



## To Name is to Own - Autonomous Name Spaces, Verifiable Identities, Assets and Services at the Edge



08-15, 17:00–18:00 (Europe/Berlin), Bits&Bäume Workshops

Language: English

**With a lightweight method of using the DNS trust root, decentralised communities can establish and self-manage secure hierarchies of trust for identities, assets and distributed services. This can be deployed outside the data centre monopoly and into the decentralised and local infrastructures at the network edge for complete autonomy with minimal resources and management. Why use blockchains with eternal history and ever increasing storage and resource requirements, when you can leverage and liberate the most highly distributed network service in existence?**

This workshop offers participants the hands on opportunity to discover potential uses of dynamic DNS updates, authorised and signed utilising DNSSEC as a trust root & SIG(0) keypairs for update authentication.

- Learn how to configure and deploy an authoritative dynamic DNS service with DNSSEC enabled.
- Discover how to publish cryptographic SIG(0) public keys to delegate and update resource records.
- Configure secure wide area DNS service discovery to allow any device to securely publish services browsable over the global internet though avahi or dns-sd (DNS Wide Area Service Discovery).
- Securely delegate DNS subdomains to servers, even on a battery powered Raspberry Pi.

# Workshop summary



## Gentle Introduction

- DNS and how it works (usually does)
- DNS updates (DNS read/write capabilities)
- Wide Area unicast DNS-SD (global scope)
- DNSSEC process and details

## Project sig0zonectl

- Stitching all the above together
- Github: <https://github.com/adam-burns/sig0zonectl>
- Please clone and explore during workshop

## Further ideas and hacking

# Workshop motivations



## **Autonomy**

- minimise external dependencies.
- minimise extractive proprietary external APIs
- Offers an initial trust root through which others can grow.

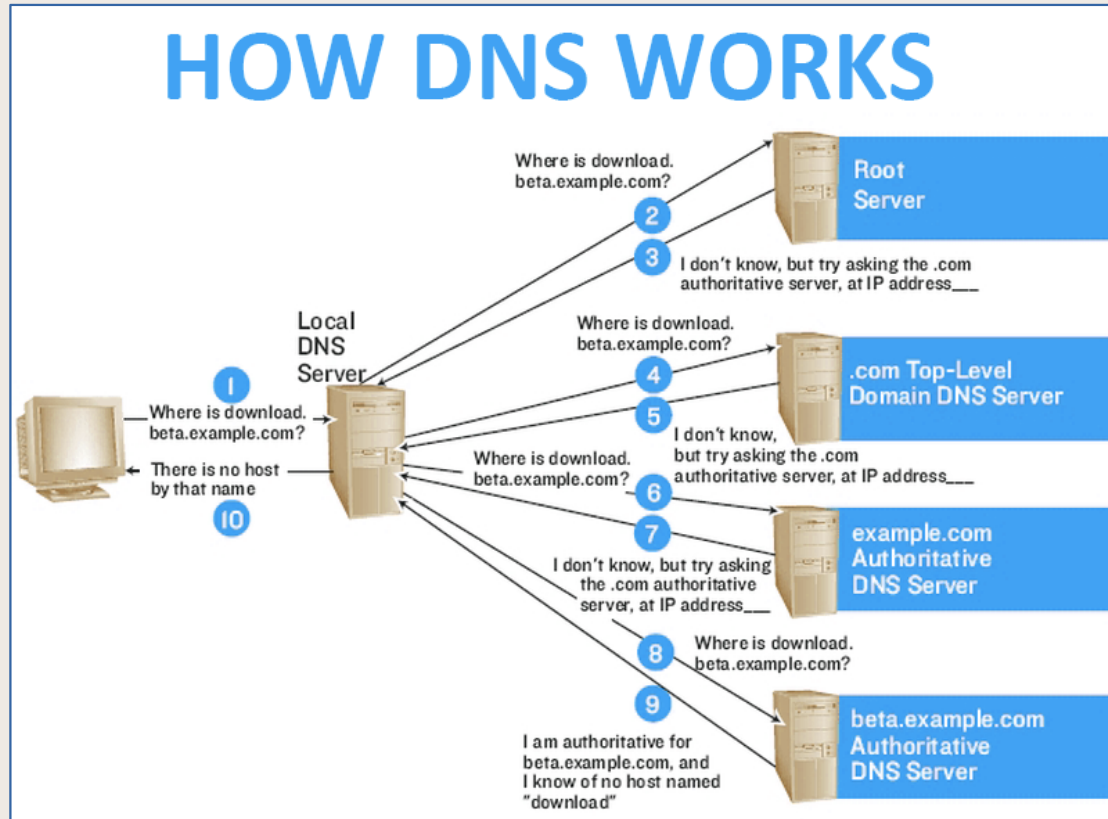
## **Sustainability**

- minimal deployment footprint  
(DNS is already around us & flows like water)
- scale use as you and your community grow

