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Certificate Management Service for the Session Initiation Protocol (SIP)

Abstract

This document defines a credential service that allows Session Initiation Protocol (SIP) User Agents (UAs) to use a SIP event package to discover the certificates of other users. This mechanism allows User Agents that want to contact a given Address-of-Record (AOR) to retrieve that AOR's certificate by subscribing to the credential service, which returns an authenticated response containing that certificate. The credential service also allows users to store and retrieve their own certificates and private keys.

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/rfc6072.

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1. Introduction

[RFC3261], as amended by [RFC3853], provides a mechanism for end-to-end encryption and integrity using Secure/Multipurpose Internet Mail Extensions (S/MIME) [RFC5751]. Several security properties of [RFC3261] depend on S/MIME, and yet it has not been widely deployed. One reason is the complexity of providing a reasonable certificate distribution infrastructure. This specification proposes a way to address discovery, retrieval, and management of certificates for SIP deployments. Combined with the SIP Identity [RFC4474] specification,

this specification allows users to have certificates that are not signed by any well known certification authority while still strongly binding the user's identity to the certificate.

In addition, this specification provides a mechanism that allows SIP User Agents such as IP phones to enroll and get their credentials without any more configuration information than they commonly have today. The end user expends no extra effort.

2. Definitions

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].

Certificate: A Public Key Infrastructure using X.509 (PKIX)-[RFC5280] style certificate containing a public key and a list of identities in the SubjectAltName that are bound to this key. The certificates discussed in this document are generally self-signed and use the mechanisms in the SIP Identity [RFC4474] specification to vouch for their validity. Certificates that are signed by a certification authority can also be used with all the mechanisms in this document; however, they need not be validated by the receiver (although the receiver can validate them for extra assurance; see Section 10.3.1).

Credential: For this document, "credential" means the combination of a certificate and the associated private key.

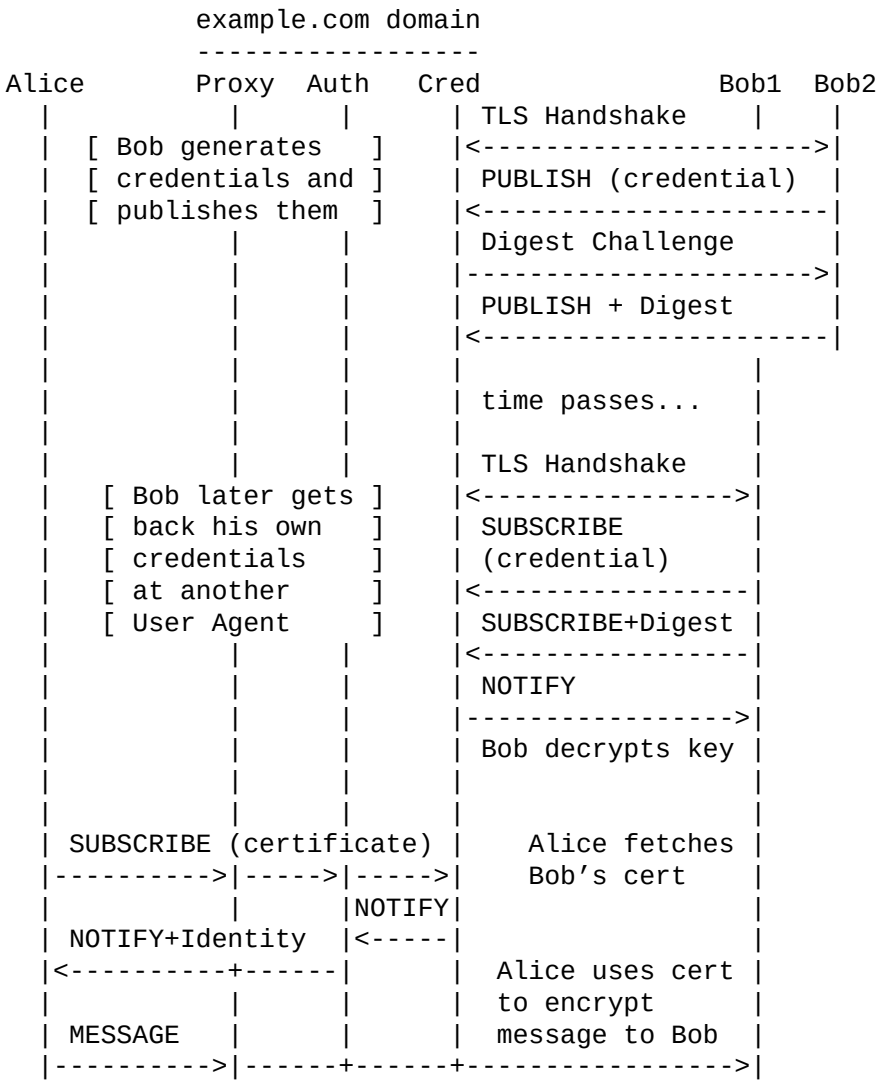
Password Phrase: A password used to encrypt and decrypt a PKCS #8 (Public Key Cryptographic System #8) private key.

