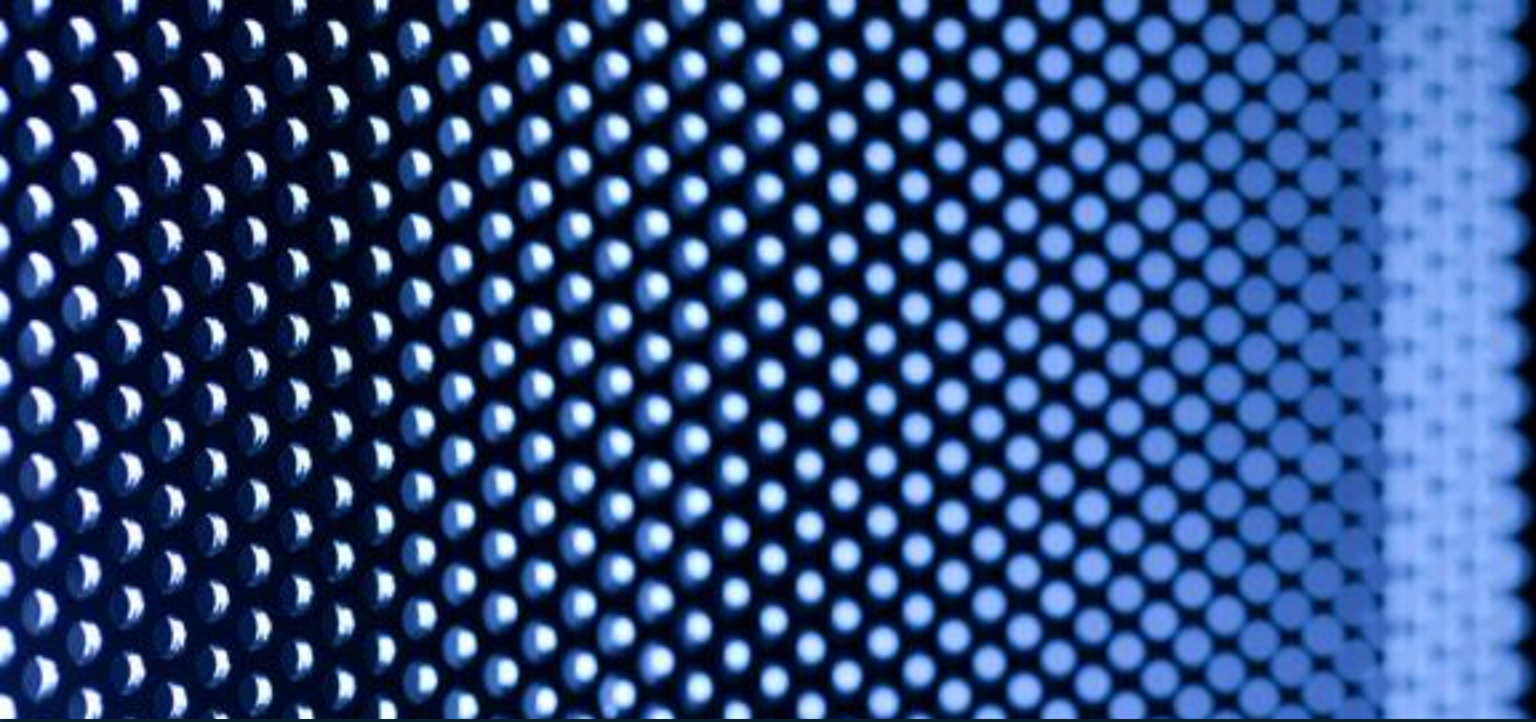

VERISIGN

DANE & Application Uses of DNSSEC

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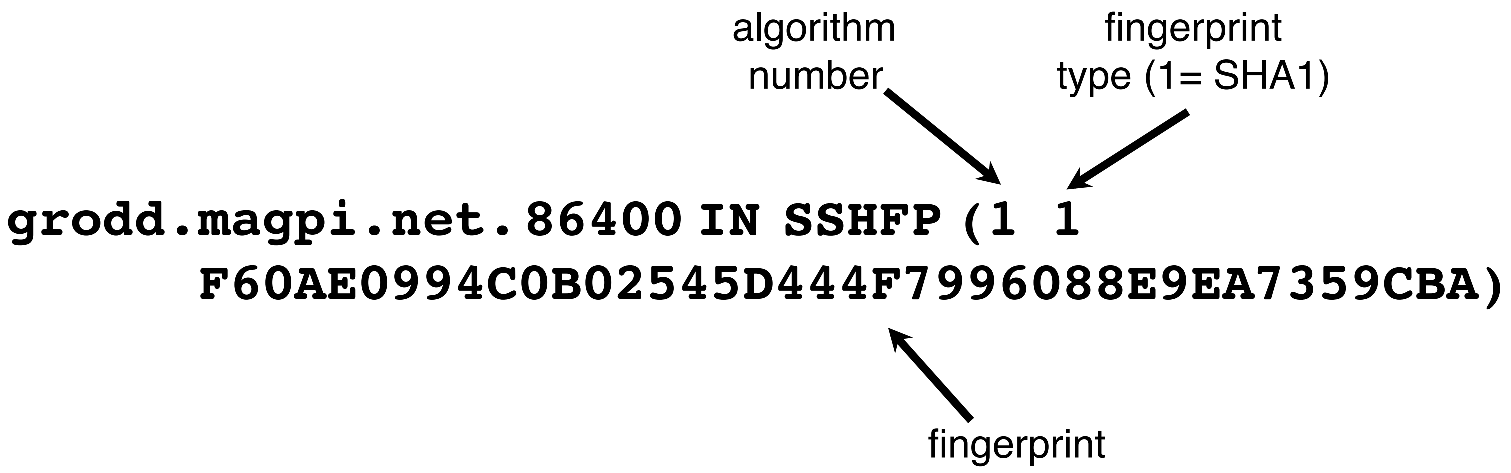
Application uses of DNSSEC