## **Freedom**

- growth of opportunity for local independent and community network service offerings
- remove unnecessary extractive 3<sup>rd</sup> party services
- remove unnecessary use of centralised data center infrastructures

# Basic DNS: talkin' bout a resolution ...



from <https://techreader.com/files/2016/12/how-the-dns-system-works.png>

DNS Server deployment types:

- **recursive caching resolver** servers (usually local, sometimes public, eg Google)
- **authoritative zone** servers (usually global)

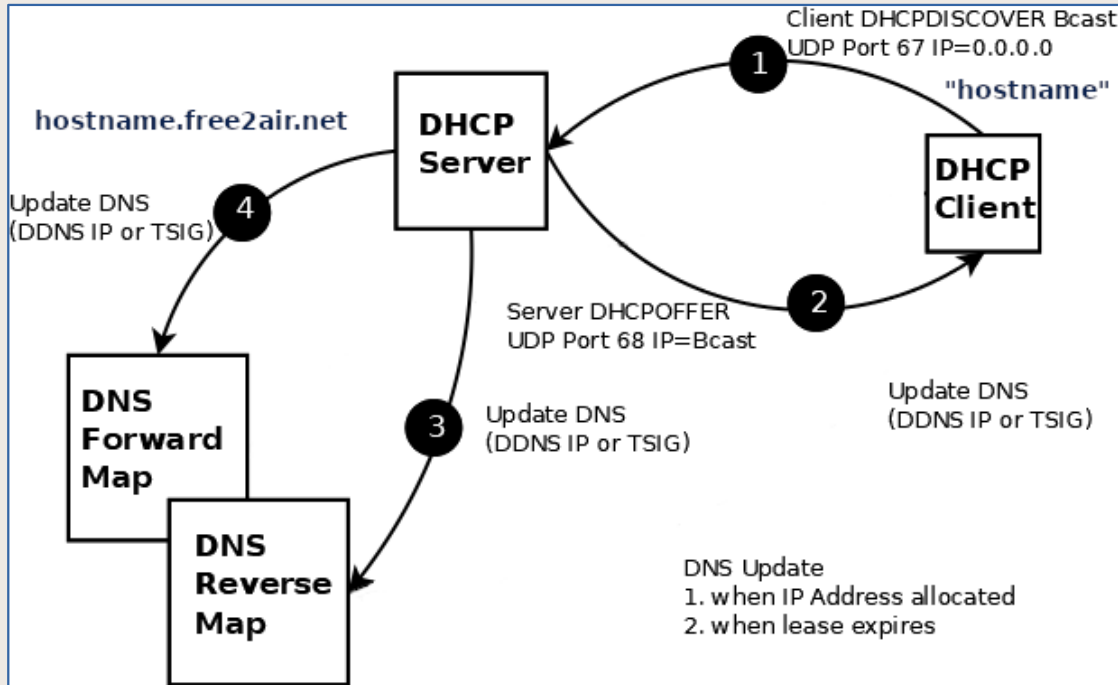
DNS transaction type usually a read-only 'query'

- ask question (query)
- get answer (resolution)

DNS serves answers to queries to resource record types, e.g. **A records** for IPv4, **AAAA records** for IPv6 & **MX records** for mail server address resolution.

