8UKCVGHG	end of time	<input type="checkbox"/>
heise >	<new record>			
	LEHO	heise.de	end of time	<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>			
fcfs >	<new record>			
www >	<new record>			

[Welcome to gnunet-setup.](#)


Name resolution in GNS



Bob



Bob's webserver

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

- ▶ Bob can locally reach his webserver via **www.gnu**

Secure introduction



TUM

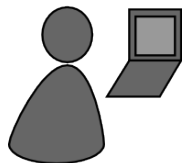


 **Bob Builder, Ph.D.**

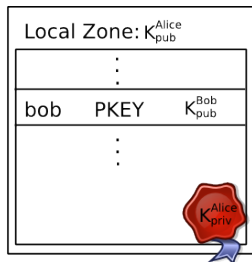
Address: Country, Street Name 23
Phone: 555-12345
Mobile: 666-54321
Mail: bob@H2R84L4JIL3G5C.zkey

- ▶ Bob gives his public key to his **friends**, possibly via QR code

Delegation

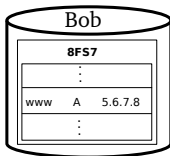


Alice

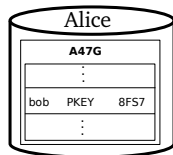
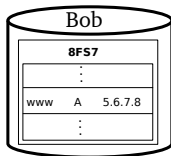
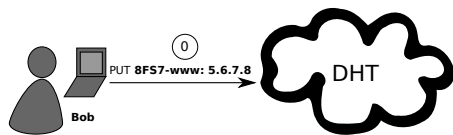


- ▶ Alice learns Bob's public key
- ▶ Alice creates delegation to zone K_{pub}^{Bob} under label **bob**
- ▶ Alice can reach Bob's webserver via **www.bob.gnu**

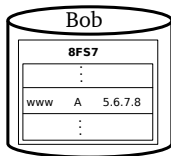
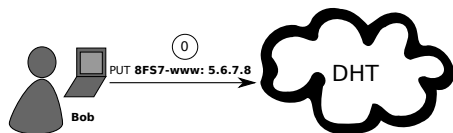
Name Resolution



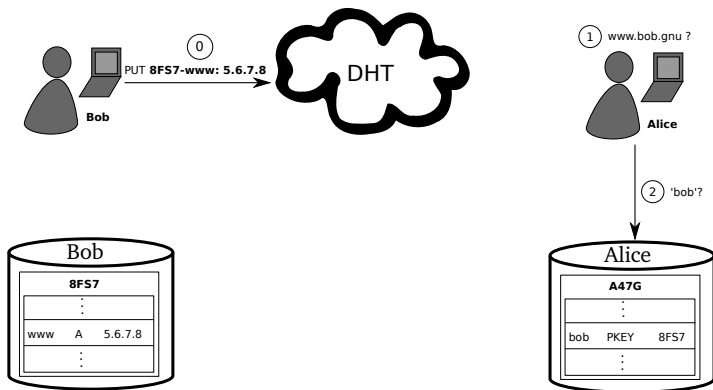
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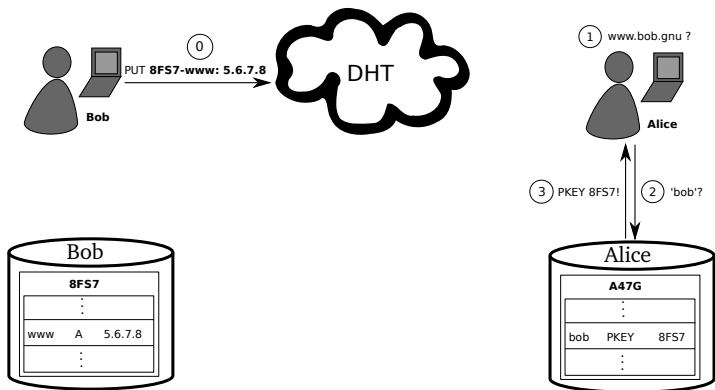
Name Resolution



