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Domain Name Associations (DNA) in the Extensible Messaging and Presence Protocol (XMPP)

Abstract

This document improves the security of the Extensible Messaging and Presence Protocol (XMPP) in two ways. First, it specifies how to establish a strong association between a domain name and an XML stream, using the concept of "prooftypes". Second, it describes how to securely delegate a service domain name (e.g., example.com) to a target server hostname (e.g., hosting.example.net); this is especially important in multi-tenanted environments where the same target server hosts a large number of domains.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 5741.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc7712.

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1. Introduction

In systems that use the Extensible Messaging and Presence Protocol (XMPP) [RFC6120], it is important to establish a strong association between the DNS domain name of an XMPP service (e.g., example.com) and the XML stream that a client or peer server initiates with that service. In other words, the client or peer server needs to verify the identity of the server to which it connects. Additionally, servers need to verify incoming connections from other servers.

To date, such verification has been established based on information obtained from the Domain Name System (DNS), the Public Key Infrastructure (PKI), or similar sources. In particular, XMPP as defined in [RFC6120] assumed that Domain Name Associations (DNA) are to be proved using the "PKIX prooftype"; that is, the server's proof consists of a PKIX certificate that is checked according to the XMPP profile of the matching rules from [RFC6125] (and the overall validation rules from [RFC5280]), the client's verification material is obtained out of band in the form of a trusted root, and secure DNS is not necessary.

By extending the concept of a domain name association within XMPP, this document does the following:

1. Generalizes the model currently in use so that additional prooftypes can be defined if needed.

2. Provides a basis for modernizing some prooftypes to reflect progress in underlying technologies such as DNS Security [RFC4033].

3. Describes the flow of operations for establishing a domain name association.

This document also provides guidelines for secure delegation of a service domain name (e.g., example.com) to a target server hostname (e.g., hosting.example.net). The need for secure delegation arises because the process for resolving the domain name of an XMPP service into the IP address at which an XML stream will be negotiated (see [RFC6120]) can involve delegation of a service domain name to a target server hostname using technologies such as DNS SRV records [RFC2782]. A more detailed description of the delegation problem can be found in [RFC7711]. The domain name association can be verified only if the delegation is done in a secure manner.

2. Terminology

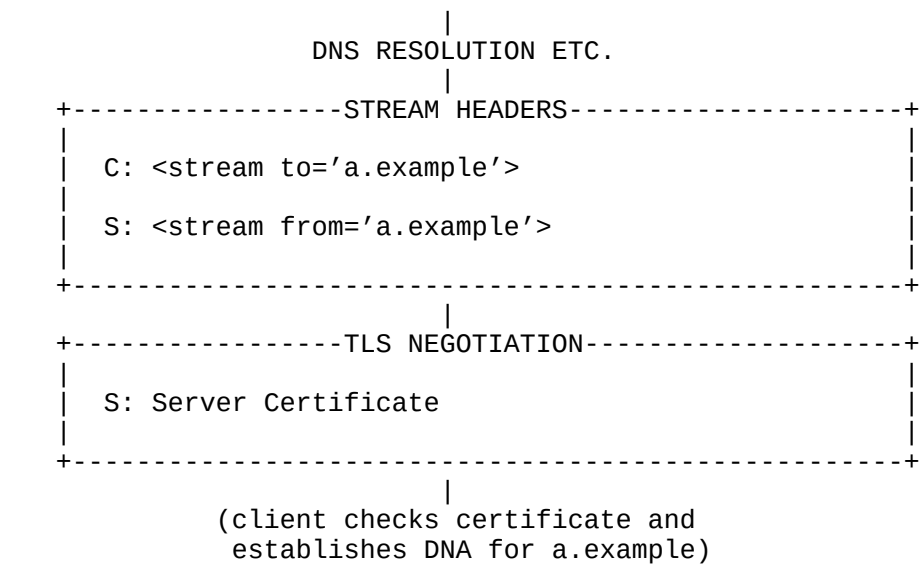
This document inherits XMPP terminology from [RFC6120] and [XEP-0220]; DNS terminology from [RFC1034], [RFC1035], [RFC2782], and [RFC4033]; and security terminology from [RFC4949] and [RFC5280]. The terms "reference identity" and "presented identity" are used as defined in the "CertID" specification [RFC6125]. For the sake of consistency with [RFC7673], this document uses the terms "service domain name" and "target server hostname" to refer to the same entities identified by the terms "source domain" and "derived domain" from [RFC6125].