**nsupdate -T** gives full list of DNS resource record types.

# Basic DNS: dynamic DNS update



butchered from <https://www.zytrax.com/books/dns/ch9/dhcp-1.png>

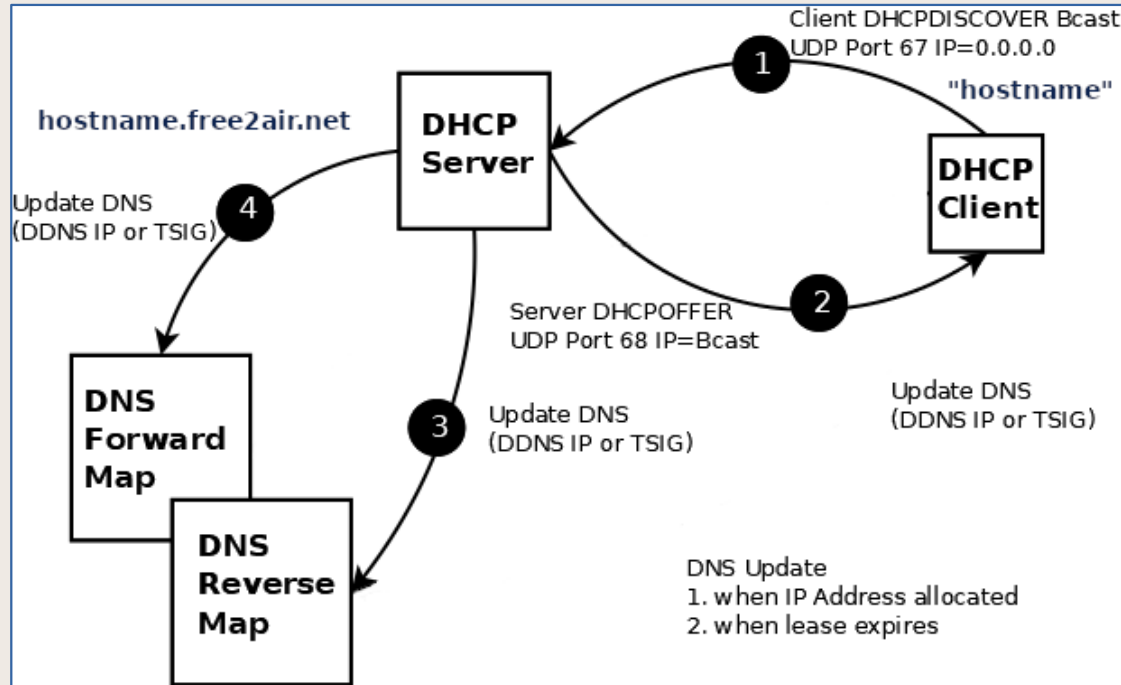
## Dynamic DNS:

- allows DNS records to be added, changed or deleted.
- uses DNS transaction type 'update'.
- often deployed with DHCP servers for quick server name deployment for internal 'trusted' infrastructure.
- uses a shared secret authentication (TSIG), which
  - requires manual reconfiguration for new secrets.
  - is not very secure for 3<sup>rd</sup> party authentication at scale.

Rant: The shortcomings of TSIG encouraged some public DNS service providers to implement non-interoperable REST APIs over HTTPS to provide non-standard "dynamic DNS-like" services to their customers.



