The GNU Name System

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30C3

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Where We Are

Source: csmoni

Source: gawand.org

Source: padresteve.com

Where We Are

Source: csmoni

Source: gawand.org

Source: padresteve.com

Source: www.businessinsid

nline.de

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الدينية لدولة الإمارات العربية المتحدة.

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Source: wikileaks.org

Source: enturebeat.com

Source: wikicommons.org

Adversary Model

- Any role
- Multiple Identities
- Computational Power
- Legal Power

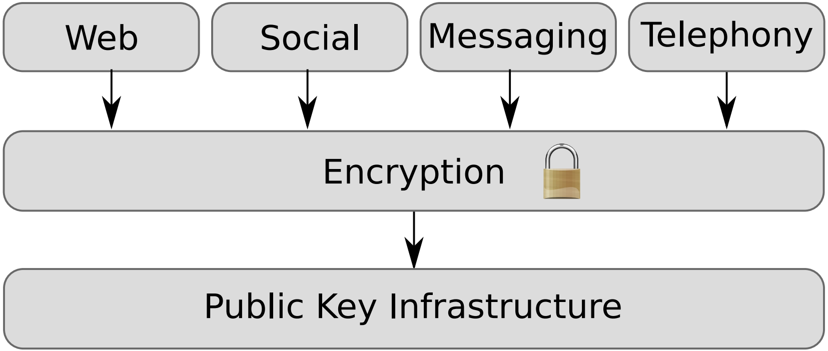
Source: matrix.wikia.com

But cannot:

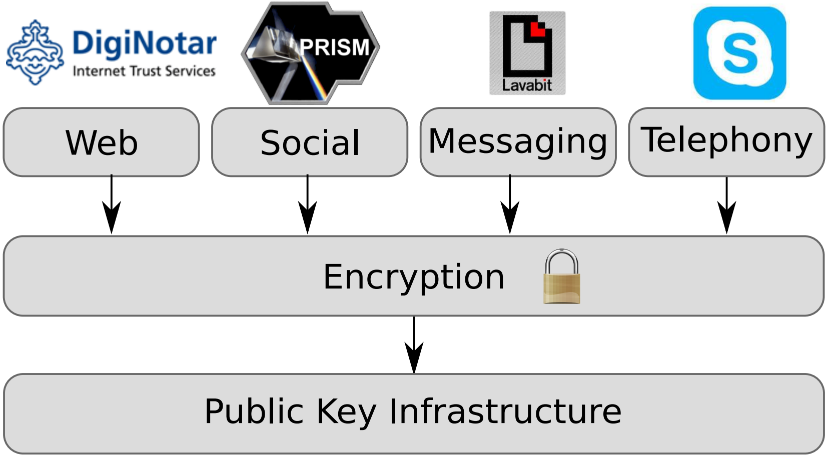
- Break or prevent crypto
- Compromise end-user system
- Prevent network communication

Source: www.trekearth.com

Broken Pillars



Broken Pillars



Web

Social

Messaging

Telephony

Encryption

Public Key Infrastructure

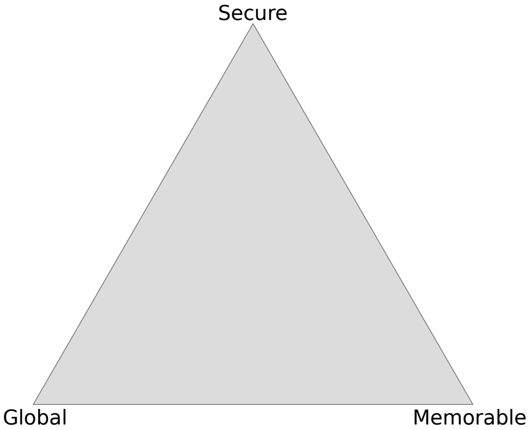
We MUST Decentralize!

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!)

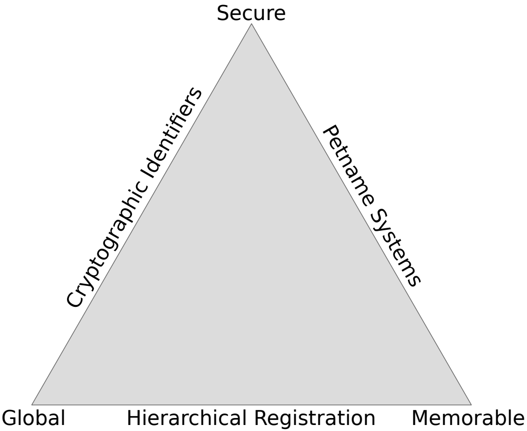
Encryption does not help if PKI is compromised!

Zooko’s Triangle



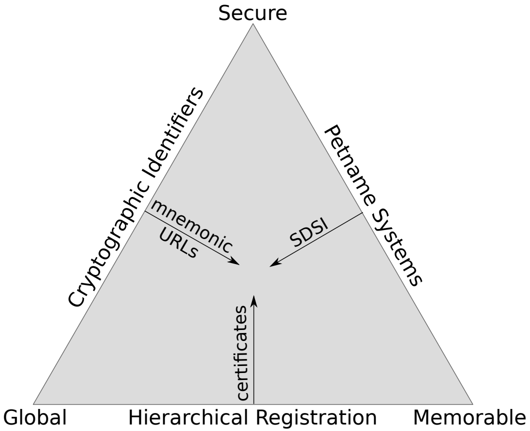
A name system can only fulfill **two**!

Zooko’s Triangle



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

Zooko's Triangle



DNSSEC security is broken by design (adversary model!)

Namecoin

Namecoin

- Memorable:

Namecoin

- Memorable: Check
- Global:

Namecoin

- Memorable: Check
- Global: Check
- Secure:

Namecoin

- Memorable: Check
- Global: Check
- Secure: different adversary model!

Namecoin

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- Global: Check
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⇒ Availability of names (registration rate) is restricted

Namecoin

- Memorable: Check
- Global: Check
- Secure: different adversary model!

