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DANE TLSA implementation and operational guidance
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Abstract

This memo provides operational guidance to server operators to help ensure that clients will be able to authenticate a server's certificate chain via published TLSA records. Guidance is also provided to clients for selecting reliable TLSA record parameters and how to use them for server authentication. Finally, guidance is given to protocol designers who wish to make use of TLSA records when securing protocols using a TLS and TLSA combination.

Status of This Memo

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1. Introduction

The Domain Name System Security Extensions (DNSSEC) add data origin authentication and data integrity to the Domain Name System. DNSSEC is defined in [RFC4033], [RFC4034] and [RFC4035].

In the context of this memo, channel security is assumed to be provided by TLS or DTLS. The Transport Layer Security (TLS) and Datagram Transport Layer Security (DTLS) protocols provide secured TCP and UDP communication over the Internet Protocol. By convention, "TLS" will be used throughout this document and, unless otherwise specified, the text applies equally as well to the DTLS protocol. Used without authentication, TLS provides protection only against eavesdropping. With authentication, TLS also provides protection

against man-in-the-middle (MITM) attacks. Since the publication of the TLS 1.0 specification in [RFC2246], two updates to the protocol have been published: TLS 1.1 [RFC4346] and TLS 1.2 [RFC5246]. The DTLS protocol was later documented in [RFC6347].

As described in the introduction of [RFC6698], TLS authentication via the existing public Certificate Authority (CA) Public Key Infrastructure (PKI) suffers from an over-abundance of trusted certificate authorities capable of issuing certificates for any domain of their choice. DNS-Based Authentication of Named Entities (DANE) leverages the DNSSEC infrastructure to publish trusted keys and certificates of end-entities or certificate-authorities for use with TLS via a new TLSA record type. DNSSEC validated DANE TLSA records have created a new PKI designed to augment or replace the trust model of the existing public CA PKI.

1.1. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

The following terms are used throughout this document:

Service Provider: A company or organization that offers to host a service on behalf of a Client Domain. The original domain name associated with the service is typically still within the control of the client and the service provider is frequently referred to by a redirection resource record. Example redirection records include MX, SRV, and CNAME. Many times, the Service Provider provides services for many customers and must carefully manage any TLS credentials offered to connecting applications to ensure name matching is handled easily by the applications.

Client Domain: Clients that make use of a Service Provider to outsource their services will be referred to as "Client Domains".

TLSA Publisher: The entity responsible for publishing a TLSA record within a DNS zone. This zone will be considered DNSSEC signed and validatable to a trust anchor, unless otherwise specified. If the Client Domain is not outsourcing their DNS service, the TLSA Publisher will be the client themselves. Otherwise the TLSA Publisher may be the outsourced DNS service instead.

public key: The term "public key" will be an informal short-hand for the subjectPublicKeyInfo component of a PKIX certificate.

SNI: The "Server Name Indication", or SNI, describes the process by which a TLS client requests to connect to a particular service name of a TLS server ([RFC3546]). Without this TLS extension, a TLS server has no choice but to offer a PKIX certificate with a default list of server names. Service Providers that are expected to host services for many clients need to present the correct certificate for the correct client, and the SNI extension provides a hint to the server which certificate should be transmitted to the client.

2. DANE TLSA record overview

[RFC6698] specifies a protocol for publishing TLS server certificate associations via DNSSEC. The DANE TLSA specification defines multiple TLSA RR types via combinations of 3 numeric parameters. These integer values of these parameters were later given symbolic names in [I-D.ietf-dane-registry-acronyms]. These parameters are:

- The TLSA Certificate Usage field. Section 2.1.1 of [RFC6698] specifies 4 values ranging from 0 to 3: PKIX-CA(0), PKIX-EE(1), DANE-TA(2), and DANE-EE(3). There is an additional private-use value: PrivCert(255). All other values are reserved for use by future specifications.

- The selector field. Section 2.1.2 of [RFC6698] specifies 2 values ranging from 0 to 1: Cert(0), SPKI(1). There is an additional private-use value: PrivSel(255). All other values are reserved for use by future specifications.

