A new stub resolver

Willem Toorop

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getdns Unbound security API is:

- A *DNS API* specification (for resolving)
  by and for application developers (for application)
- First implementation by VERISIGN LABS and NLnet Labs

From Verisign:

Theogene Bucuti, Craig Despeaux, Angelique Finan, Neel Goyal, Scott Hollenbeck, Shumon Huque, Sanjay Mahurpawar, Allison Mankin, Sai Mogali, Prithvi Ranganath, Rushi Shah, Vinay Soni, Bob Steagall, Gowri Visweswaran, Glen Wiley

From NLnet Labs:

Olaf Kolkman, Benno Overeinder, Willem Toorop, Wouter Wijngaards

From Sinodun:

Sara and John Dickinson

From No Mountain Software:

Melinda Shore

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- OpenBSD & FreeBSD already have unbound in system
- getdns might have a role too

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Bootstrap encrypted channel (TLS)
from DNSSEC authenticated keys (DANE)
especially applicable/suitable to system software!

- Lack of user interaction (who do you trust)
- Policy published over sidechannel (DNSSEC)

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- Translate names ↔ numbers (also DNS)

DNS: Domain Name System
The phonebook of the Internet

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- What about something other than numbers
  (i.e. `MX`, `SPF`, `SSHFP`, `TLSA`, `OPENPGPKEY` etc.)

DNS: Domain Name System
Global decentralized distributed database for more than just names and numbers.

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Issues with the system stub

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- Blocks on I/O (no asynchronous DNS)
- No control over I/O

  (upstreams, transport, how to fallback/timeout, privacy)

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- Data unauthenticated
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- Yes, but it does so by giving (origin) authenticated answers
  - where *origin* means that the authoritative party for a zone authenticates the domain names within that zone

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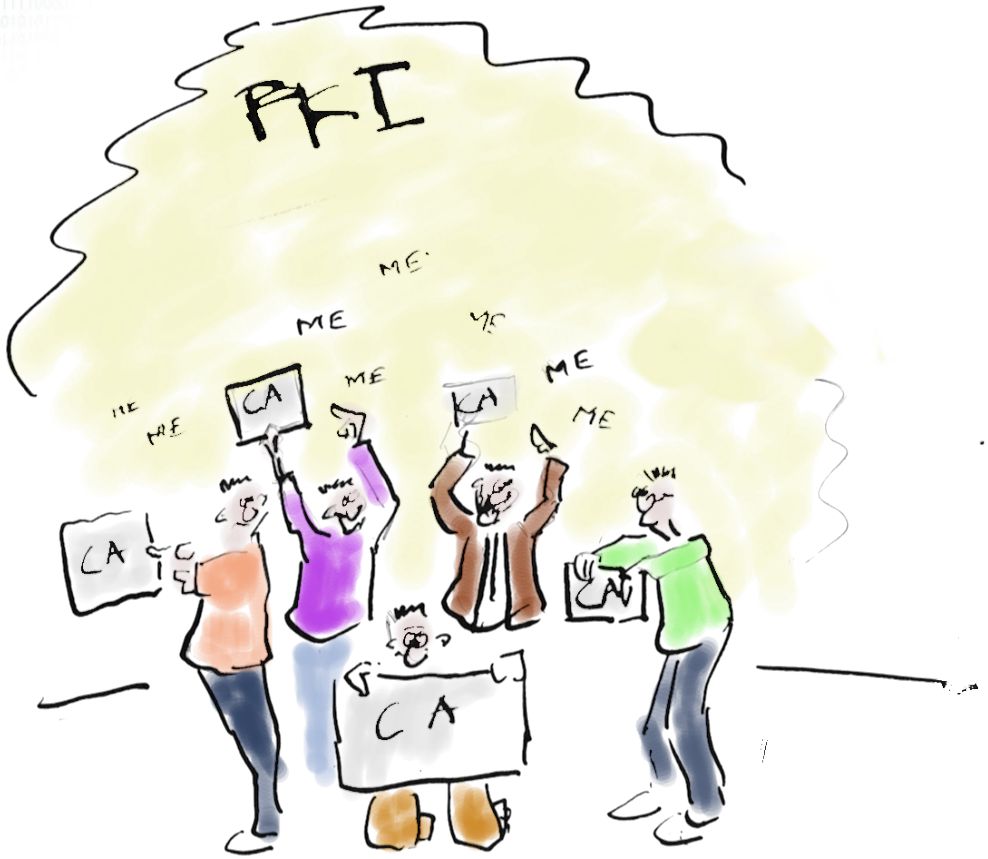
- *How does this concern the stub?*
  - Authentication is interesting for applications

DNSSEC - for applications - for TLS

- Transport Layer Security (TLS) uses both asymmetric and symmetric encryption
- A symmetric key is sent encrypted with remote public key

- How is the remote public key authenticated?

DNSSEC - for applications - for TLS

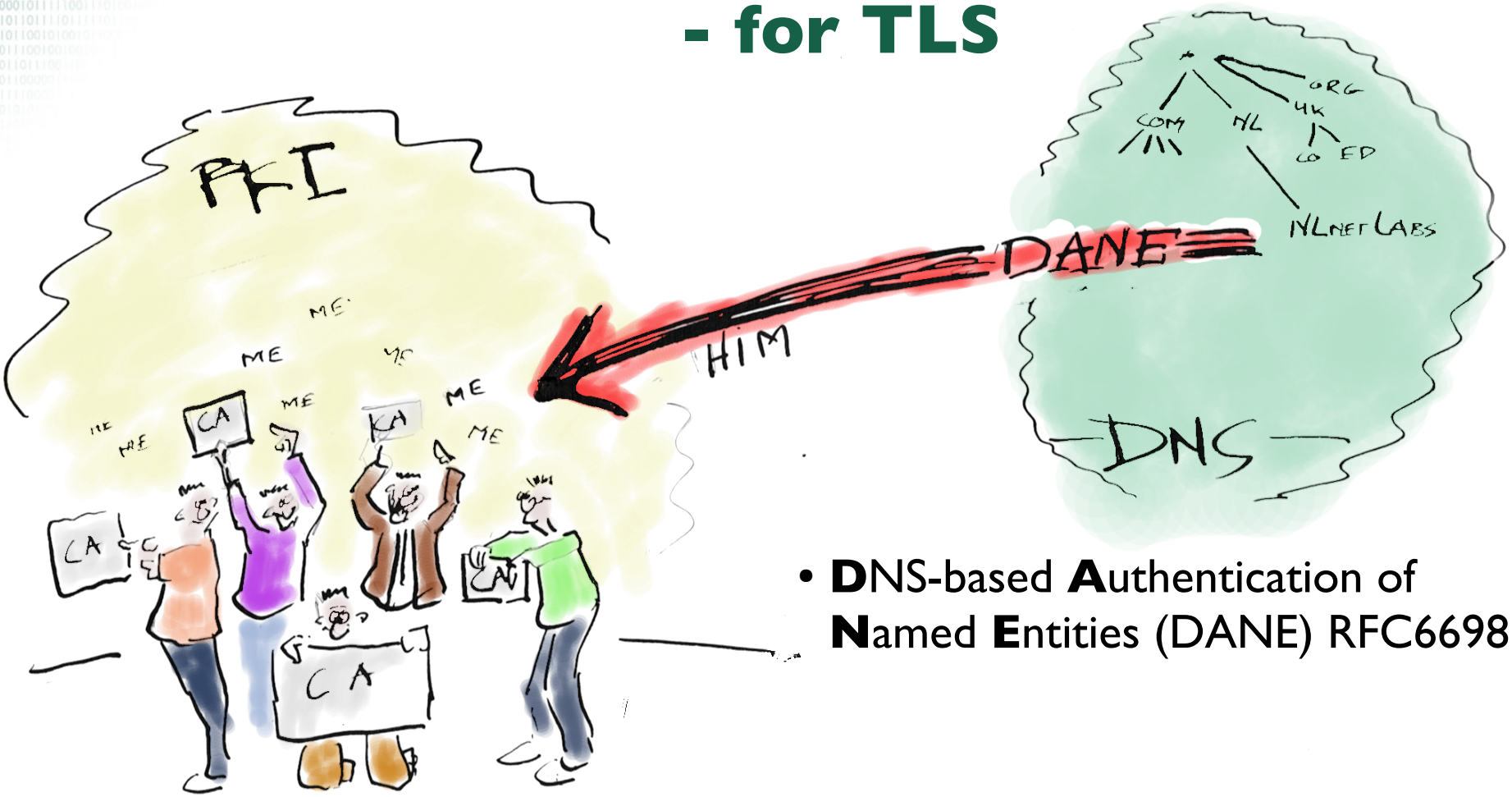


- How is the remote public key authenticated?

DNSSEC - for applications - for TLS

- Through Certificate Authorities (CAs), maintained in OS, browser...
- Every CA is authorized to authenticate for ***any*** name (as strong as the weakest link)
- There are 650+ CAs (See https://www.eff.org/observatory)

DNSSEC - for applications - for TLS



- **D**NS-based **A**uthentication of **N**amed **E**ntities (DANE) RFC6698

Why?
Issues with the system stub

- DNSSEC!
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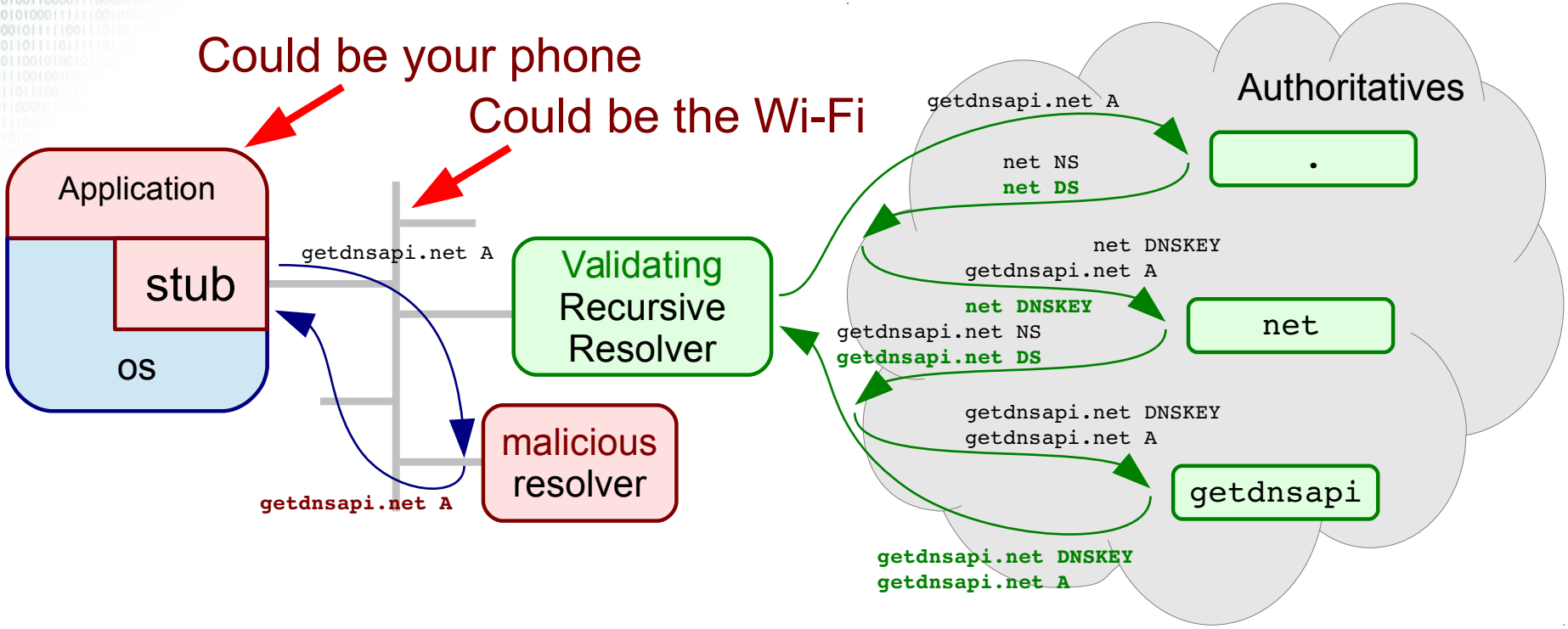
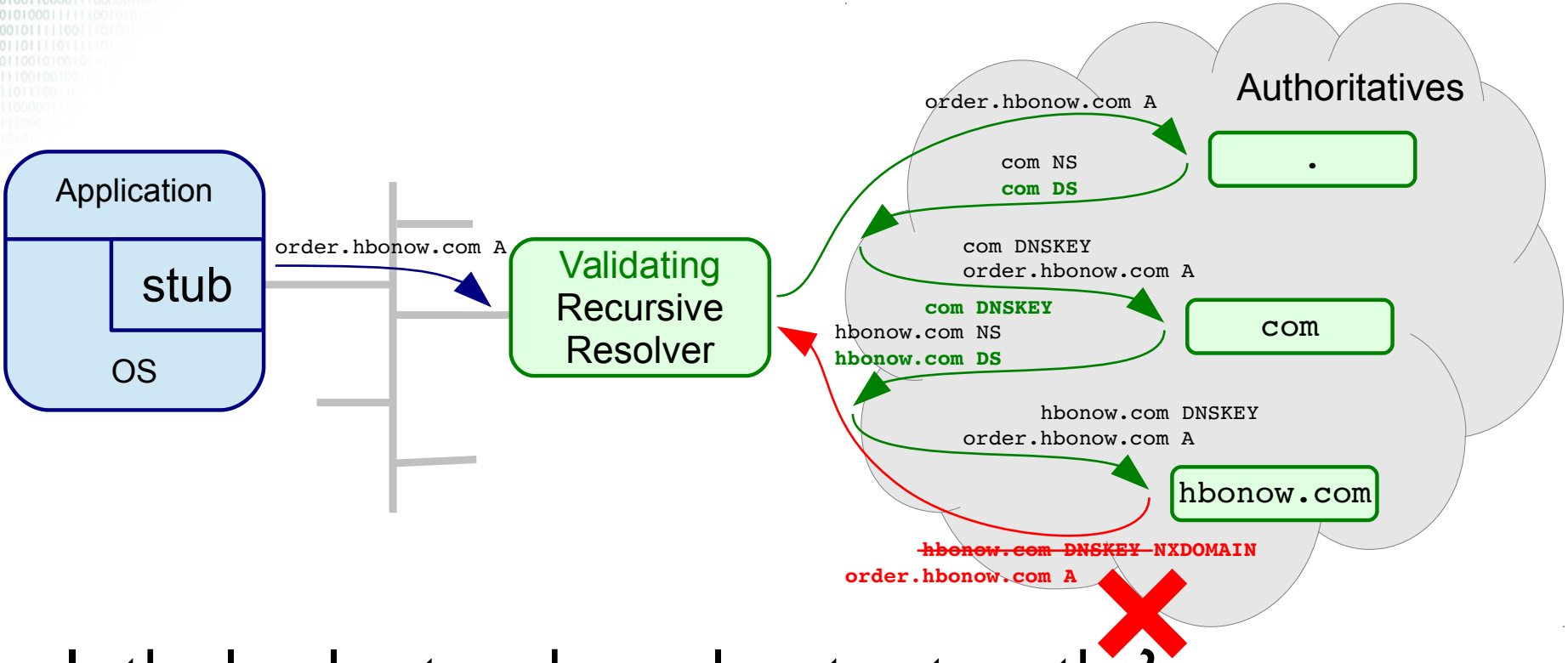
- Yes, but it does so by giving (origin) authenticated answers
- *How does this concern the stub?*
  - Authentication is interesting for applications
  - DNSSEC deployment is not completely finished yet