⇒ Availability of names (registration rate) is restricted

⇒ Adversary must not have 51% compute power

The GNU Name System

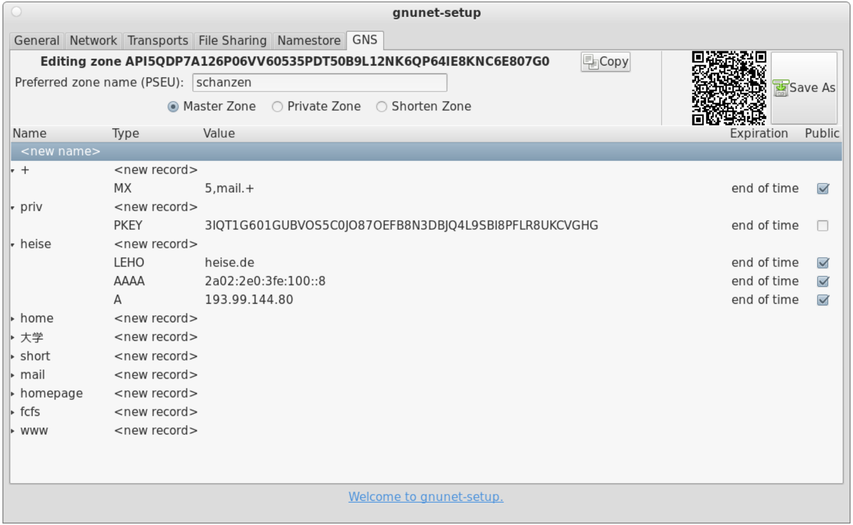
Properties of GNS

- 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

Uses for GNS in GNUnet

- Identify IP services hosted in the P2P network
- Identities in social networking applications

Zone Management: like in DNS



Editing zone API5QDP7A126P06VV60535PDT50B9L12NK6QP64IE8KNC6E807G0

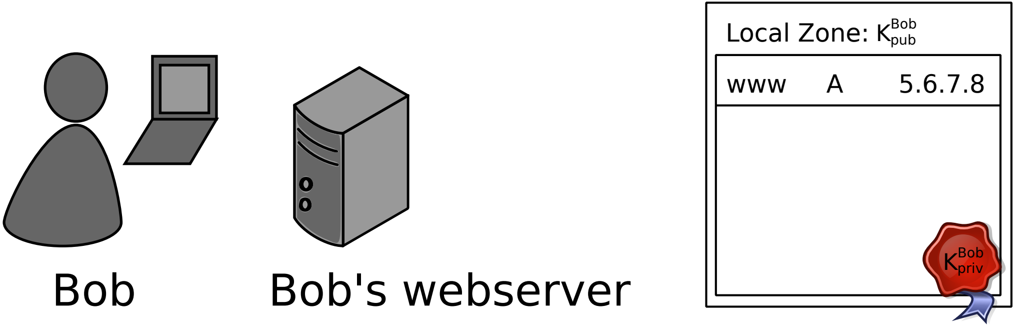
Preferred zone name (PSEU): schanzen

● Master Zone ○ Private Zone ○ Shorten Zone

Name	Type	Value	Expiration	Public
<new name>				
+	<new record>			
	MX	5,mail.+	end of time	☑
priv	<new record>			
	PKEY	3IQT1G601GUBVOS5C0JO87OEFB8N3DBJQ4L9SBI8PFLR8UKCVGHG	end of time	□
heise	<new record>			
	LEHO	heise.de	end of time	☑
	AAAA	2a02:2e0:3fe:100::8	end of time	☑
	A	193.99.144.80	end of time	☑
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.

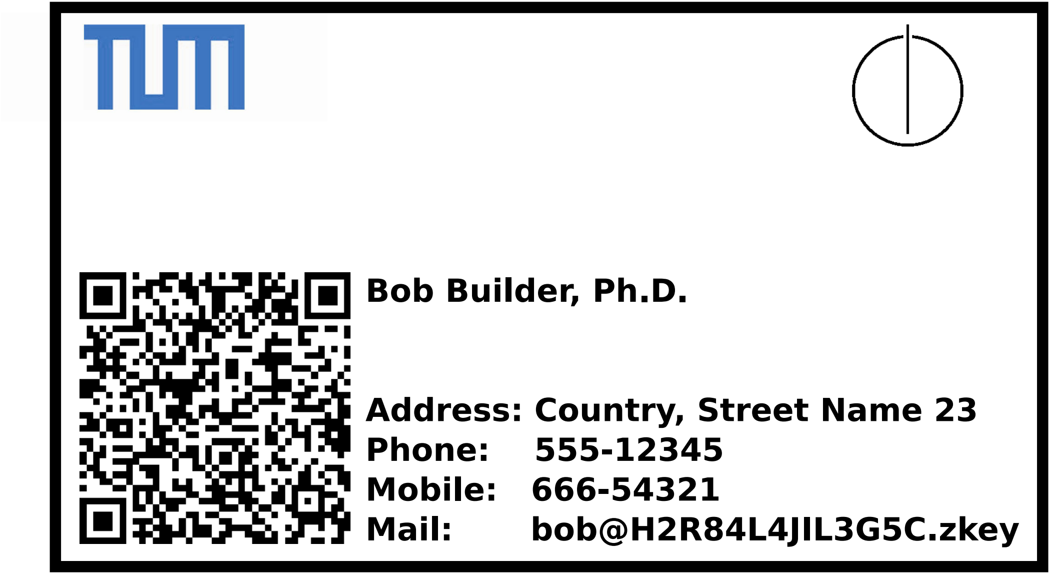
Name resolution in GNS



Local Zone: K^{Bob}_{pub}

www	A	5.6.7.8

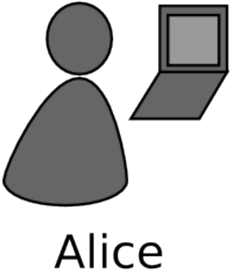
Secure introduction

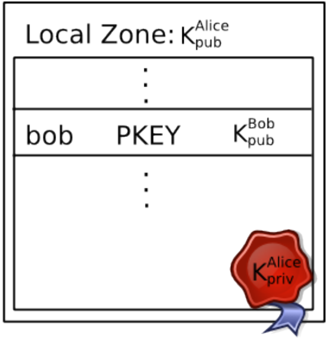


Bob Builder, Ph.D.

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

Delegation




Local Zone: K_{pub}^{Alice}

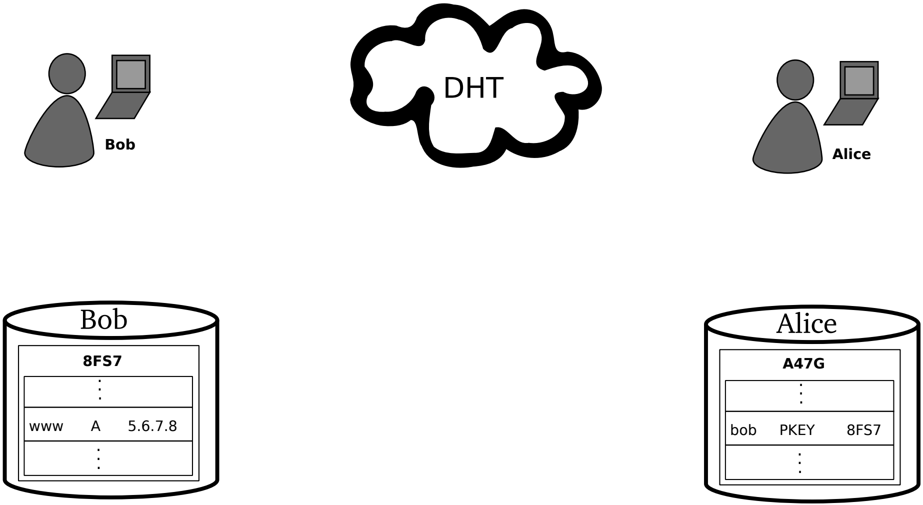
⋮

bob PKEY K_{pub}^{Bob}

⋮

- Alice learns Bob’s public key
- Alice creates delegation to zone **bob**
- Alice can reach Bob’s webserver via **www.bob.gnu**