# Example: Community Wireless Network

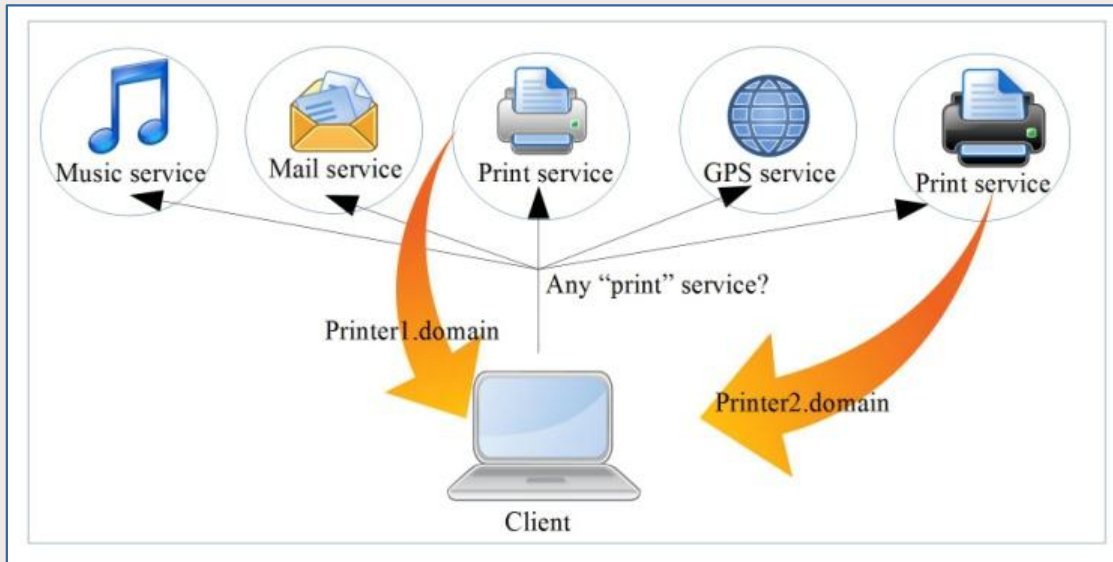


butchered from <https://www.zytrax.com/books/dns/ch9/dhcp-1.png>

# selected example of DHCP TSIG auto-deployed resource records  
# DNS A records under free2air.net domain

Arifs-iPhone	A	93.97.42.65
Aude5-PC	A	81.187.145.171
BLACKBERRY-3199	A	93.97.42.66
CMAC	A	81.187.145.166
FRANCESCA	A	93.97.42.65
Giless-iPhone	A	93.97.42.66
grrs-iPhone-7	A	93.97.42.71
iDizz	A	93.97.42.69
iPod	A	81.187.145.163
iPod-4	A	81.187.145.166
james-iphone-2	A	93.97.42.66
JNR-iPhone	A	93.97.42.71
Lejito-s-iPhone	A	93.97.42.68
Livvys-iPhone	A	93.97.42.65
minint-pv12anv	A	93.97.42.67
Phone	A	93.97.42.68
Riz	A	93.97.42.66
robs-iPhone	A	93.97.42.67
#		
Hards-iPhone	A	10.1.0.197
iPhone-2011-emb	A	10.1.0.247

# DNS Service Discovery (DNS-SD)



```
$ORIGIN _dns-sd._udp.domain.  
b PTR domain.  
db PTR domain.  
dr PTR domain.  
lb PTR domain.  
r PTR domain.  
_services PTR _printer._tcp.domain.  
$ORIGIN _printer._tcp.domain.  
PTR Printer1.domain  
PTR Printer2.domain
```

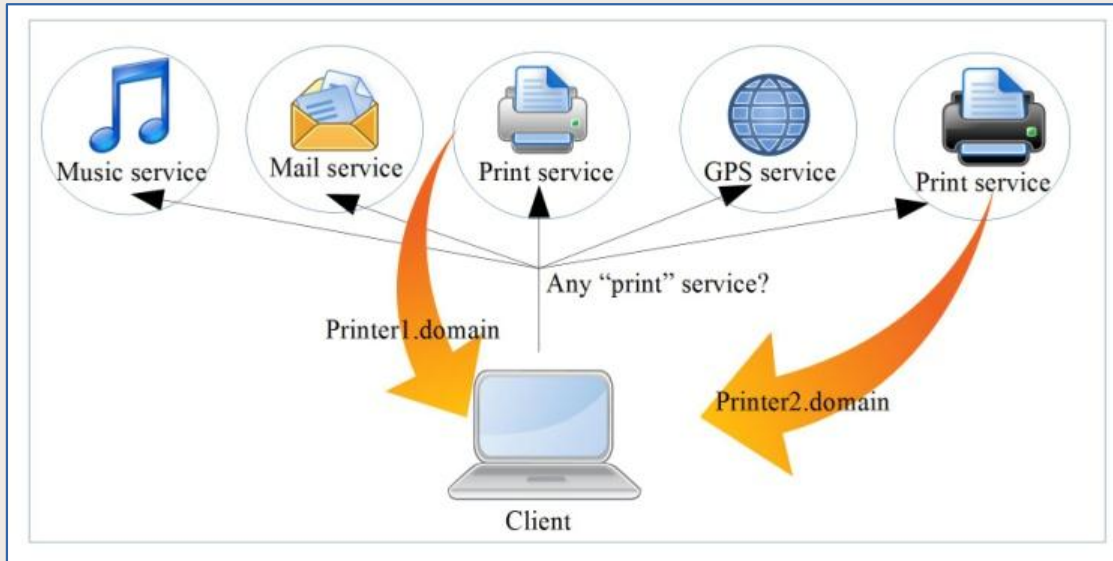
DNS-SD provides for 3 core functions within a DNS domain that include the use of further DNS **PTR**, **TXT** & **SRV** resource records for:

- service registration (service offering)
- service enumeration (service browsing)
- service use (service resolving/lookup)

DNS-SD offers these functions over two core transport mechanisms for two distinct scopes:

- multicast DNS for local broadcast domains (for .local addresses)
- unicast DNS for global domains (for all other TLD addresses)