3. Overview

The general approach is to provide a new SIP service referred to as a "credential service" that allows SIP User Agents (UAs) to subscribe to other users' certificates using a new SIP event package [RFC3265]. The certificate is delivered to the subscribing UA in a corresponding SIP NOTIFY request. An authentication service as described in the SIP Identity [RFC4474] specification can be used to vouch for the identity of the sender of the certificate by using the sender's proxy domain certificate to sign the NOTIFY request. The authentication service is vouching that the sender is allowed to populate the SIP From header field value. The sender of the message is vouching that this is an appropriate certificate for the user identified in the SIP From header field value. The credential service can manage public certificates as well as the user's private keys. Users can update their credentials, as stored on the credential service, using a SIP

PUBLISH [RFC3903] request. The UA authenticates to the credential service using a shared secret when a UA is updating a credential. Typically the shared secret will be the same one that is used by the UA to authenticate a REGISTER request with the Registrar for the domain (usually with SIP Digest Authentication).

The following figure shows Bob publishing his credentials from one of his User Agents (e.g., his laptop software client), retrieving his credentials from another of his User Agents (e.g., his mobile phone), and then Alice retrieving Bob's certificate and sending a message to Bob. SIP 200-class responses are omitted from the diagram to make the figure easier to understand.



Bob's UA (Bob2) does a Transport Layer Security (TLS) [RFC5246] handshake with the credential server to authenticate that the UA is connected to the correct credential server. Then Bob's UA publishes his newly created or updated credentials. The credential server challenges the UA using a Digest Authentication scheme to authenticate that the UA knows Bob's shared secret. Once the UA is authenticated, the credential server stores Bob's credentials.

Another of Bob's User Agents (Bob1) wants to fetch its current credentials. It does a TLS [RFC5246] handshake with the credential server to authenticate that the UA is connected to the correct credential server. Then Bob's UA subscribes for the credentials. The credential server challenges the UA to authenticate that the UA knows Bob's shared secret. Once the UA is authenticated, the credential server sends a NOTIFY that contains Bob's credentials. The private key portion of the credential may have been encrypted with a secret that only Bob's UA (and not the credential server) knows. In this case, once Bob's UA decrypts the private key, it will be ready to go. Typically Bob's UA would do this when it first registers on the network.

Some time later Alice decides that she wishes to discover Bob's certificate so that she can send him an encrypted message or so that she can verify the signature on a message from Bob. Alice's UA sends a SUBSCRIBE message to Bob's AOR. The proxy in Bob's domain routes this to the credential server via an "authentication service" as defined in [RFC4474]. The credential server returns a NOTIFY that contains Bob's public certificate in the body. This is routed through an authentication service that signs that this message really can validly claim to be from the AOR "sip:bob@example.com". Alice's UA receives the certificate and can use it to encrypt a message to Bob.

It is critical to understand that the only way that Alice can trust that the certificate really is the one for Bob and that the NOTIFY has not been spoofed is for Alice to check that the Identity [RFC4474] header field value is correct.

The mechanism described in this document works for both self-signed certificates and certificates signed by well known certification authorities. In order to deploy certificates signed by well known certification authorities, certification authorities would have to support adding SIP URIs to the SubjectAltName of the certificates they generate. This is something that has been rarely implemented by commercial certification authorities. However, most UAs would only use self-signed certificates and would use an authentication service as described in [RFC4474] to provide a strong binding of an AOR to the certificates.

The mechanisms described in this document allow for three different styles of deployment:

1. Deployments where the credential server only stores certificates and does not store any private key information. If the deployment had users with multiple devices, some other scheme (perhaps even manual provisioning) would be used to get the right private keys onto all the devices that a user employs.

2. Deployments where the credential server stores certificates and also stores an encrypted version of the private keys. The credential server would not know or need the password phrase for decrypting the private key. The credential server would help move the private keys between devices, but the user would need to enter a password phrase on each device to allow that device to decrypt (and encrypt) the private key information.

3. Deployments where the credential server generates and stores the certificates and private keys. Deployments such as these may not use password phrases. Consequently, the private keys are not encrypted inside the PKCS #8 objects. This style of deployment would often have the credential server, instead of the devices, create the credentials.