3. Client-to-Server (C2S) DNA

The client-to-server case is much simpler than the server-to-server case because the client does not assert a domain name; this means that verification happens in only one direction. Therefore, we describe this case first to help the reader understand domain name associations in XMPP.

3.1. C2S Flow

The following flow chart illustrates the protocol flow for establishing a domain name association for an XML stream from a client (C) to a server (S) using the standard PKIX prooftype specified in [RFC6120].



3.2. C2S Description

The simplified order of events (see [RFC6120] for details) in establishing an XML stream from a client (user@a.example) to a server (a.example) is as follows:

1. The client resolves via DNS the service _xmpp-client._tcp.a.example.

2. The client opens a TCP connection to the resolved IP address.

3. The client sends an initial stream header to the server:

   <stream:stream to='a.example'>

4. The server sends a response stream header to the client, asserting that it is a.example:

   <stream:stream from='a.example'>

5. The parties attempt TLS negotiation, during which the XMPP server (acting as a TLS server) presents a PKIX certificate proving that it is a.example.

6. The client checks the PKIX certificate that the server provided; if the proof is consistent with the XMPP profile of the matching rules from [RFC6125] and the certificate is otherwise valid according to [RFC5280], the client accepts that there is a strong domain name association between its stream to the target server and the DNS domain name of the XMPP service.

The certificate that the server presents might not be acceptable to the client. As one example, the server might be hosting multiple domains and secure delegation as described in Section 6 is necessary. As another example, the server might present a self-signed certificate, which requires the client to either (1) apply the fallback process described in Section 6.6.4 of [RFC6125] or (2) prompt the user to accept an unauthenticated connection as described in Section 3.4 of [RFC7590].

4. Server-to-Server (S2S) DNA

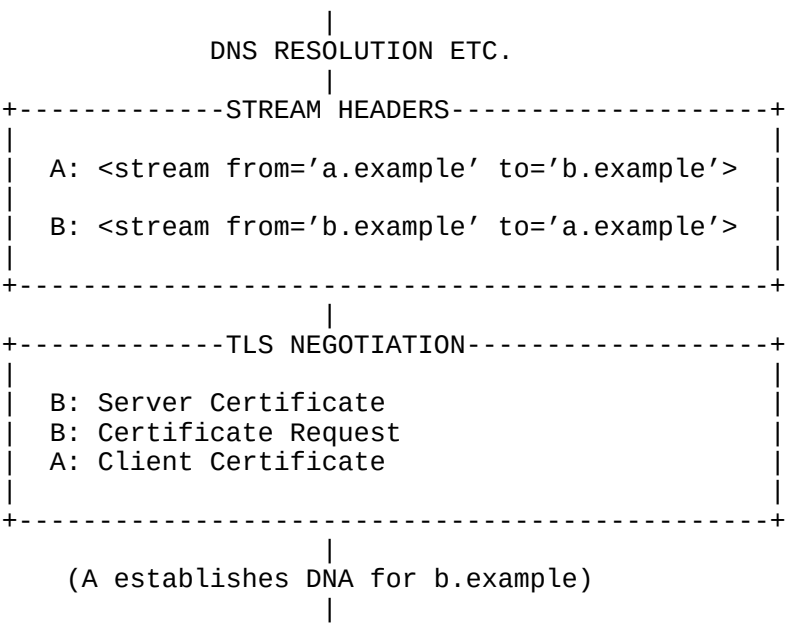
The server-to-server case is significantly more complex than the client-to-server case, and it involves the checking of domain name associations in both directions along with other "wrinkles" described in the following sections. In some parts of the flow, server-to-server communications use the Server Dialback protocol first specified in (the now obsolete) [RFC3920] and since moved to

[XEP-0220]. See "Impact of TLS and DNSSEC on Dialback" [XEP-0344] for considerations when using it together with TLS and DNSSEC. Also, "Bidirectional Server-to-Server Connections" [XEP-0288] provides a way to use the server-to-server connections for bidirectional exchange of XML stanzas, which reduces the complexity of some of the processes involved.