DNSSEC - the first mile



- Is the local network resolver trustworthy?

DNSSEC - the first mile



- Is the local network resolver trustworthy?
- Who's to blame?

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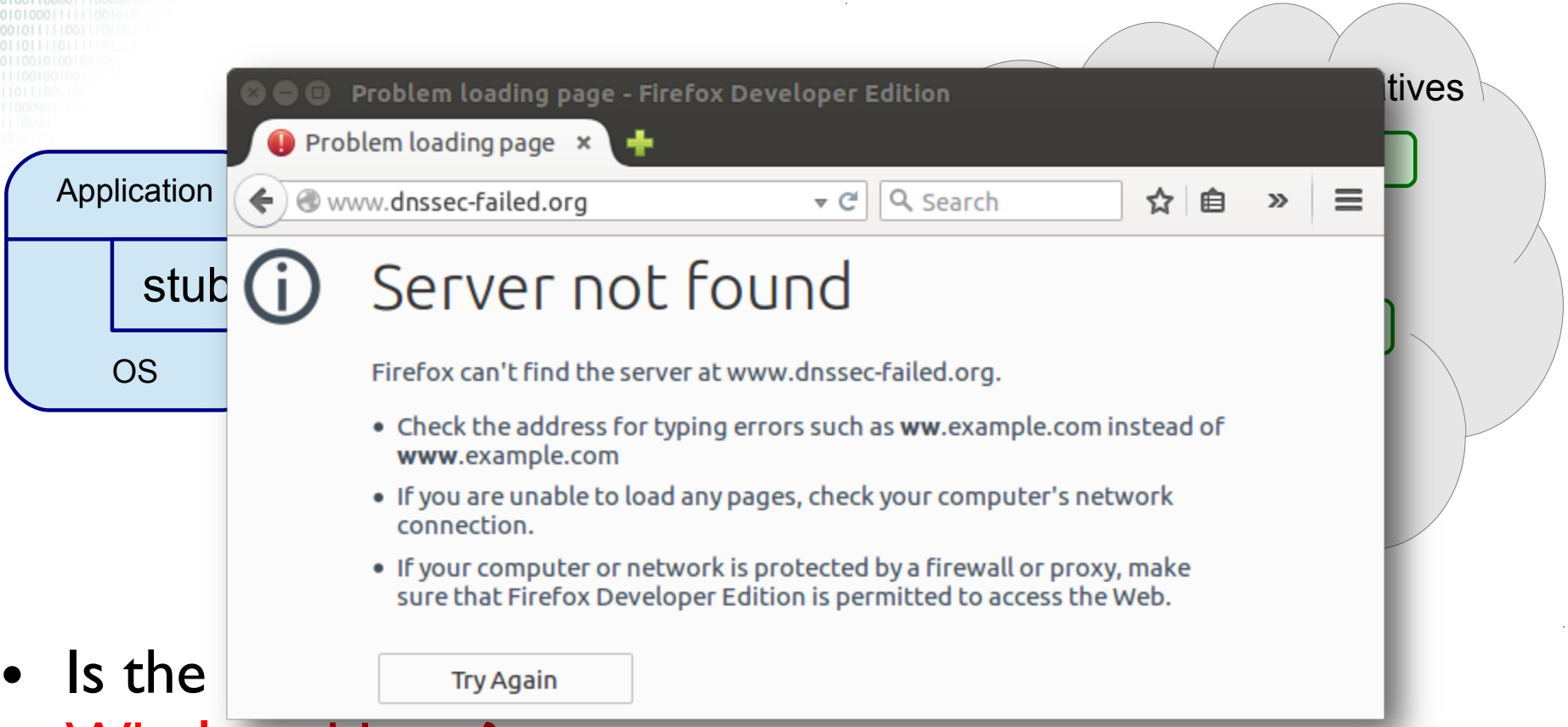

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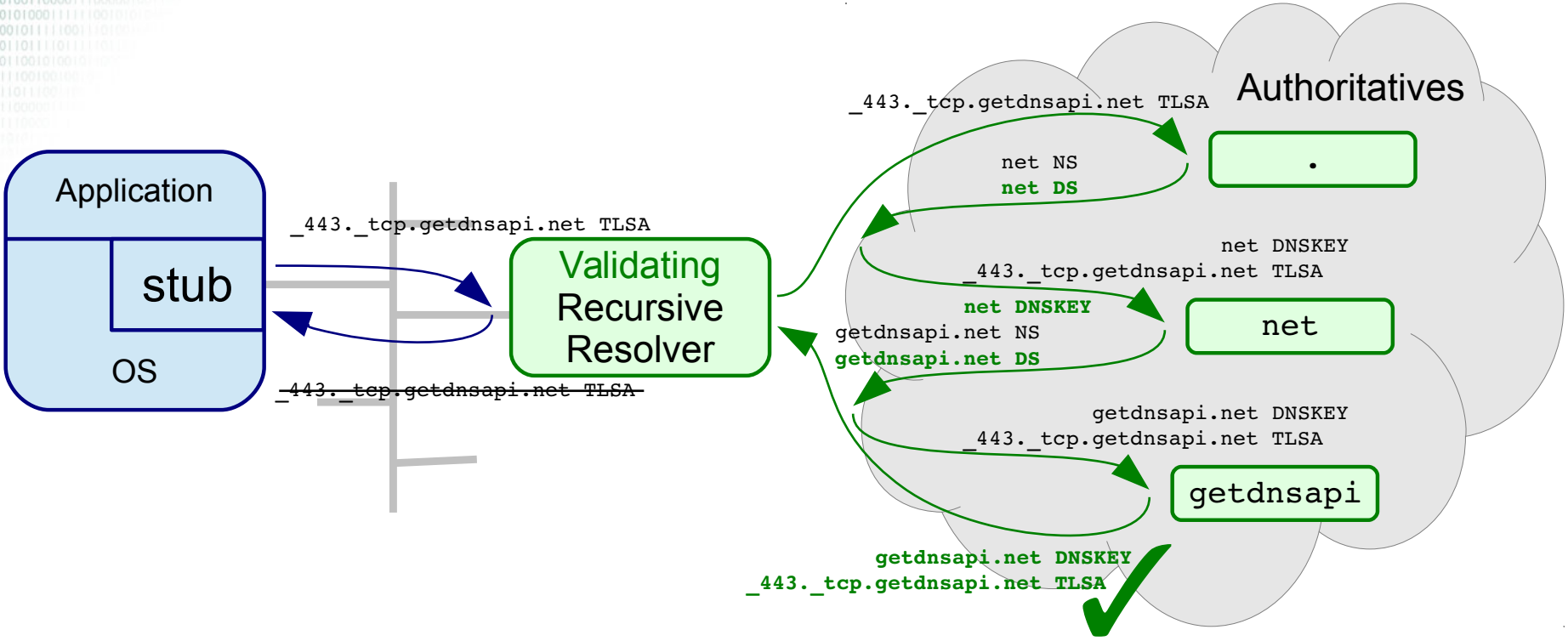

- Is the local network resolver trustworthy?
- Who's to blame?
- Application does not know an answer is secure
  (AD bit not given with `getaddrinfo()`)

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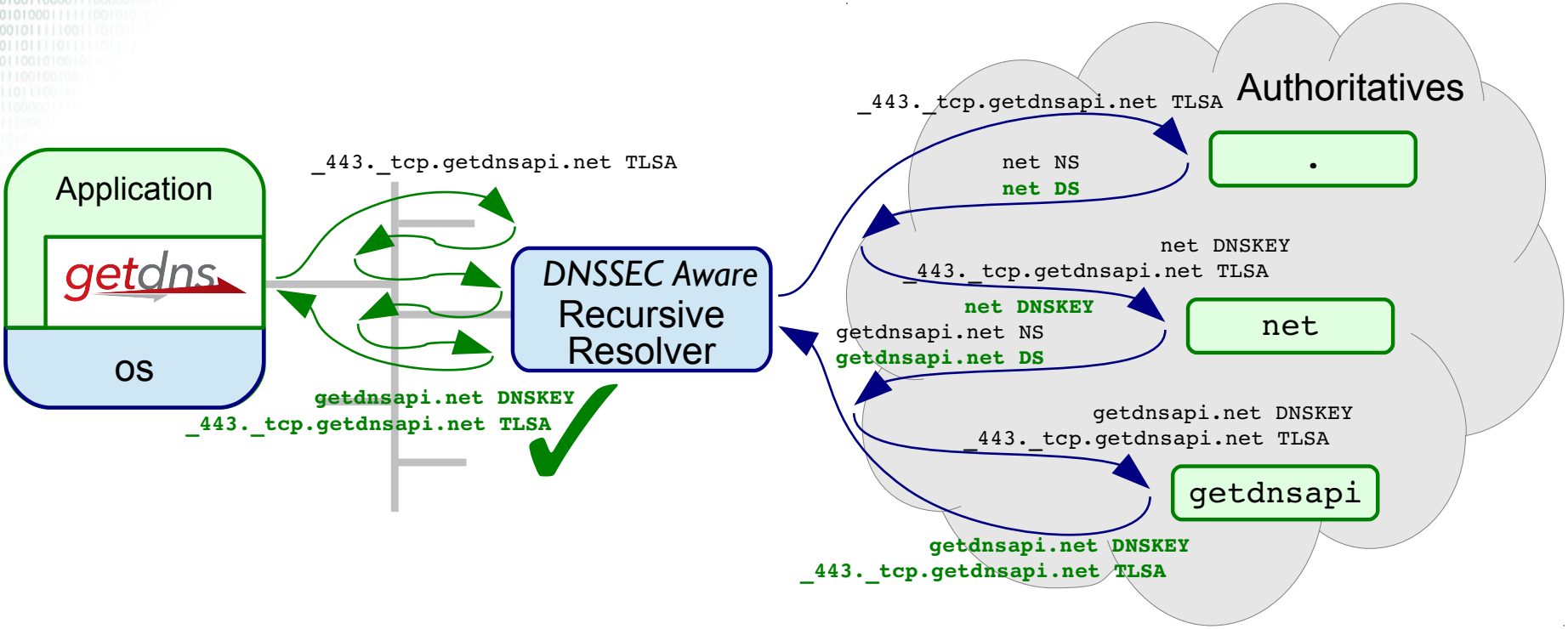

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- Network resolver does not need to validate