- One of the more exciting prospects for DNSSEC
- DNSSEC can be employed to store cryptographic keys in the DNS, and ..
- Allow applications to securely obtain (authenticate) those keys and use them in application security protocols
- Some possible applications: SSH, SSL/TLS, HTTPS, S/MIME, PGP, SMTP, DKIM, and many others ..
- Existing records:
  - SSHFP, IPSECKEY, DKIM TXT record, …
  - DANE records: TLSA, OPENPGPKEY
- Upcoming:
  - SMIMEA, IPSECA, …

SSHFP record

- Secure Shell Host Key Fingerprint (RFC 4255)
- Allows you to validate SSH host keys using DNSSEC



algorithm number

fingerprint type (1= SHA1)

```
grodd.magpi.net. 86400 IN SSHFP (1 1
        F60AE0994C0B02545D444F7996088E9EA7359CBA)
```

fingerprint

In **OpenSSH**, you can use the client configuration directive "**VerifyHostKeyDNS**" to use this. Enabled by default in some newer operating systems like FreeBSD 10.

IPSECKEY record

- RFC 4025: method for storing IPsec keying material in DNS
- rdata format: precedence, gateway-type, algorithm, gateway address, public key
- Not much uptake of this record
- Will likely be superseded by newer proposals, like IPSECA

```
38.2.0.192.in-addr.arpa. 7200 IN  IPSECKEY ( 10 1 2
     192.0.2.38
     AQNRU3mG7TVTO2BkR47usntb102uFJtugbo6BSGvgqt4AQ== )
```

TLS and the Internet PKI

- A very large number of security protocols authenticate server names with X.509 certificates
  - TLS, IPsec, HTTPS, SIPS, SMTP, IMAP, XMPP, …
- These certificates are issued and signed by the Internet PKI, composed of a set of globally trusted public Certification Authorities (CAs)

Public CA model issues

- Applications need to trust a large number of global Certification Authorities (CA)
- No namespace constraints! Any CA can issue certificates for any entity on the Internet
- Least common denominator security: our collective security is equal to the weakest one!
- Furthermore, many of them issue subordinate CA certificates to their customers, again with no naming constraints
- Most CAs aren’t capable of issuing certificates with any but the most basic capabilities (e.g. alternate name forms or other extensions)

Public CA model issues

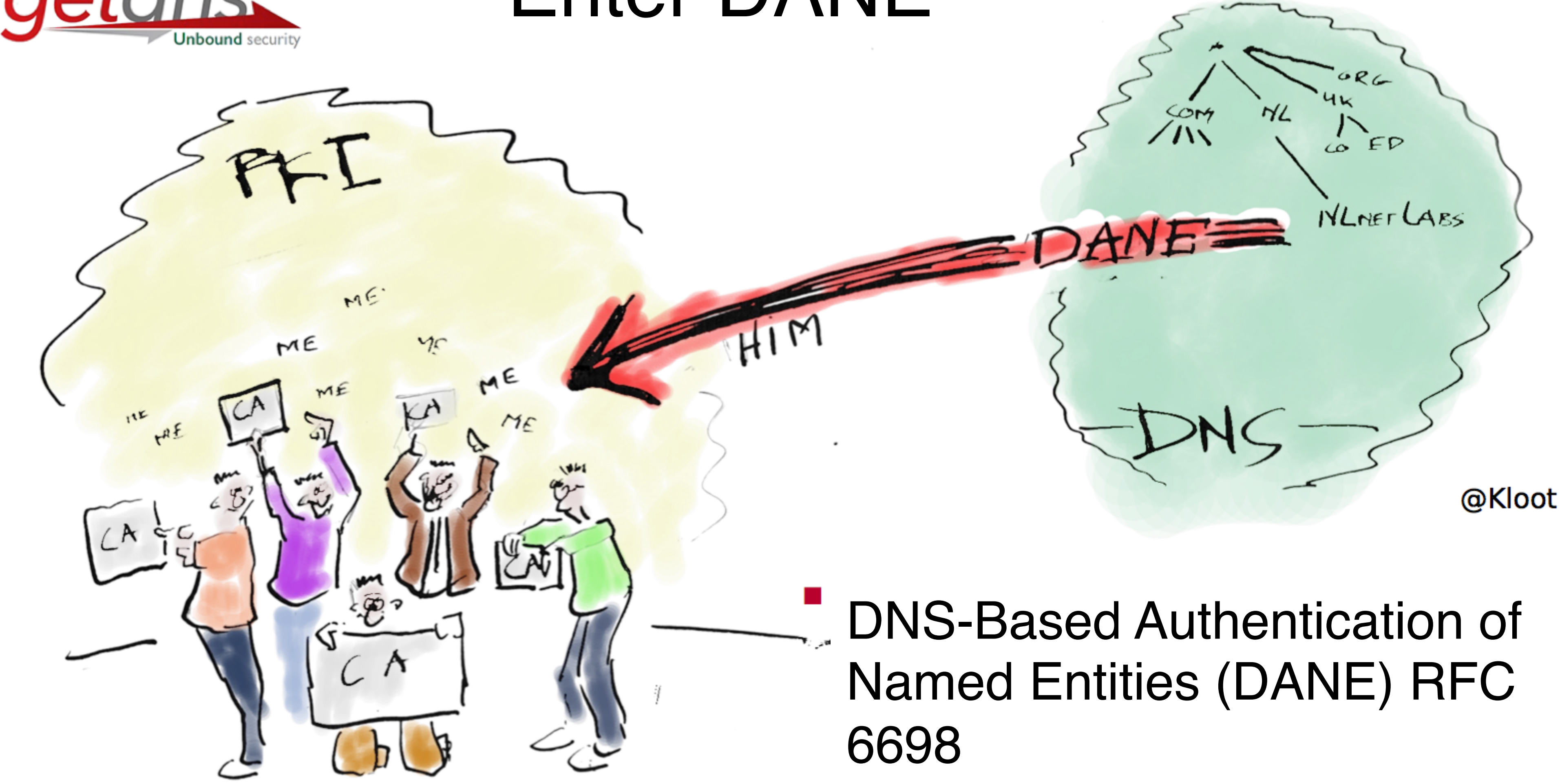
- “Analysis of the HTTPS Certificate Ecosystem”, UMich, October 2013, Internet Measurement Conference
  - http://conferences.sigcomm.org/imc/2013/papers/imc257-durumericAemb.pdf
  - Over 1,800 separate CAs are capable of issuing certificates for anyone! (Root CAs and intermediate CAs issued by them)