4. UA Behavior with Certificates

When a User Agent wishes to discover some other user's certificate, it subscribes to the "certificate" SIP event package as described in Section 6 to get the certificate. While the subscription is active, if the certificate is updated, the Subscriber will receive the updated certificate in a notification.

The Subscriber needs to decide how long it is willing to trust that the certificate it receives is still valid. If the certificate is revoked before it expires, the Notifier will send a notification with an empty body to indicate that the certificate is no longer valid. If the certificate is renewed before it expires, the Notifier will send a notification with a body containing the new certificate. Note that the Subscriber might not receive the notification if an attacker blocks this traffic. The amount of time that the Subscriber caches a certificate SHOULD be configurable. A default of one day is RECOMMENDED.

Note that the actual duration of the subscription is unrelated to the caching time or validity time of the corresponding certificate. Allowing subscriptions to persist after a certificate is no longer valid ensures that Subscribers receive the replacement certificate in a timely fashion. The Notifier could return an immediate

notification with the certificate in response to a subscribe request and then immediately terminate subscription, setting the reason parameter to "probation". The Subscriber will have to periodically poll the Notifier to verify the validity of the certificate.

If the UA uses a cached certificate in a request and receives a 437 (Unsupported Certificate) response, it SHOULD remove the certificate it used from the cache and attempt to fetch the certificate again. If the certificate is changed, then the UA SHOULD retry the original request with the new certificate. This situation usually indicates that the certificate was recently updated, and that the Subscriber has not received a corresponding notification. If the certificate fetched is the same as the one that was previously in the cache, then the UA SHOULD NOT try the request again. This situation can happen when the request is retargeted to a different user than the original request. The 437 response is defined in [RFC4474].

> Note: A UA that has a presence list MAY want to subscribe to the certificates of all the presentities in the list when the UA subscribes to their presence, so that when the user wishes to contact a presentity, the UA will already have the appropriate certificate. Future specifications might consider the possibility of retrieving the certificates along with the presence documents.

The details of how a UA deals with receiving encrypted messages is outside the scope of this specification. It is worth noting that if Charlie's User Agent Server (UAS) receives a request that is encrypted to Bob, it would be valid and legal for that UA to send a 302 redirecting the call to Bob.

5. UA Behavior with Credentials

UAs discover their own credentials by subscribing to their AOR with an event type of "credential" as described in Section 7. After a UA registers, it SHOULD retrieve its credentials by subscribing to them as described in Section 6.5.

When a UA discovers its credential, the private key information might be encrypted with a password phrase. The UA SHOULD request that the user enter the password phrase on the device, and the UA MAY cache this password phrase for future use.

There are several different cases in which a UA should generate a new credential:

- If the UA receives a NOTIFY with no body for the credential package.
- If the certificate has expired.
- If the certificate's notAfter date is within the next 600 seconds, the UA SHOULD attempt to create replacement credentials. The UA does this by waiting a random amount of time between 0 and 300 seconds. If no new credentials have been received in that time, the UA creates new credentials to replace the expiring ones and sends them in a PUBLISH request following the rules for modifying event state as described in Section 4.4 of [RFC3903].
- If the user of the device has indicated via the user interface that they wish to revoke the current certificate and issue a new one.

Credentials are created by constructing a new key pair that will require appropriate randomness as described in [RFC4086] and then creating a certificate as described in Section 10.6. The UA MAY encrypt the private key with a password phrase supplied by the user as specified in Section 10.5. Next, the UA updates the user's credential by sending a PUBLISH [RFC3903] request with the credentials or just the certificate as described in Section 7.8.

If a UA wishes to revoke the existing certificate without publishing a new one, it MUST send a PUBLISH with an empty body to the credential server.

6. Event Package Formal Definition for "certificate"

6.1. Event Package Name

This document defines a SIP event package as defined in [RFC3265]. The event-package token name for this package is:

certificate

6.2. SUBSCRIBE Bodies

This package does not define any SUBSCRIBE bodies.

6.3. Subscription Duration

Subscriptions to this event package can range from no time to weeks. Subscriptions in days are more typical and are RECOMMENDED. The default subscription duration for this event package is one day.

The credential service is encouraged to keep the subscriptions active for AORs that are communicating frequently, but the credential service MAY terminate the subscription at any point in time.

6.4. NOTIFY Bodies

The body of a NOTIFY request for this package MUST either be empty or contain an application/pkix-cert body (as defined in [RFC2585]) that contains the certificate, unless an Accept header field has negotiated some other type. The Content-Disposition MUST be set to "signal" as defined in [RFC3204].