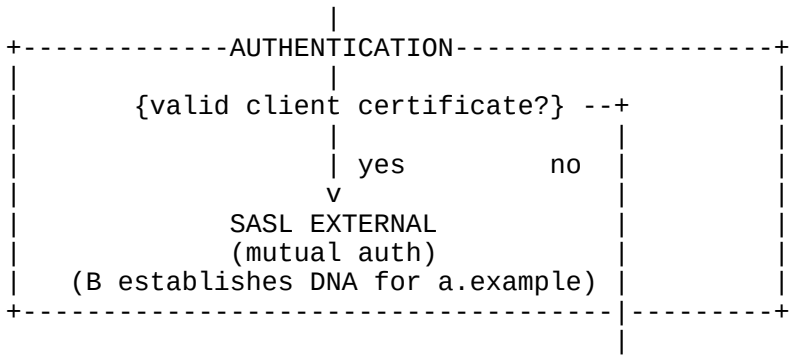
4.1. S2S Flow

The following flow charts illustrate the protocol flow for establishing domain name associations between Server 1 (the initiating entity) and Server 2 (the receiving entity), as described in the remaining sections of this document.

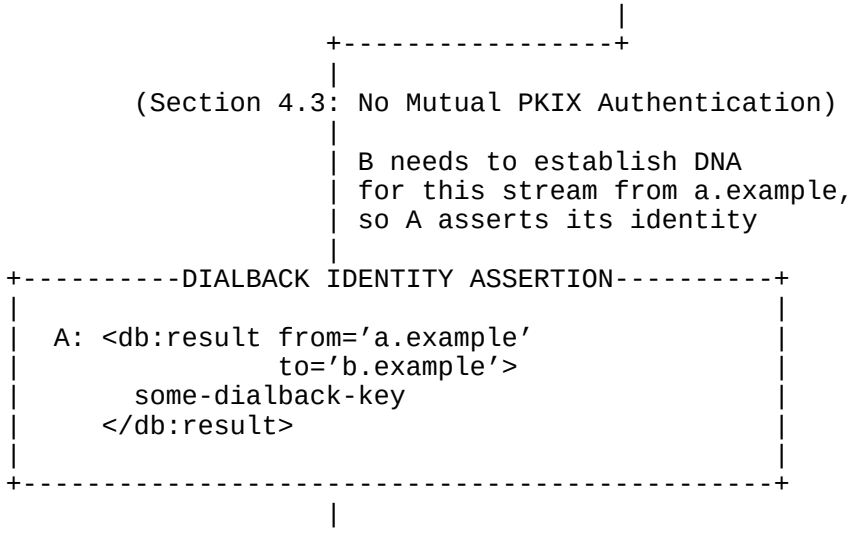
A simple S2S scenario would be as follows:

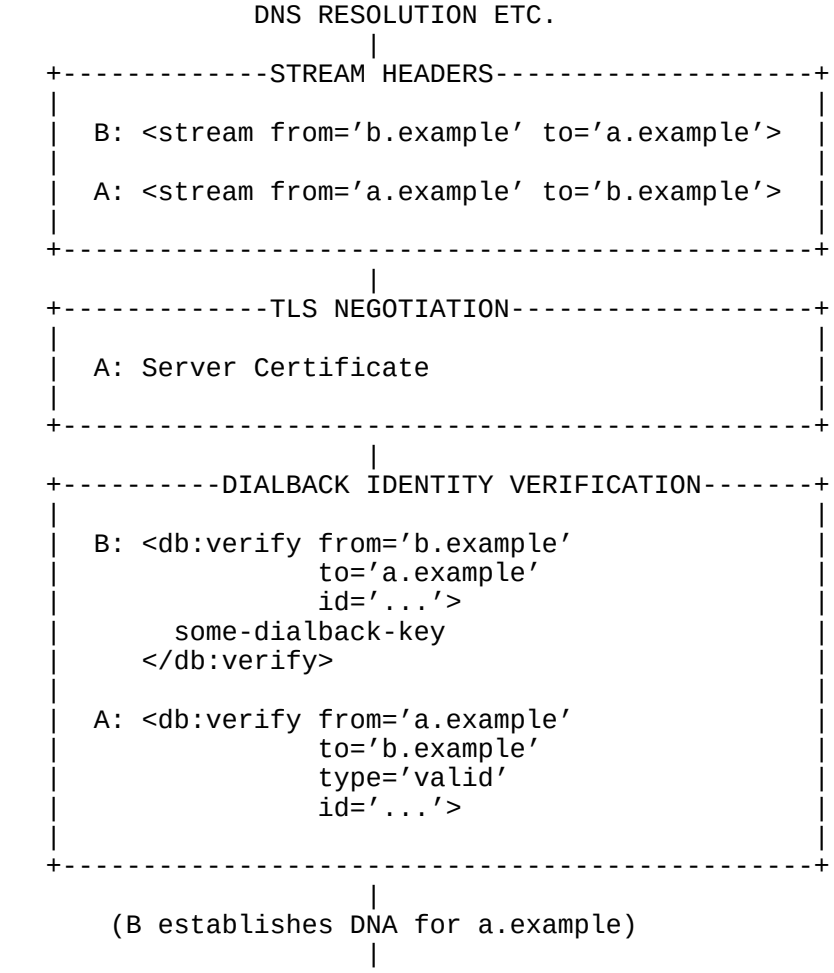


After the domain name association has been established in one direction, it is possible to perform mutual authentication using the Simple Authentication and Security Layer (SASL) [RFC4422] and thus establish domain name associations in both directions.



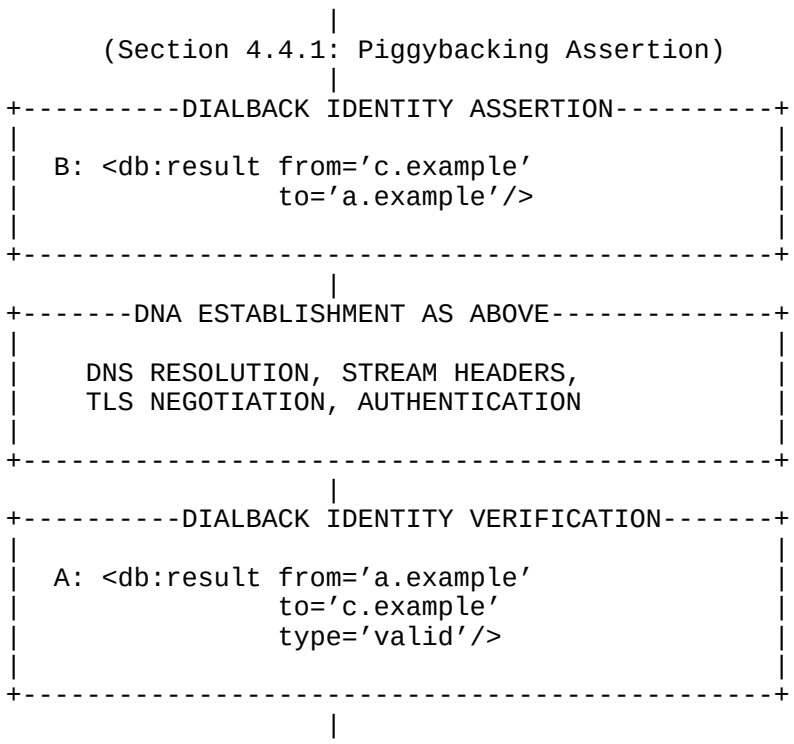
However, if mutual authentication cannot be completed using SASL, the receiving server needs to establish a domain name association in another way. This scenario is described in Section 4.3.