- The matching type field. Section 2.1.3 of [RFC6698] specifies 3 values ranging from 0 to 2: Full(0), SHA2-256(1), SHA2-512(2) There is an additional private-use value: PrivMatch(255). All other values are reserved for use by future specifications.

We may consider the TLSA Certificate Usage values 0 through 3 to be a combination of two one-bit flags. The low-bit chooses between referencing trust-anchor (TA) and end-entity (EE) certificates. The high bit chooses between public PKI issued and domain-issued certificates:

- When the low bit is set (PKIX-EE(1) and DANE-EE(3)) the TLSA record matches an EE (server) certificate.

- When the low bit is not set (PKIX-CA(0) and DANE-TA(2)) the TLSA record matches a trust-anchor (a certificate authority) that issued a certificate somewhere in the certificate chain that authenticates the final end-entity certificate.

- When the high bit is set (DANE-TA(2) and DANE-EE(3)), the server certificate chain is domain-issued and may be verified without reference to any existing public certificate authority PKI. Trust is entirely placed on the content of the TLSA records obtained via DNSSEC.

- When the high bit is not set (PKIX-CA(0) and PKIX-EE(1)), the TLSA record publishes a server policy stating that its certificate chain must pass PKIX validation [RFC5280] and the DANE TLSA record is used to constrain the server certificate chain to contain the referenced CA or EE certificate.

The selector field specifies whether the TLSA RR matches the whole certificate (Cert(0)) or just its subjectPublicKeyInfo (SPKI(1)). The subjectPublicKeyInfo is an ASN.1 DER encoding of the certificate's algorithm id, any parameters and the public key data).

The matching type field specifies how the TLSA RR Certificate Association Data field is to be compared with the certificate or public key. A value of Full(0) means an exact match: the full DER encoding of the certificate or public key is given in the TLSA RR. A SHA2-256(1) value means a SHA-256 digest of the certificate or public key, and likewise SHA-512(2) means a SHA-512 digest is used. Of these, only SHA-256(1) is mandatory to implement. Clients SHOULD implement SHA-512(2), but servers SHOULD NOT exclusively publish SHA-512(2) digests. Unless a "second preimage" attack is found against SHA-256(1), servers should only publish SHA-256(1) digests.

2.1. Example TLSA record

In the example TLSA record below:

```
_25._tcp.mail.example.com. IN TLSA 3 0 1 (
                              E8B54E0B4BAA815B06D3462D65FBC7C0
                              CF556ECCF9F5303EBFBB77D022F834C0 )
```

The TLSA Certificate Usage is DANE-EE(3), the selector is Cert(0) (Cert) and the matching type is SHA2-256(1). The rest of the record is the certificate association data field, which is in this case the SHA-256 digest of the server certificate.

3. General DANE Guidelines

These guidelines provide guidance for using or designing protocols for DANE, regardless of what of TLSA record will be used.

3.1. TLS Requirements

TLS clients that support DANE/TLSA MUST support at least TLS 1.0 and SHOULD support TLS 1.2. TLS clients and servers using DANE SHOULD support the "Server Name Indication" extension of TLS.

3.2. DANE DNS Record Size Guidelines

Selecting a combination of TLSA parameters to use requires careful thought. One important consideration to take into account is the size of the resulting TLSA record after its parameters are selected.

3.2.1. UDP and TCP Considerations

Deployments SHOULD avoid TLSA record sizes that cause UDP fragmentation.

Although DNS over TCP would provide the ability to transfer larger DNS records between clients and servers, it is not universally deployed and is still blocked by some firewalls. Clients that request DNS records via UDP typically only use TCP upon receipt of a truncated response in TCP.

3.2.2. Packet Size Considerations for TLSA Parameters

Server operators SHOULD NOT publish TLSA records using both a TLSA Selector of Cert(0) and a TLSA Matching Type of Full(0), as even a single certificate is generally too large to be reliably delivered via DNS over UDP. Furthermore, two TLSA records containing full certificates may need to be published in during certificate rollover.

While TLSA records using a TLSA Selector of SPKI(1) and a TLSA Matching Type of Full(0) publish full public keys without the full X.509 wrapping, are generally more compact, these too should be used with caution as they are still larger than necessary. Instead, servers SHOULD make use of the digest-based TLSA Matching Types within TLSA records instead. The complete certificate should, instead, be transmitted to the client in-band during the TLS handshake.