- “The Shape & Size of Threats: Defining a Networked System’s Attack Surface”
  - Eric Osterweil (Verisign), Danny McPherson (Verisign), Lixia Zhang (UCLA), NPsec 2014 conference

Can DNSSEC help?

- Can we leverage DNSSEC to address these deficiencies?
- DNS has hierarchical, decentralized administration
- Certificates and public keys placed in the DNS can be authenticated with DNSSEC signatures
- Name constraints are inherent
- Deployed infrastructure is becoming real
- Root and many of the TLDs are signed, so most organizations can sign their zones and have an intact secure chain of trust to the root
- Validation is also becoming more prevalent (see prior slides in deployment status)

Enter DANE



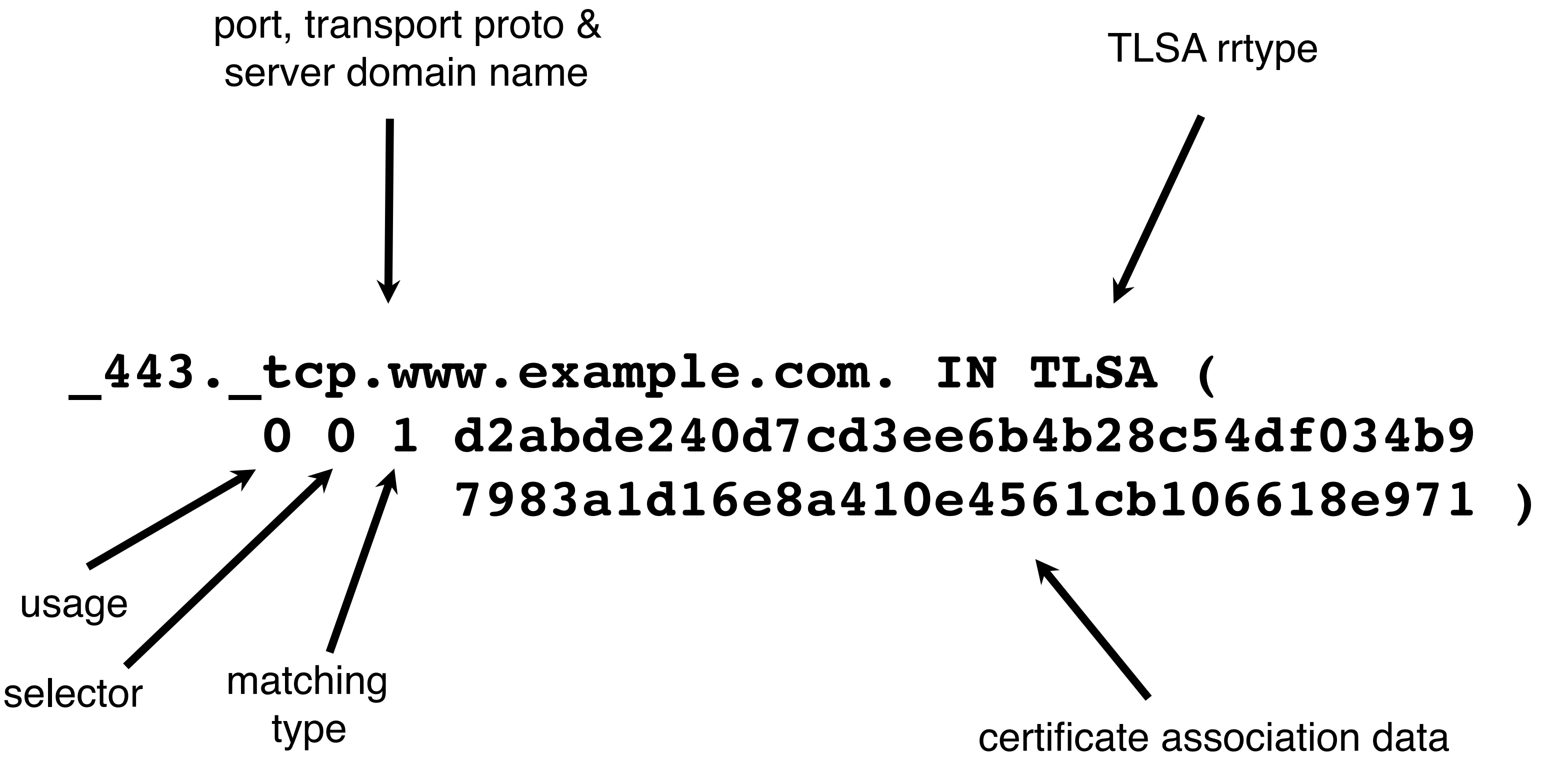
@Kloot

- DNS-Based Authentication of Named Entities (DANE) RFC 6698

DANE and the TLSA record

- RFC 6698: The **DNS-based Authentication of Named Entities (DANE)** Protocol for Transport Layer Security
- http://tools.ietf.org/html/rfc6698