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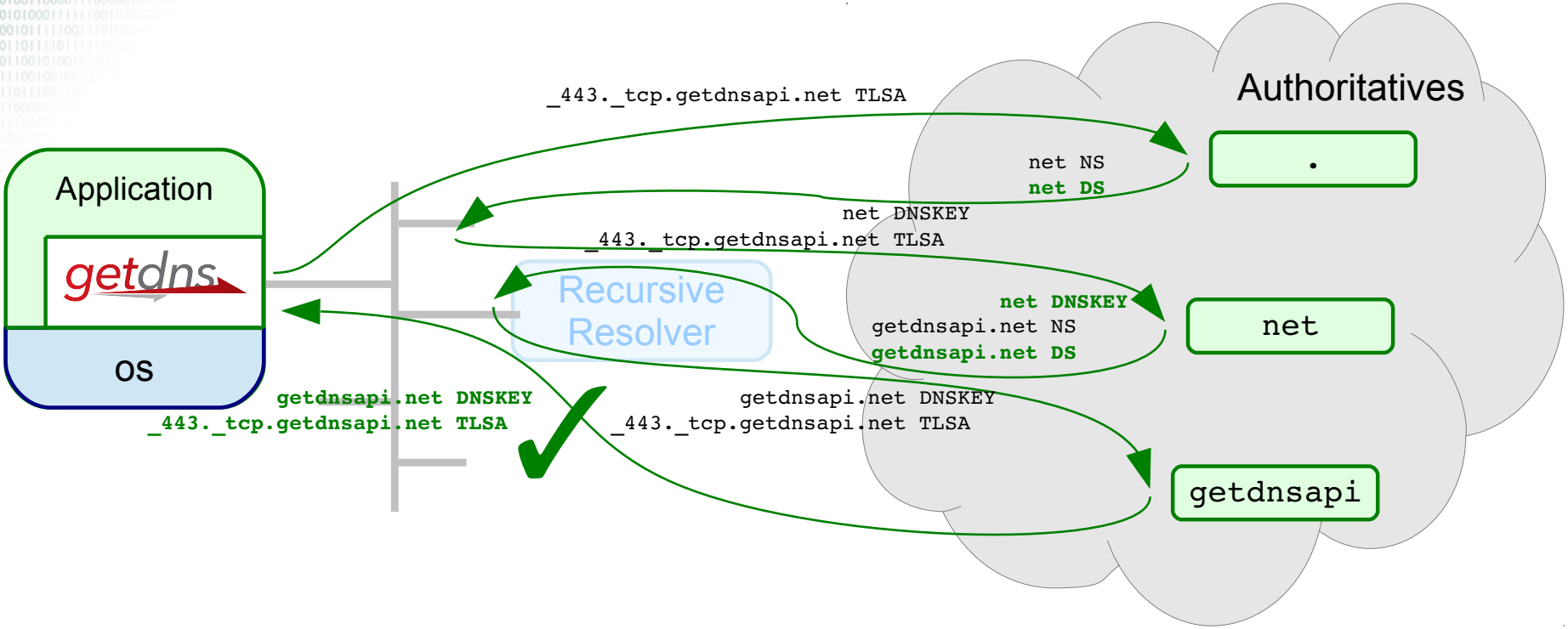
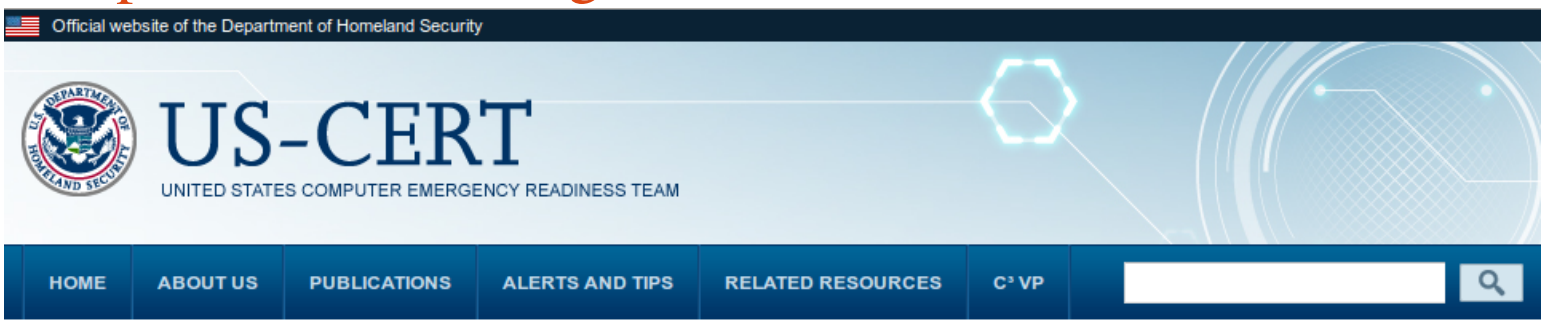


- Is the local network resolver trustworthy?
- Who's to blame?
- Application does not know an answer is secure
- Network resolver does not need to validate
- And when it is not even DNSSEC-aware

DNSSEC - the first mile

- https://www.us-cert.gov/ncas/alerts/TA15-240A



Configure enterprise perimeter network devices to block all outbound User Datagram Protocol (UDP) and Transmission Control Protocol (TCP) traffic to destination port 53, except from specific, authorized DNS servers (including both authoritative and caching/forwarding name servers).

- Is
- W
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From: https://tools.ietf.org/html/draft-ietf-dane-smtp-with-dane-19

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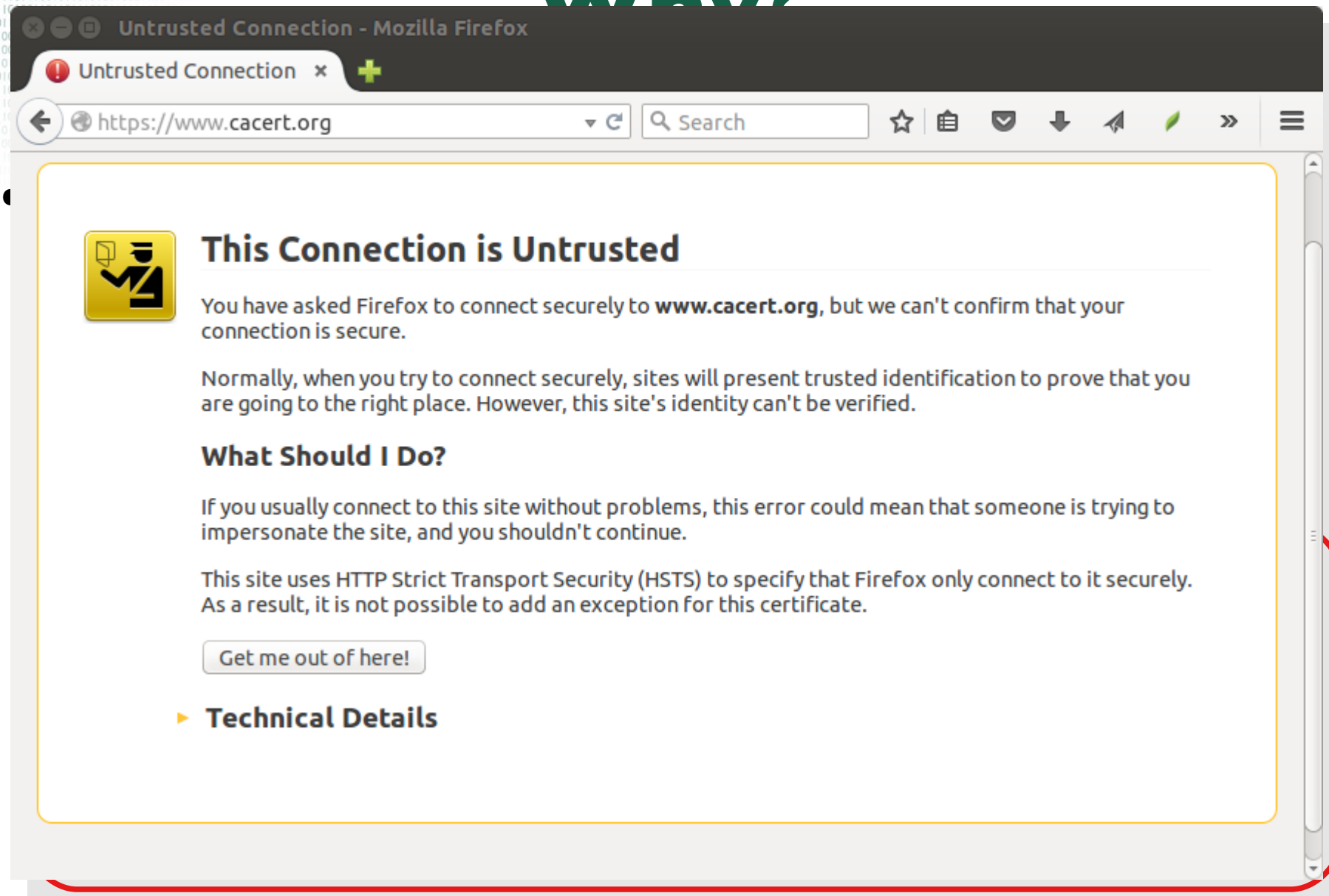
Untrusted Connection - Mozilla Firefox
Untrusted Connection
https://www.cacert.org
Search
This Connection is Untrusted
You have asked Firefox to connect securely to www.cacert.org, but we can't confirm that your connection is secure.
Normally, when you try to connect securely, sites will present trusted identification to prove that you are going to the right place. However, this site's identity can't be verified.
What Should I Do?
If you usually connect to this site without problems, this error could mean that someone is trying to impersonate the site, and you shouldn't continue.
This site uses HTTP Strict Transport Security (HSTS) to specify that Firefox only connect to it securely. As a result, it is not possible to add an exception for this certificate.
Get me out of here!
Technical Details

Why?
Issues with the system stub

- DNSSEC!
- (Inband policy assertion susceptible to downgrade attacks)

```
220 getdns.nlnetlabs.nl ESMTP Sendmail 8.14.9/8.14.9; Tue, 1 Sep 2015 11:37:51 +0200 (CEST)
EHLO nlnetlabs.nl
250-getdns.nlnetlabs.nl Hello [IPv6:2a04:b900:0:1:14bc:270e:5c12:6e7b], pleased to meet you
250-ENHANCEDSTATUSCODES
250-STARTTLS
250-PIPELINING
250-8BITMIME
```

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Why?
Issues with the system stub

- https://github.com/phicoh/openssh-getdns/tree/getdns
- Validates `SSHFP` with a trust anchor on a default (configurable) location
  (opposed to checking `AD` bit or using non-standard `resolv.conf` option)

```
--with-trust-anchor=KEYFILE
                        Default location of the trust anchor file.
                        [default=SYSCONFDIR/unbound/getdns-root.key]
```

- Manage default trust anchor with `unbound-anchor`

Bootstrap encrypted channel (TLS)
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Why?
Motivation by API (spec) designers

- From Design considerations
  - … *There are other DNS APIs available, but there has been very little uptake …*
  - … *talking to application developers …*
  - … *the APIs were developed by and for DNS people, not application developers …*
- Goal
  - … *API design from talking to application developers …*
  - … *create a natural follow-on to getaddrinfo() ...*

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Motivation by API (spec) designers

- Goal

  … *API design from talking to application developers* …

  … *create a natural follow-on to getaddrinfo()* ...

- Current spec: https://getdnsapi.net/spec.html
- Originally edited by Paul Hoffman (publiced April 2013)
- Mailing-list : https://getdnsapi.net/mailman/listinfo/spec
  Archive : https://getdnsapi.net/pipermail/spec/
- Maintained by the getdnsapi.net team since October 2014

Features (& implementation)

- Both stub and full recursive modes (recusive by default)
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- Delivers validated DNSSEC even in stub mode (off by default)
  - libldns still (but only) used for `ldns_verify_rrsig()` & `ldns_rr_compare_ds_dnskey()`
  - Plan to lift those out before coming major release

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- Resolves names and gives fine-grained access to the response with a response dict type:
  - Easy to inspect: `getdns_pretty_print_dict()`

Features (& implementation)

- Bo fault)
- D y)
- R t)

```
{
  "answer_type": GETDNS_NAMETYPE_DNS,
  "status": GETDNS_RESPSTATUS_GOOD,
  "canonical_name": <bindata of "www.getdnsapi.net.">,
  "just_address_answers":
  [ { "address_data": <bindata for 185.49.141.37>,
      "address_type": <bindata of "IPv4">
    },
    { "address_data": <bindata for 2a04:b900:0:100::37>,
      "address_type": <bindata of "IPv6">
    }
  ],
  "replies_full":
  [
    <bindata of 0x000081800001000200040001037777777...>,
    <bindata of 0x000081800001000200040009037777777...>
  ],
  "replies_tree":
  [
    { ... first reply ... },
    { ... second reply ... },
```

Features (& implementation)

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- D y)
- R t)

```
"replies_tree":
[
  { "header" : { "qdcount": 1, "ancount": 2, "rd": 1, "ra": 1,
                 "opcode": GETDNS_OPCODE_QUERY,
                 "rcode" : GETDNS_RCODE_NOERROR, ... },

    "question": { "qname" : <bindata for www.getdnsapi.net.>,
                  "qtype" : GETDNS_RRTYPE_A
                  "qclass": GETDNS_RRCLASS_IN, },

    "answer"  : [ { "name" : <bindata for www.getdnsapi.net.>,
                    "type" : GETDNS_RRTYPE_A,
                    "class": GETDNS_RRCLASS_IN,
                    "rdata": { "ipv4_address": <bindata for 185.49.141.37>,
                               "rdata_raw": <bindata of 0xb9318d25> },
                  }, ...
    "authority": [ ... ],
    "additional": [],
    "canonical_name": <bindata of "www.getdnsapi.net.">,
    "answer_type": GETDNS_NAMETYPE_DNS
  },
  { "header" : { ...
```