In summary, the use of a TLSA Matching Type of Full(0) is NOT RECOMMENDED and the use of SHA-256(1) and SHA-512(2), instead, are encouraged.

3.3. Certificate Name Check Conventions

Certificates presented by a TLS server will contain either a Common Name (CN) or subjectAltName (or both). The server's "hostname" should be published within these fields, ideally within the subjectAltName as usage of the Common Name field is depreciated.

This section discusses what must steps must be taken to match an expected name against the name found within a certificate, if checking is required.

The TLSA Publisher for TLSA records for a given service MUST ensure that at least one of these TLSA records will match the server's certificate chain. If SNI is not employed for a TLS connection, the TLSA record must match the server's default certificate. If the SNI extension is sent by the client with a host_name (see [RFC3546] Section 3.1) equal to the base domain of the TLSA RRset, at least one TLSA record must match the certificate presented by the server for that host_name.

When, for example, the TLSA RRset is published at "_25._tcp.mail.example.com", the TLSA base domain is "mail.example.com". At least one of the TLSA records in the _25._tcp.mail.example.com RRset MUST match the server certificate chain, provided the client TLS hanshake included the SNI extension with a host_name of "mail.example.com".

Note: Except with TLSA Certificate Usage DANE-EE(3), where name checks are not applicable (see Section 4.1), DANE aware clients SHOULD use the base domain of the TLSA RRset to verify that the client has reached the correct server by checking that the TLSA base domain is matched by one of the subjectAltName ([RFC5280]) values in the server certificate. The commonName from the certificate subject DN SHOULD only be used when no subjectAltNames of type 'dns' are present. Additional acceptable names may be specified by protocol specific DANE specifications. For example, with SMTP both the destination domain name and the MX host name are acceptable names to be found in the server certificate.

Since the server's ability to respond with the right certificate chain requires the TLS client to provide the correct SNI information, clients SHOULD send the SNI extension with a host_name value of the base domain of the TLSA RRset. Clients failing to transmit SNI information may be unable to properly authenticate the presented certificate due to certificate naming mismatches.

3.4. Service Provider and TLSA Publisher Synchronization

Complications arise when the TLSA Publisher is not the same entity as the Service Provider. In this situation, the TLSA Publisher and the Service Provider must cooperate to ensure that TLSA records published by the TLSA Publisher don't fall out of sync with the server certificate configuration used by the Service Provider.

Ideally, the TLSA Publisher and the Service Provider should be the same entity. If a TLSA record must be published in the Client Domain's base domain, CNAME records can easily point at the real TLSA record in the Service Provider's zone assuming TLSA Certificate Usage DANE-EE(3) TLSA records are published by the Service Provider (see Section 3.5). Having the master TLSA record in the Service Provider's zone avoids the complexity of bilateral coordination of server certificate configuration and TLSA record management.

For example, with SMTP, the Client Domain's MX record's exchange name can point directly at the Service Provider's SMTP hosts. When the Client Domain's DNS zone is signed, the MX record's exchange name can be securely used as the base name for TLSA records that are published and managed by the Service Provider.

If directly pointing at the Service Provider's domain is not possible, then care must be taken during a Service Provider's certificate rollover. Before a Service Provider publishes a new certificate, it should make that certificate available to all of its Client Domains and the Client Domains should publish a new TLSA record in advance of the certificate usage date. Only once the new certificate is in place and in-use globally may the older TLSA record be removed.

3.5. TLSA Base Domain and CNAMEs

When the protocol does not support service location indirection via MX, SRV or similar DNS records, the service may be redirected via a CNAME. A CNAME is a more blunt instrument for this purpose, since unlike an MX or SRV record, it remaps the origin domain to the target domain for all protocols, not just a singular one. Also Unlike MX or SRV records, CNAME records may chain (though DNS resolving implementations will generally impose an implementation dependent maximum nesting depth).

When CNAMEs are employed, the best place to seek DANE TLSA records is in the Service Provider's domain, as discussed in Section 3.4. Therefore, DANE PKI clients connecting to a server whose domain name is a CNAME alias SHOULD follow the CNAME hop-by-hop to its ultimate target host (noting at each step whether the CNAME is DNSSEC validated) and use the final target host as the base domain for TLSA lookups.