A future extension MAY define other NOTIFY bodies. If no "Accept" header field is present in the SUBSCRIBE, the body type defined in this document MUST be assumed.

Implementations that generate large notifications are reminded to follow the message size restrictions for unreliable transports articulated in Section 18.1.1 of [RFC3261].

6.5. Subscriber Generation of SUBSCRIBE Requests

A UA discovers a certificate by sending a SUBSCRIBE request with an event type of "certificate" to the AOR for which a certificate is desired. In general, the UA stays subscribed to the certificate for as long as it plans to use and cache the certificate, so that the UA can be notified about changes or revocations to the certificate.

Subscriber User Agents will typically subscribe to certificate information for a period of hours or days, and automatically attempt to re-subscribe just before the subscription is completely expired.

When a user de-registers from a device (logoff, power down of a mobile device, etc.), Subscribers SHOULD unsubscribe by sending a SUBSCRIBE request with an Expires header field of zero.

6.6. Notifier Processing of SUBSCRIBE Requests

When a SIP credential server receives a SUBSCRIBE request with the certificate event-type, it is not necessary to authenticate the subscription request. The Notifier MAY limit the duration of the subscription to an administrator-defined period of time. The duration of the subscription does not correspond in any way to the period for which the certificate will be valid.

When the credential server receives a SUBSCRIBE request for a certificate, it first checks to see if it has credentials for the requested URI. If it does not have a certificate, it returns a NOTIFY request with an empty message body.

6.7. Notifier Generation of NOTIFY Requests

Immediately after a subscription is accepted, the Notifier MUST send a NOTIFY with the current certificate, or an empty body if no certificate is available for the target user. In either case it forms a NOTIFY with the From header field value set to the value of the To header field in the SUBSCRIBE request. This server sending the NOTIFY needs either to implement an authentication service (as described in SIP Identity [RFC4474]) or else the server needs to be set up such that the NOTIFY request will be sent through an authentication service. Sending the NOTIFY request through the authentication service requires the SUBSCRIBE request to have been routed through the authentication service, since the NOTIFY is sent within the dialog formed by the subscription.

6.8. Subscriber Processing of NOTIFY Requests

The resulting NOTIFY will contain an application/pkix-cert body that contains the requested certificate. The UA MUST follow the procedures in Section 10.3 to decide if the received certificate can be used. The UA needs to cache this certificate for future use. The maximum length of time for which it should be cached is discussed in Section 10.1. The certificate MUST be removed from the cache if the certificate has been revoked (if a NOTIFY with an empty body is received), or if it is updated by a subsequent NOTIFY. The UA MUST check that the NOTIFY is correctly signed by an authentication service as described in [RFC4474]. If the identity asserted by the authentication service does not match the AOR that the UA subscribed to, the certificate in the NOTIFY is discarded and MUST NOT be used.

6.9. Handling of Forked Requests

This event package does not permit forked requests. At most one subscription to this event type is permitted per resource.

6.10. Rate of Notifications

Notifiers SHOULD NOT generate NOTIFY requests more frequently than once per minute.

6.11. State Agents and Lists

The credential server described in this section that serves certificates is a state agent as defined in [RFC3265], and implementations of the credential server MUST be implemented as a state agent.

Implementers MUST NOT use the event list extension [RFC4662] with this event type. It is not possible to make such an approach work, because the authentication service would have to simultaneously assert several different identities.

6.12. Behavior of a Proxy Server

There are no additional requirements on a SIP proxy, other than to transparently forward the SUBSCRIBE and NOTIFY requests as required in SIP. This specification describes the proxy, authentication service, and credential service as three separate services, but it is certainly possible to build a single SIP network element that performs all of these services at the same time.

7. Event Package Formal Definition for "credential"

7.1. Event Package Name

This document defines a SIP event package as defined in [RFC3265]. The event-package token name for this package is:

credential

7.2. SUBSCRIBE Bodies

This package does not define any SUBSCRIBE bodies.

7.3. Subscription Duration

Subscriptions to this event package can range from hours to one week. Subscriptions in days are more typical and are RECOMMENDED. The default subscription duration for this event package is one day.

The credential service SHOULD keep subscriptions active for UAs that are currently registered.

7.4. NOTIFY Bodies

An implementation compliant to this specification MUST support the multipart/mixed type (see [RFC2046]). This allows a notification to contain multiple resource documents including at a minimum the application/pkix-cert body with the certificate and an application/pkcs8 body that has the associated private key information for the certificate. The application/pkcs8 media type is defined in [RFC5958].