# Example: Community Wireless DNS-SD

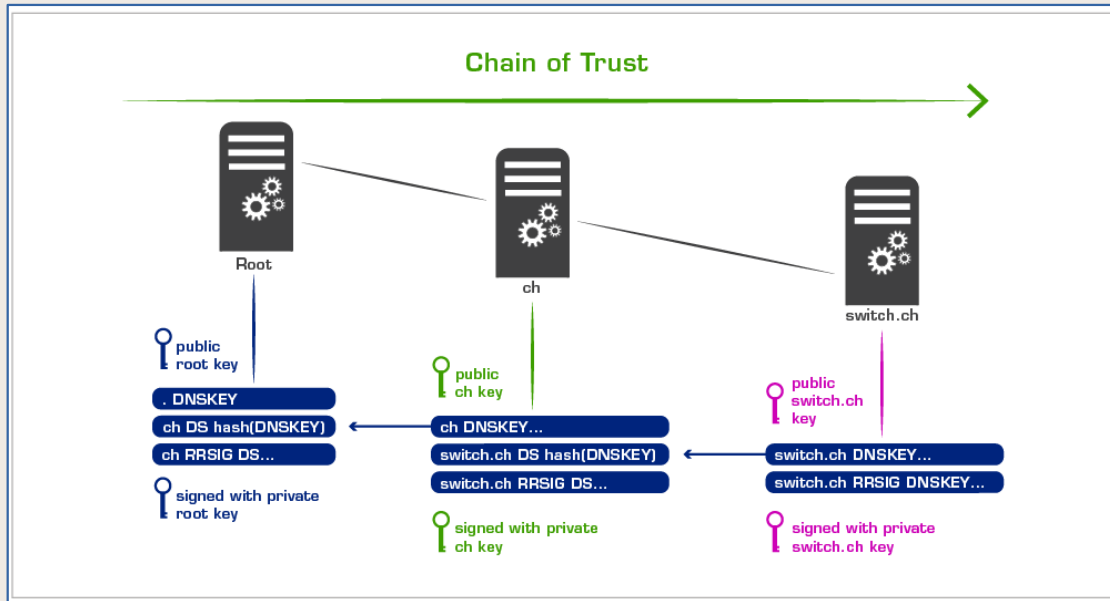


Service Browsing example for print services  
from [https://www.researchgate.net/publication/279177017\\_Internet\\_of\\_Things\\_A\\_Survey\\_on\\_Enabling\\_Technologies\\_Protocols\\_and\\_Applications](https://www.researchgate.net/publication/279177017_Internet_of_Things_A_Survey_on_Enabling_Technologies_Protocols_and_Applications)

```
# small selection of DNS-SD browsable services
# and service instance examples
# under free2air.net domain
#
$ORIGIN _dns-sd._udp.free2air.net.
_services PTR      _ftp._tcp.free2air.net.
PTR      _ipp._tcp.free2air.net.
PTR      _rfb._tcp.free2air.net.
PTR      _ssh._tcp.free2air.net.
PTR      _daap._tcp.free2air.net.
PTR      _http._tcp.free2air.net.
PTR      _printer._tcp.free2air.net.
PTR      _sftp-ssh._tcp.free2air.net.
PTR      _afpovertcp._tcp.free2air.net.
PTR      _bittorrent._tcp.free2air.net.
PTR      _pulse-sink._tcp.free2air.net.
PTR      _workstation._tcp.free2air.net.
PTR      _pulse-server._tcp.free2air.net.
PTR      _pulse-source._tcp.free2air.net.
$ORIGIN _tcp.free2air.net.
_workstation PTR      media\032iii._workstation
_ssh PTR      media\032iii._ssh
_rfb PTR      RemoteGuest._rfb
$ORIGIN _rfb._tcp.free2air.net.
RemoteGuest TXT      "fullname=" "type=shared" "u=guest"
```