Implementations failing to find a TLSA record using a base name of the final target of a CNAME expansion MAY choose to issue a TLSA query using the original destination name. I.e, the preferred tlsa base name would derived for the most-expanded name, and failing that would be the initial query name.

Protocol-specific TLSA specifications may provide additional guidance or restrictions when following CNAME expansions.

3.5.1. Redirecting TLSA lookups in the Client Domain

If CNAMEs are not followed, Client Domains will need to publish TLSA records that match the Service Provider's certificate chain or always use an entity that was both the Service Provider and the TLSA publisher. Having the TLSA base domain be different than the Service Provider's domain imposes a difficult key management burden on the Client Domain and the Service Provider.

Fortunately, it is possible to publish CNAMEs in the Client Domain pointing to the Service Provider's TLSA RRset if the TLSA certificate usage field is set to DANE-EE(3). Otherwise, a client that used the alias name (from the hosted domain rather than the Service Provider's domain) as the base domain to obtain the TLSA RRset would look for the hosted domain in the server certificate when performing name checks, and would generally fail to authenticate the server except in the rare cases when the server's certificate does include the Client Domain. SNI SHOULD be used to help perform the right certificate selection by the server, although this imposes a management burden on the TLS server that could be avoided by ensuring the TLSA base domain is within the Service Provider's control in the first place.

Example CNAME record for a TLSA domain:

```
 ; TLSA RRs aliased to Service Provider, but the base domain is
 ; the hosted domain.  Likely to fail name check unless Service
 ; Provider usage is "3".
 ;
 _25._tcp.mail.example.com. IN CNAME _25._tcp.mail.example.net.
     _25._tcp.mail.example.net. IN TLSA 3 1 1 ...
```

Note: when the TLSA RRset query domain (base domain plus port and protocol prefixes) resolves to a DNSSEC validated CNAME that points to a DNSSEC signed zone with the actual TLSA records, as the above example indicates, it has no effect on the value of the base domain, which remains the original domain to which the client prefixed the port and protocol. In the example above, the base domain is "mail.example.com" and not "mail.example.net".

Though CNAMEs are illegal on the right hand side of most indirection records, such as MX and SRV records, they are supported by some implementations. For example, if the MX or SRV host is a CNAME alias, some implementations may "chase" the CNAME. They SHOULD use the target hostname as the base domain for TLSA records as well as the host_name in SNI, provided the CNAME RR is found to be "secure" at each step in the CNAME expansion.

3.6. TLSA Base Name Priorities

There are multiple steps within a chaining DNS lookup process that TLSA base names can be pulled from. This section will discuss what the preferred selection points are. TBD.

1. Final Domain Name

2. Redirect Name

3. Initial Name

3.7. Interaction with Certificate Transparency

[RFC6962] Certificate Transparency or CT for short, defines an approach to mitigate the risk of rogue or compromised public CAs issuing unauthorized certificates. This section clarifies the interaction of CT and DANE. CT is a protocol and auditing system that applies only to public CAs, and only when they are free to issue unauthorized certificates for a domain. If the CA is not a public CA, or DANE TLSA RRs constrain the end-entity certificate to a fixed public key, there is no role for CT, and clients need not apply CT checks.

When a server is authenticated via a DANE TLSA RR with TLSA Certificate Usage PKIX-EE(1) or DANE-EE(3), the domain owner has unambiguously specified the certificate associated with the given service. Even if a rogue CA were able to issue an unauthorized end-entity certificate that binds a public key to a name in that domain, barring "second preimage" attacks on the hashing algorithms in use, any such certificate would not match the TLSA record and would be rejected. Therefore, when a TLS client authenticates the TLS server via a TLSA certificate association with usage PKIX-EE(1) or DANE-EE(3), CT checks need not be performed. Publication of the server certificate or public key (digest) in a TLSA record in a DNSSEC signed zone by the domain owner assures the client that the certificate is not an unauthorized certificate issued by a rogue CA without the domain owner's consent.