The absence of an Accept header in the SUBSCRIBE indicates support for multipart/mixed and the content types application/pkix-cert and application/pkcs8. If an Accept header is present, these types MUST be included, in addition to any other types supported by the client.

The application/pkix-cert body is a Distinguished Encoding Rules (DER)-encoded X.509v3 certificate [RFC2585]. The application/pkcs8 body contains a DER-encoded [RFC5958] object that contains the private key. The PKCS #8 objects MUST be of type PrivateKeyInfo. The integrity and confidentiality of the PKCS #8 objects are provided by the TLS transport. The transport encoding of all the MIME bodies is binary.

7.5. Subscriber Generation of SUBSCRIBE Requests

A Subscriber User Agent will subscribe to its credential information for a period of hours or days and will automatically attempt to re-subscribe before the subscription has completely expired.

The Subscriber SHOULD subscribe to its credentials whenever a new user becomes associated with the device (a new login). The Subscriber SHOULD also renew its subscription immediately after a reboot, or when the Subscriber’s network connectivity has just been re-established.

The UA needs to authenticate with the credential service for these operations. The UA MUST use TLS to directly connect to the server acting as the credential service or to a server that is authoritative for the domain of the credential service. The UA MUST NOT connect through an intermediate proxy to the credential service. The UA may be configured with a specific name for the credential service; otherwise, normal SIP routing is used. As described in RFC 3261, the TLS connection needs to present a certificate that matches the

expected name of the server to which the connection was formed, so that the UA knows it is talking to the correct server. Failing to do this may result in the UA publishing its private key information to an attacker. The credential service will authenticate the UA using the usual SIP Digest mechanism, so the UA can expect to receive a SIP challenge to the SUBSCRIBE or PUBLISH requests.

7.6. Notifier Processing of SUBSCRIBE Requests

When a credential service receives a SUBSCRIBE for a credential, the credential service has to authenticate and authorize the UA, and validate that adequate transport security is being used. Only a UA that can authenticate as being able to register as the AOR is authorized to receive the credentials for that AOR. The credential service MUST challenge the UA to authenticate the UA and then decide if it is authorized to receive the credentials. If authentication is successful, the Notifier MAY limit the duration of the subscription to an administrator-defined period of time. The duration of the subscription MUST NOT be larger than the length of time for which the certificate is still valid. The Expires header field SHOULD be set so that it is not longer than the notAfter date in the certificate.

7.7. Notifier Generation of NOTIFY Requests

Once the UA has authenticated with the credential service and the subscription is accepted, the credential service MUST immediately send a Notify request. The authentication service is applied to this NOTIFY request in the same way as the certificate subscriptions. If the credential is revoked, the credential service MUST terminate any current subscriptions and force the UA to re-authenticate by sending a NOTIFY with its Subscription-State header field set to "terminated" and a reason parameter set to "deactivated". (This causes a Subscriber to retry the subscription immediately.) This is so that if a secret for retrieving the credentials gets compromised, the rogue UA will not continue to receive credentials after the compromised secret has been changed.

Any time the credentials for this URI change, the credential service MUST send a new NOTIFY to any active subscriptions with the new credentials.

The notification MUST be sent over TLS so that it is integrity protected, and the TLS needs to be directly connected between the UA and the credential service with no intermediaries.

7.8. Generation of PUBLISH Requests

A User Agent SHOULD be configurable to control whether it publishes the credential for a user or just the user's certificate.

When publishing just a certificate, the body contains an application/pkix-cert. When publishing a credential, the body contains a multipart/mixed containing both an application/pkix-cert and an application/pkcs8 body.

When the UA sends the PUBLISH [RFC3903] request, it needs to do the following:

- The UA MUST use TLS to directly connect to the server acting as the credential service or to a server that is authoritative for the domain of the credential service. The UA MUST NOT connect through an intermediate proxy to the credential service.

- The Expires header field value in the PUBLISH request SHOULD be set to match the time for which the certificate is valid.

- If the certificate includes Basic Constraints, it SHOULD set the cA boolean to false.

7.9. Notifier Processing of PUBLISH Requests

When the credential service receives a PUBLISH request to update credentials, it MUST authenticate and authorize this request in the same way as for subscriptions for credentials. If the authorization succeeds, then the credential service MUST perform the following checks on the certificate:

- The notBefore validity time MUST NOT be in the future.

- The notAfter validity time MUST be in the future.

- If a cA BasicConstraints boolean is set in the certificate, it is set to FALSE.

If all of these succeed, the credential service updates the credential for this URI, processes all the active certificates and credential subscriptions to this URI, and generates a NOTIFY request with the new credential or certificate. Note the SubjectAltName SHOULD NOT be checked, as that would restrict which certificates could be used and offers no additional security guarantees.