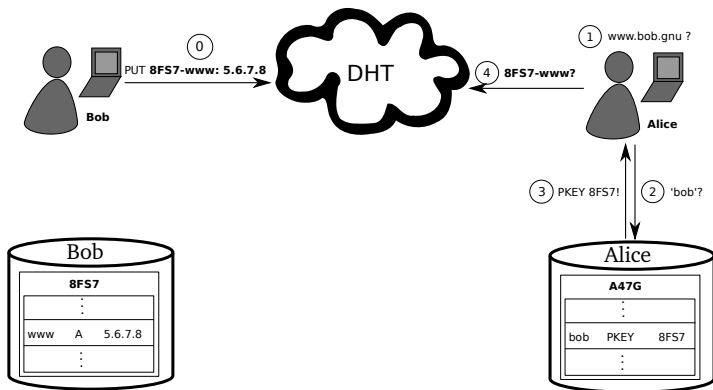
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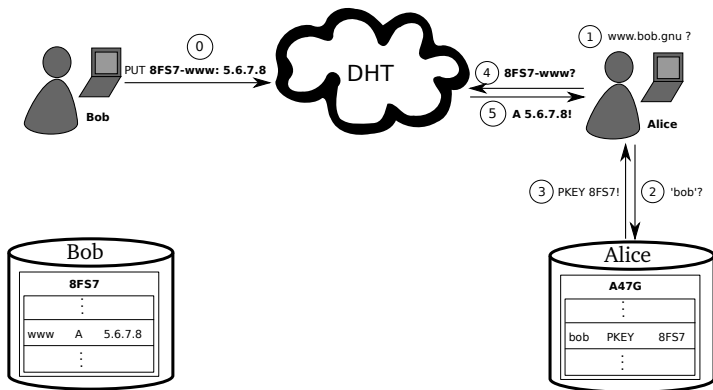
Name Resolution



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 overlaid on the page, titled "freedom.gnu" with the subtext "identity verified". The dialog has two tabs: "Permissions" and "Connection".

Permissions

- The identity of this website has been verified by GNS CA. [Certificate Information](#)

Connection

- 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?](#)

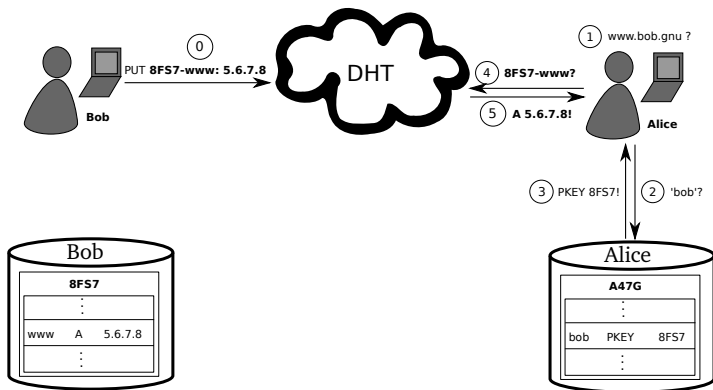
The background of the browser shows the GNU Operating System website, with a navigation menu including "Why", "Licenses", "Education", "Software", "Documentation", and "Help". The main heading is "Operating System" and "What is GNU?".

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 as a kernel.

[The Hurd, GNU's own kernel](#), is some way from being ready for daily use. Thus, GNU is typically used today with a kernel called Linux. This combination is the [GNU/Linux operating system](#). GNU/Linux is used by millions, though many [call it "linux" by mistake](#).