When a server is authenticated via a DANE TLSA RR with TLSA usage DANE-CA(2) and the server certificate does not chain to a known public root CA, CT cannot apply (CT logs only accept chains that start with a known, public root). Since TLSA Certificate Usage DANE-CA(2) is generally intended to support non-PKIX trust anchors, clients need not perform CT checks with usage DANE-CA(2) using unknown root CAs.

A server operator that wants to perform CT checks should use TLSA RRs with usage PKIX-CA(0) and use a known, trusted public PKIX root issuer.

3.8. Design Considerations for Protocols Using DANE

When a TLS client goes to the trouble of authenticating a certificate presented by a TLS server, it should not continue to use the server in case of authentication failure or else authentication serves no purpose. Servers publishing TLSA records MUST be configured to allow correctly configured clients to successfully authenticate the server's TLS certificate.

If all the TLSA records for a service are found unusable (possibly due to unsupported parameter combinations), it is application protocol specific as to whether the connection should be established anyway without relying on TLS security, with only TLS encryption but not authentication, or whether to refuse to connect entirely. Protocols must choose whether to prioritize security or robustness. Refusing to connect in the case of unusable parameters is clearly the better option if transport security is critical, but some protocols may value operational robustness when transport security is merely a "nice to have" rather than a requirement.

3.8.1. Design Considerations for non-PKIX Protocols

For some application protocols, the existing public CA PKI may not be viable (such as with SMTP over TLS). For these (non-PKIX) protocols, protocol documents SHOULD NOT suggest publishing TLSA records with TLSA Certificate Usage PKIX-CA(0) or PKIX-EE(1), as clients cannot be expected to perform [RFC5280] PKIX validation or [RFC6125] identity verification.

Protocols designed for non-PKIX use SHOULD choose to treat any TLSA records with TLSA Certificate Usage PKIX-CA(0) or PKIX-EE(1) as unusable. After verifying that the only available TLSA Certificate Usage types are PKIX-CA(0) or PKIX-EE(1), protocol specifications MAY instruct clients to either refuse to initiate a connection or to connect via unauthenticated TLS if no alternative authentication mechanisms are available.

If non-PKIX protocols do allow for publication of TLSA records with TLSA Certificate Usage PKIX-CA(0) or PKIX-EE(1), clients SHOULD make use of the TLSA verification to the fullest extent possible.

3.8.1.1. TLSA Certificate Usage PKIX-EE(1)

With non-PKIX protocols, clients using TLSA Certificate Usage PKIX-EE(1) records MAY ignore the PKIX validation requirement, and authenticate the server per the content of the TLSA record alone. Since servers will hopefully rely on SNI to select the correct certificate for presentation, the client SHOULD use the SNI extension to signal the base domain of the TLSA RRset.

3.8.1.2. TLSA Certificate Usage PKIX-CA(0)

With TLSA Certificate Usage PKIX-CA(0) in non-PKIX protocols, the usability of the TLSA records depends on its matching type.

If the matching type is Full(0), the client has all the information it needs to match the server trust-chain to the TLSA record. The client MAY ignore the PKIX validation requirement and authenticate the server via its DANE TLSA records alone (sending SNI with the base domain as usual). The client SHOULD use the base domain of the TLSA record(s) in certificate name checks.

If the matching type is not Full(0), the TLSA record contains only a digest of the trust certificate authority certificate or public key. The full certificate may not be included in the server's certificate chain and the client may not be able to match the server trust chain against the TLSA record when a non-PKIX protocol is being used, as the client won't have the needed CA trust list. See Section 3.9.1 for a more complete discussion of this case. The client cannot reliably authenticate the server in this case and SHOULD treat the TLSA record as unusable.

If the client is configured with a set of trusted CAs that are believed to be sufficiently complete to authenticate all the servers it expects to communicate with, then it MAY elect to honor certificate usage PKIX-CA(0) TLSA records that publish digests of the trusted CA certificate or public key.

3.9. TLSA Records and Trust Anchor Digests

With TLSA records that match the EE certificate, the TLS client has no difficulty matching the TLS record against the server certificate, as this certificate is always present in the TLS server certificate chain. The TLS client can, if necessary, extract the public key from the server certificate, and can compute the appropriate digest.