# Basic DNSSEC: DNS Chain of Trust

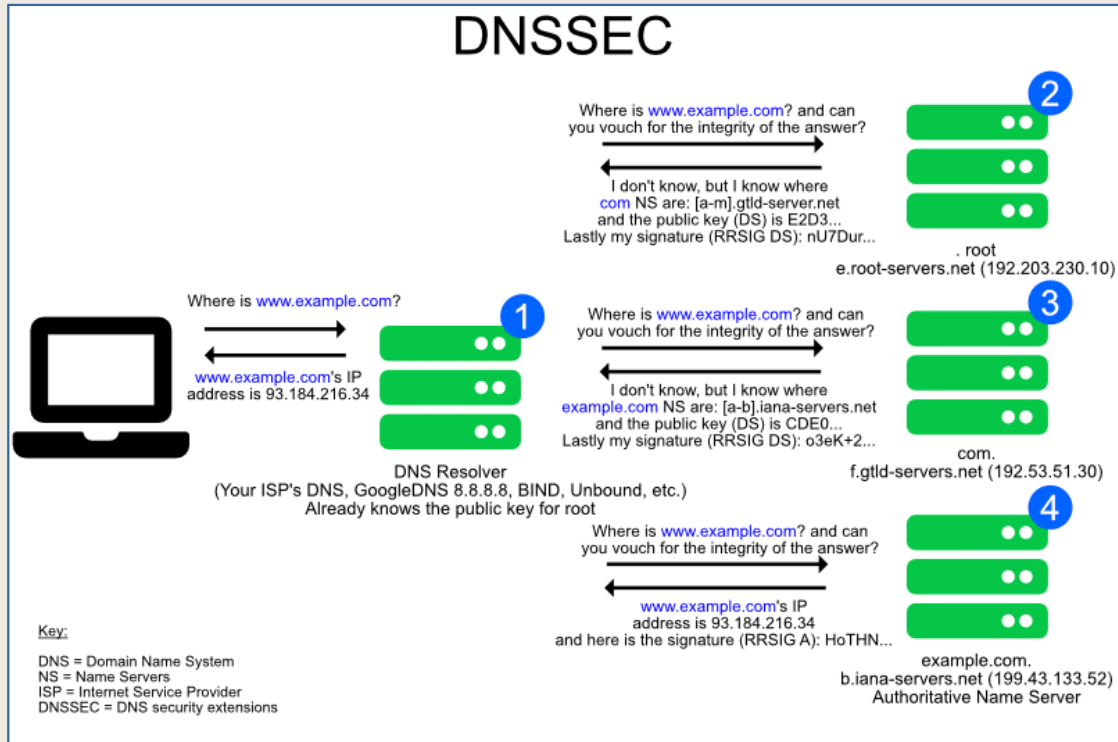


from [https://www.nic.ch/export/shared/.content/images/dnssec\\_chain\\_en.png](https://www.nic.ch/export/shared/.content/images/dnssec_chain_en.png)

DNS Security Extensions (DNSSEC) introduces a cryptographic chain of trust for integrity, with the **DNS root key** as the trust anchor.

The **DNS root key signing ceremony** is a regular event guided by an audited strong security process that brings together multiple independent stakeholders to update and **sign the DNS root key**.

# Basic DNSSEC: in practice



from [https://dnscrypt.info/\\_nuxt/img/DNS-DNSSEC.0de4990.png](https://dnscrypt.info/_nuxt/img/DNS-DNSSEC.0de4990.png)

DNSSEC adds new DNS resource record types:

- **DNSKEY records** for zone & key signing\*.
- **DS records** for hashes of child zone DNSKEYs (linking chain of trust).
- **RRSIG records** for signatures of individual resource records.
- **NSEC records** for proof of non-existence of resource records within a signed zone.

Most major DNS server implementations (e.g. BIND9, Knot DNS) allow automated managed DNSSEC signing of even dynamic DNS zones(!)

\* Early versions of DNSSEC used **KEY records** which is now only used for **SIG(0)** authentication.