Name Resolution



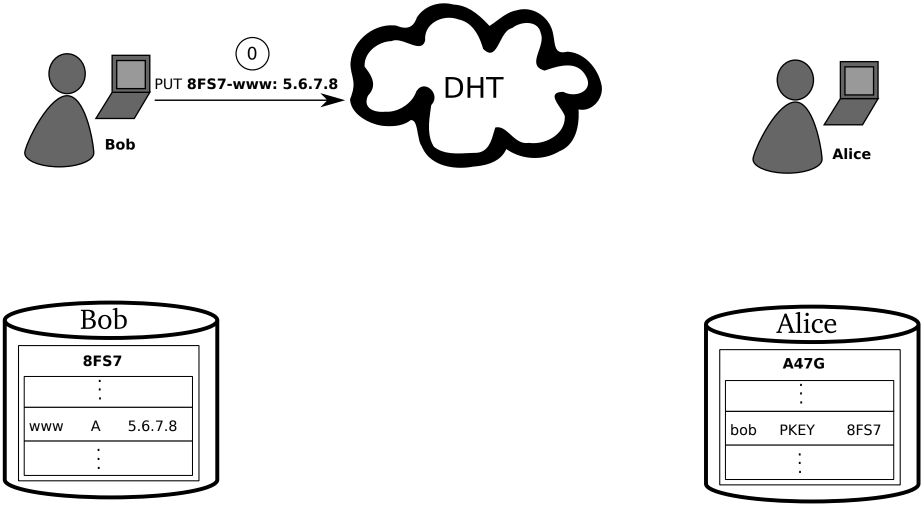
8FS7

	⋮	
www	A	5.6.7.8
	⋮	

A47G

	⋮	
bob	PKEY	8FS7
	⋮	

Name Resolution



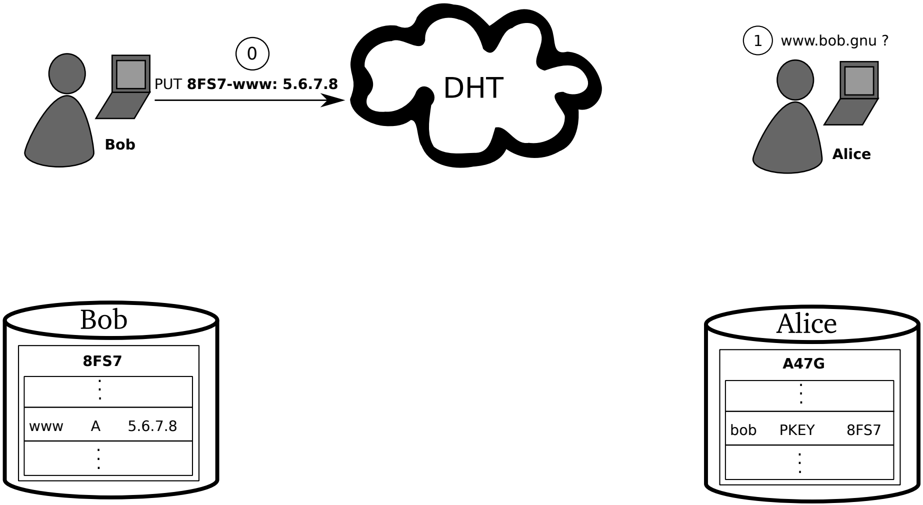
Bob

8FS7		
⋮		
www	A	5.6.7.8
⋮		

Alice

A47G		
⋮		
bob	PKEY	8FS7
⋮		

Name Resolution



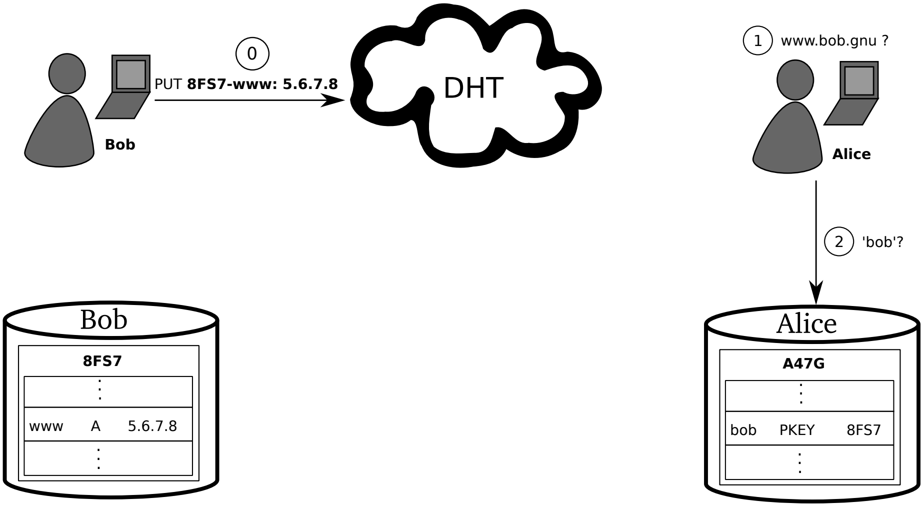
Bob

8FS7		
⋮		
www	A	5.6.7.8
⋮		

Alice

A47G		
⋮		
bob	PKEY	8FS7
⋮		

Name Resolution



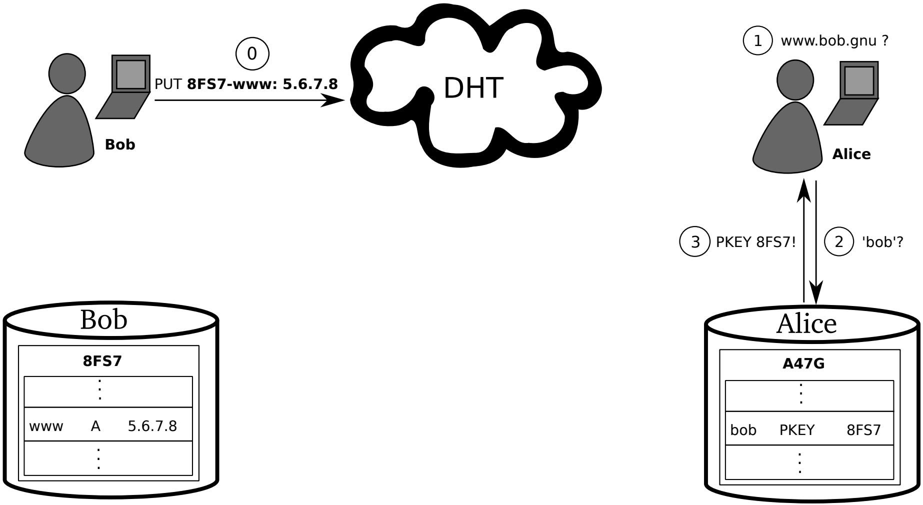
8FS7

⋮		
www	A	5.6.7.8
⋮		

A47G

⋮		
bob	PKEY	8FS7
⋮		

Name Resolution



8FS7		
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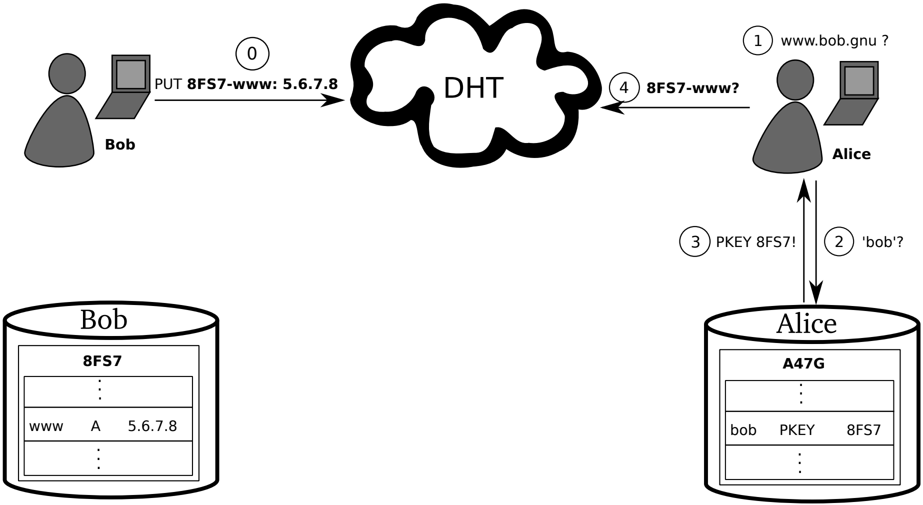