With DANE TLSA records that match the digest of a TA certificate or public key, a complication arises when the TA certificate is omitted from the server's certificate chain. This can happen when the trust-anchor is a root certificate authority, as stated in section 7.4.2 of [RFC5246]:

> The sender's certificate MUST come first in the list. Each following certificate MUST directly certify the one preceding it. Because certificate validation requires that root keys be distributed independently, the self-signed certificate that specifies the root certificate authority MAY be omitted from the chain, under the assumption that the remote end must already possess it in order to validate it in any case.

This means that TLSA records that match a TA certificate or public key digest are not entirely sufficient to validate the peer certificate chain. If no matching certificate is found in the server's certificate chain, the chain may be signed by an omitted root CA whose digest matches the TLSA record. We will consider each trust-anchor TLSA Certificate Usage in turn.

3.9.1. Trust Anchor Digests With TLSA Certificate Usage 0

In this case, from the server's perspective, the omission of the root CA seems reasonable, since in addition to authentication via DANE TLSA records, the client is expected to perform [RFC5280] PKIX validation of the server's trust chain and thus to already have a copy of the omitted root certificate.

From the client's perspective the situation is more nuanced. Despite the server's indicated preference for PKIX validation, the client may not possess (or may not fully trust) a complete set of public root CAs. This is especially likely in protocols where the existing public CA PKI is not applicable, as described in Section 3.8.1. If it is likely that a client lacks a sufficiently complete list of trusted CAs, and that a non-negligible number of DNS servers publish TLSA Certificate Usage PKIX-CA(0) TLSA records with digests of omitted root CAs, then such a client SHOULD treat such TLSA records as "unusable". Simply ignoring PKIX validation is not an option, since the client will also be unable to match the TLSA record without position of the root certificate. The client MAY choose fall back to unauthenticated TLS, if PKIX is also not an option (see [I-D.ietf-dane-srv]) or refuse to initiate a connection.

3.9.2. Trust Anchor Digests With TLSA Certificate Usage 2

With TLSA Certificate Usage DANE-CA(2), there is no expectation that the client is pre-configured with the trust anchor certificate. With

TLSA Certificate Usage DANE-CA(2) clients are expecting to rely on the TLSA records alone. But, with a matching type other than PKIX-CA(0) the TLSA records contain neither the full trust anchor certificate nor the full public key. If the TLS server's certificate chain does not contain the trust-anchor certificate, clients will be unable to authenticate the server.

TLSA Publishers that publish TLSA Certificate Usage DANE-CA(2) with a non-zero matching type MUST ensure that the corresponding server is configured to include the associated trust anchor certificate in its TLS handshake certificate chain, even if that certificate is a self-signed root CA and would have been optional in the context of the existing public CA PKI.

Since servers are expected to always provide usage DANE-CA(2) trust anchor certificates (either via DNS or else via the TLS hanshake), clients SHOULD fully support this TLSA Certificate Usage. Clients MAY choose to treat it as unusable if experience proves that servers don't consistently live up to their obligations.

3.10. Trust anchor public keys

TLSA records with TLSA Certificate Usage PKIX-CA(0) or DANE-CA(2), selector SPKI(1) and a matching type of Full(0) publish the full public key of a trust anchor via DNS. In section 6.1.1 of [RFC5280] the definition of a trust anchor consists of the following four parts:

1. the trusted issuer name,

2. the trusted public key algorithm,

3. the trusted public key, and

4. optionally, the trusted public key parameters associated with the public key.

Items 2-4 are precisely the contents of the subjectPublicKeyInfo published in the TLSA record, but the issuer name is not included in the public key.

With TLSA Certificate Usage PKIX-CA(0), when the client is able to perform PKIX validation, the client can construct a complete PKIX trust chain as it will have access to the trust anchor name. So in that case, the client can verify that the server certificate chain is issued by a trust anchor that matches the TLSA record.

With TLSA Certificate Usage DANE-CA(2), the client may not have the missing trust anchor certificate, and cannot generally verify whether a particular certificate chain is "issued by" the trust anchor described in the TLSA record. If the server certificate chain includes a CA certificate whose public key matches the TLSA record, the client can match that CA as the intended issuer. Otherwise, the client can only check that the topmost certificate in the server's chain is "signed by" by the trust anchor public key in the TLSA record.