- Defines a new DNS record type “**TLSA**”, that can be used for better & more secure ways to authenticate SSL/TLS certificates
  - By specifying constraints on which CA can vouch for a certificate, or which specific PKIX end-entity certificate is valid
  - By specifying that a service certificate or a CA can be directly authenticated in the DNS itself.

TLSA record example



port, transport proto & server domain name

TLSA rrtype

```
_443._tcp.www.example.com. IN TLSA (
      0 0 1 d2abde240d7cd3ee6b4b28c54df034b9
            7983a1d16e8a410e4561cb106618e971 )
```

usage

selector

matching type

certificate association data

TLSA configuration parameters

Usage field:

0	PKIX-TA: CA Constraint
1	PKIX-EE: Service Certificate Constraint
2	DANE-TA: Trust Anchor Assertion
3	DANE-EE: Domain Issued Certificate

Selector field:

0	Match full certificate
1	Match only SubjectPublicKeyInfo

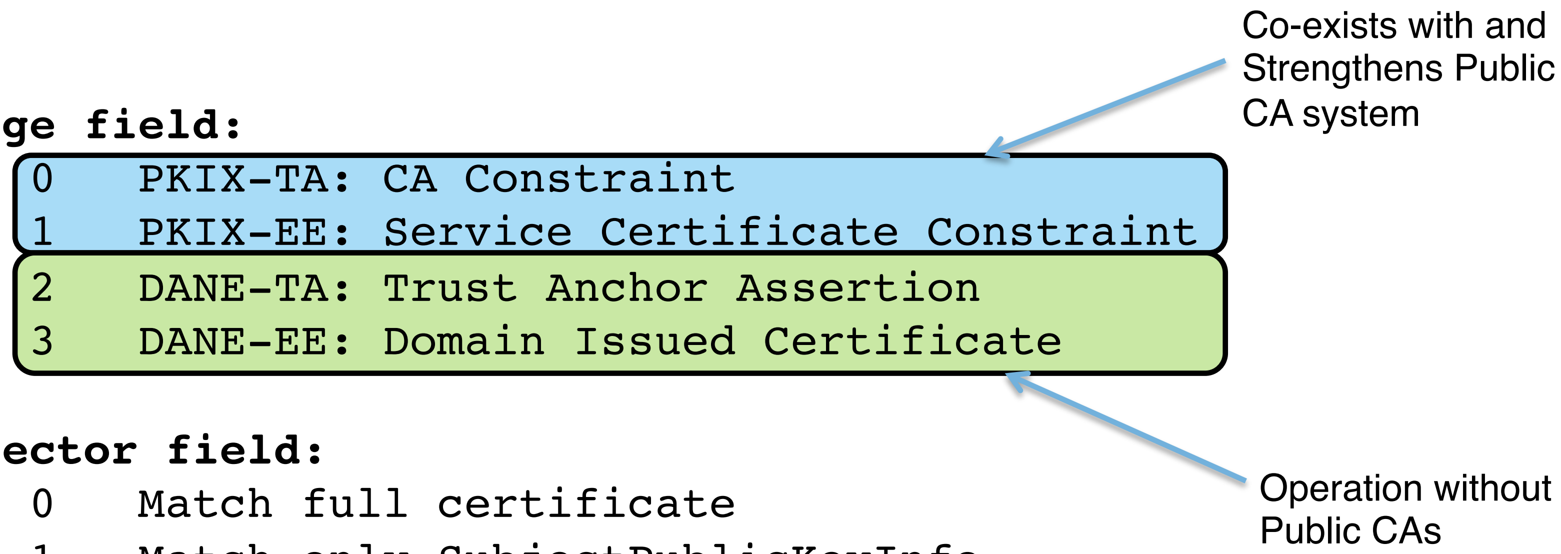
Matching type field:

0	Exact match on selected content
1	SHA-256 hash of selected content
2	SHA-512 hash of selected content

Certificate Association Data: raw cert data in hex

TLSA configuration parameters

Usage field:



0	PKIX-TA: CA Constraint
1	PKIX-EE: Service Certificate Constraint
2	DANE-TA: Trust Anchor Assertion
3	DANE-EE: Domain Issued Certificate

Co-exists with and Strengthens Public CA system

Operation without Public CAs

Selector field:

0	Match full certificate
1	Match only SubjectPublicKeyInfo

Matching type field:

0	Exact match on selected content
1	SHA-256 hash of selected content
2	SHA-512 hash of selected content

Certificate Association Data: raw cert data in hex

Usage types

0 **PKIX-TA: CA Constraint**
Specify which CA should be trusted to authenticate the certificate for the service. Full PKIX certificate chain validation needs to be performed.

1 **PKIX-EE: Service Certificate Constraint**
Define which specific service certificate ("EE cert") should be trusted for the service. Full PKIX cert validation needs to be performed.

2 **DANE-TA: Trust Anchor Assertion**
Specify a domain operated CA which should be trusted independently to vouch for the service certificate.

3 **DANE-EE: Domain Issued Certificate**
Define a specific service certificate for the service at this domain name.

Example TLSA record (for WWW)

```
_443._tcp.fedoraproject.org. 263 IN TLSA 0 0 1 (
            19400BE5B7A31FB733917700789D2F0A2471C0C9D506
            C0E504C06C16D7CB17C0 )

_443._tcp.fedoraproject.org. 263 IN RRSIG TLSA 5 4 300 (
            20141114150617 20141015150617 7725
fedoraproject.org.
            hrk0si7I/BWTz0wEtMcFZNUCj/0o5796k5FVuZx6eXrc
            YOe/ChHA/Shu/WHr3iM1yNGi86+8t4wMq9GA+JZthWZC
            ZmENxf9OTNe/t/LBAc2EDW/fMBJq0JO2b4ZkJHXCEyX0
            CDsIYz8shZ20nPGlrsYqwLdQiCeravWcwcJiPuc= )
```

Usage 0 ("CA Constraint") – this record says:

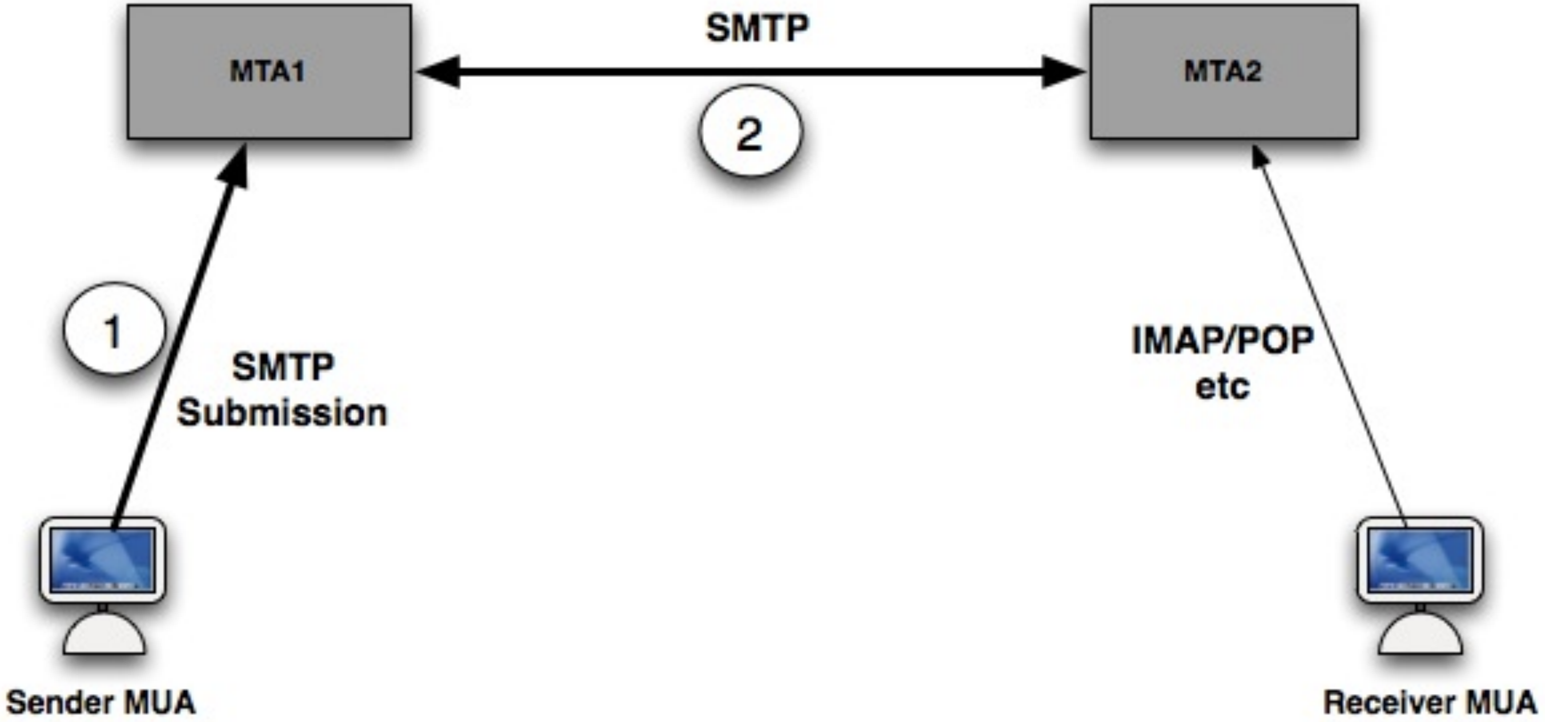
- For service at fedoraproject.org tcp port 443
- only the CA with the specified SHA-256 certificate fingerprint (19400BE5B…) should be trusted