Name Resolution



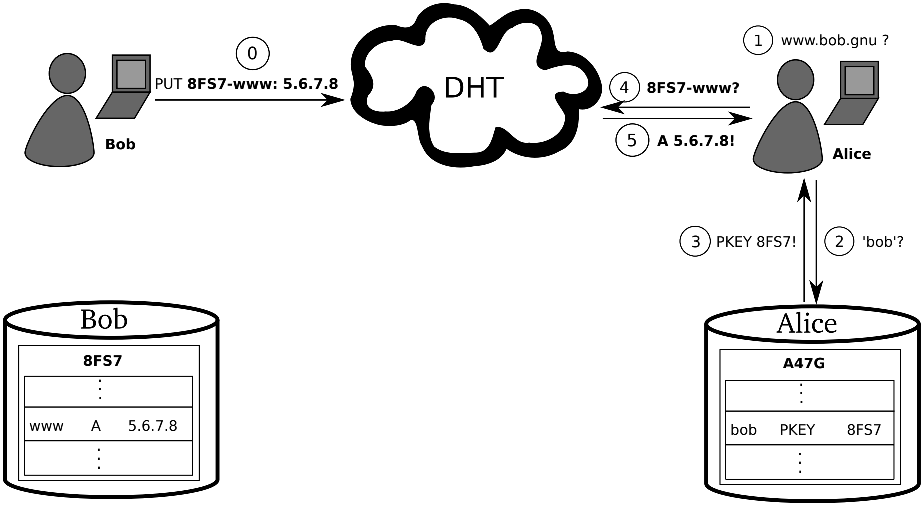
8FS7

	⋮	
www	A	5.6.7.8
	⋮	

A47G

	⋮	
bob	PKEY	8FS7
	⋮	

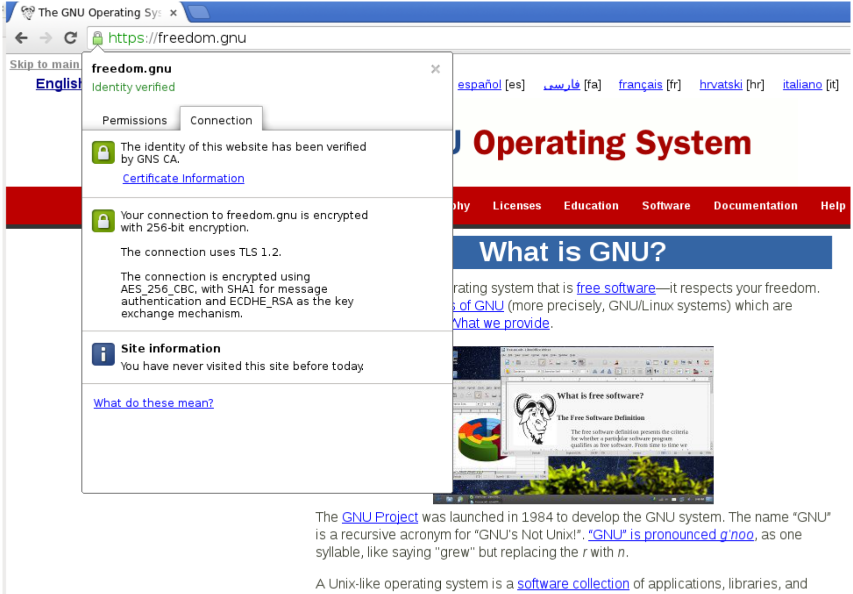
Name Resolution



8FS7		
	⋮	
www	A	5.6.7.8
	⋮	

A47G		
	⋮	
bob	PKEY	8FS7
	⋮	

GNS as PKI (via DANE/TLSA)



The GNU Operating Sys ×

https://freedom.gnu

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?

Skip to main

English

español [es] فارسی [fa] français [fr] hrvatski [hr] italiano [it]

U Operating System

phy Licenses Education Software Documentation Help

What is GNU?