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- Both stub and full recursive modes (recusive by default)
  - Full recursive via libunbound
  - `--enable-stub-only` configure option (no libunbound dependency)
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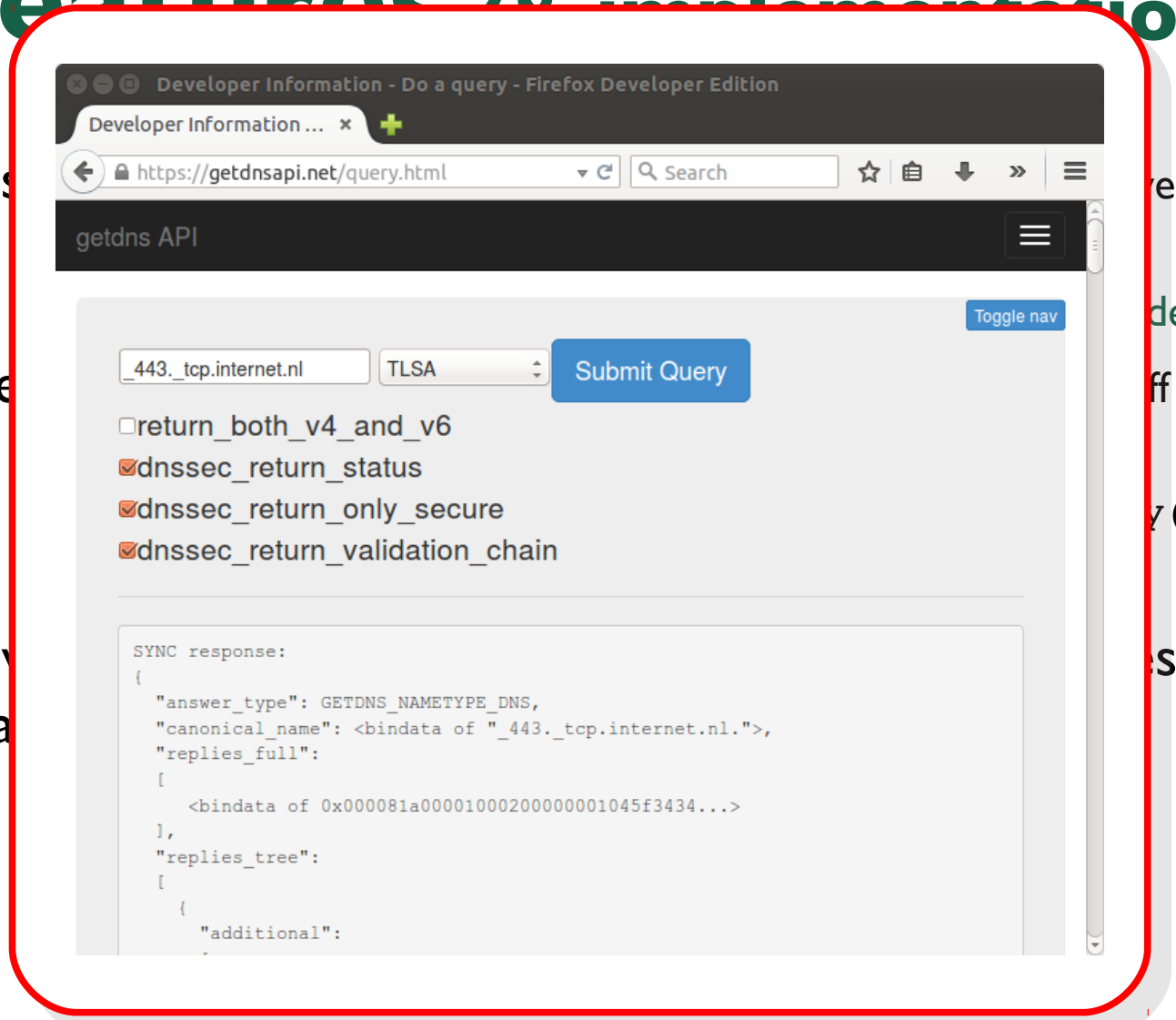
- Resolves names and gives fine-grained access to the response with a response dict type:
  - Easy to inspect: `getdns_pretty_print_dict()`
    - `getdns_print_json_dict()`
    - `getdns_print_json_list()`
  - Maps well to popular modern scripting languages

Features (& implementation)

- Both s… …e by default)
- Delive… …dependency)
  …ff by default)
- Resol… …sponse with a…
  - Have a look at https://getdnsapi.net/query.html



Features (& implementation)
DNSSEC extensions

- On a per query basis by setting extensions
- `dnssec_return_status`
  - Returns security assertion. Omits bogus answers
  - ```
    { # This is the response object
      "replies_tree":
      [
        { # This is the first reply
          "dnssec_status": GETDNS_DNSSEC_INSECURE,
    ```
  - `"dnssec_status"` can be `GETDNS_DNSSEC_SECURE`, `GETDNS_DNSSEC_INSECURE` or `GETDNS_DNSSEC_INDETERMINATE`

- `void getdns_context_set_return_dnssec_status(context, enable);`
    ```

Features (& implementation)
DNSSEC extensions

- `dnssec_return_only_secure` (The DANE extension)
  - Returns security assertion. Omits bogus and insecure answers
  - ```
    { # This is the response object
      "replies_tree": [],
      "status": GETDNS_RESPSTATUS_NO_SECURE_ANSWERS,
    ```
  - Or `"status": GETDNS_RESPSTATUS_ALL_BOGUS_ANSWERS`
    ```

Features (& implementation)
DNSSEC extensions

- dnssec_return_validation_chain

```
– { # Response object
    "validation_chain":
    [ { "name" : <bindata for .>, "type": GETDNS_RRTYPE_DNSKEY, ... },
      { "name" : <bindata for .>, "type": GETDNS_RRTYPE_DNSKEY, ... },

      { "name" : <bindata for .>, "type": GETDNS_RRTYPE_RRSIG,
        "rdata": { "signers_name": <bindata for .>,
                   "type_covered": GETDNS_RRTYPE_DNSKEY, ... }, ... },

      { "name" : <bindata for net.>, "type": GETDNS_RRTYPE_DS, ... },
      { "name" : <bindata for net.>, "type": GETDNS_RRTYPE_RRSIG,
        "rdata": { "signers_name": <bindata for .>,
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```

- Can be combined with dnssec_return_status and dnssec_return_only_secure
- No replies omitted! Only now "dnssec_status" can be GETDNS_DNSSEC_BOGUS

Features (& implementation)

- Asynchronous modus operandi is the default
  - From specification section 1.8:
    ... there is no standard method to set the event base in the DNS API: those are all added as extensions ...

    ... Each implementation of the DNS API will specify an extension function that tells the DNS context which event base is being used.
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  - Or without extension: `getdns_context_run()`

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- Set custom memory management functions
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  - Beware of heartbleed!
- Hook your app into getdns
  - Hook into the applications native event base
    (nodejs bindings & iOS grand central dispatch POC example)

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hop-by-hop communication options (for stub)

- `add_opt_parameters` extension
  - To set arbitrary EDNS0 options
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- Setting of "tried in turn" transport lists
  - `GETDNS_TRANSPORT_UDP`
  - `GETDNS_TRANSPORT_TCP`
  - `GETDNS_TRANSPORT_TLS` (https://tools.ietf.org/html/draft-ietf-dprive-start-tls-for-dns-01)

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  - `getdns_context_set_dns_transport_list();`
- Special Cookies/TCP/TLS only open resolver for experimentation available on 2a04:b900:0:100::38 and 185.49.141.38

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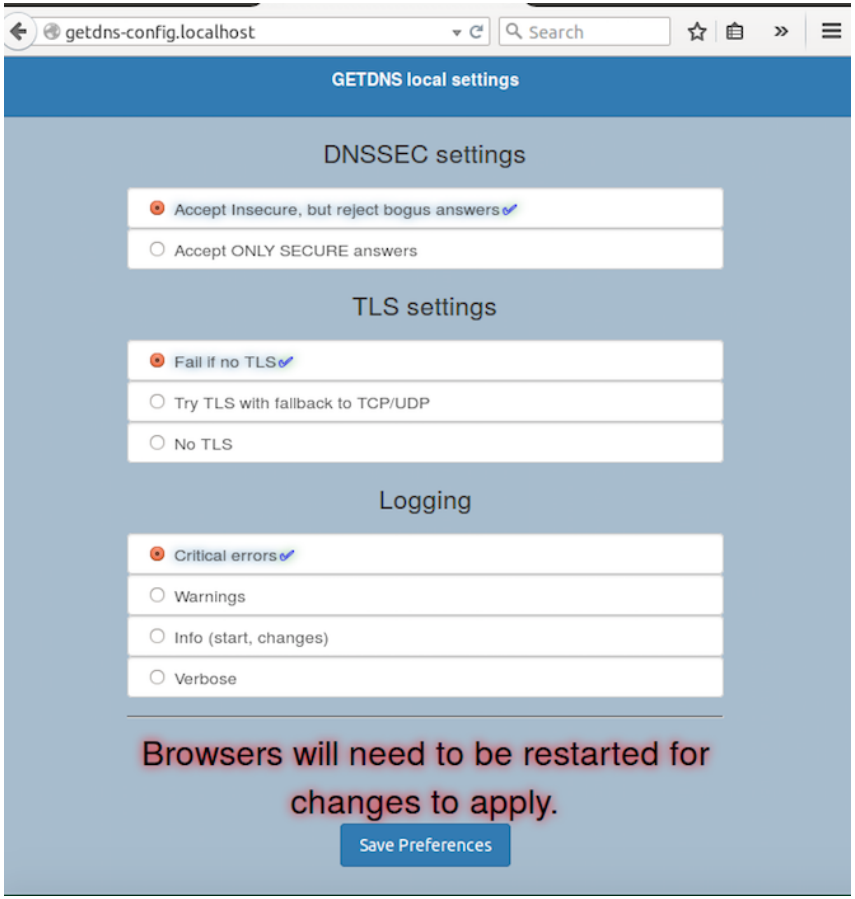

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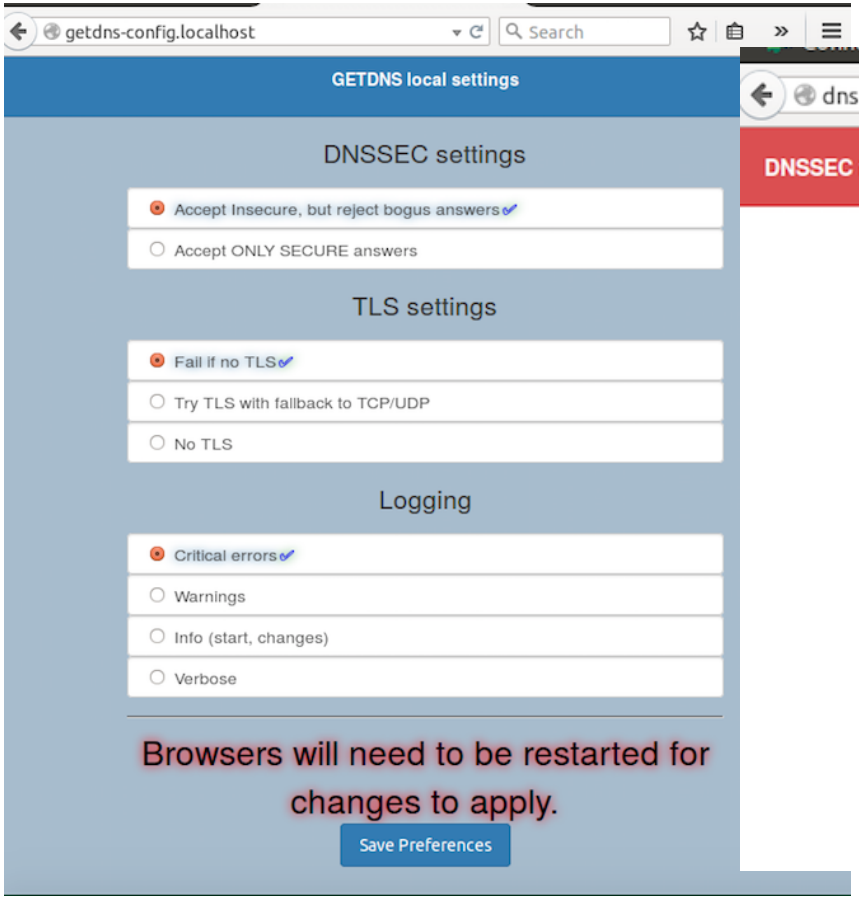
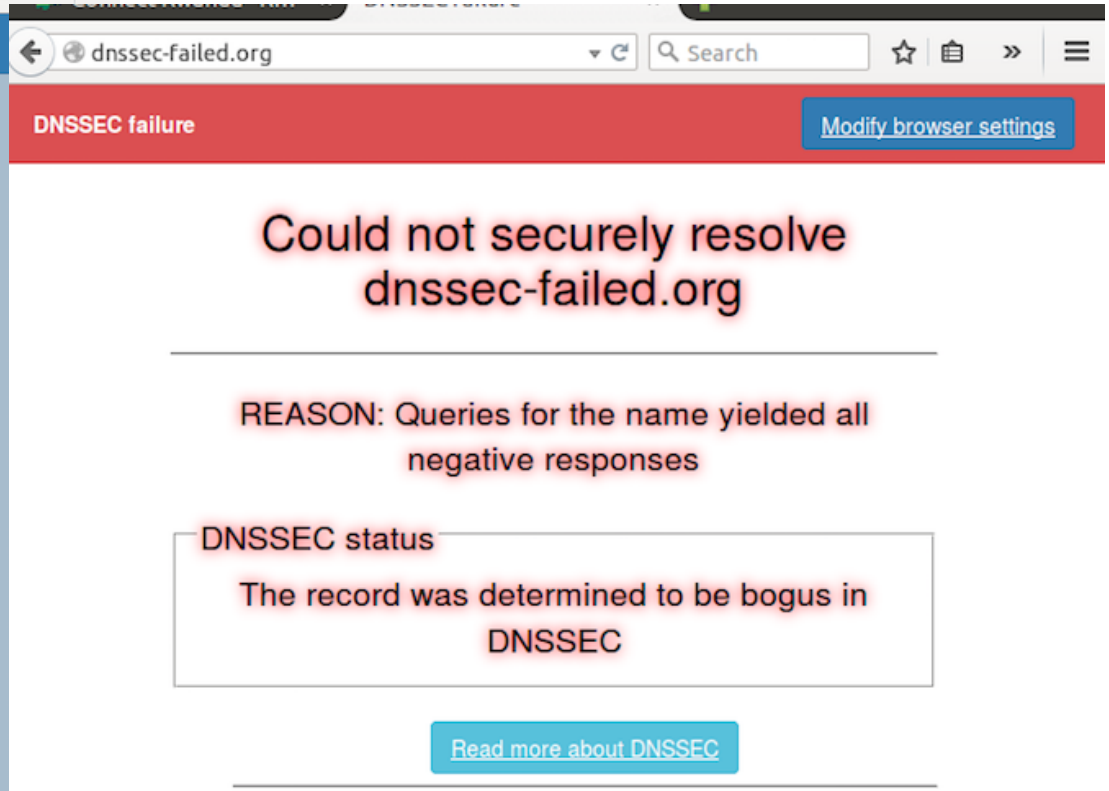
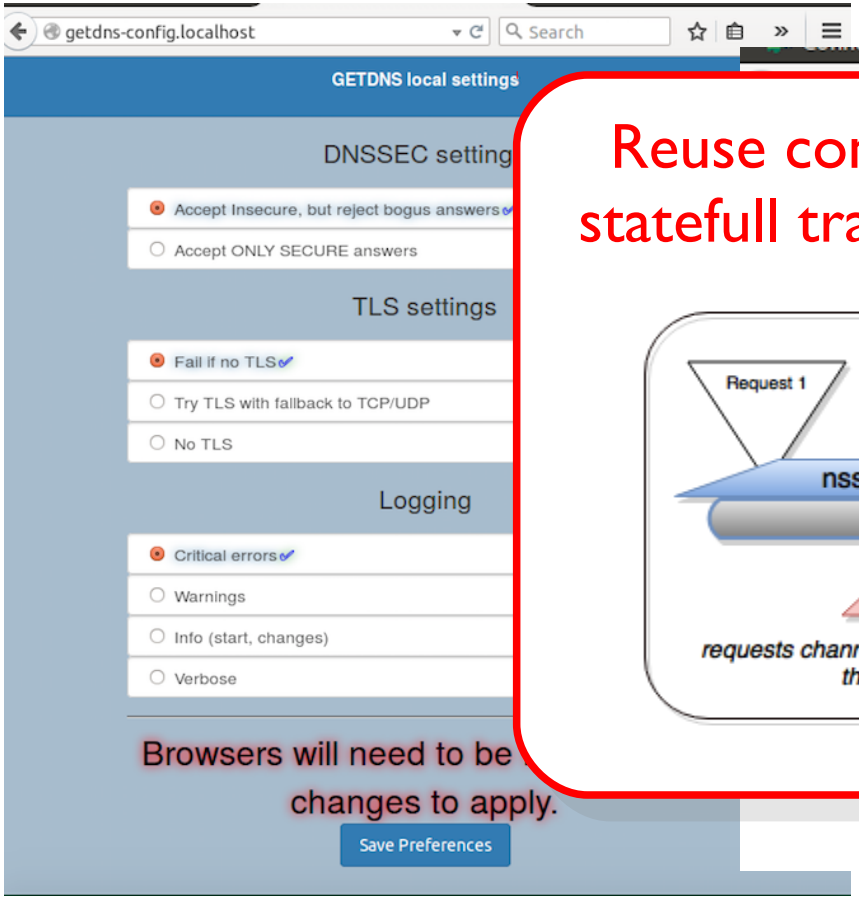




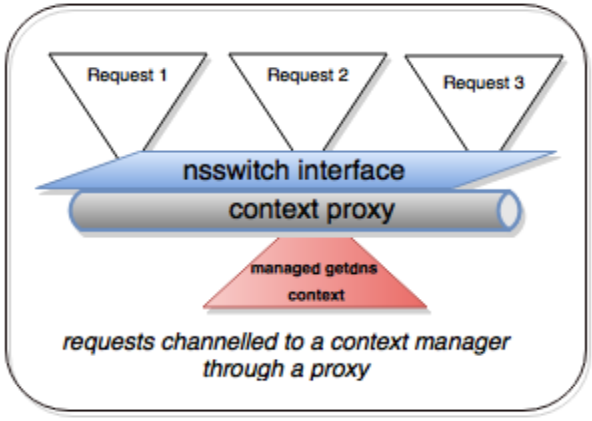
Features (& implementation)

hop-by-hop communication options (for stub)

- nsswitch module! by Theogene H. Bucuti, University of North Texas and Gowri Visweswaran and Allison Mankin, Verisign Labs



Reuse context to reuse statefull transport sessions



Bindings

- **nodejs** by Neel Goyal (integrated with native async event loop)
- https://github.com/getdnsapi/getdns-node

- **python** by Melinda Shore
  https://github.com/getdnsapi/getdns-python-bindings

- **java** by Vinay Soni, Prithvi Ranganath and Sanjay Mahurpawar
  https://github.com/getdnsapi/getdns-java-bindings

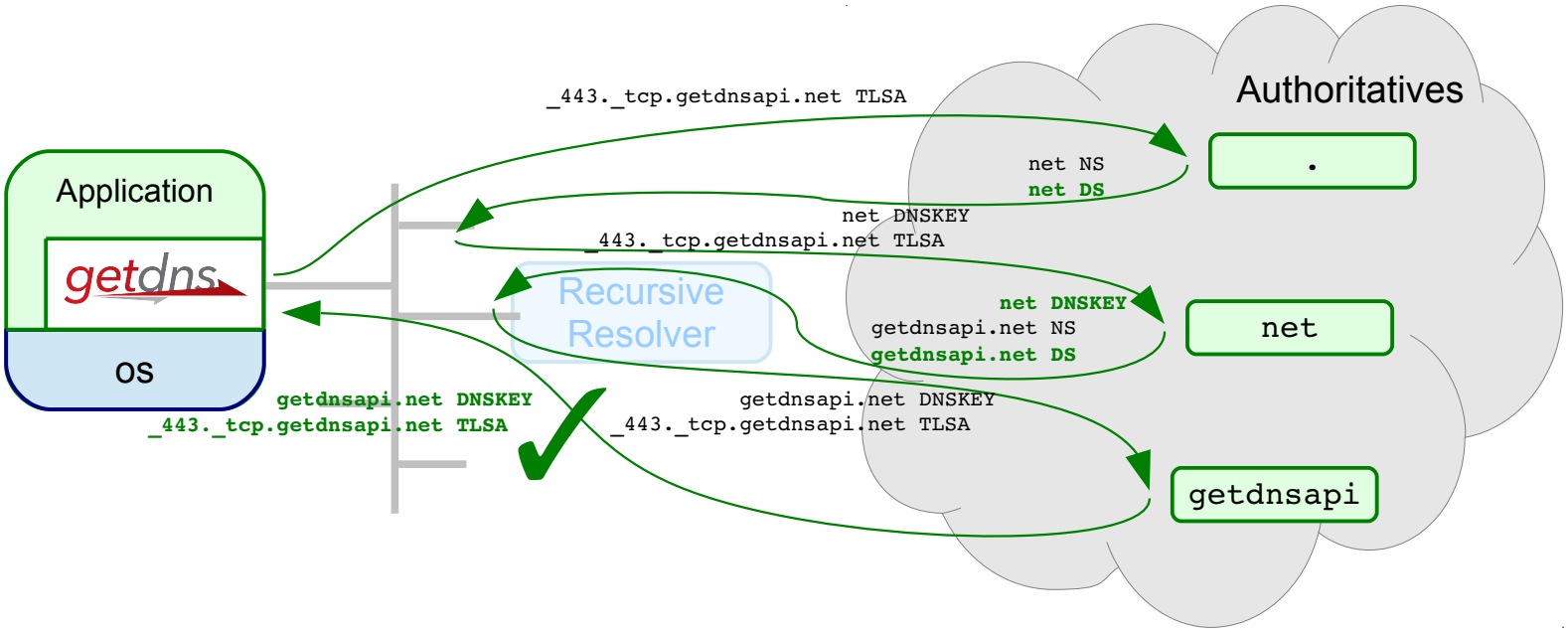
- **php** by Scott Hollenbeck
  https://github.com/getdnsapi/getdns-php-bindings

Example query
full recursion

