Decentralized Public Key Infrastructures

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Learning Objectives

The GNU Name System

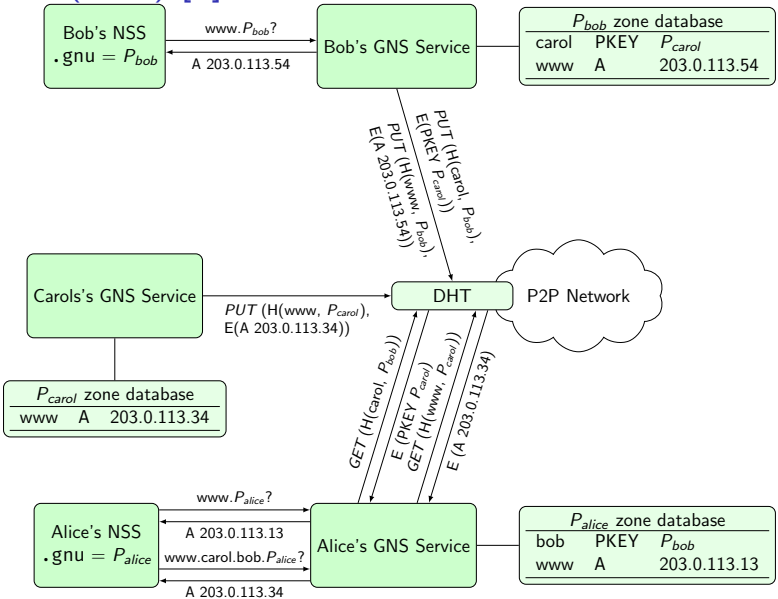
Private Information Retrieval

Comparisson of Name Systems

Introduction to GNUnet

References

The GNU Name System (GNS) [?]



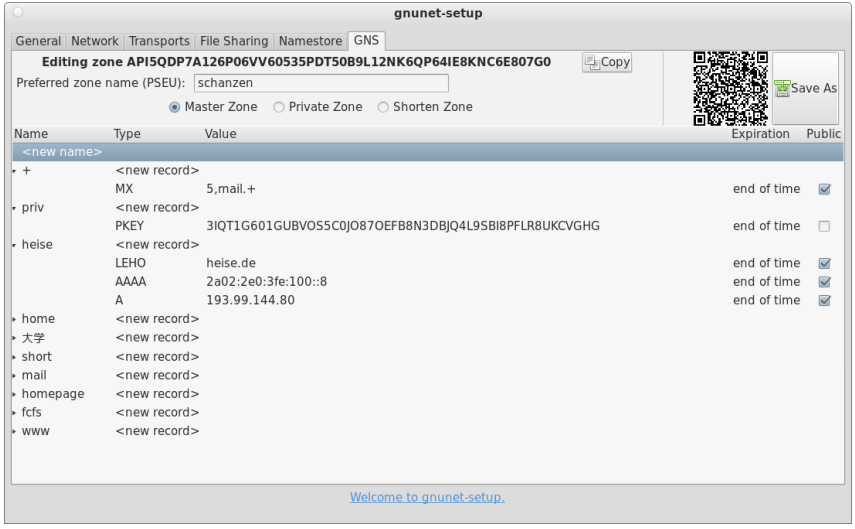
The GNU Name System[1]

Properties of GNS

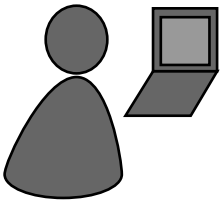
- Decentralized name system with secure memorable names
- Delegation used to achieve transitivity
- Also supports globally unique, secure identifiers
- Achieves query and response privacy
- Provides alternative public key infrastructure
- Interoperable with DNS