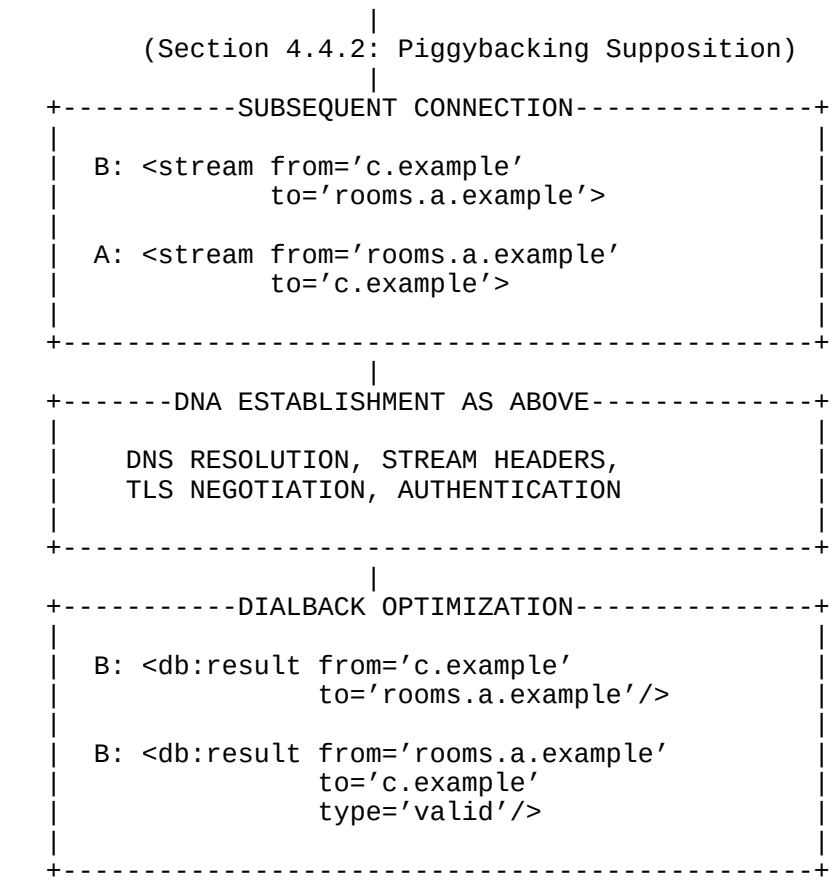


If one of the servers hosts additional service names (e.g., Server 2 might host c.example in addition to b.example and Server 1 might host rooms.a.example in addition to a.example), then the servers can use Server Dialback "piggybacking" to establish additional domain name associations for the stream, as described in Section 4.4.

There are two varieties of piggybacking. The first is here called "assertion".



The second variety of piggybacking is here called "supposition".



4.2. A Simple S2S Scenario

To illustrate the problem, consider the simplified order of events (see [RFC6120] for details) in establishing an XML stream between Server 1 (a.example) and Server 2 (b.example):

1. Server 1 resolves via DNS the service _xmpp-server._tcp.b.example.

2. Server 1 opens a TCP connection to the resolved IP address.

3. Server 1 sends an initial stream header to Server 2, asserting that it is a.example:

   <stream:stream from='a.example' to='b.example'>

4. Server 2 sends a response stream header to Server 1, asserting that it is b.example:

   <stream:stream from='b.example' to='a.example'>

5. The servers attempt TLS negotiation, during which Server 2 (acting as a TLS server) presents a PKIX certificate proving that it is b.example and Server 1 (acting as a TLS client) presents a PKIX certificate proving that it is a.example.

6. Server 1 checks the PKIX certificate that Server 2 provided, and Server 2 checks the PKIX certificate that Server 1 provided; if these proofs are consistent with the XMPP profile of the matching rules from [RFC6125] and are otherwise valid according to [RFC5280], each server accepts that there is a strong domain name association between its stream to the other party and the DNS domain name of the other party (i.e., mutual authentication is achieved).

Several simplifying assumptions underlie the "happy path" scenario just outlined:

- The PKIX certificate presented by Server 2 during TLS negotiation is acceptable to Server 1 and matches the expected identity.

- The PKIX certificate presented by Server 1 during TLS negotiation is acceptable to Server 2; this enables the parties to complete mutual authentication.

- There are no additional domains associated with Server 1 and Server 2 (say, a sub-domain rooms.a.example on Server 1 or a second domain c.example on Server 2).

- The server administrators are able to obtain PKIX certificates issued by a widely accepted Certification Authority (CA) in the first place.

- The server administrators are running their own XMPP servers, rather than using hosting services.

Let's consider each of these "wrinkles" in turn.

4.3. No Mutual PKIX Authentication

If the PKIX certificate presented by Server 1 during TLS negotiation is not acceptable to Server 2, Server 2 is unable to mutually authenticate Server 1. Therefore, Server 2 needs to verify the asserted identity of Server 1 by other means.

1. Server 1 asserts that it is a.example using the Server Dialback protocol:

   ```
   <db:result from='a.example' to='b.example'>
             some-dialback-key</db:result>
   ```

2. Server 2 resolves via DNS the service _xmpp-server._tcp.a.example.

3. Server 2 opens a TCP connection to the resolved IP address.

4. Server 2 sends an initial stream header to Server 1, asserting that it is b.example:

   ```
   <stream:stream from='b.example' to='a.example'>
   ```

5. Server 1 sends a response stream header to Server 2, asserting that it is a.example:

   ```
   <stream:stream from='a.example' to='b.example'>
   ```

6. The servers attempt TLS negotiation, during which Server 1 (acting as a TLS server) presents a PKIX certificate.

7. Server 2 checks the PKIX certificate that Server 1 provided (this might be the same certificate presented by Server 1 as a client certificate in the initial connection). However, Server 2 does not accept this certificate as proving that Server 1 is authorized as a.example and therefore uses another method (here, the Server Dialback protocol) to establish the domain name association.