```
from getdns import *

ctx = Context()
ext = { "dnssec_return_only_secure": EXTENSION_TRUE }
res = ctx.general( '_443._tcp.getdnsapi.net', RRTYPE_TLSA, ext)

if res['status'] == RESPSTATUS_GOOD:
        # Process TLSA RRs
```



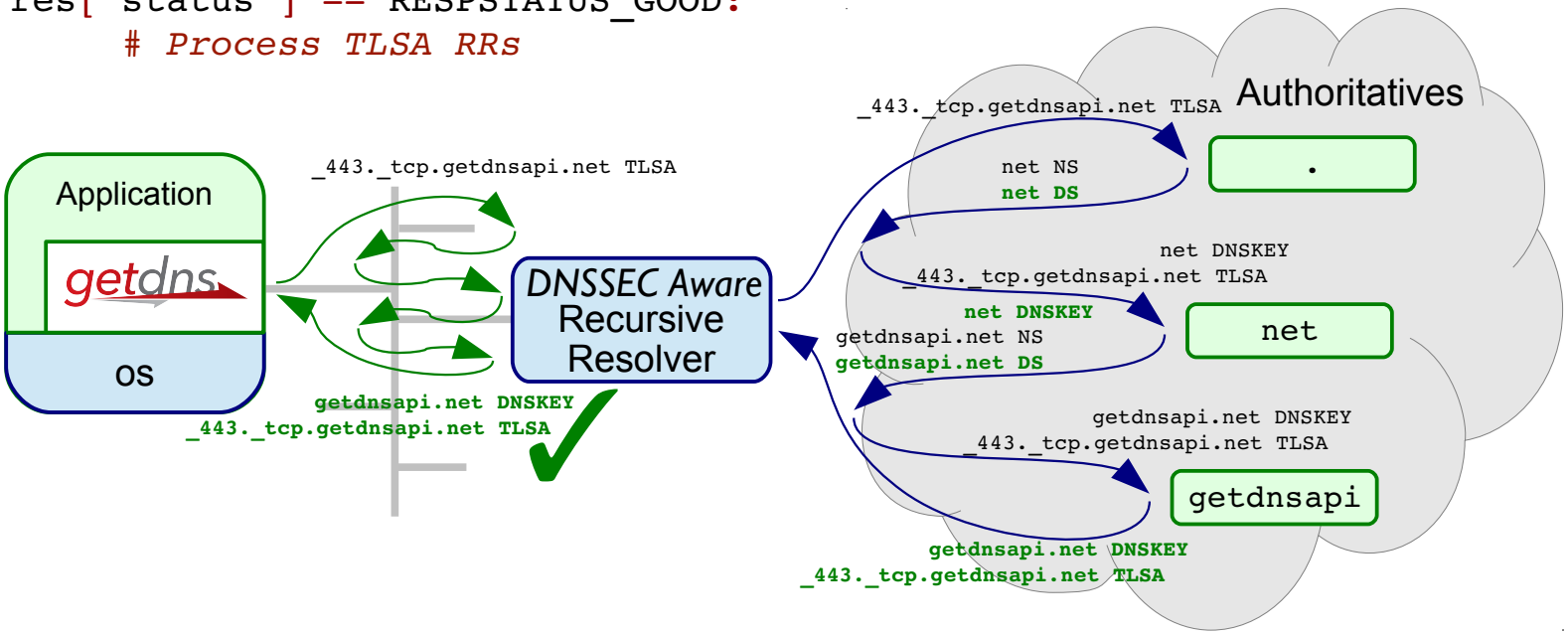
Example query
stub mode

```
from getdns import *

ctx = Context()
ctx.resolution_type = RESOLUTION_STUB

ext = { "dnssec_return_only_secure": EXTENSION_TRUE }
res = ctx.general( '_443._tcp.getdnsapi.net', RRTYPE_TLSA, ext)

if res['status'] == RESPSTATUS_GOOD:
        # Process TLSA RRs
```



Example query
Fall back

```
from getdns import *

ctx = Context()
ctx.resolution_type = RESOLUTION_STUB

ext = { "dnssec_return_only_secure": EXTENSION_TRUE }
res = ctx.general('_443._tcp.getdnsapi.net', RRTYPE_TLSA, ext)

if res['status'] == RESPSTATUS_ALL_BOGUS_ANSWERS:
        ctx.resolution_type = RESOLUTION_RECURSING
        res = ctx.general('_443._tcp.getdnsapi.net', RRTYPE_TLSA, ext)

if res['status'] == RESPSTATUS_GOOD:
        # Process TLSA Rrs
```

Example query
Fall back