[1] Joint work with Martin Schanzenbach and Matthias Wachs

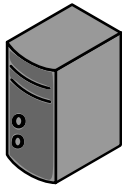
Zone Management: like in DNS



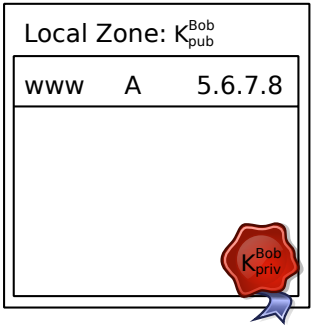
Name resolution in GNS



Bob

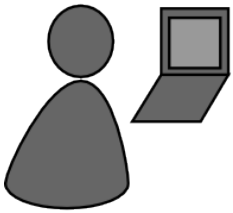


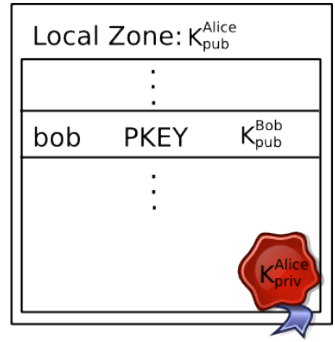
Bob's webserver




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

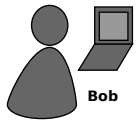
Delegation

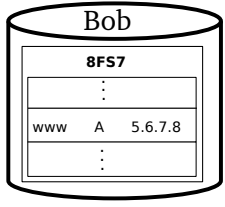


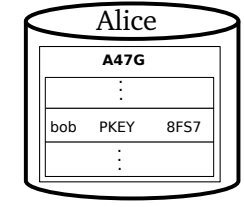


- Alice learns Bob's public key
- Alice creates delegation to zone K_{pub}^{Bob} under label **bob**
- Alice can reach Bob's webserver via **www.bob.gnu**