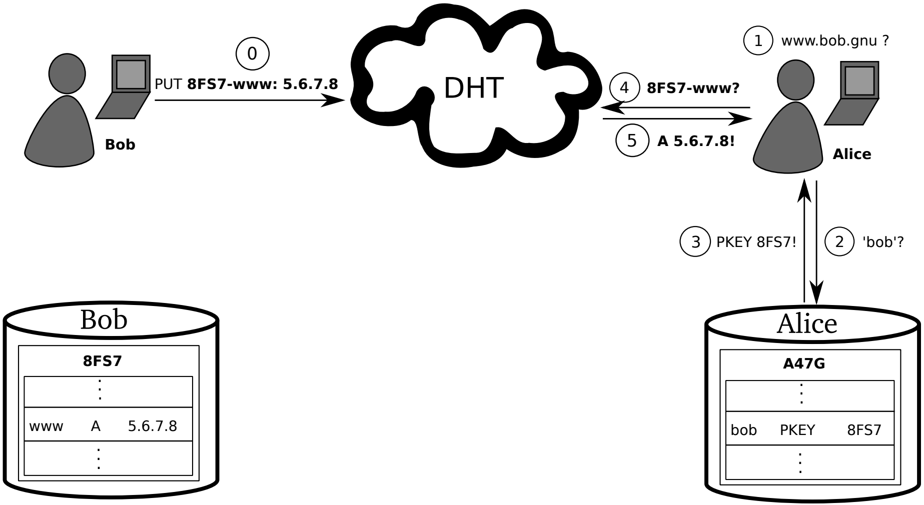
rating system that is free software—it respects your freedom.
s of GNU (more precisely, GNU/Linux systems) which are
What we provide.

What is free software?
The Free Software Definition
The free software definition presents the criteria for whether a particular software program qualifies as free software. From time to time we

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

Security Issue: DHT



8FS7

⋮		
www	A	5.6.7.8
⋮		

A47G

⋮		
bob	PKEY	8FS7
⋮		

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 $q_{P,l}$

Query Privacy: Cryptography

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

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

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

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

Query Privacy: Cryptography

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

$$\begin{aligned} h &:= H(l, P) && (1) \\ d &:= h \cdot x \mod n && (2) \\ B_{P,l} &:= S_d(E_{HKDF(l,P)}(R_{P,l})), dG && (3) \end{aligned}$$

Searching for l in zone P

$$\begin{aligned} h &= H(l, P) && (4) \\ q_{P,l} &= H(dG) = H(hxG) = H(hP) \Rightarrow \texttt{obtain } B_{P,l} && (5) \\ R_{P,l} &= D_{HKDF(l,P)}(B_{P,l}) && (6) \end{aligned}$$

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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- Peer receives new valid RC, floods to all neighbours
- All peers store all valid RCs forever

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Revocation Magic

- Peers maybe offline during initial flood
- Network might be temporarily partitioned

⇒ Need to reconsile revocation sets on connect

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

Efficient Set Union

(based on “What’s the difference? Efficient Set Reconciliation without Prior Context”, Eppstein et al., SIGCOMM’11)

- Alice and Bob have sets A and B

- The sets are very large
- …but their symmetric difference $\delta = |(A - B) \cup (B - A)|$ is small

- Now Alice wants to know $B - A$ (the elements she’s missing)
- …and Bob $A - B$ (the elements he’s missing)

- How can Alice and Bob do this efficiently?
  - w.r.t. communication and computation

Bad Solution

- Naive approach: Alice sends A to Bob, Bob sends $B - A$ back to Alice
- . . . and vice versa.

- Communication cost: $O(|A| + |B|)$:(
- Ideally, we want to do it in $O(\delta)$.
- First improvement: Don't send elements of A and B, but send/request hashes. Still does not improve complexity :(

- We need some more fancy data structure!

Bloom Filters

Constant size data structure that “summarizes” a set.

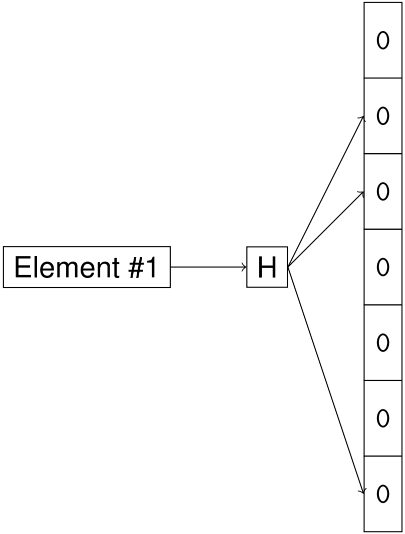
Operations:

$d = \mathit{NewBF}(\mathit{size})$ Create a new, empty bloom filter.

$\mathit{Insert}(d, e)$ Insert element *e* into the BF *d*.

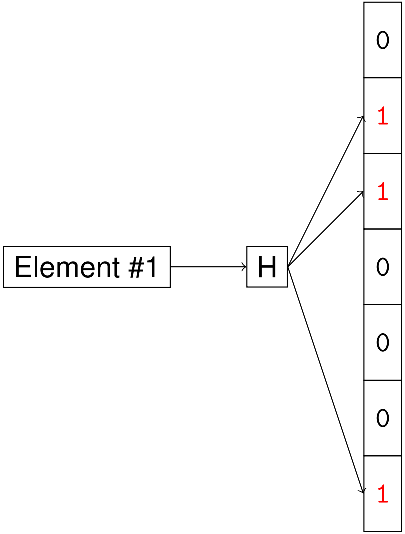
$b = \mathit{Contains}(d, e)$ Check if BF *d* contains element *e*.
$b \in \{$“Definitely not in set”, “Probably in set”$\}$