```
from getdns import *

ctx = Context()
ctx.resolution_type = RESOLUTION_STUB

ext = { "dnssec_return_only_secure": EXTENSION_TRUE }
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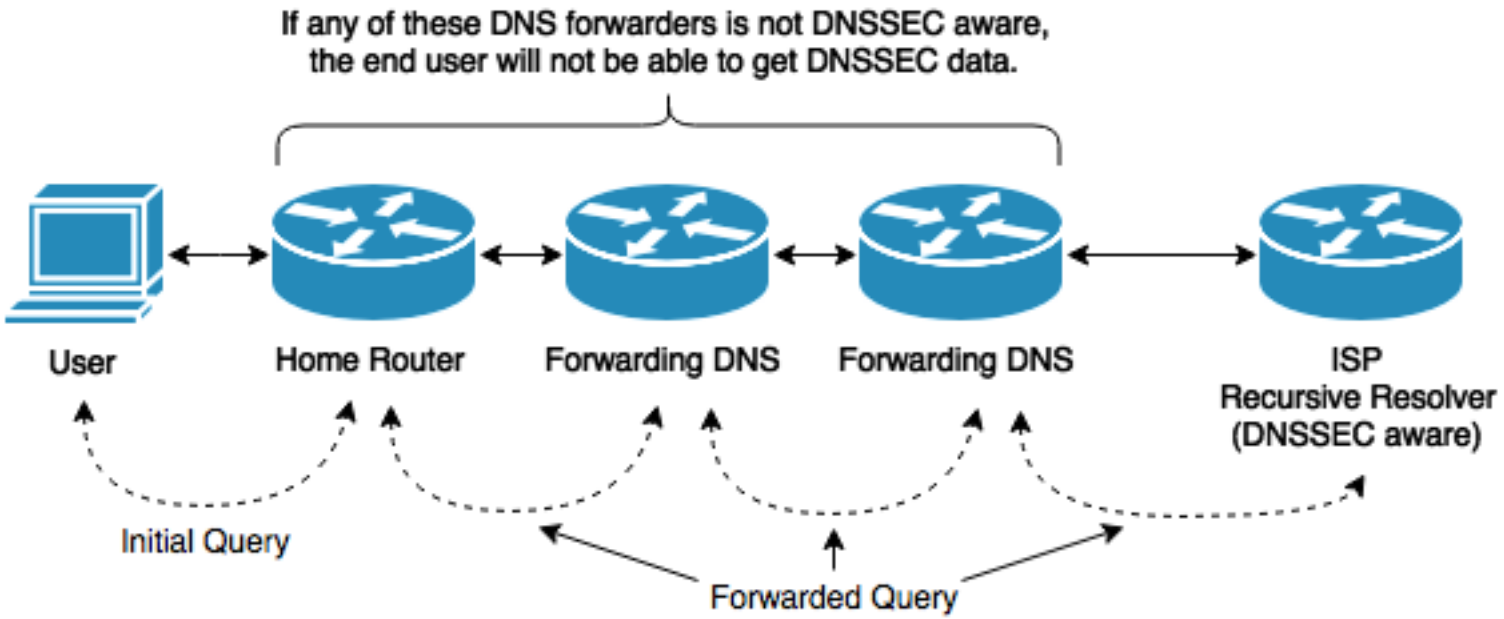
        # Process TLSA Rrs
```

See also : https://tools.ietf.org/html/draft-ietf-dnsop-dnssec-roadblock-avoidance

And : Discovery method for a DNSSEC validating stub resolver,
Xavier Torrent Gorjón, University of Amsterdam, July 2015
https://nlnetlabs.nl/downloads/publications/os3-2015-rp2-xavier-torrent-gorjon.pdf

Example query
Fall back

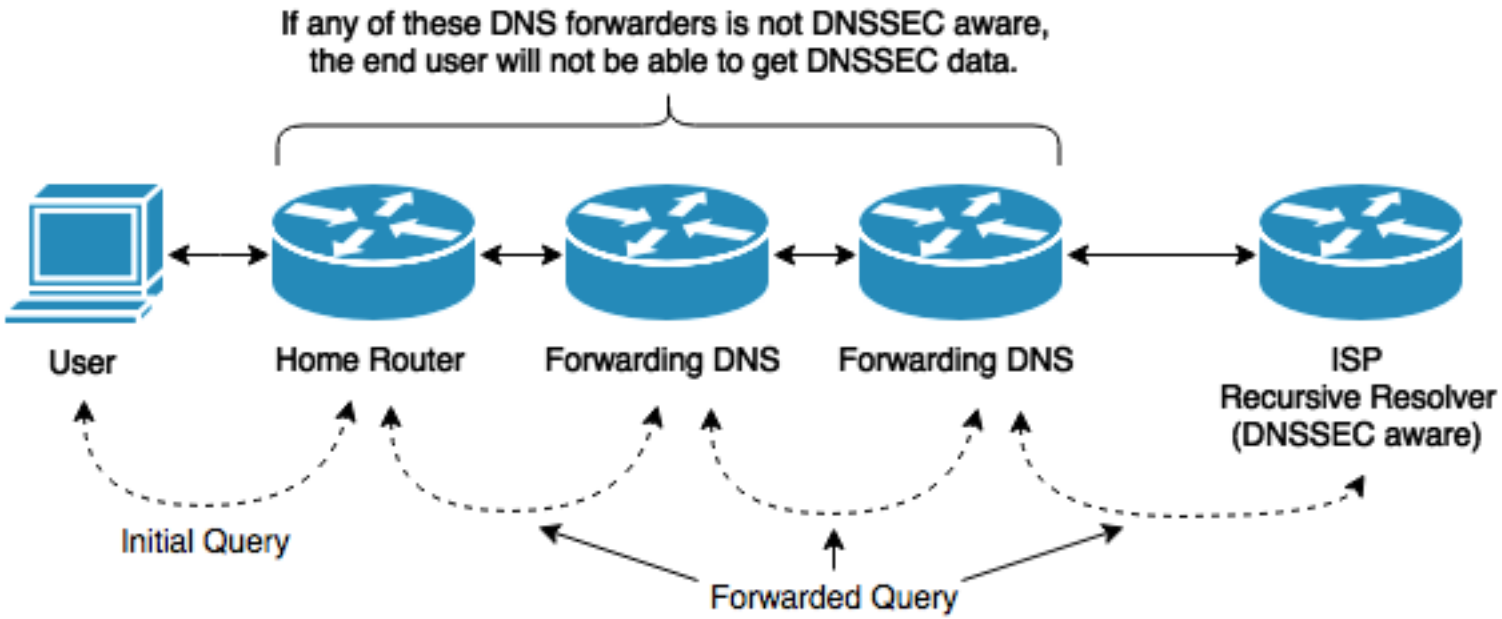
```
from
ctx
ctx.
ext
res
if r
if r
```



See a

And

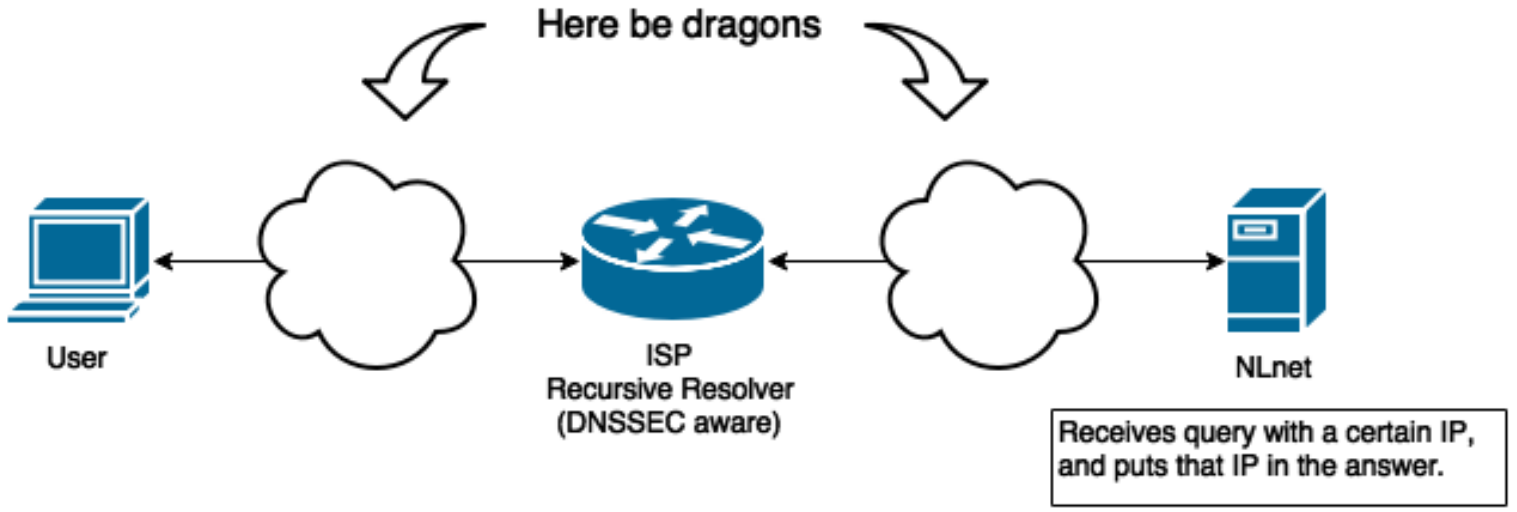
Example query
Fall back



Measurements done at > 8000 RIPE ATLAS probes, +- 10.000 results

64.71% is able to deliver verifiable positive answer
55.67% is able to deliver verifiable negative answer
29.51% is able to deliver verifiable wildcard answer

Example query
Fall back



Query for an A record to echo.v4.nlnetlabs.nl.
Server replies with the IP of the recursive resolver!

80% is able to deliver verifiable positive answer

Example query
Fall back

```
from getdns import *

ctx = Context()
ctx.resolution_type = RESOLUTION_STUB

ext = { "dnssec_return_only_secure": EXTENSION_TRUE }
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        res = ctx.general('_443._tcp.getdnsapi.net', RRTYPE_TLSA, ext)

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        # Process TLSA Rrs
```

- Roadblock avoidance extension? Nice to have for the nsswitch module!

Example query
Fall back

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- Roadblock avoidance extension? Nice to have for the nsswitch module!
- Alternatively bypass DNS network operation completely with: https://tools.ietf.org/html/draft-shore-tls-dnssec-chain-extension

Example query
Fall back

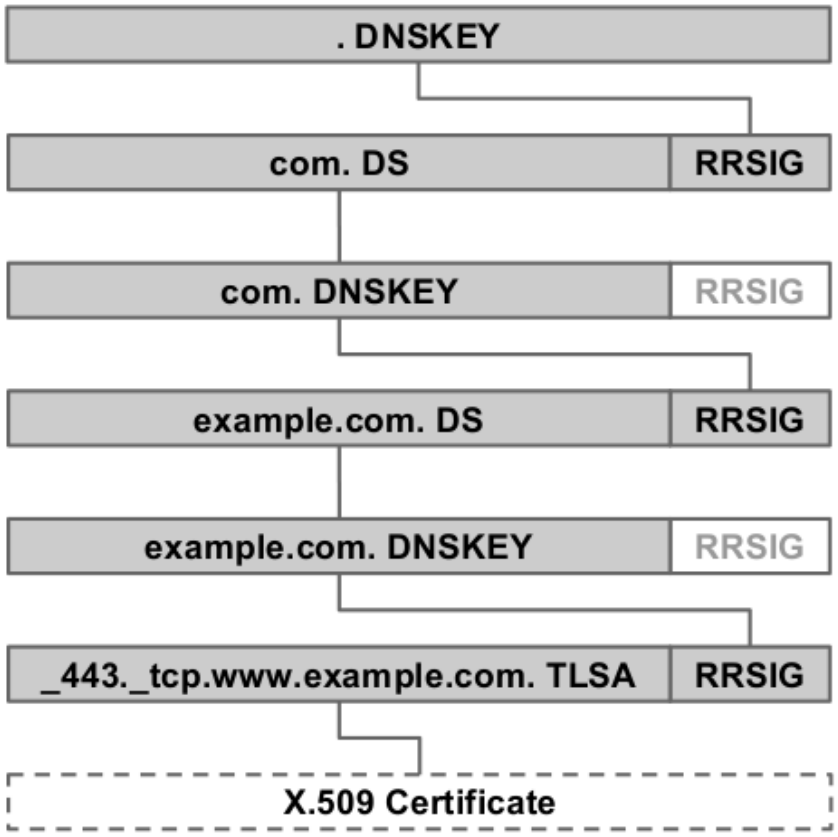
```
from getdns impor

ctx = Context()
ctx.resolution_

ext = { "dnssec
res = ctx.gener

if res['status'
        ctx.res
        res = c                                          SA, ext)

if res['status'
        # Proce
```



- Roadblock av dule!
- Alternatively
  https://tools.ie

Example query
Fall back

```
from getdns import *

ctx = Context()
ctx.resolution_type = RESOLUTION_STUB

ext = { "dnssec_return_only_secure": EXTENSION_TRUE }
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        ctx.resolution_type = RESOLUTION_RECURSING
        res = ctx.general('_443._tcp.getdnsapi.net', RRTYPE_TLSA, ext)

if res['status'] == RESPSTATUS_GOOD:
        # Process TLSA Rrs
```

- Roadblock avoidance extension? Nice to have for the nsswitch module!
- Alternatively bypass DNS network operation completely with: https://tools.ietf.org/html/draft-shore-tls-dnssec-chain-extension
- (good application of the `dnssec_return_validation_chain` extension!)

Example query
process records

```
# Correctly query and process DANE records


if res['status'] == RESPSTATUS_GOOD:
        # Process TLSA Rrs
        tlsas = [ answer for reply in res['replies_tree']
                         for answer in reply['answer']
                          if answer['type'] == RRTYPE_TLSA ]

        # Setup TLS only if the remote certificate (or CA)
        # matches one of the TLSA RRs.


elif res['status'] == RESPSTATUS_ALL_TIMEOUT or \
     res['status'] == RESPSTATUS_ALL_BOGUS_ANSWERS:
        # DON'T EVEN TRY!

else:
        assert(res['status'] == RESPSTATUS_NO_SECURE_ANSWERS)
        # Conventional PKIX without DANE processing
```

C function primitives
Async lookups

```
getdns_return_t getdns_general(
    getdns_context          *context,
    const char              *name,
    uint16_t                 request_type,
    getdns_dict             *extensions,
    void                    *userarg,
    getdns_transaction_t    *transaction_id,
    getdns_callback_t        callbackfn
);
```

- **context** contains configuration parameters
  - Stub or recursive modus operandi, timeout values, root-hints, forwarders, trust anchor, search path (+ how to evaluate (not implemented yet) etc.)
- **context** contains the resolver cache (i.e. libunbound context)

C function primitives
Async lookups

```
getdns_return_t getdns_general(
    getdns_context          *context,
    const char              *name,
    uint16_t                 request_type,
    getdns_dict             *extensions,
    void                    *userarg,
    getdns_transaction_t    *transaction_id,
    getdns_callback_t        callbackfn
);
```

- `context` contains configuration parameters
- **`name`** and **`request_type`** the name and type to lookup

C function primitives
Async lookups