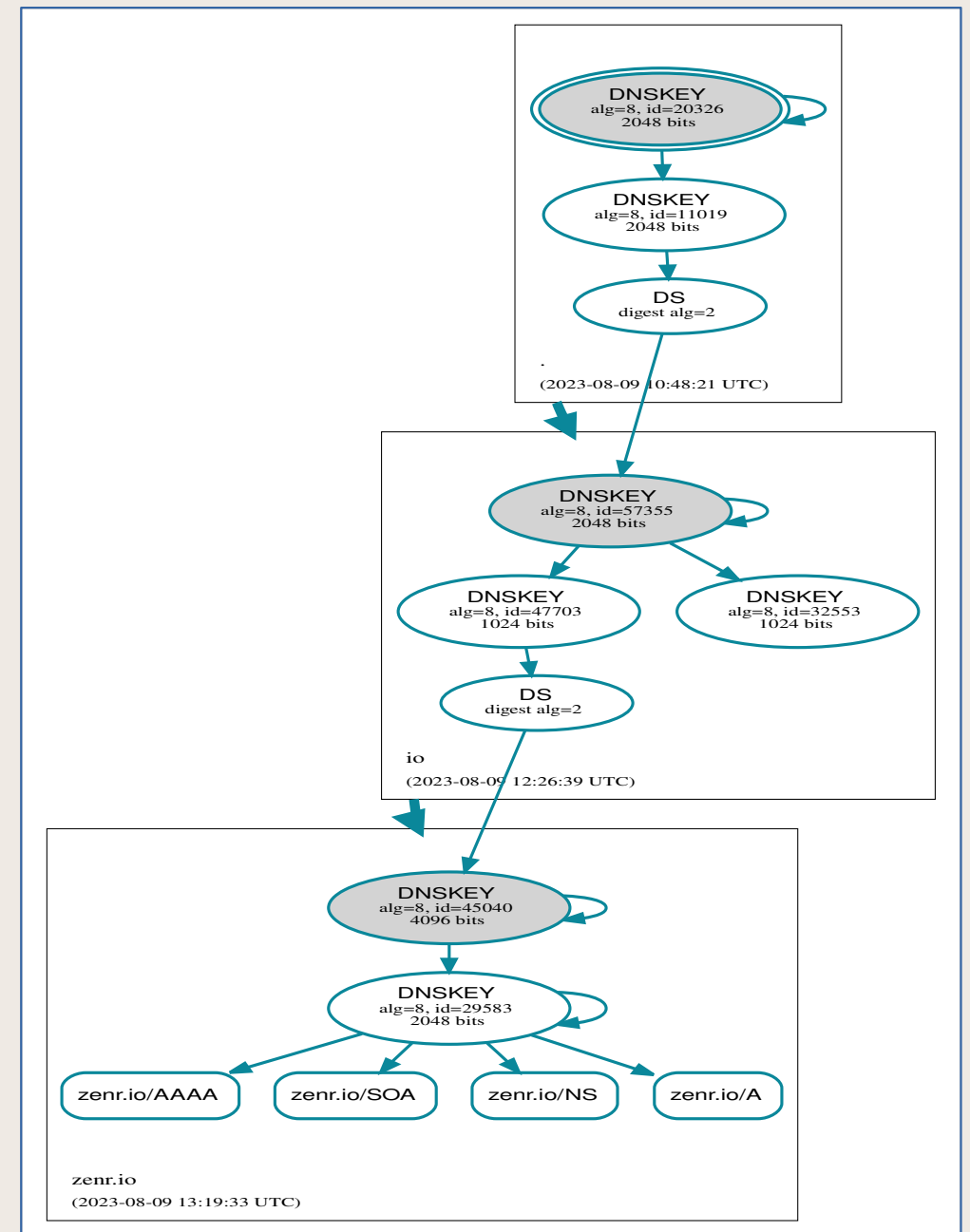
# Example: Visualising DNSSEC chains of trust

The website **dnsviz.net** offers an on-line service of the open source dnsviz toolkit to visualise details of DNSSEC chains of trust.

For a selected domain, it uses:

- **DNSKEY records** to show zone key details.
- **DS records** to show link details in the chain of trust.
- **RRSIG records & NSEC records** to show the set of signed resource record types within a signed zone.

Fun-with-DNS note: DNSSEC also supports IDN with punycode – for example, use dnsviz to visualise the trust chain of **xn--dr8h.zembla.zenr.io**.



Example visualisation of zenr.io trust chain from root

# SIG(0) DNS Update Authentication

```
$ dig +noall +answer +multiline vortex.zenr.io KEY
vortex.zenr.io.      600 IN KEY 512 3 15 (
    2MK3KZkUgYQVumU9bhy1KzIZ2FhFQZ8yLP2nFMJRCEQ=
    ); alg = ED25519 ; key id = 56161
```

Using **dig** to get further information about the KEY zebla.zenr.io

SIG(0) is a modern standard authentication method that uses a public and private key pair to sign DNS(SEC) update requests.

The public key is published as a DNS **KEY** resource record.

The private key should be kept secure with the host that generates the key pair and submits the DNS update request.

# SIG(0) Domain KEY Request

```
$ ./request_key zembla.zenr.io
Generating key pair.
Kzembla.zenr.io.+015+55028
New SIG0 keypair for zembla.zenr.io generated in
./keystore
KEY request 'zembla._signal.zenr.io IN KEY 512 3 15
duQIg/NgFjwsE8ZKUuXJUG2/NNFs4o4byuwnekT062U=' added
$
```

Using the sig0zonectl tool **request\_key** to generate a domain KEY resource record

```
$ dig +noall +answer +multiline zembla._signal.zenr.io KEY
zembla._signal.zenr.io.      60 IN KEY 512 3 15 (
    duQIg/NgFjwsE8ZKUuXJUG2/NNFs4o4byuwnekT062U=
    ); alg = ED25519 ; key id = 23799
```

Using **dig** to get further information about the KEY zembla.zenr.io

Using the sig0zonectl tool **request\_key**, **zembla.zenr.io** is an initial KEY name requested from the DNS server authoritative for **zenr.io** zone.