DANE/TLSA tools and software

- TLSA Record Generation
  - Command line tools: “swede”, “hash-slinger”, “ldns-dane”
  - Web based tool: https://www.huque.com/bin/gen_tlsa

- TLSA validators for web
  - Some 3rd party validator plugins are available (Firefox, Chrome, Opera, Safari):
  - https://www.dnssec-validator.cz/
  - http://blog.huque.com/2014/02/dnssec-dane-tlsa-browser-addons.html
  - Bloodhound Mozilla fork:
  - https://www.dnssec-tools.org/wiki/index.php/Bloodhound

DANE for SMTP



DANE can be used to help secure (1) and (2)

DANE for SMTP

- DANE in conjunction with SMTP over TLS, or SMTP + STARTTLS can be used to more fully secure email delivery
- DANE can authenticate the certificate of the SMTP submission server that the user's mail client (MUA) communicates with
- DANE can authenticate TLS connections between SMTP servers ("MTA"s or Mail Transfer Agents)
- This second use case is where DANE solves some important problems that are unaddressed today

DANE for SMTP

- Most connections between SMTP servers today use encryption opportunistically (i.e. if both sides support and advertise it, it is used)
- Even when encryption is used, it is vulnerable to attack:
  - Attackers can strip away the TLS capability advertisement and downgrade the connection to not use TLS
  - TLS connections are often unauthenticated (e.g. the use of self signed certificates as well as mismatched certificates is common)
- DANE can address both these vulnerabilities
  - Authenticate the certificate using a DNSSEC signed TLSA record
  - Use the presence of the TLSA record as an indicator that encryption must be performed (prevent downgrade)
  - http://tools.ietf.org/html/draft-ietf-dane-smtp-with-dane

Example TLSA record (for SMTP)

```
_25._tcp.mx1.freebsd.org. 2389 IN TLSA 3 0 1 (
            5EC0508C3F337D18509F41BFF9D8AB07FED588A132FA
            12FA1E223BA6B9403ACB )

_25._tcp.mx1.freebsd.org. 2389 IN RRSIG  TLSA 8 5 3600 (
            20141023072418 20141009105807 39939
freebsd.org.
            ll6DEQ7oP2lbEcOeJyPk+I8tYiGz4CzuDiqiMbr4Mzp3
            90UWdej3kdAz4t+1BT0dO3/o0nz0pp3HFsDu+gkwT6YH
            Jg4C6mi3STPciCP1tjbFuW/dv4lPkCUaN7kJt/qwPrR6
            0kQmyvcuUoYgUDPbNYbJNJXai+mFai5WqLS2MEP15ydU
            nt8KympnjHS5mVLVGXW0e7tLY1afQz1VrIeYsGW8YztM
            DYUpCXjWiq+YpCFv7rZ7ICejQR6ot1M35CDsfjk68eu0
            EAjx+HlqaTdGyilcMB+GduFwqkULDPIgiFu/3xb+srJR
            zuR89YpHga9OCnz6nXJgQ6cxvSImZWbKuw== )
```

This is a domain-issued certificate (usage 3), which can be authenticated without a trusted CA.

Early large adopters of SMTP + DANE

Quite a few are large email systems in Germany. See a larger list at https://www.tlsa.info/

- posteo.de
- mailbox.org
- umbkw.de
- bund.de
- denic.de
- freebsd.org
- unitybox.de
- debian.org, debian.net
- ietf.org
- nlnetlabs.nl
- nic.cz
- nic.ch
- torproject.org

SMTP servers that support DANE

- Postfix MTA (works today, version 2.11 onwards)
- Exim (currently under development)

```
Quick start for Postfix:

  postconf -e "smtpd_use_tls = yes”
  postconf -e "smtp_dns_support_level = dnssec”
  postconf -e "stmp_tls_security_level = dane”
```

XMPP servers

- XMPP (Jabber) has seen some uptake of DANE.
- To authenticate the c2s and/or s2s portion of the XMPP protocol
- List of XMPP servers with DANE TLSA records:
    - https://xmpp.net/reports.php#dnssecdane

```
Example:

_xmpp-server._tcp.mail.de. 3600 IN SRV 10 20 5269 jabber.mail.de.

_5269._tcp.jabber.mail.de. 600  IN TLSA  3 1 1 (
                         A0315F0CF61CAC787140833C2C608550476
                         246DDA54122D66BB339D5 0FBB10E3 )
```

OpenPGPKEY

- OPENPGPKEY record
- Used to publish an OpenPGP public key in the DNS
- DNSSEC signature provides authentication
- Spec under development, but RR code already assigned
    - https://tools.ietf.org/html/draft-ietf-dane-openpgpkey