If the Subscriber submits a PUBLISH request with no body and Expires=0, this revokes the current credentials. Watchers of these credentials will receive an update with no body, indicating that they MUST stop any previously stored credentials. Note that subscriptions to the certificate package are NOT terminated; each Subscriber to the certificate package receives a notification with an empty body.

7.10. Subscriber Processing of NOTIFY Requests

When the UA receives a valid NOTIFY request, it should replace its existing credentials with the new received ones. If the UA cannot decrypt the PKCS #8 object, it MUST send a 437 (Unsupported Certificate) response. Later, if the user provides a new password phrase for the private key, the UA can subscribe to the credentials again and attempt to decrypt with the new password phrase.

7.11. Handling of Forked Requests

This event package does not permit forked requests.

7.12. Rate of Notifications

Notifiers SHOULD NOT generate NOTIFY requests more frequently than once per minute.

7.13. State Agents and Lists

The credential server described in this section which serves credentials is a state agent, and implementations of the credential server MUST be implemented as a state agent.

Implementers MUST NOT use the event list extension [RFC4662] with this event type.

7.14. Behavior of a Proxy Server

The behavior is identical to behavior described for certificate subscriptions in Section 6.12.

8. Identity Signatures

The [RFC4474] authentication service defined a signature algorithm based on SHA-1 called rsa-sha1. This specification adds a signature algorithm that is roughly the same but based on SHA-256 and called rsa-sha256.

When using the rsa-sha256 algorithm, the signature MUST be computed in exactly the same way as described in Section 9 of [RFC4474] with the exception that instead of using sha1WithRSAEncryption, the computation is done using sha256WithRSAEncryption as described in [RFC5754].

Implementations of this specification MUST implement both rsa-sha1 and rsa-sha256. The IANA registration for rsa-sha256 is defined in Section 11.3.

9. Examples

In all of these examples, large parts of the messages are omitted to highlight what is relevant to this document. The lines in the examples that are prefixed by $ represent encrypted blocks of data.

9.1. Encrypted Page Mode Instant Message

In this example, Alice sends Bob an encrypted page mode instant message. Alice does not already have Bob's public key from previous communications, so she fetches Bob's public key from Bob's credential service:

```
SUBSCRIBE sip:bob@biloxi.example.com SIP/2.0
...
Event: certificate
```

The credential service responds with the certificate in a NOTIFY.

```
NOTIFY alice@atlanta.example.com  SIP/2.0
Subscription-State: active; expires=7200
....
From: <sip:bob@biloxi.example.com>;tag=1234
Identity: ".... stuff removed ...."
Identity-Info: <https://atlanta.example.com/cert>;alg=rsa-sha256
....
Event: certificate
Content-Type: application/pkix-cert
Content-Disposition: signal

< certificate data >
```

Next, Alice sends a SIP MESSAGE to Bob and can encrypt the body using Bob's public key as shown below.

```
MESSAGE sip:bob@biloxi.example.com SIP/2.0
...
Content-Type: application/pkcs7-mime
Content-Disposition: render

$ Content-Type: text/plain
$
$ < encrypted version of "Hello" >
```

9.2. Setting and Retrieving UA Credentials

When Alice's UA wishes to publish Alice's certificate and private key to the credential service, it sends a PUBLISH request like the one below. This must be sent over a TLS connection directly to the domain of the credential service. The credential service presents a certificate where the SubjectAltName contains an entry that matches the domain name in the request line of the PUBLISH request and challenges the request to authenticate her.