BF: Insert



$$H(\text{Element \#1}) = (2, 3, 7)$$

BF: Insert



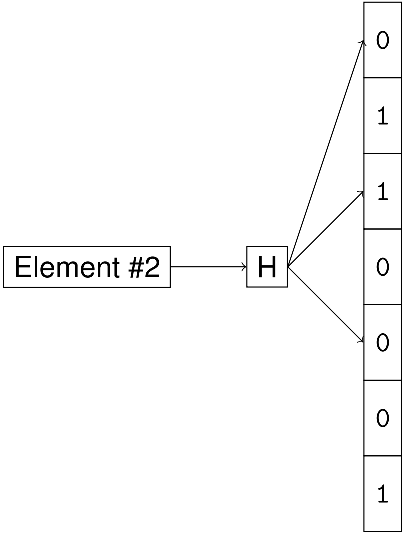
Element #1

H

0
1
1
0
0
0
1

$$H(\text{Element \#1}) = (2, 3, 7)$$

BF: Insert



Element #2

H

0

1

1

0

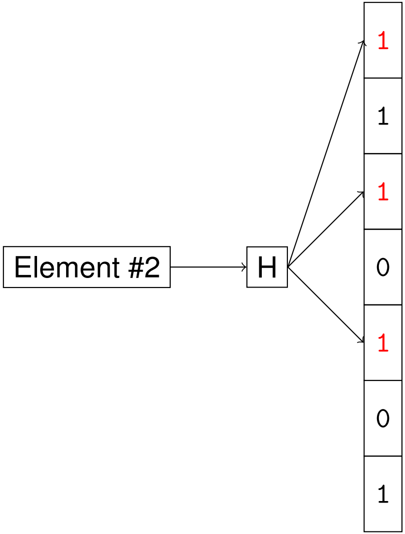
0

0

1

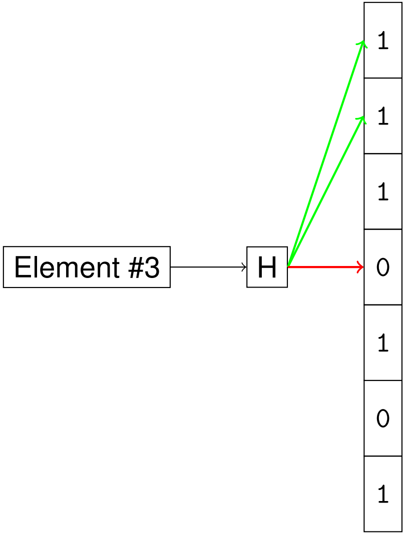
$$H(\text{Element \#1}) = (2, 3, 7)$$
$$H(\text{Element \#2}) = (1, 3, 5)$$

BF: Insert



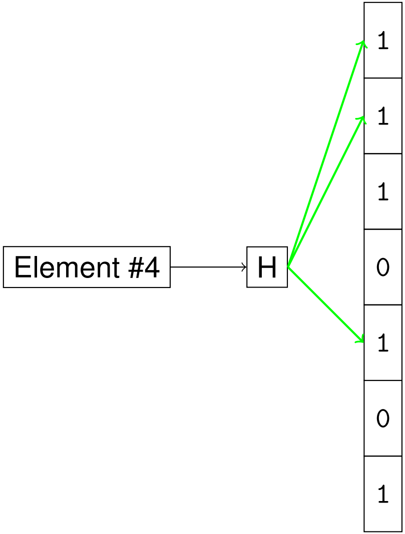
$$H(\text{Element \#1}) = (2, 3, 7)$$
$$H(\text{Element \#2}) = (1, 3, 5)$$

BF: Membership Test



$$H(\text{Element \#1}) = (2,3,7)$$
$$H(\text{Element \#2}) = (1,3,5)$$

BF: Membership Test (false positive)



$$H(\text{Element \#1}) = (2, 3, 7)$$
$$H(\text{Element \#2}) = (1, 3, 5)$$

Counting Bloom Filters

BF where buckets hold a **positive integer**.

Additional Operation:

Remove(d, e) Remove element from the CBF d.

$\Rightarrow$ False negatives when removing a non-existing element.

Invertible Bloom Filters

Similar to CBF, but

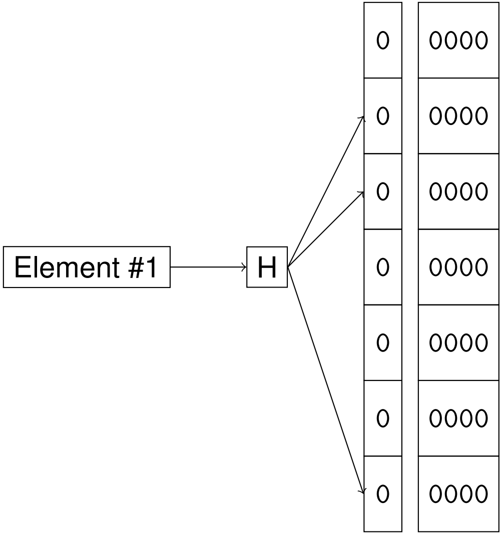
- Allow **negative counts**
- Additionaly store **(XOR-)sum of hashes** in buckets.

Additional Operations:

$(e, r) = \mathit{Extract}(d)$ Extract an element (e) from the IBF d, with result code $r \in \{\mathit{left}, \mathit{right}, \mathit{done}, \mathit{fail}\}$

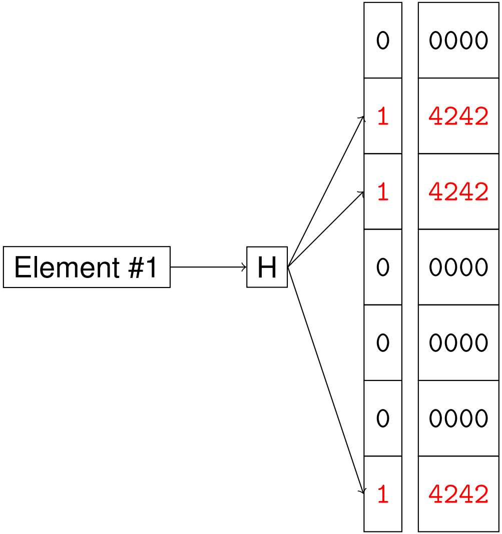
$d' = \mathit{SymDiff}(d_1, d_2)$ Create an IBF that represents the symmetric difference of d_1 and d_2.