Example OPENPGPKEY record

sha224(username)._openpgpkey.<domain>

e.g. for shuque@huque.com

1st label: sha224 hash of “shuque” =
4f7c2705c0f139ede60573f8537a0790fb64df5d4a819af951d259bc

2nd label: “_openpgpkey”

Remaining labels: domain name portion of the email addr:
Huque.com

Resulting record looks like this:

4f7c2705c0f139ede60573f8537a0790fb64df5d4a819af951d259bc.
_openpgpkey.huque.com. IN OPENPGPKEY <base64 encoding of the openpgp key>

SMIMEA

- Using DNSSEC to associate certificates with domain names for S/MIME
  - https://tools.ietf.org/html/draft-ietf-dane-smime
- S/MIME is a method of encrypted and signing MIME data used in email messages
- The SMIMEA DNS record proposes to associate S/MIME certificates with DNS domain names
- Verisign DANE/SMIMEA early Mail User Agent Prototype
  - http://la51.icann.org/en/schedule/wed-dnssec/presentation-dnssec-dane-smime-15oct14-en

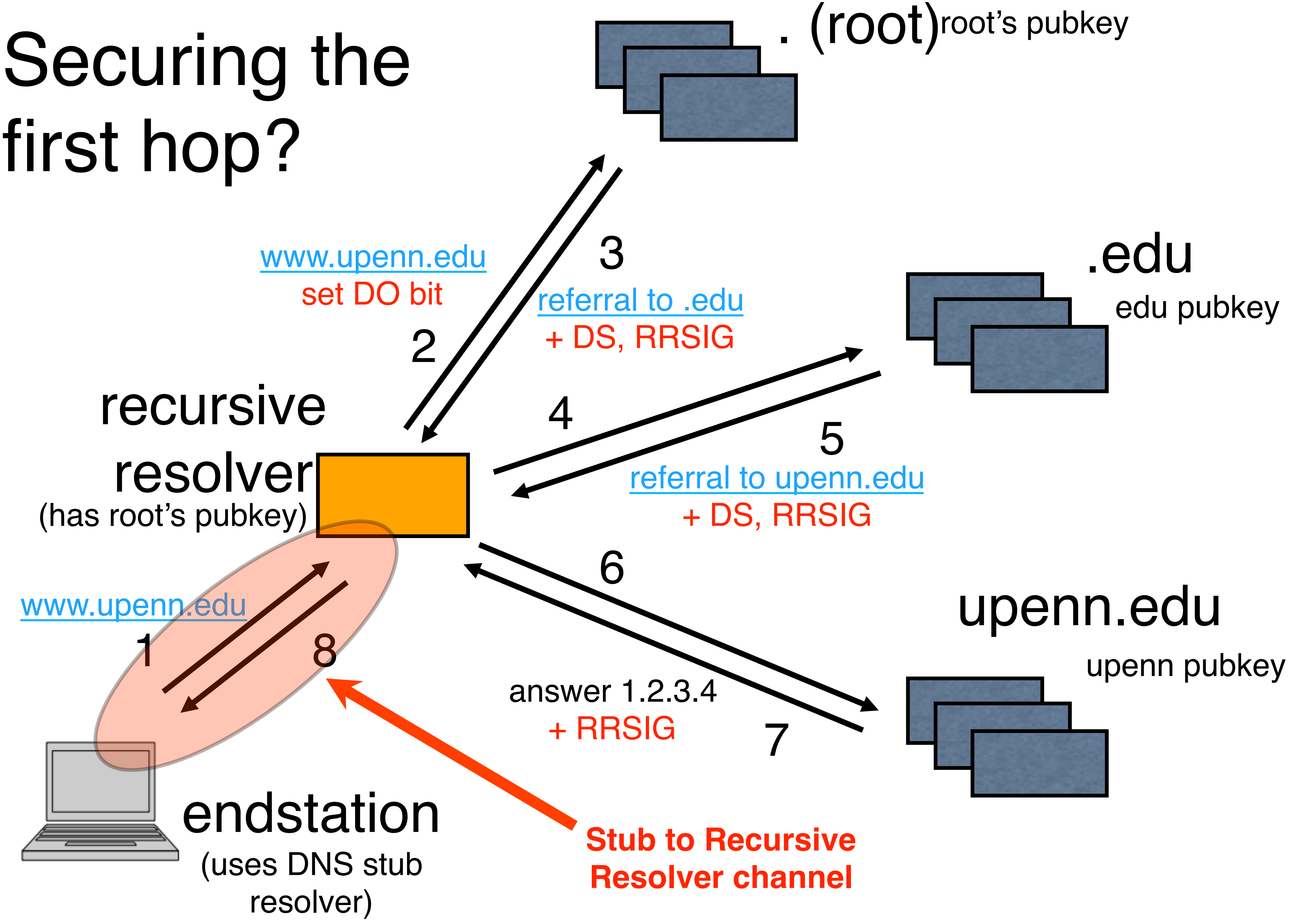
getdns: a brief introduction

A new application friendly interface to the DNS

Application access to any kind of DNS data

- Today's commonly used DNS application interfaces, like **getaddrinfo()**, **getnameinfo()** are designed to obtain the most common types of DNS data, e.g. name to IP address mappings, reverse DNS mappings, etc.
- How do applications ask for other types of data, eg. TLSA, SSHFP records, or even SRV records?
- How can we tell if a response was successfully authenticated with DNSSEC?
- Some lower level, harder to use libraries exist (libresolv etc) that can do some of this, but application developers deserve something much better

Securing the first hop?