8. Server 2 proceeds with Server Dialback in order to establish the domain name association. In order to do this, it sends a request for verification as described in [XEP-0220]:

```
<db:verify from='b.example' to='a.example'
           id='...'>some-dialback-key</db:verify>
```

9. Server 1 responds to this:

```
<db:verify from='a.example' to='b.example' id='...' type='valid/>
```

allowing Server 2 to establish the domain name association.

In some situations (e.g., if the Authoritative Server in Server Dialback presents the same certificate as the Originating Server), it is the practice of some XMPP server implementations to skip steps 8 and 9. These situations are discussed in "Impact of TLS and DNSSEC on Dialback" [XEP-0344].

4.4. Piggybacking

4.4.1. Assertion

Consider the common scenario in which Server 2 hosts not only b.example but also a second domain c.example (often called a "multi-tenanted" environment). If a user of Server 2 associated with c.example wishes to communicate with a friend at a.example, Server 2 needs to send XMPP stanzas from the domain c.example rather than b.example. Although Server 2 could open a new TCP connection and negotiate new XML streams for the domain pair of c.example and a.example, that is wasteful (especially if Server 2 hosts a large number of domains). Server 2 already has a connection to a.example, so how can it assert that it would like to add a new domain pair to the existing connection?

The traditional method for doing so is the Server Dialback protocol [XEP-0220]. Here, Server 2 can send a <db:result/> element for the new domain pair over the existing stream.

```
<db:result from='c.example' to='a.example'>
  some-dialback-key
</db:result>
```

This <db:result/> element functions as Server 2's assertion that it is (also) c.example (thus, the element is functionally equivalent to the 'from' address of an initial stream header as previously described).

In response to this assertion, Server 1 needs to obtain some kind of proof that Server 2 really is also c.example. If the certificate presented by Server 2 is also valid for c.example, then no further action is necessary. However, if not, then Server 1 needs to do a bit more work. Specifically, Server 1 can pursue the same strategy it used before:

1. Server 1 resolves via DNS the service _xmpp-server._tcp.c.example.

2. Server 1 opens a TCP connection to the resolved IP address (which might be the same IP address as for b.example).

3. Server 1 sends an initial stream header to Server 2, asserting that it is a.example:

   <stream:stream from='a.example' to='c.example'>

4. Server 2 sends a response stream header to Server 1, asserting that it is c.example:

   <stream:stream from='c.example' to='a.example'>

5. The servers attempt TLS negotiation, during which Server 2 (acting as a TLS server) presents a PKIX certificate proving that it is c.example.

6. At this point, Server 1 needs to establish that, despite different certificates, c.example is associated with the origin of the request. This is done using Server Dialback [XEP-0220]:

   <db:verify from='a.example' to='c.example'
              id='...'>some-dialback-key</db:verify>

7. Server 2 responds to this:

   <db:verify from='c.example' to='a.example' id='...' type='valid/>

   allowing Server 1 to establish the domain name association.

Now that Server 1 accepts the domain name association, it informs Server 2 of that fact:

   <db:result from='a.example' to='c.example' type='valid'/>

The parties can then terminate the second connection, because it was used only for Server 1 to associate a stream with the domain name c.example (the dialback key links the original stream to the new association).

4.4.2. Supposition

Piggybacking can also occur in the other direction. Consider the common scenario in which Server 1 provides XMPP services not only for a.example but also for a sub-domain such as a Multi-User Chat [XEP-0045] service at rooms.a.example. If a user from c.example at Server 2 wishes to join a room on the groupchat service, Server 2 needs to send XMPP stanzas from the domain c.example to the domain rooms.a.example rather than a.example.

First, Server 2 needs to determine whether it can piggyback the domain rooms.a.example on the connection to a.example:

1. Server 2 resolves via DNS the service _xmpp-server._tcp.rooms.a.example.

2. Server 2 determines that this resolves to an IP address and port to which it is already connected.

3. Server 2 determines that the PKIX certificate for that active connection would also be valid for the rooms.a.example domain and that Server 1 has announced support for dialback errors.