```
getdns_return_t getdns_general(
    getdns_context          *context,
    const char              *name,
    uint16_t                 request_type,
    getdns_dict             *extensions,
    void                    *userarg,
    getdns_transaction_t    *transaction_id,
    getdns_callback_t        callbackfn
);
```

- `context` contains configuration parameters
- `name` and `request_type` the name and type to lookup
- **`extensions`** additional parameters specific for this lookup
  - `return_both_v4_and_v6`, `specify_class`, `dnssec_return_status`, `dnssec_return_only_secure`, `dnssec_return_validation_chain`
  - `add_opt_parameter`

C function primitives
Async lookups

```
getdns_return_t getdns_general(
    getdns_context          *context,
    const char              *name,
    uint16_t                 request_type,
    getdns_dict             *extensions,
    void                    *userarg,
    getdns_transaction_t    *transaction_id,
    getdns_callback_t        callbackfn
);
```

- `context` contains configuration parameters
- `name` and `request_type` the name and type to lookup
- `extensions` additional parameters specific for this lookup
- **`userarg`** is passed in on the call to **`callbackfn`**
- **`transaction_id`** is set to a unique value that is also passed in on the call to **`callbackfn`**

C function primitives

Async lookups

```
getdns_return_t getdns_general(
    getdns_context          *context,
    const char              *name,
    uint16_t                 request_type,
    getdns_dict             *extensions,
    void                    *userarg,
    getdns_transaction_t    *transaction_id,
    getdns_callback_t        callbackfn
);

typedef void (*getdns_callback_t)(
    getdns_context          *context,
    getdns_callback_type_t   callback_type,
    getdns_dict             *response,
    void                    *userarg,
    getdns_transaction_t     transaction_id
);
// callback_type = complete, cancel, timeout or error
```

C function primitives

Synchronous lookups

```
getdns_return_t getdns_general(
    getdns_context          *context,
    const char              *name,
    uint16_t                 request_type,
    getdns_dict             *extensions,
    void                    *userarg,
    getdns_transaction_t    *transaction_id,
    getdns_callback_t        callbackfn
);

getdns_return_t getdns_general_sync(
    getdns_context          *context,
    const char              *name,
    uint16_t                 request_type,
    getdns_dict             *extensions,
    getdns_dict            **response
);
```

C function primitives
Address lookups

```
getdns_return_t getdns_address(
    getdns_context          *context,
    const char              *name,
    getdns_dict             *extensions,
    void                    *userarg,
    getdns_transaction_t    *transaction_id,
    getdns_callback_t        callbackfn
);
```

- **getdns_address** also lookups in other name systems
  - local files, WINS, mDNS, NIS (only local files implemented)
- **getdns_address** returns both IPv4 and IPv6
  - like when the `return_both_v4_and_v6` extension is set

C function primitives
Reverse lookups

```
getdns_return_t getdns_hostname(
    getdns_context          *context,
    getdns_dict             *address,
    getdns_dict             *extensions,
    void                    *userarg,
    getdns_transaction_t    *transaction_id,
    getdns_callback_t        callbackfn
);
```

- With **address**: `{ "address_type": <bindata of "IPv4">`
  `"address_data": <bindata for 185.49.141.37> }`

  will lookup `37.141.49.185.in-addr.arpa PTR`

Data structures

```
typedef struct getdns_dict getdns_dict;
typedef struct getdns_list getdns_list;
typedef struct getdns_bindata {  size_t  size;
                                 uint8_t *data; } getdns_bindata;
```

- Used to represent extensions, addresses and response objects

Data structures

```
typedef struct getdns_dict getdns_dict;
typedef struct getdns_list getdns_list;
typedef struct getdns_bindata {  size_t  size;
                                 uint8_t *data; } getdns_bindata;
```

- Used to represent extensions, addresses and response objects
- `char *getdns_pretty_print_dict(const getdns_dict *dict);`

Extension dict

```
{
  "return_both_v4_and_v6": GETDNS_EXTENSION_TRUE,
  "add_opt_parameter":
  { “maximum_udp_payload_size”: 1232,
    “do_bit”: 1
    “options”:
    [ { “option_code”: 10
        “option_data”: <bindata of 0x96bd16564dfb5f5e > } ] }
}
```

Data structures

```
typedef struct getdns_dict getdns_dict;
typedef struct getdns_list getdns_list;
typedef struct getdns_bindata {  size_t  size;
                                 uint8_t *data; } getdns_bindata;
```

- Used to represent extensions, addresses and response objects

Response object dict

```
{
  "answer_type": GETDNS_NAMETYPE_DNS,
  "status": GETDNS_RESPSTATUS_GOOD,
  "canonical_name": <bindata of "www.getdnsapi.net.">,
  "just_address_answers":
  [ { "address_data": <bindata for 185.49.141.37>,
      "address_type": <bindata of "IPv4">
    }
  ],
  "replies_full": [ <bindata of 0x000818000010002004...> ],
  "replies_tree": [ { … first reply …  } ],
```

Data structures
Accessor functions

- reading `getdns_dicts`:

```
getdns_return_t getdns_dict_get_dict(
    const getdns_dict *dict, const char *name, getdns_dict **answer);

getdns_return_t getdns_dict_get_list(
    const getdns_dict *dict, const char *name, getdns_list **answer);

getdns_return_t getdns_dict_get_bindata(
    const getdns_dict *dict, const char *name, getdns_bindata **answer);

getdns_return_t getdns_dict_get_int(
    const getdns_dict *dict, const char *name, uint32_t *answer)


getdns_return_t getdns_dict_get_data_type(
    const getdns_dict *dict, const char *name, getdns_data_type *answer);

getdns_return_t getdns_dict_get_names(
    const getdns_dict *dict, getdns_list **answer);
```

Data structures
Accessor functions

- reading `getdns_lists`:

```
getdns_return_t getdns_list_get_dict(
    const getdns_list *list, size_t index, getdns_dict **answer);

getdns_return_t getdns_list_get_list(
    const getdns_list *list, size_t index, getdns_list **answer);

getdns_return_t getdns_list_get_bindata(
    const getdns_list *list, size_t index, getdns_bindata **answer);

getdns_return_t getdns_list_get_int(
    const getdns_list *list, size_t index, uint32_t *answer);


getdns_return_t getdns_list_get_data_type(
    const getdns_list *list, size_t index, getdns_data_type *answer);

getdns_return_t getdns_list_get_length(
    const getdns_list *this_list, size_t *answer);
```

Data structures
Accessor functions

- Creating/writing to `getdns_dicts`:

```
getdns_dict * getdns_dict_create();

getdns_return_t getdns_dict_set_dict(
    getdns_dict *dict, const char *name, const getdns_dict *child_dict);

getdns_return_t getdns_dict_set_list(
    getdns_dict *dict, const char *name, const getdns_list *child_list);

getdns_return_t getdns_dict_set_bindata(
    getdns_dict *dict, const char *name, const getdns_bindata
*child_bindata);

getdns_return_t getdns_dict_set_int(
    getdns_dict *dict, const char *name, uint32_t child_uint32)

void getdns_dict_destroy(getdns_dict *dict);
```

Data structures
Accessor functions

Response object dict

```
{
  "answer_type": GETDNS_NAMETYPE_DNS,
  "status": GETDNS_RESPSTATUS_GOOD,
  "canonical_name": <bindata of "www.getdnsapi.net.">,
  "just_address_answers":
  [ { "address_data": <bindata for 185.49.141.37>,
      "address_type": <bindata of "IPv4">
    }
  ],
  "replies_full": [ <bindata of 0x000818000010002004...> ],
  "replies_tree": [ { … first reply …  } ],
```

```
if ((r = getdns_address_sync(ctx, "getdnsapi.net", ext, &resp)))
        return r;
else if ((r = getdns_dict_get_list(resp, "just_address_answers", &jaa)))
        return r;
else if ((r = getdns_list_get_dict(jaa, 0, &addr_dict)))
        return r;
else if ((r = getdns_list_get_bindata(addr_dict, "address_data", &addr)))
        return r;
```

Data structures
Accessor functions

```
if ((r = getdns_address_sync(ctx, "getdnsapi.net", ext, &resp)))
        return r;
else if ((r = getdns_dict_get_list(resp, "just_address_answers", &jaa)))
        return r;
else if ((r = getdns_list_get_dict(jaa, 0, &addr_dict)))
        return r;
else if ((r = getdns_list_get_bindata(addr_dict, "address_data", &addr)))
        return r;
```

- Not so bad in other languages
- Python

```
resp = ctx.address('getdnsapi.net')
addr = resp.just_address_answers[0]['address_data']
```

- Nodejs

```
function callback(err, resp)
{
    var addr = resp.just_address_answers[0].address_data;
}
ctx.getAddress('getdnsapi.net', callback);
```

Data structures
Accessor functions

- Not so bad in other languages
- The alternative would introduce a lot of new types:
  - Python:

```
addr = resp.replies_tree[0]['answer'][0]['rdata']['ipv6_address']
```

  - C

```
getdns_response *resp;  getdns_reply    *reply;
getdns_rrs      *rrs;   getdns_rr       *rrs;
getdns_rdata    *rdata; struct sockaddr_storage addr;
if ((r = getdns_response_get_reply(resp, 0, &reply)))
        return r;
else if ((r = getdns_reply_get_answer_section(reply, &rrs)))
        return r;
else if ((r = getdns_rrs_get_rr(rrs, &rr)))
        return r;
else if ((r = getdns_rr_get_rdata(rr, &rdata)))
        return r;
else if ((r = getdns_rdata_get_rdatafield_address(rdata, 0, &addr)))
        return r;
```

Data structures
Accessor functions

- Not so bad in other languages
- The alternative would introduce a lot of new types.
- With current approach, the library can easily grow
- New rdata fields or new extensions without a new API
  (dns cookies, roadblock avoidance, client subnet, etc.)

Data structures
Accessor functions

- Not so bad in other languages
- The alternative would introduce a lot of new types.
- With current approach, the library can easily grow
- New rdata fields or new extensions without a new API
  (dns cookies, roadblock avoidance, client subnet, etc.)
- Just in time parsing of wireformat data on the roadmap
  (internally already iterator like accessor types for wireformat data ; they will be part of ldns2 too)

Hook into getdns

- Provide function pointers that getdns will use to do memory & IO handling/management

Hook into getdns
Custom memory functions

- Provide function pointers that getdns will use to do memory & IO handling/management

```
getdns_return_t
getdns_context_create(getdns_context ** context, int set_from_os);

getdns_return_t
getdns_context_create_with_memory_functions(
    getdns_context **context,
    int set_from_os,
    void *(*malloc) (size_t),
    void *(*realloc)(void *, size_t),
    void  (*free)   (void *)
);
```

Hook into getdns
Custom memory functions

- Provide function pointers that getdns will use to do memory & IO handling/management

```
getdns_return_t
getdns_context_create_with_extended_memory_functions(
    getdns_context **context,
    int set_from_os,
    void *userarg,
    void *(*malloc) (void *userarg, size_t),
    void *(*realloc)(void *userarg, void *, size_t),
    void  (*free)   (void *userarg, void *)
);
```

Hook into getdns
Custom memory functions

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getdns_return_t
getdns_context_create_with_extended_memory_functions(
    getdns_context **context,
    int set_from_os,
    void *userarg,
    void *(*malloc) (void *userarg, size_t),
    void *(*realloc)(void *userarg, void *, size_t),
    void  (*free)   (void *userarg, void *)
);

getdns_dict *getdns_dict_create_with_context(
    getdns_context *context
);
getdns_list *getdns_list_create_with_context(
    getdns_context *context
);
```

Hook into getdns
Custom memory functions

- Provide function pointers that getdns will use to do memory & IO handling/management

```
getdns_dict *getdns_dict_create_with_context(
    getdns_context *context
);
getdns_dict *getdns_dict_create_with_memory_functions(
    void *(*malloc) (size_t),
    void *(*realloc)(void *, size_t),
    void  (*free)   (void *)
);
getdns_dict *getdns_dict_create_with_extended_memory_functions(
    void *userarg,
    void *(*malloc) (void *userarg, size_t),
    void *(*realloc)(void *userarg, void *, size_t),
    void  (*free)   (void *userarg, void *)
);
```

Hook into getdns

Custom event loop

- Poor mans OOP

<getdns_extra.h>

```
typedef struct getdns_eventloop_vmt getdns_eventloop_vmt;
typedef struct getdns_eventloop {
        getdns_eventloop_vmt *vmt;
        /* object data here */
} getdns_eventloop;

getdns_return_t getdns_context_set_eventloop(
    getdns_context* context, getdns_eventloop *eventloop);
```

Hook into getdns

Custom event loop

- Poor mans OOP

<getdns_extra.h>

```
typedef struct getdns_eventloop_vmt getdns_eventloop_vmt;
typedef struct getdns_eventloop {
        getdns_eventloop_vmt *vmt;
        /* object data here */
} getdns_eventloop;

getdns_return_t getdns_context_set_eventloop(
    getdns_context* context, getdns_eventloop *eventloop);

/* Virtual Method Table */
struct getdns_eventloop_vmt {
        void            (*cleanup) (getdns_eventloop *this);
        getdns_return_t (*schedule)(getdns_eventloop *this,
            int fd, uint64_t timeout, getdns_eventloop_event *ev)
        getdns_return_t (*clear)   (getdns_eventloop *this,
            getdns_eventloop_event *ev)
        void            (*run)     (getdns_eventloop *this);
        void            (*run_once)(getdns_eventloop *this, int blocking);
};
```