The DNS server may grant or ignore this request.

The registration request is published as a DNS **KEY** resource record in a holding name space.

The private key should be kept secure with the host that generates the key pair and submits the DNS update request.

# SIG(0) Domain KEY Acceptance

```
$ ./process_requests zenr.io

LIST of KEY REQUESTS
_signal.zenr.io.      PTR      zembla._signal.zenr.io.

PROCESSING KEY REQUESTS

KEY 'zembla.zenr.io' added under zone 'zenr.io' with '[key
id = 23799]', IDN 'zembla.zenr.io'.
```

Using the sig0zonectl tool **process\_requests** to register new KEY zembla.zenr.io

```
$ ZONE="zenr.io" ./process_requests

LIST of KEY REQUESTS
_signal.zenr.io.      PTR      vortex._signal.zenr.io.

PROCESSING KEY REQUESTS

KEY 'vortex.zenr.io' IS NOT added under zone 'zenr.io', as
DNS resource records already exist.
```

Using The sig0zonectl tool **process\_requests** denying KEY domain request zembla.zenr.io

With access to the **zenr.io** private KEY, the zone admin can use the **process\_requests** tool to grant initial subdomain KEY additions on a “first come, first served” (FCFS) policy basis.

If the subzone has no existing records at all, the KEY record in the holding name space is replicated and SIG(0) update access is granted for the KEY domain and all subdomains.

If any DNS resource record already exists, then the addition request made for publishing the KEY is denied.



# DNS-SD domain configuration

```
$ ./dnssd-domain zembla.zenr.io
$
```

Using the sig0zectl tool **dnssd-domain** to establish DNS-SD browsing & registration PTR resource records for a domain

DNS-SD offers standard DNS PTR resources to ease browsing & registering services within a domain.

```
$ORIGIN _dns-sd._udp.zembla.zenr.io.
b PTR zembla.zenr.io.
lb PTR zembla.zenr.io.
db PTR zembla.zenr.io.
r PTR zembla.zenr.io.
dr PTR zembla.zenr.io.
```

Listing of zone PTR updates under zembla.zenr.io after above command

For any particular domain, DNS-SD aware software query these PTR resource records underneath `_dns-sd._udp` to determine default domain hierarchies for service browsing and registration.

# DNS-SD service registration

```
$ DNSSD_SERVICES="_http._tcp" \  
./dnssd-domain zembla.zenr.io  
$
```

The sig0zonectl **dnssd-service** script gives examples of how to register DNS-SD service types and instances for browsing & enumeration within a domain

```
$ avahi-browse -brat -d zembla.zenr.io  
...
```

The dig or avahi-browse tool can be used to enumerate details of all service types and instances registered within a domain (long output not shown)

```
$ avahi-browse -tr _http._tcp -d zembla.zenr.io  
+   n/a  n/a  zembla    _http._tcp    zembla.zenr.io  
=   n/a  n/a  zembla    _http._tcp    zembla.zenr.io  
hostname = [zembla.zenr.io]  
address  = [2a01:4f8:c17:3dd5:8000::10]  
port     = [80]  
txt      = ["Hello_this_is_a__http._tcp_service_instance"]
```

The dig or avahi-browse tool can be used to enumerate details of one of the example `_http._tcp` service instance registered above

The DNS-SD standard offers a service instance set of DNS resource records with enough information to browse service types and enumerate service instance access details.

Each service type can be browsed & enumerated, DNS\_SD allows further DNS resource record types such as **PTR**, **SRV** and **TXT** resource records underneath the service type subdomain (eg `_http._tcp`) to determine sufficient information to access the resource, including IP address & port, together with any service specific details.

# Future Work

Further hacks in order of difficulty:

- Simple dynamic IP tool for IPv4 & IPv6 address updates (PoC script completed)
- Find my Phone style tool updating DNS **LOC** resource records for any named resource – not everyone's gear lives in a data centre (PoC script completed)
- DNSSEC DNS sub-delegation automation.
- ansible script and/or docker-compose config to assist with zone on-device DNS zone delegation (WIP – still a manual configuration process).
- DANE browser implementation\*
- Federated W3C DID identity & verifiable credential name spaces