Server 2 sends a dialback key to Server 1 over the existing connection:

```
<db:result from='c.example' to='rooms.a.example'>
  some-dialback-key
</db:result>
```

Server 1 then informs Server 2 that it accepts the domain name association:

```
<db:result from='rooms.a.example' to='c.example' type='valid'/>
```

5. Alternative Prooftypes

The foregoing protocol flows assumed that domain name associations were proved using the PKIX prooftype. However, sometimes XMPP server administrators are unable or unwilling to obtain valid PKIX certificates for all of the domains they host at their servers. For example:

- In order to issue a PKIX certificate, a CA might try to send email messages to authoritative mailbox names [RFC2142], but the administrator of a subsidiary service such as im.cs.podunk.example cannot receive email sent to hostmaster@podunk.example.

- A hosting provider such as hosting.example.net might not want to take on the liability of holding the certificate and private key for a tenant such as example.com (or the tenant might not want the hosting provider to hold its certificate and private key).

- Even if PKIX certificates for each tenant can be obtained, the management of so many certificates can introduce a large administrative load.

(Additional discussion can be found in [RFC7711].)

In these circumstances, prooftypes other than PKIX are desirable or necessary. As described below, two alternatives have been defined so far: DNS-Based Authentication of Named Entities (DANE) and PKIX over Secure HTTP (POSH).

5.1. DANE

The DANE prooftype is defined as follows:

1. The server’s proof consists of either a service certificate or domain-issued certificate (TLSA usage PKIX-EE or DANE-EE; see [RFC6698] and [RFC7218]).

2. The proof is checked by verifying an exact match or a hash of either the SubjectPublicKeyInfo or the full certificate.

3. The client’s verification material is obtained via secure DNS [RFC4033] as described in [RFC7673].

4. Secure DNS is necessary in order to effectively establish an alternative chain of trust from the service certificate or domain-issued certificate to the DNS root.

The DANE prooftype makes use of DNS-Based Authentication of Named Entities [RFC6698], specifically the use of DANE with DNS SRV records [RFC7673]. For XMPP purposes, the following rules apply:

- If there is no SRV resource record, pursue the fallback methods described in [RFC6120].
- Use the 'to' address of the initial stream header to determine the domain name of the TLS client's reference identifier (because the use of the Server Name Indication extension (TLS SNI) [RFC6066] is purely discretionary in XMPP, as mentioned in [RFC6120]).

5.2. POSH

The POSH prooftype is defined as follows:

1. The server's proof consists of a PKIX certificate.
2. The proof is checked according to the rules from [RFC6120] and [RFC6125].
3. The client's verification material is obtained by retrieving a hash of the PKIX certificate over HTTPS at a well-known URI [RFC5785].
4. Secure DNS is not necessary, because the HTTPS retrieval mechanism relies on the chain of trust from the public key infrastructure.

POSH is defined in [RFC7711]. For XMPP purposes, the following rules apply:

- If no verification material is found via POSH, pursue the fallback methods described in [RFC6120].
- Use the 'to' address of the initial stream header to determine the domain name of the TLS client's reference identifier (because the use of TLS SNI [RFC6066] is purely discretionary in XMPP, as mentioned in [RFC6120]).

The well-known URIs [RFC5785] to be used for POSH are:

- "/.well-known/posh/xmpp-client.json" for client-to-server connections
- "/.well-known/posh/xmpp-server.json" for server-to-server connections

6. Secure Delegation and Multi-Tenancy

One common method for deploying XMPP services is multi-tenancy: e.g., XMPP services for the service domain name example.com are actually hosted at the target server hosting.example.net. Such an arrangement is relatively convenient in XMPP given the use of DNS SRV records [RFC2782], such as the following delegation from example.com to hosting.example.net:

```
_xmpp-server._tcp.example.com. 0 IN SRV 0 0 5269 hosting.example.net
```

Secure connections with multi-tenancy can work using the PKIX prooftype on a small scale if the provider itself wishes to host several domains (e.g., related domains such as jabber-de.example and jabber-ch.example). However, in practice the security of multi-tenancy has been found to be unwieldy when the provider hosts large numbers of XMPP services on behalf of multiple tenants (see [RFC7711] for a detailed description). There are two possible results: either (1) server-to-server communications to example.com are unencrypted or (2) the communications are TLS-encrypted but the certificates are not checked (which is functionally equivalent to a connection using an anonymous key exchange). This is also true of client-to-server communications, forcing end users to override certificate warnings or configure their clients to accept or "pin" certificates for hosting.example.net instead of example.com. The fundamental problem here is that if DNSSEC is not used, then the act of delegation via DNS SRV records is inherently insecure.