Hook into getdns

Custom event loop

- Poor mans OOP

<getdns_extra.h>

```
typedef struct getdns_eventloop_vmt getdns_eventloop_vmt;
typedef struct getdns_eventloop {
        getdns_eventloop_vmt *vmt;
        /* object data here */
} getdns_eventloop;

getdns_return_t getdns_context_set_eventloop(
    getdns_context* context, getdns_eventloop *eventloop);
```

User program

```
#define MAX_TIMEOUTS FD_SETSIZE

/* Eventloop based on select */
typedef struct my_eventloop {
        getdns_eventloop        base;
        getdns_eventloop_event *fd_events[FD_SETSIZE];
        uint64_t                fd_timeout_times[FD_SETSIZE];
        getdns_eventloop_event *timeout_events[MAX_TIMEOUTS];
        uint64_t                timeout_times[MAX_TIMEOUTS];
} my_eventloop;

my_eventloop my_loop;
getdns_context_set_eventloop(context, &my_loop.base)
```

Hook into getdns

Custom event loop

- Poor mans OOP

<getdns_extra.h>

```
typedef struct getdns_eventloop_vmt getdns_eventloop_vmt;
typedef struct getdns_eventloop {
        getdns_eventloop_vmt *vmt;
        /* object data here */
} getdns_eventloop;

getdns_return_t getdns_context_set_eventloop(
    getdns_context* context, getdns_eventloop
```

Timeouts must be a set that may be modified during iteration

```
#define MAX_TIMEOUTS FD_SETSIZE

/* Eventloop based on select */
typedef struct my_eventloop {
        getdns_eventloop         base;
        getdns_eventloop_event *fd_events[FD_SETSIZE];
        uint64_t                fd_timeout_times[FD_SETSIZE];
        getdns_eventloop_event *timeout_events[MAX_TIMEOUTS];
        uint64_t                timeout_times[MAX_TIMEOUTS];
} my_eventloop;

my_eventloop my_loop;
getdns_context_set_eventloop(context, &my_loop.base)
```

Hook into getdns

Custom event loop

User program

```
#define MAX_TIMEOUTS FD_SETSIZE

/* Eventloop based on select */
typedef struct my_eventloop {
        getdns_eventloop         base;
        getdns_eventloop_event *fd_events[FD_SETSIZE];
        uint64_t                fd_timeout_times[FD_SETSIZE];
        getdns_eventloop_event *timeout_events[MAX_TIMEOUTS];
        uint64_t                timeout_times[MAX_TIMEOUTS];
} my_eventloop;

void my_eventloop_init(my_eventloop *loop)
{
        static getdns_eventloop_vmt my_eventloop_vmt = {
                my_eventloop_cleanup,
                my_eventloop_schedule, my_eventloop_clear, NULL, NULL };

        (void) memset(loop, 0, sizeof(my_eventloop));
        loop->base.vmt = &my_eventloop_vmt;
}

my_eventloop my_loop;
my_eventloop_init(&my_loop);
getdns_context_set_eventloop(context, &my_loop.base)
```

Hook into getdns
Custom event loop

- From specification section 1.8:

  ... Each implementation of the DNS API will specify an extension function that tells the DNS context which event base is being used.

- libevent

  Include : `#include <getdns/getdns_ext_libevent.h>`
  Use : `getdns_extension_set_libevent_base(context, base);`
  Link : -lgetdns -lgetdns_ext_event

```
struct event_base *base = event_base_new();
getdns_extension_set_libevent_base(context, base);

getdns_address(context, "getdnsapi.net", 0, 0, 0, callback);

event_base_dispatch(base);
event_base_free(base);
```

```
my_eventloop_init(&my_loop);
getdns_context_set_eventloop(context, &my_loop.base)
```

Hook into getdns

Custom event loop

User program

- libevent

  Include : `#include <getdns/getdns_ext_libevent.h>`
  Use : `getdns_extension_set_libevent_base(context, base);`
  Link : -lgetdns -lgetdns_ext_event

- libev

  Include : `#include <getdns/getdns_ext_libev.h>`
  Use : `getdns_extension_set_libev_loop(context, loop);`
  Link : -lgetdns -lgetdns_ext_ev

- libuv

  Include : `#include <getdns/getdns_ext_libuv.h>`
  Use : `getdns_extension_set_libuv_loop(context, base);`
  Link : -lgetdns -lgetdns_ext_uv

```
my_eventloop_init(&my_loop);
getdns_context_set_eventloop(context, &my_loop.base)
```

Hook into getdns

Custom event loop

<getdns_extra.h>

```
/* Virtual Method Table */
struct getdns_eventloop_vmt {
        void            (*cleanup) (getdns_eventloop *this);
        getdns_return_t (*schedule)(getdns_eventloop *this,
            int fd, uint64_t timeout, getdns_eventloop_event *ev)
        getdns_return_t (*clear)   (getdns_eventloop *this,
            getdns_eventloop_event *ev)
        void            (*run)     (getdns_eventloop *this);
        void            (*run_once)(getdns_eventloop *this, int blocking);

};
```

User program

```
void my_eventloop_cleanup(my_eventloop *loop)
{
}
```

- Destructor, called on
  - getdns_context_destroy()
  - getdns_context_detach_eventloop()
  - getdns_context_set_eventloop()

Hook into getdns

Custom event loop

<getdns_extra.h>

```c
/* event data */
typedef void (*getdns_eventloop_callback)(void *userarg);
typedef struct getdns_eventloop_event {
        void *userarg;
        getdns_eventloop_callback read_cb;
        getdns_eventloop_callback write_cb;
        getdns_eventloop_callback timeout_cb;

        /* Pointer to the underlying event */
        void *ev;
} getdns_eventloop_event;
```

User program

```c
getdns_return_t my_eventloop_schedule(getdns_eventloop *loop,
    int fd, uint64_t timeout, getdns_eventloop_event *event)
{
        my_eventloop *my_loop  = (my_eventloop *)loop;

        assert(loop);
        assert(event);
        assert(fd < FD_SETSIZE);

        if (fd >= 0 && (event->read_cb || event->write_cb)) {

                assert(my_loop->fd_events[fd] == NULL);
```

Hook into getdns

Custom event loop

<getdns_extra.h>

```
/* event data */
typedef void (*getdns_eventloop_callback)(void *userarg);
typedef struct getdns_eventloop_event {
        void *userarg;
        getdns_eventloop_callback read_cb;
        getdns_eventloop_callback write_cb;
        getdns_eventloop_callback timeout_cb;

        /* Pointer to the underlying event */
        void *ev;
} getdns_eventloop_event;
```

User program

```
getdns_return_t my_eventloop_schedule(getdns_eventloop *loop,
    int fd, uint64_t timeout, getdns_eventloop_event *event)
{
        my_eventloop *my_loop  = (my_eventloop *)loop;

        if (fd >= 0 && (event->read_cb || event->write_cb)) {
                my_loop->fd_events[fd] = event;
                my_loop->fd_timeout_times[fd] = get_now_plus(timeout);
                event->ev = (void *) (intptr_t) fd + 1;
                return GETDNS_RETURN_GOOD;
        }
```

Hook into getdns
Custom event loop

User program

```
getdns_return_t my_eventloop_schedule(getdns_eventloop *loop,
    int fd, uint64_t timeout, getdns_eventloop_event *event)
{
        my_eventloop *my_loop  = (my_eventloop *)loop;

        if (fd >= 0 && (event->read_cb || event->write_cb)) {
                my_loop->fd_events[fd] = event;
                my_loop->fd_timeout_times[fd] = get_now_plus(timeout);
                event->ev = (void *) (intptr_t) fd + 1;
                return GETDNS_RETURN_GOOD;
        }

        assert(event->timeout_cb && !event->read_cb && !event->write_cb);
        for (size_t i = 0; i < MAX_TIMEOUTS; i++) {
                if (my_loop->timeout_events[i] == NULL) {
                        my_loop->timeout_events[i] = event;
                        my_loop->timeout_times[i] = get_now_plus(timeout);
                        event->ev = (void *) (intptr_t) i + 1;
                        return GETDNS_RETURN_GOOD;
                }
        }
        return GETDNS_RETURN_GENERIC_ERROR;
}
```

Hook into getdns
Custom event loop

User program

```
getdns_return_t
my_eventloop_clear(getdns_eventloop *loop, getdns_eventloop_event *event)
{
        my_eventloop *my_loop = (my_eventloop *)loop;
        size_t i;

        i = (intptr_t)event->ev - 1;

        if (event->timeout_cb && !event->read_cb && !event->write_cb) {

                my_loop->timeout_events[i] = NULL;
        } else {

                my_loop->fd_events[i] = NULL;
        }
        event->ev = NULL;
        return GETDNS_RETURN_GOOD;
}
```

Hook into getdns

Custom event loop

Running the loop

User program

```
uint64_t now, timeout = (uint64_t)-1;
size_t   i;

now = get_now_plus(0);

for (i = 0; i < MAX_TIMEOUTS; i++) {

        if (!my_loop->timeout_events[i])
                continue;

        if (now > my_loop->timeout_times[i])
                my_timeout_cb(my_loop->timeout_events[i]);

        else if (my_loop->timeout_times[i] < timeout)
                timeout = my_loop->timeout_times[i];
}
```

Hook into getdns

Custom event loop

Running the loop

User program

```
fd_set   readfds, writefds;
int      fd, max_fd = -1;

FD_ZERO(&readfds);
FD_ZERO(&writefds);

for (fd = 0; fd < FD_SETSIZE; fd++) {
        if (!my_loop->fd_events[fd])
                continue;

        if (my_loop->fd_events[fd]->read_cb)
                FD_SET(fd, &readfds);
        if (my_loop->fd_events[fd]->write_cb)
                FD_SET(fd, &writefds);

        if (fd > max_fd)
                max_fd = fd;

        if (my_loop->fd_timeout_times[fd] < timeout)
                timeout = my_loop->fd_timeout_times[fd];
}
if (max_fd == -1 && timeout == (uint64_t)-1)
        return;
```

Hook into getdns

Custom event loop

Running the loop

User program

```
struct timeval tv;

if (now > timeout) {
        tv.tv_sec = 0;
        tv.tv_usec = 0;
} else {
        tv.tv_sec  = (timeout - now) / 1000000;
        tv.tv_usec = (timeout - now) % 1000000;
}
if (select(max_fd + 1, &readfds, &writefds, NULL, &tv) < 0) {
        perror("select() failed");
        exit(EXIT_FAILURE);
}
```

Hook into getdns

Custom event loop

Running the loop

User program

```
now = get_now_plus(0);
for (fd = 0; fd < FD_SETSIZE; fd++) {
        if (my_loop->fd_events[fd] &&
            my_loop->fd_events[fd]->read_cb &&
            FD_ISSET(fd, &readfds))
                my_read_cb(fd, my_loop->fd_events[fd]);

        if (my_loop->fd_events[fd] &&
            my_loop->fd_events[fd]->write_cb &&
            FD_ISSET(fd, &writefds))
                my_write_cb(fd, my_loop->fd_events[fd]);

        if (my_loop->fd_events[fd] &&
            my_loop->fd_events[fd]->timeout_cb &&
            now > my_loop->fd_timeout_times[fd])
                my_timeout_cb(my_loop->fd_events[fd]);

        i = fd;
        if (my_loop->timeout_events[i] &&
            my_loop->timeout_events[i]->timeout_cb &&
            now > my_loop->timeout_times[i])
                my_timeout_cb(my_loop->timeout_events[i]);
}
```

Hook into getdns

Custom event loop

nodejs program

```
var getdns = require('getdns');

function callback(err, result) {
  console.log(err ? Err : result.canonical_name + ': '
                        + JSON.stringify(result.just_address_answers));
}
ctx = getdns.createContext();
ctx.getAddress('getdnsapi.net', callback);
ctx.getAddress('verisignlabs.com', callback);
ctx.getAddress('sinodun.com', callback);
ctx.getAddress('nomountain.net', callback);
ctx.getAddress('vbsdcon.com', callback);
```

Program output

```
willem@bonobo:~/vbsdcon$ nodejs parallel.js
getdnsapi.net.: [{"address_data":[42,4,185,0,0,0,1,0,0,0,0,0,0,0,0,55], …
sinodun.com.: [{"address_data":[88,98,24,67],"address_type":"IPv4"}]
vbsdcon.com.: [{"address_data":[69,58,186,114],"address_type":"IPv4"}]
verisignlabs.com.: [{"address_data":[38,32,0,116,0,19,68,0,0,0,0,0,0,0,2 …
nomountain.net.: [{"address_data":[38,7,242,152,0,5,16,75,0,0,0,0,11,128 …
```

Roadmap

- Current release 0.3.3
- More bindings (ruby *(alpha)*, perl, lua, go *(proposed)*)
- More platforms (windows, android)
- Before 1.0 (this year)
  - No more dependency on ldns
  - Just-in-time parsing of response objects
  - The complete spec implemented
    - `add_warning_for_bad_dns` & `add_call_debugging` extensions
    - `TSIG`
- After 1.0
  - Multi-threading & multi-processes support
  - statefull session reuse

Security starts with a name

website	https://getdnsapi.net
API spec	https://getdnsapi.net/spec.html
latest tarball	https://getdnsapi.net/dist/getdns-0.3.3.tar.gz
github repo	https://github.com/getdnsapi/getdns
node repo	https://github.com/getdnsapi/getdns-node
python repo	https://github.com/getdnsapi/getdns-python-bindings
java repo	https://github.com/getdnsapi/getdns-java-bindings
php repo	https://github.com/getdnsapi/getdns-php-bindings
API list	https://getdnsapi.net/mailman/listinfo/spec
users list	https://getdnsapi.net/mailman/listinfo/users
me	Willem Toorop <willem@nlnetlabs.nl>