Privacy Issue: DHT



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 ($x \in \mathbb{Z}_n$)
- P public key of zone, a point $P := xG$
- l label for record in a zone ($l \in \mathbb{Z}_n$)
- $R_{P,l}$ set of records for label l in zone P
- $q_{P,l}$ query hash (hash code for DHT lookup)
- $B_{P,l}$ block with 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 $q_{P,I}$

$$h := H(I, P) \tag{1}$$

$$d := h \cdot x \pmod n \tag{2}$$

$$B_{P,I} := S_d(E_{HKDF(I,P)}(R_{P,I})), dG \tag{3}$$

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

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Searching for records under label I in zone P

$$h := H(I, P) \quad (5)$$

$$q_{P,I} := H(hP) = H(hxG) = H(dG) \Rightarrow \text{obtain } B_{P,I} \quad (6)$$

$$R_{P,I} = D_{HKDF(I,P)}(B_{P,I}) \quad (7)$$

A Laundry List of Features

Revocation

Revocation Basics

- ▶ Revocation certificate (RC): message signed with private key
 - ▶ Peer receives new valid RC, floods to all neighbours
 - ▶ All peers store all valid RCs forever
- ⇒ Expensive operation ⇒ proof-of-work

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Revocation Magic

- ▶ Peers maybe offline during initial flood
 - ▶ Network might be temporarily partitioned
- ⇒ Need to reconcile revocation sets on connect

Whenever two peers establish a P2P connection, they must compute the set union of their RC sets!

The “.zkey” pTLD

- ▶ “LABELS.PKEY.zkey” format
 - ▶ PKEY is the public key of the zone
 - ▶ Works a bit like “.onion”
- ⇒ Globally unique identifiers!



NICKnames

- ▶ “alice.bob.carol.dave.gnu” is a bit long for Edward (“.gnu”)
- ▶ Also, we need to trust Bob, Carol and Dave (for each lookup)
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- ▶ Memorable, short trust path in the future! TOFU!
- ▶ Krista better pick a reasonably unique NICK.

Shadow Records

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- ▶ Expiration time controls validity, like in DNS
- ▶ DHT propagation has higher delays, compared to DNS
- ▶ SHADOW is a flag in a record
- ▶ Shadow records are only valid if no other, non-expired record of the same type exists

Practical Concerns

- ▶ Name registration
- ▶ Support for browsing
- ▶ New record types
- ▶ Integration with applications
- ▶ State of the implementation

Registering a name in GNS

- ▶ Bob gives his PKEY to his **friends** via QR code
- ▶ or registers it at the **GNUnet fcfs** authority *pin.gnu* as "bob"
- ▶ → Bob's friends can resolve his records via **.petname.gnu*
- ▶ → or **.bob.pin.gnu*

From DNS to GNS

Names are not globally unique, but ...

... we need support for Virtual Hosting!

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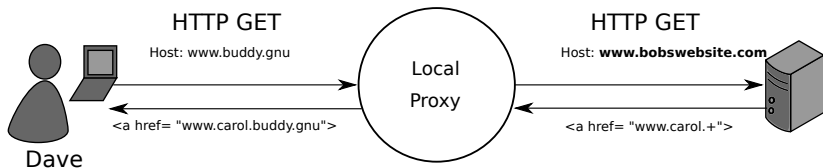
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Solution: Client Side SOCKS Proxy

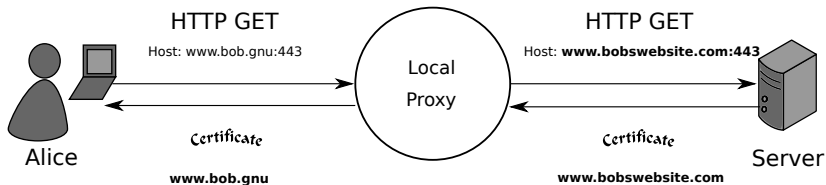
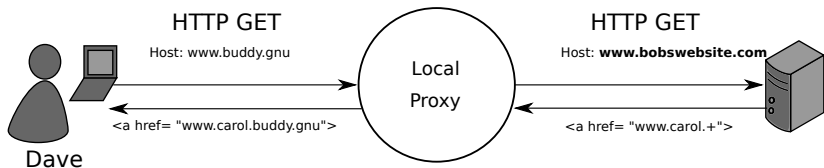
Legacy Hostname (LEHO) Records

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Relative Names

- ▶ GNS records can contain “.+”
- ▶ CNAME: “server1.+”
- ▶ MX: “mail.+”
- ▶ “.+” stands for “relative to current zone”

Supporting this for links in browsers would be nice.