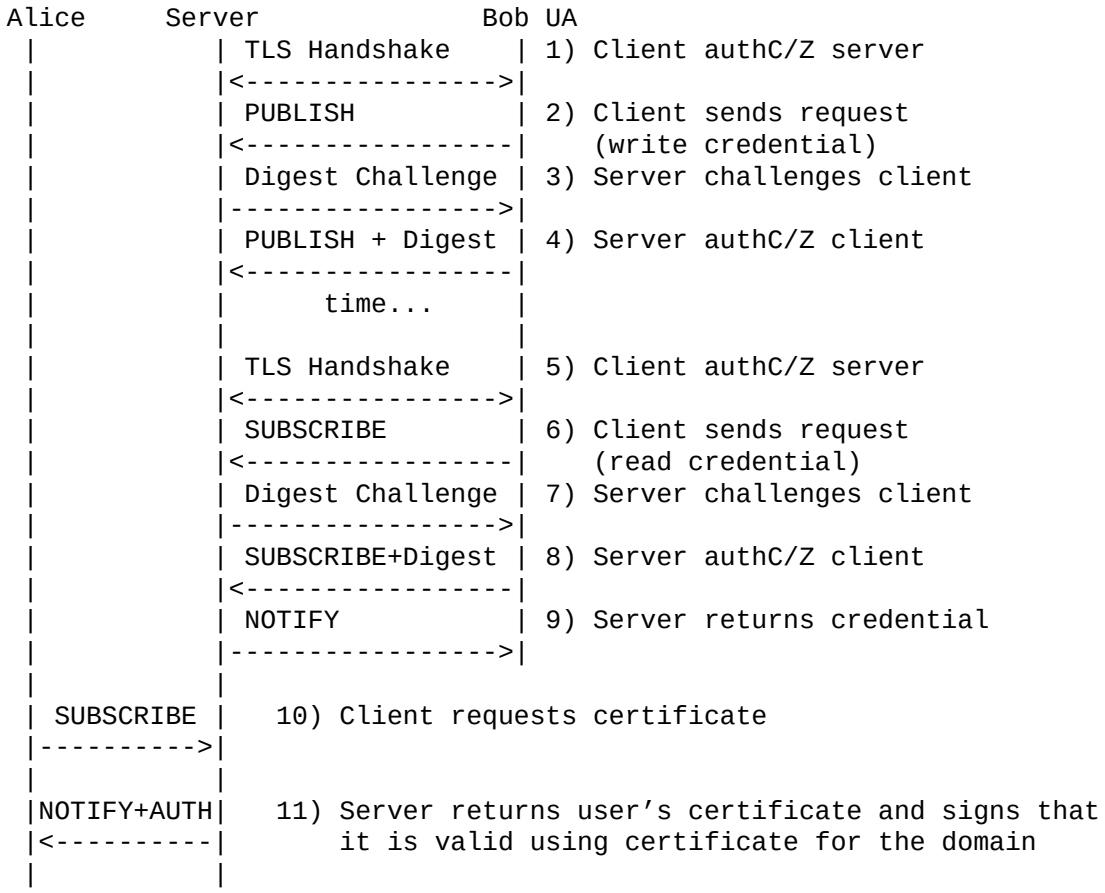
```
PUBLISH sips:alice@atlanta.example.com SIP/2.0
...
Event: credential
Content-Type: multipart/mixed;boundary=boundary
Content-Disposition: signal

--boundary
Content-ID: 123
Content-Type: application/pkix-cert

< Public certificate for Alice >
--boundary
Content-ID: 456
Content-Type: application/pkcs8

< Private Key for Alice >
--boundary
```

If one of Alice's UAs subscribes to the credential event, the credential service will challenge the request to authenticate her, and the NOTIFY will include a body similar to the one in the PUBLISH example above.

10. Security Considerations

The high-level message flow from a security point of view is summarized in the following figure. The 200 responses are removed from the figure, as they do not have much to do with the overall security.

In this figure, authC refers to authentication and authZ refers to authorization.



When the UA, labeled Bob, first created a credential for Bob, it would store this on the credential server. The UA authenticated the server using the certificates from the TLS handshake. The server authenticated the UA using a digest-style challenge with a shared secret.

The UA, labeled Bob, wishes to request its credentials from the server. First, it forms a TLS connection to the server, which provides integrity and privacy protection and also authenticates the

server to Bob's UA. Next, the UA requests its credentials using a SUBSCRIBE request. The server challenges the SUBSCRIBE Request to authenticate Bob's UA. The server and Bob's UA have a shared secret that is used for this. If the authentication is successful, the server sends the credentials to Bob's UA. The private key in the credentials may have been encrypted using a shared secret that the server does not know.

A similar process would be used for Bob's UA to publish new credentials to the server. Bob's UA would send a PUBLISH request containing the new credentials. When this happened, all the other UAs that were subscribed to Bob's credentials would receive a NOTIFY with the new credentials.

Alice wishes to find Bob's certificate and sends a SUBSCRIBE to the server. The server sends the response in a NOTIFY. This does not need to be sent over a privacy or integrity protected channel, as the authentication service described in [RFC4474] provides integrity protection of this information and signs it with the certificate for the domain.

This whole scheme is highly dependent on trusting the operators of the credential service and trusting that the credential service will not be compromised. The security of all the users will be compromised if the credential service is compromised.