Since trust chain validation via bare public keys rather than trusted CA certificates may be difficult to implement using existing TLS libraries, servers SHOULD include the trust anchor certificate in their certificate chain when the TLSA Certificate Usage is DANE-CA(2).

If none of the server's certificate chain elements match a public key specified in full (selector = Cert(0), match type = Full(0)) in a TLSA record, clients SHOULD attempt to check whether the topmost certificate in the chain is signed by the provided public key, and if so consider the server trust chain valid, with authentication complete if name checks are also successful.

4. Type Specific DANE Guidelines

4.1. Type 3 Guidelines

4.2. Type 2 Guidelines

4.3. Type 1 Guidelines

4.4. Type 0 Guidelines

TLSA Certificate Usage PKIX-CA(0) allows a domain to publish constraints on the set of certificate authorities trusted to issue certificates for its TLS servers. It is expected that clients will only accept trust chains which contain a match for one of the published TLSA records. This is simple for TLSA Certificate Usage PKIX-EE(1) where the PKIX trust chain always contains the leaf server certificate. The situation for TLSA Certificate Usage PKIX-CA(0) is more subtle.

TLSA Publishers may publish TLSA records for a particular public root CA, expecting that clients will then only accept chains anchored at that root. It is possible, however, that the client's set of trusted certificates includes some intermediate CAs, either with or without the corresponding root CA. When a client constructs a trust chain leading from a trusted intermediate CA to the server leaf

certificate, such a chain may omit any trusted roots published in the server's TLSA records.

If the omitted root is also trusted, the client may erroneously reject the server chain if it fails to determine that the shorter chain it constructed extends to a longer trusted chain that matches the TLSA records. This means that a client SHOULD not always stop extending the chain when the first locally trusted certificate is found. If no TLSA records have matched any of the elements of the chain, it MUST attempt to build a longer chain if the trusted certificate found is not self-issued, in the hope that a certificate closer to the root may in fact match the server's TLSA records.

5. Note on DNSSEC security

Clearly the security of the DANE TLSA PKI rests on the security of the underlying DNSSEC infrastructure. While this memo is not a guide to DNSSEC security, a few comments may be helpful to TLSA implementors.

With the existing public CA PKI, name constraints are rarely used and public root CAs can issue certificates for any domain of its choice. With DNSSEC, the situation is different. Only the registrar of record can update a domain's DS record in the registry parent zone (in some cases, however, the registry is the sole registrar). With gTLDs, for which multiple registrars compete to provide domains in a single registry, it is important to make sure that rogue registrars cannot easily initiate an unauthorized domain transfer, and thus take over DNSSEC for the domain. DNS Operators SHOULD use a registrar lock of their domains to offer some protection of this possibility.

When the registrar is also the DNS operator for the domain, one needs to consider whether the registrar will allow orderly migration of the domain to another registrar or DNS operator in a way that will maintain DNSSEC integrity. TLSA Publishers SHOULD ensure their registrar publishes a suitable domain transfer policy.

DNSSEC signed RRsets cannot be securely revoked before they expire. Operators should plan accordingly and not generate signatures with excessively long duration. For domains publishing high-value keys, a signature lifetime of a few days is reasonable, and the zone should be resigned every day. For more domains with less critical data, a reasonable signature lifetime is a couple of weeks to a month, and the zone should be resigned every week. Monitoring of the signature lifetime is important. If the zone is not resigned in a timely manner, one risks a major outage with the entire domain becoming invalid.

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7. Security Considerations

Application protocols that cannot make use of the existing public CA PKI (so called non-PKIX protocols), may choose to not implement certain PKIX-dependent TLSA record types defined in [RFC6698], or may choose to make a best-effort use of such records. In neither case is security compromised, since by assumption PKIX verification is simply not an option for these protocols. When the TLS server is authenticated based on the TLSA records alone, the client is as well authenticated as possible, treating the TLSA records as unusable would lead to weaker security.

Therefore, when TLSA records are used with protocols where PKIX does not apply, the recommended trade-off is for servers to not publish PKIX-dependent TLSA records, and for clients to use them as best they can, but otherwise treat them unusable. Of course when PKIX validation is an option clients SHOULD perform PKIX validation per [RFC6698].

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