New Record Types

- ▶ PKEY: delegate to another GNS zone
- ▶ NICK: preferred names for shortening
- ▶ LEHO: legacy hostname

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- ▶ PKEY: delegate to another GNS zone
- ▶ NICK: preferred names for shortening
- ▶ LEHO: legacy hostname
- ▶ GNS2DNS: delegate to DNS
- ▶ VPN: peers hosting TCP/IP services
- ▶ PHONE: call users using `gnunet-conversation`

DNS Delegation

- ▶ Delegate to DNS using GNS2DNS records
- ▶ GNS2DNS record specifies:
 - ▶ Name of DNS resolver (i.e. “ns1.example.com” or “piratedns.”)
 - ▶ DNS domain to continue resolution in (i.e. “example.com” or “piratebay.org”)
- ▶ GNS will first resolve DNS resolver name to A/AAAA record
- ▶ GNS will then resolve “*left.of.gns2dns.example.com*” using DNS

VPN Delegation

- ▶ Delegates to GUNet VPN
- ▶ VPN record specifies:
 - ▶ Identity of hosting peer (no anonymity!)
 - ▶ Service identifier (hash code)
- ▶ GNS can map VPN record to A/AAAA record of `gnunet-vpn` tunnel

PHONE service

- ▶ PHONE record specifies:
 - ▶ Identity of hosting peer (no anonymity yet!)
 - ▶ Line number (to support multiple phones per peer)
- ▶ `gnunet-conversation` uses *reverse lookup* for caller ID

Application Integration

- ▶ SOCKS proxy (`gnunet-gns-proxy`)
- ▶ NSS plugin
- ▶ DNS packet interception (`gnunet-dns-service`)
- ▶ GNS (C) API
- ▶ GNS (IPC) protocol
- ▶ GNS command-line tool

Current State

- ▶ GNS part of GUNet since 0.9.3
- ▶ Crypto changed to Curve25519 in 0.10.0
- ▶ Internationalized Domain Names are supported

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- ▶ GNS part of GUNet since 0.9.3
- ▶ Crypto changed to Curve25519 in 0.10.0
- ▶ Internationalized Domain Names are supported
- ▶ Installation is “non-trivial” (for your parents)
- ▶ SOCKS proxy is known to be problematic

Next Steps

- ▶ Improve DHT scalability and performance
- ▶ Import DNS TLDs (“.fr” is open data)
- ▶ Interoperate with GnuPG / Web-of-Trust
- ▶ Integrate with social networking applications
- ▶ Install widely by providing easy-to-use packages

Conclusion

- ▶ Decentralization is necessary
- ▶ Decentralization creates challenges for research:
 - ▶ Privacy-enhancing network protocol design
 - ▶ Secure software implementations
 - ▶ Software engineering and system architecture
 - ▶ Programming languages and tool support

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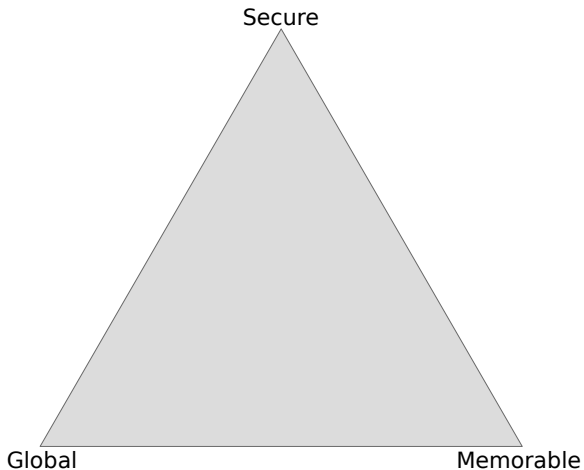
We must decentralize or accept autocracy and planetary collapse.