IBF: Insert



$H(\text{Element \#1}) = (2, 3, 7)$
$H'(\text{Element \#1}) = 4242$

IBF: Insert



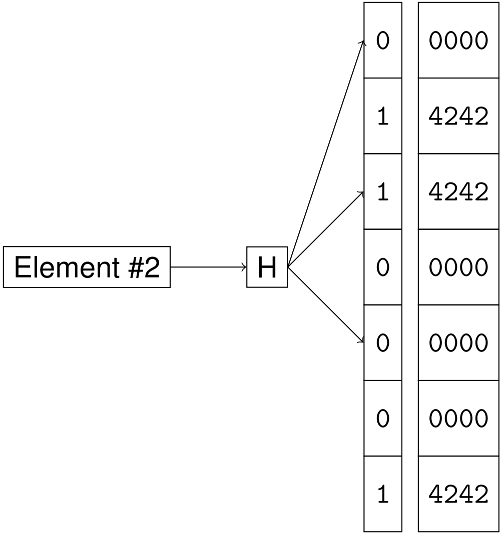
Element #1

H

0	0000
1	4242
1	4242
0	0000
0	0000
0	0000
1	4242

$$H(\text{Element \#1}) = (2, 3, 7)$$
$$H'(\text{Element \#1}) = 4242$$

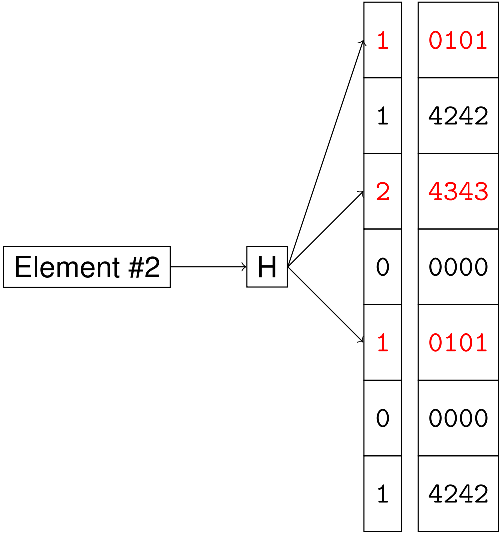
IBF: Insert



0	0000
1	4242
1	4242
0	0000
0	0000
0	0000
1	4242

$$H(\text{Element \#1}) = (2, 3, 7)$$
$$H'(\text{Element \#1}) = 4242$$
$$H(\text{Element \#2}) = (1, 3, 5)$$
$$H'(\text{Element \#2}) = 0101$$

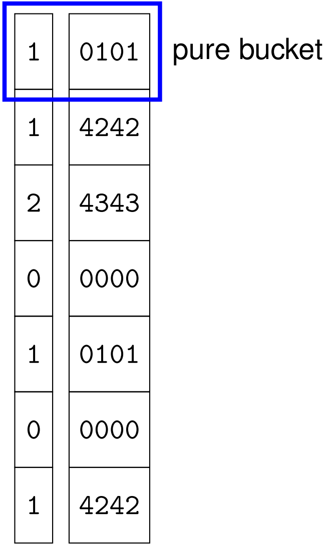
IBF: Insert



1	0101
1	4242
2	4343
0	0000
1	0101
0	0000
1	4242

$$H(\text{Element } \#1) = (2, 3, 7)$$
$$H'(\text{Element } \#1) = 4242$$
$$H(\text{Element } \#2) = (1, 3, 5)$$
$$H'(\text{Element } \#2) = 0101$$

IBF: Extract



1	0101
1	4242
2	4343
0	0000
1	0101
0	0000
1	4242

pure bucket

- Pure bucket ⇒ extractable element hash
- Extraction ⇒ more pure buckets (hopefully/probably)
- Less elements ⇒ more chance for pure buckets

Symmetric Difference

We can directly compute the symmetric difference without extraction.

- Subtract counts
- XOR hashes

The Set Union Protocol

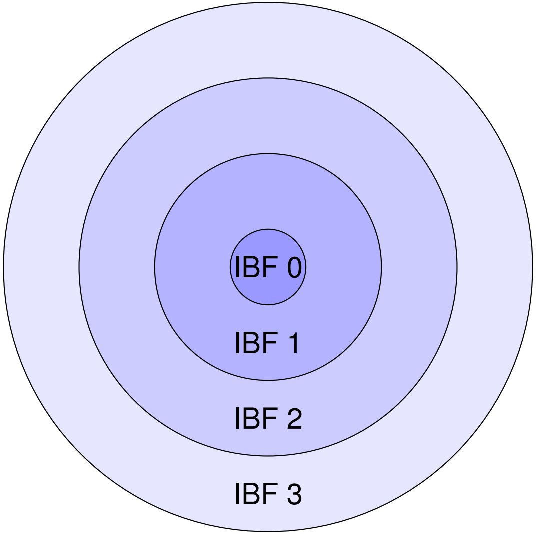
1. Create IBFs
2. Compute SymDiff
3. Extract element hashes

- Amount of communication and computation only depends on δ, not $|A| + |B|$:)
- How do we choose the initial size of the IBF?
- $\Rightarrow$ Do difference estimation first!

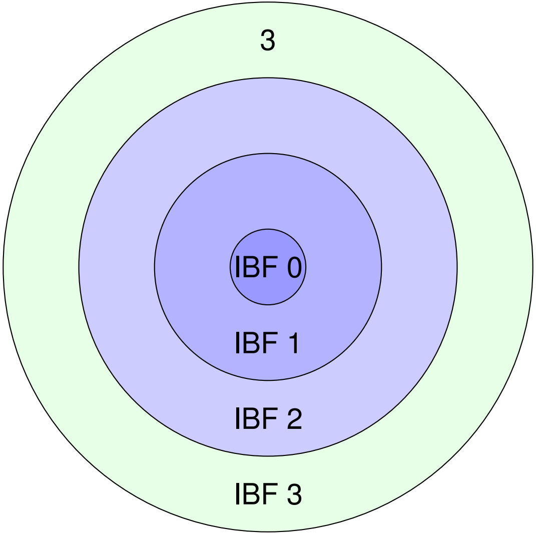
Difference Estimation

- Needed: Estimator accurate for *small* distances
- Turns out we can re-use IBFs for difference estimation
- *Sample* the set by looking at hashes, create multiple IBFs

Strata Estimator



Strata Estimator



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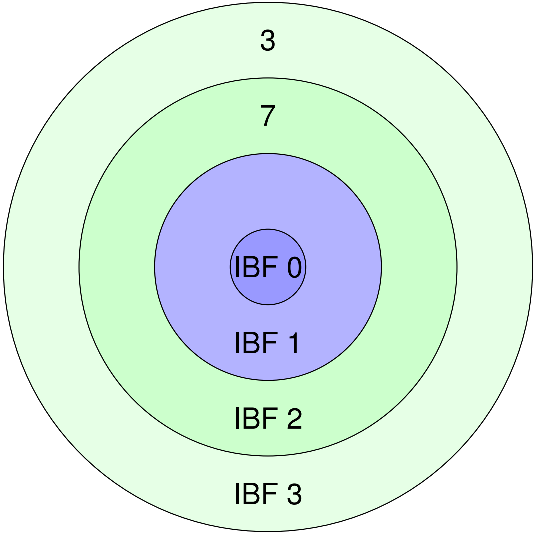
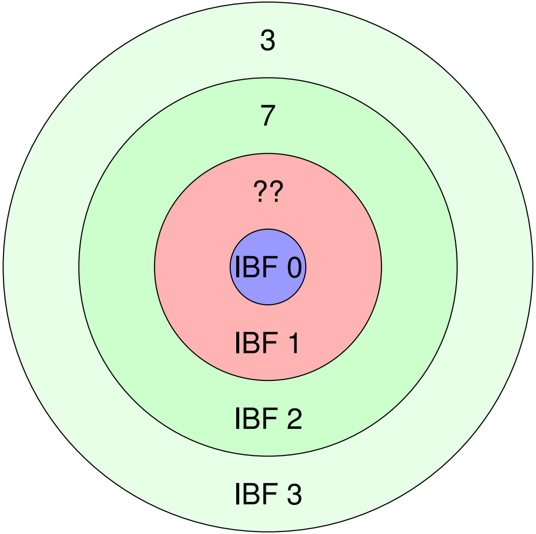
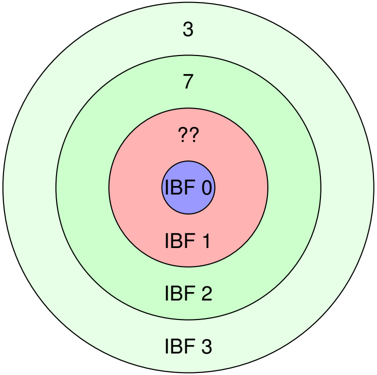