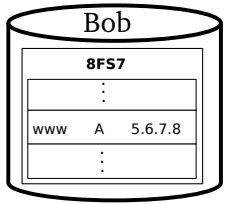
Name Resolution

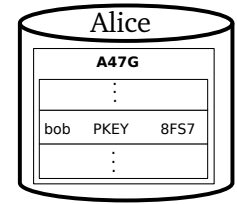




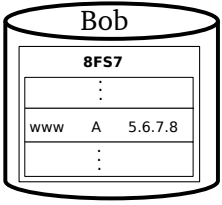


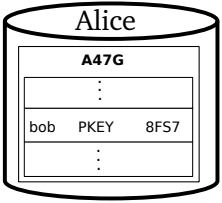
Name Resolution



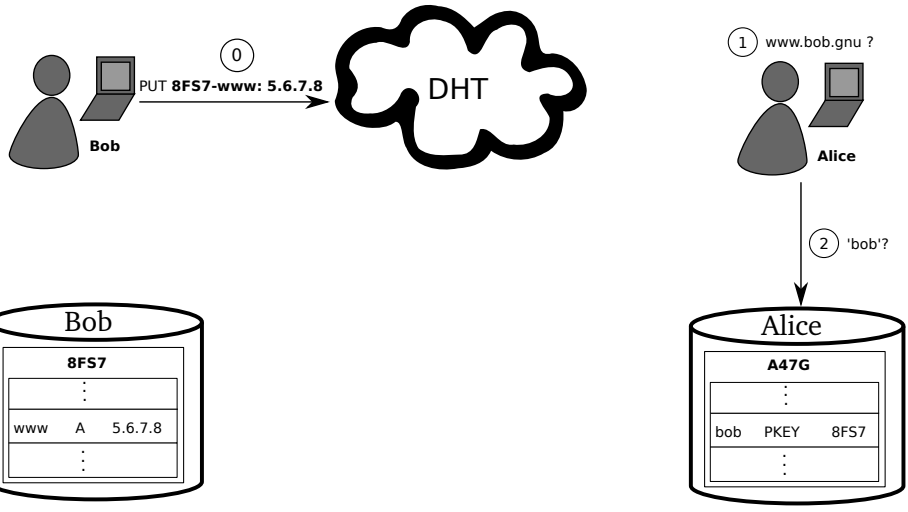


Name Resolution

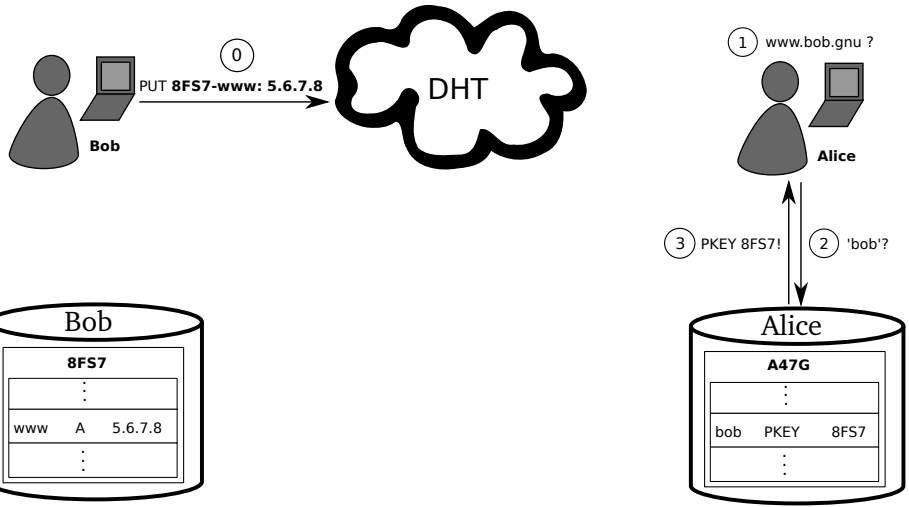




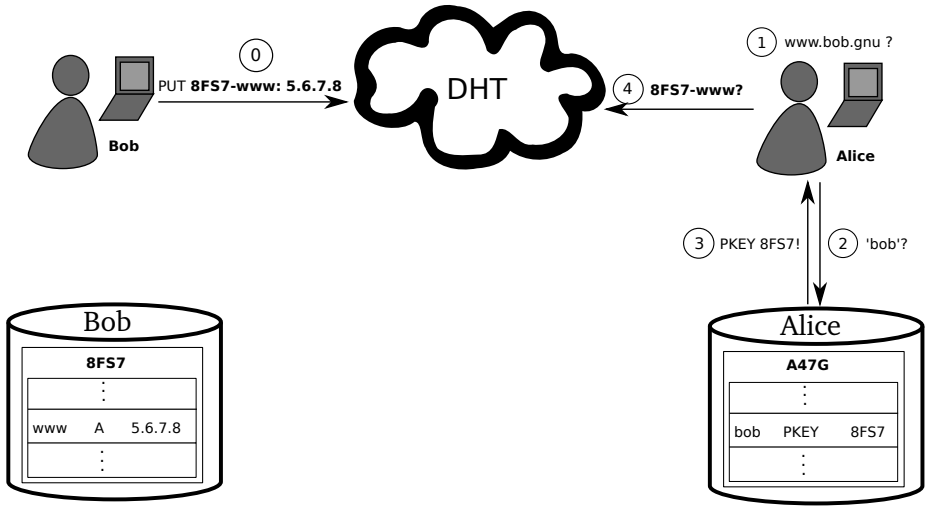
Name Resolution



Name Resolution



Name Resolution



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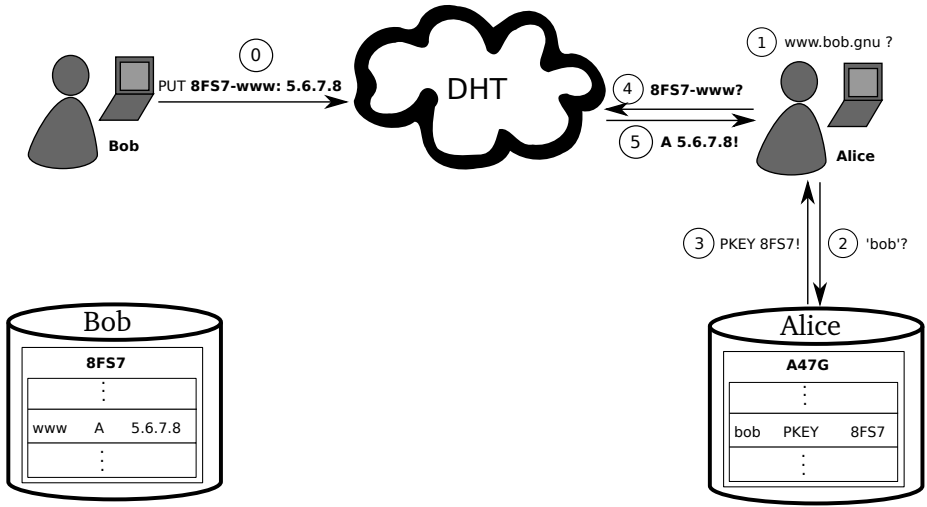
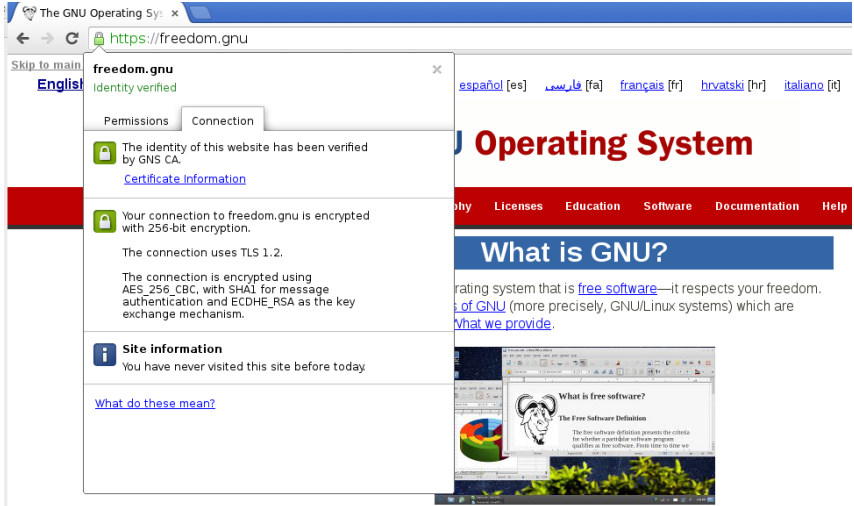
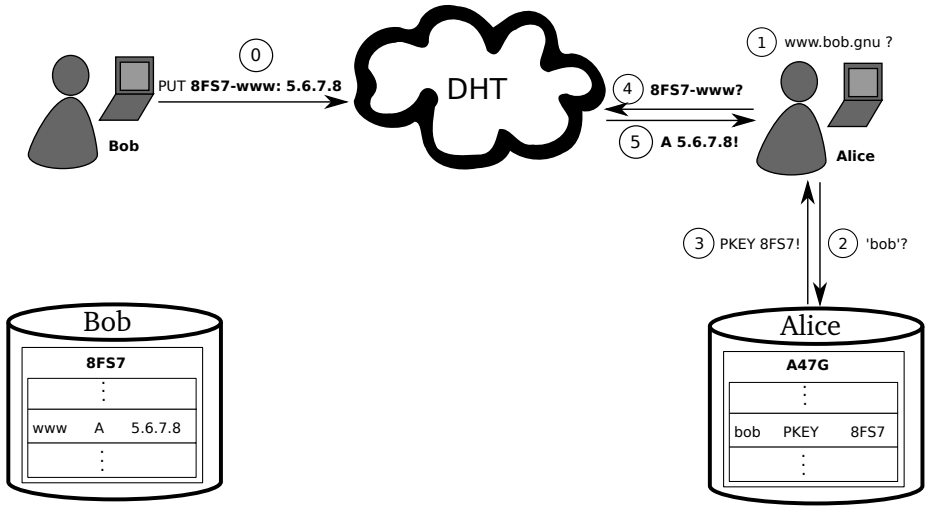


GNS as PKI (via DANE/TLSA)



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 $q_{P,I}$

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

$$d := h \cdot x \mod o \tag{2}$$

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

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

Query Privacy: Cryptography

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

$$h := H(l, P) \tag{1}$$
$$d := h \cdot x \mod o \tag{2}$$