Do you have any questions?

References:

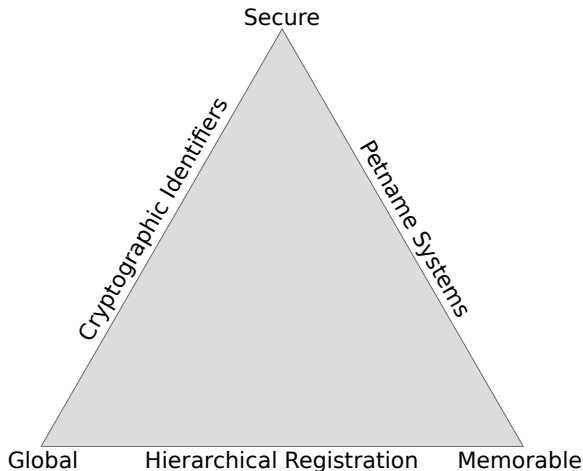
- ▶ Nathan Evans and Christian Grothoff. *R⁵N: Randomized Recursive Routing for Restricted-Route Networks*. **5th International Conference on Network and System Security**, 2011.
- ▶ Matthias Wachs, Martin Schanzenbach and Christian Grothoff. *On the Feasibility of a Censorship Resistant Decentralized Name System*. **6th International Symposium on Foundations & Practice of Security**, 2013.
- ▶ M. Schanzenbach *Design and Implementation of a Censorship Resistant and Fully Decentralized Name System*. **Master's Thesis (TUM)**, 2012.
- ▶ Christian Grothoff, Bart Polot and Carlo von Loesch. *The Internet is broken: Idealistic Ideas for Building a GNU Network*. **W3C/IAB Workshop on Strengthening the Internet Against Pervasive Monitoring (STRINT)**, 2014.
- ▶ Jeffrey Burdges, Florian Dold, Christian Grothoff and Marcello Stanisci. *Enabling Secure Web Payments with GNU Taler*. **SPACE 2016**.
- ▶ Christian Grothoff and Jens Porup. *The NSAs SKYNET program may be killing thousands of innocent people*. **ARS Technica**, 3/2016.

Zooko's Triangle



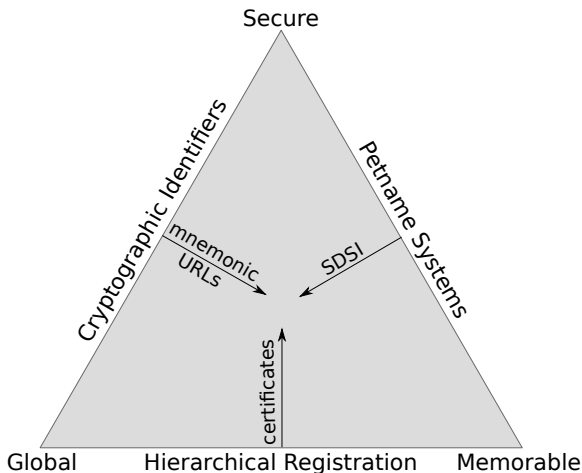
A name system can only fulfill **two!**

Zooko's Triangle



DNS, “.onion” IDs and `/etc/hosts/` are representative designs.

Zooko's Triangle



DNSSEC security is broken by design (adversary model!)

Namecoin

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- ▶ Memorable:

Namecoin

- ▶ Memorable: Check
- ▶ Global:

Namecoin

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- ⇒ Adversary must not have 51% compute power