Strata Estimator



Estimation

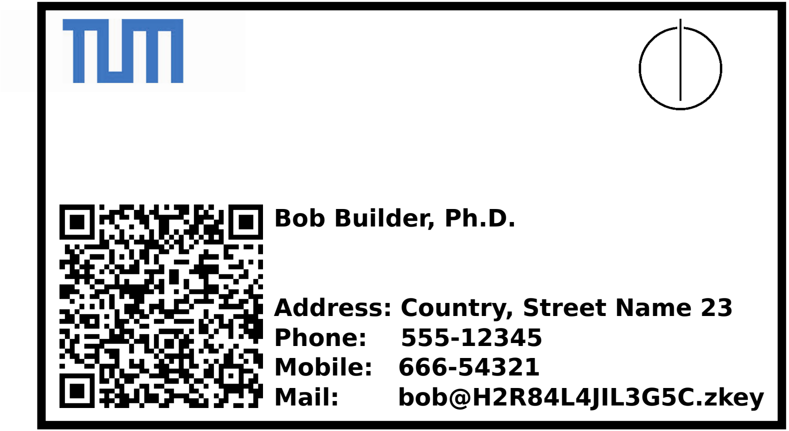


Estimate as $(3 + 7) \cdot 2^2$.
(Number of extracted hashes scaled by expected number of elements in the remaining IBFs)

The “.zkey” pTLD

- “LABELS.*PKEY*.zkey” format
- PKEY is the public key of the zone
- Works a bit like “.onion”

⇒ Globally unique identifiers!



Bob Builder, Ph.D.

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

NICKnames

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

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- 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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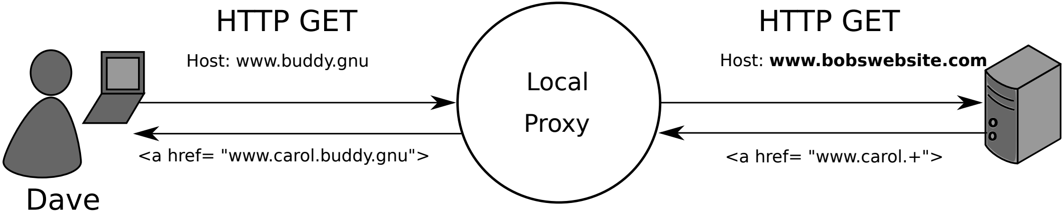
Solution: Client Side SOCKS Proxy

Legacy Hostname (LEHO) Records

LEHO records give a hint about the DNS name the server expects.



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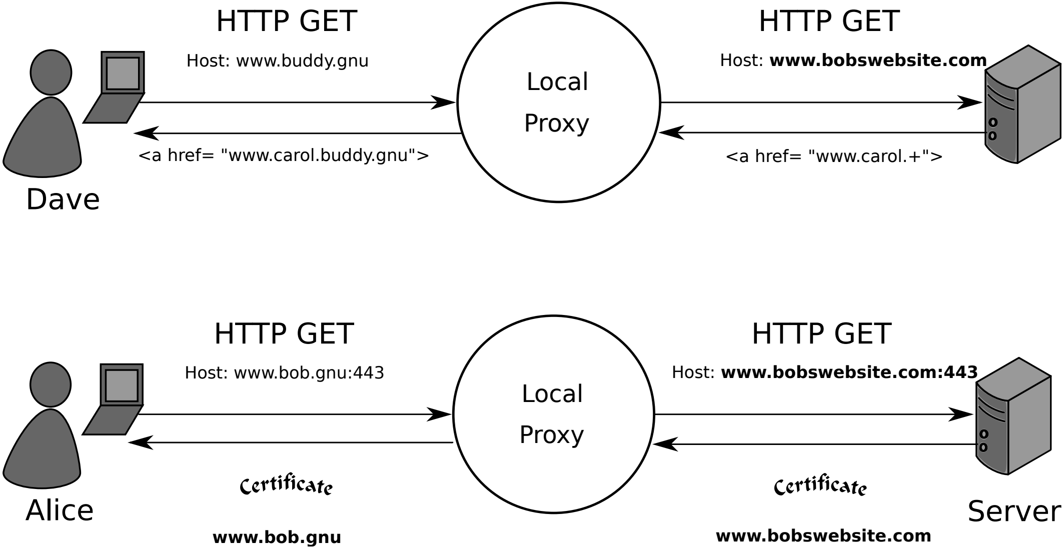

Long-Term Vision

- Integration with browser and HTTP server
- HTTP server receives “GNS-Zone: PKEY” instead of “Hostname”
- HTTP client uses “TLSA” record of GNS, instead of “LEHO”

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, too.

New Record Types

- PKEY: delegate to another GNS zone
- NICK: preferred names for shortening
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New Record Types

- 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 GNUnet 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!)
  - Line number (to support multiple phones per peer)
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ybti assembly plug

- Bart Polot will present more about Conversation
- Florian Dold will present more fun GNUnet crypto
- Julian Kirsch will present Knock

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

Application Integration

```
FILE *p;
char *cmd;
char line[128];
struct in_addr ip;

if (-1 == asprintf(&cmd, "%s %s\n", "gnunet-gns -r -u", name))
  return -1;

p = popen(cmd,"r");

if (p != NULL )
{
  if (fgets( line, sizeof(line), p ) != NULL)
  {
    if (line[strlen(line)-1] == '\n')
    {
      line[strlen(line)-1] = '\0';
      if (inet_pton(af, line, &ip)))
      {
         //Do something
      }
      else
      {
        fclose (p);
        free (cmd);
        return -1;
      }
    }
  }
  ...
```

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- GNS part of GNUnet since 0.9.3
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GNS Key Exchange Party Plug

- Matthias Wachs will describe process at Lightning Talks 2
- Install GNUnet today & create private key
- Use `gnunet-bcd` to create business cards

⇒ Print business cards at Wau Holland tomorrow!

End

Thank you!

grothoff@in.tum.de

Get the code:

https://gnunet.org/gns