The specification for the use of SRV records with DANE [RFC7673] explains how to use DNSSEC for secure delegation with the DANE prooftype, and the POSH specification [RFC7711] explains how to use HTTPS redirects for secure delegation with the POSH prooftype.

7. Prooftype Model

In general, a Domain Name Association (DNA) prooftype conforms to the following definition:

prooftype: A mechanism for proving an association between a domain name and an XML stream, where the mechanism defines (1) the nature of the server's proof, (2) the matching rules for comparing the client's verification material against the server's proof, (3) how the client obtains its verification material, and (4) whether or not the mechanism depends on secure DNS.

The PKIX, DANE, and POSH prooftypes adhere to this model. (Some prooftypes depend on, or are enhanced by, secure DNS [RFC4033] and thus also need to describe how they ensure secure delegation.)

Other prooftypes are possible; examples might include TLS with Pretty Good Privacy (PGP) keys [RFC6091], a token mechanism such as Kerberos [RFC4120] or OAuth [RFC6749], and Server Dialback keys [XEP-0220].

Although the PKIX prooftype reuses the syntax of the XMPP Server Dialback protocol [XEP-0220] for signaling between servers, this framework document does not define how the generation and validation of Server Dialback keys (also specified in [XEP-0220]) constitute a DNA prooftype. However, nothing in this document prevents the continued use of Server Dialback for signaling, and a future specification (or an updated version of [XEP-0220]) might define a DNA prooftype for Server Dialback keys in a way that is consistent with this framework.

8. Guidance for Server Operators

This document introduces the concept of a prooftype in order to explain and generalize the approach to establishing a strong association between the DNS domain name of an XMPP service and the XML stream that a client or peer server initiates with that service.

The operations and management implications of DNA prooftypes will depend on the particular prooftypes that an operator supports. For example:

- To support the PKIX prooftype [RFC6120], an operator needs to obtain certificates for the XMPP server from a Certification Authority (CA). However, DNS Security is not required.

- To support the DANE prooftype [RFC7673], an operator can generate its own certificates for the XMPP server or obtain them from a CA. In addition, DNS Security is required.

- To support the POSH prooftype [RFC7711], an operator can generate its own certificates for the XMPP server or obtain them from a CA, but in addition needs to deploy the web server for POSH files with certificates obtained from a CA. However, DNS Security is not required.

Considerations for the use of the foregoing prooftypes are explained in the relevant specifications. See in particular Section 13.7 of [RFC6120], Section 6 of [RFC7673], and Section 7 of [RFC7711].

Naturally, these operations and management considerations are additive: if an operator wishes to use multiple prooftypes, the complexity of deployment increases (e.g., the operator might want to obtain a PKIX certificate from a CA for use in the PKIX prooftype and generate its own certificate for use in the DANE prooftype). This is

an unavoidable aspect of supporting as many prooftypes as needed in order to ensure that domain name associations can be established in the largest possible percentage of cases.

9. IANA Considerations

The POSH specification [RFC7711] establishes the "POSH Service Names" registry for use in well-known URIs [RFC5785]. This specification registers two such service names for use in XMPP: "xmpp-client" and "xmpp-server". The completed registration templates follow.

9.1. POSH Service Name for xmpp-client Service

Service name: xmpp-client

Change controller: IETF

Definition and usage: Specifies the location of a POSH file containing verification material or a reference thereto that enables a client to verify the identity of a server for a client-to-server stream in XMPP

Specification: RFC 7712 (this document)

9.2. POSH Service Name for xmpp-server Service

Service name: xmpp-server

Change controller: IETF

Definition and usage: Specifies the location of a POSH file containing verification material or a reference thereto that enables a server to verify the identity of a peer server for a server-to-server stream in XMPP

Specification: RFC 7712 (this document)

10. Security Considerations

With regard to the PKIX prooftype, this document supplements but does not supersede the security considerations of [RFC6120] and [RFC6125].

With regard to the DANE and POSH prooftypes, the reader is referred to [RFC7673] and [RFC7711], respectively.

Any future prooftypes need to thoroughly describe how they conform to the prooftype model specified in Section 7 of this document.

11. References

11.1. Normative References

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