. (root) root's pubkey

www.upenn.edu
set DO bit

2

3

referral to .edu
+ DS, RRSIG

.edu

edu pubkey

recursive resolver
(has root's pubkey)

4

5

referral to upenn.edu
+ DS, RRSIG

6

upenn.edu

upenn pubkey

www.upenn.edu

1

8

answer 1.2.3.4
+ RRSIG

7

endstation
(uses DNS stub resolver)

Stub to Recursive Resolver channel

DNS first hop protection

- Applications normally query a DNS stub resolver
- The stub resolver communicates over the network with a recursive resolver. How do we secure that path?
- Complex solutions exist (but rarely used)
  - e.g. employ a channel security mechanism between the stub and the validating recursive resolver:
  - TSIG, SIG(0), IPsec
- Run full-service validating resolver on endstation
- There may be other solutions, like DNScrypt – not standards based, only supported by a few resolvers, not widely used
- getdns can solve this problem

getdns: a new DNS library for applications

- getdns: A new application-friendly interface to the DNS

- Get and use arbitrary data in the DNS easily
- Get this data securely, authenticated with DNSSEC if it’s available
  - Full iterative resolver mode with validation
  - Validating stub resolver mode

- Designed by application developers. Most previous APIs have been developed by DNS protocol people with less concern for the needs of app developers.

getdns

- API specification:
  - http://www.getdnsapi.net/spec.html
- Latest revision: January 2015
  - Creative Commons Attribution 3.0 Unported license

- An opensource implementation at http://getdnsapi.net/
  - A joint project of Verisign Labs and NLNet Labs
  - First release (0.1.0) in February 2014
  - Latest release (0.1.6) in January 2015
  - C library
  - Bindings in Python, and Node.js (upcoming: java, go, ruby, perl)
  - BSD 3 License

getdns features

- Asynchronous and synchronous modes of operation
- Sensible defaults suitable for consumption by most users
- But behavior highly configurable for users with advanced knowledge of the DNS
- DNS query results are returned in an easy to parse “response dictionary” data structure
- Members of the data structure can be lists, dictionaries, integers, and binary strings
- Can return DNSSEC status, and can be instructed to only return DNSSEC authenticated results

getdns functions

Four main functions defined.

getdns_address()	Obtain IPv4 and/or IPv6 addresses
getdns_hostname()	Obtain reverse DNS mappings
getdns_service()	Obtain SRV record answers
getdns_general()	General purpose DNS record query

Read the API specification for full details:

http://www.getdnsapi.net/spec.html

getdns response dictionary (partial)

```
{
  "answer_type": GETDNS_NAMETYPE_DNS,
  "canonical_name": <bindata of "www.internet2.edu.">,
  "just_address_answers": [
    {
      "address_data": <bindata for 207.75.164.248>,
      "address_type": <bindata of "IPv4">
    },
    {
      "address_data": <bindata for 2001:48a8:68fe::248>,
      "address_type": <bindata of "IPv6">
    }
  ],
  "replies_full":
  [
     <bindata of 0x0000081a0000100040000000103777777...>,
     <bindata of 0x0000081a000010004005000d03777777...>
  ], …
```

getdns response dictionary (partial)

```
"dnssec_status": GETDNS_DNSSEC_SECURE,

"replies_tree":
  [
    {
      "additional": [],
      "answer":
      [
        {
          "class": GETDNS_RRCLASS_IN,
          "name": <bindata for www.internet2.edu.>,
          "rdata":
          {
            "cname": <bindata for webprod2.internet2.edu.>,
            "rdata_raw": <bindata for webprod2.internet2.edu.>
          },
          "ttl": 120,
          "type": GETDNS_RRTYPE_CNAME
        },
 […]
```

getdns: example code: hostname lookup

```
# Example python code to query a domain name and
# return all associated IPv4 and IPv6 addresses.

hostname = sys.argv[1]

ctx = getdns.Context()
extensions = {"return_both_v4_and_v6”:getdns.GETDNS_EXTENSION_TRUE}

results = ctx.address(name=hostname, extensions=extensions)
status = results['status']

if status == getdns.GETDNS_RESPSTATUS_GOOD:
    for addr in results['just_address_answers']:
        print addr['address_data']
else:
    print "%s: getdns.address() error: %d" % (hostname, status)
```

```
$ ./program.py www.internet2.edu
207.75.164.248
2001:48a8:68fe::248
```

getdns: example code: TLSA record lookup

```
# Example python code to lookup an authenticated TLSA
# record for a domain name, transport, & service port.

qname = “_443._tcp.fedoraproject.org”
qtype = getdns.GETDNS_RRTYPE_TLSA

ctx = getdns.Context()
extensions = {
  "dnssec_return_only_secure”:getdns.GETDNS_EXTENSION_TRUE
}

results = ctx.general(name=qname, request_type=qtype,
                      extensions=extensions)
status = results['status']

if status == getdns.GETDNS_RESPSTATUS_GOOD:
    # here we’d normally parse and do something useful with the
    # result data. For now just pretty print the dict.
    pprint.pprint(results)
else:
    print "%s: getdns.address() error: %d" % (hostname, status)
```

Questions or comments?

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