$$B_{P,l} := S_d(E_{HKDF(l,P)}(R_{P,l})), dG \tag{3}$$
$$q_{P,l} := H(dG) \tag{4}$$

Searching for records under label l in zone P

$$h := H(l, P) \tag{5}$$
$$q_{P,l} := H(hP) = H(hxG) = H(dG) \Rightarrow \texttt{obtain}\ \ B_{P,l} \tag{6}$$
$$R_{P,l} = D_{HKDF(l,P)}(B_{P,l}) \tag{7}$$

Using cryptographic identifiers

- Zone are identified by a public key
- "alice.bob.*PUBLIC-KEY*" is perfectly legal in GNS!

$\Rightarrow$ 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	✓	✓	✓	✓	✓	✓	✓

Possible Future Work (Project 2, BS thesis)

- Implement Fog-of-Trust (ideally in Rust)

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?

Exercise

```
# apt-get install git autoconf automake autopoint gettext
# apt-get install libunistring-dev libgnutls28-dev
# apt-get install openssl gnutls-bin libtool libltdl
# apt-get install libcurl-gnutls-dev libidn11-dev
# apt-get install libsqlite3-dev
$ git clone git://gnunet.org/libmicrohttpd
$ git clone git://gnunet.org/gnunet
$ git clone 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