> Note: There has been significant discussion of the topic of avoiding deployments in which the credential servers store the private keys, even in some encrypted form that the credential server does not know how to decrypt. Various schemes were considered to avoid this, but they all result in either moving the problem to some other server, which does not seem to make the problem any better, or having a different credential for each device. For some deployments where each user has only one device, this is fine, but for deployments with multiple devices, it would require that when Alice went to contact Bob, Alice would have to provide messages encrypted for all of Bob's devices. The SIPPING Working Group did consider this architecture and decided it was not appropriate due both to the information it revealed about the devices and users, and to the amount of signaling required to make it work.

This specification requires that TLS be used for the SIP communications to place and retrieve a UA's private key. This provides security in two ways:

1. Confidentiality is provided for the Digest Authentication exchange, thus protecting it from dictionary attacks.

2. Confidentiality is provided for the private key, thus protecting it from being exposed to passive attackers.

In order to prevent man-in-the-middle attacks, TLS clients MUST check that the SubjectAltName of the certificate for the server they connected to exactly matches the server they were trying to connect to. The TLS client must be directly connected to the correct server; otherwise, any intermediaries in the TLS path can compromise the certificate and instead provide a certificate for which the attacker knows the private key. This may lead the UA that relies on this compromised certificate to lose confidential information. Failing to use TLS or selecting a poor cipher suite (such as NULL encryption) may result in credentials, including private keys, being sent unencrypted over the network and will render the whole system useless.

The correct checking of chained certificates as specified in TLS [RFC5246] is critical for the client to authenticate the server. If the client does not authenticate that it is talking to the correct credential service, a man-in-the-middle attack is possible.

10.1. Certificate Revocation

If a particular credential needs to be revoked, the new credential is simply published to the credential service. Every device with a copy of the old credential or certificate in its cache will have a subscription and will rapidly (order of seconds) be notified and replace its cache. Clients that are not subscribed will subscribe when they next need to use the certificate and will get the new certificate.

It is possible that an attacker could mount a denial-of-service (DoS) attack such that the UA that had cached a certificate did not receive the NOTIFY with its revocation. To protect against this attack, the UA needs to limit how long it caches certificates. After this time, the UA would invalidate the cached information, even though no NOTIFY had ever been received due to the attacker blocking it.

The duration of this cached information is in some ways similar to a device deciding how often to check a Certificate Revocation List (CRL). For many applications, a default time of one day is

suggested, but for some applications it may be desirable to set the time to zero so that no certificates are cached at all and the credential is checked for validity every time the certificate is used.

The UA MUST NOT cache the certificates for a period longer than that of the subscription duration. This is to avoid the UA using invalid cached credentials when the Notifier of the new credentials has been prevented from updating the UA.

10.2. Certificate Replacement

The UAs in the system replace the certificates close to the time that the certificates would expire. If a UA has used the same key pair to encrypt a very large volume of traffic, the UA MAY choose to replace the credential with a new one before the normal expiration.

10.3. Trusting the Identity of a Certificate

When a UA wishes to discover the certificate for sip:alice@example.com, the UA subscribes to the certificate for alice@example.com and receives a certificate in the body of a SIP NOTIFY request. The term "original URI" is used to describe the URI that was in the To header field value of the SUBSCRIBE request. So, in this case, the original URI would be sip:alice@example.com.

If the certificate is signed by a trusted certification authority, and one of the names in the SubjectAltName matches the original URI, then this certificate MAY be used, but only for exactly the original URI and not for other identities found in the SubjectAltName. Otherwise, there are several steps the UA MUST perform before using this certificate.

- The From header field in the NOTIFY request MUST match the original URI that was subscribed to.

- The UA MUST check the Identity header field as described in the Identity [RFC4474] specification to validate that bodies have not been tampered with and that an authentication service has validated this From header field.

- The UA MUST check the validity time of the certificate and stop using the certificate if it is invalid. (Implementations are reminded to verify both the notBefore and notAfter validity times.)

- The certificate MAY have several names in the SubjectAltName, but the UA MUST only use this certificate when it needs the certificate for the identity asserted by the authentication service in the NOTIFY. This means that the certificate should only be indexed in the certificate cache by the AOR that the authentication service asserted and not by the value of all the identities found in the SubjectAltName list.

These steps result in a chain of bindings that result in a trusted binding between the original AOR that was subscribed to and a public key. The original AOR is forced to match the From header field. The authentication service validates that this request did come from the identity claimed in the From header field value and that the bodies in the request that carry the certificate have not been tampered with. The certificate in the body contains the public key for the identity. Only the UA that can authenticate as this AOR, or devices with access to the private key of the domain, can tamper with this body. This stops other users from being able to provide a false public key. This chain of assertion from original URI, to From, to body, to public key is critical to the security of the mechanism described in this specification. If any of the steps above are not followed, this chain of security will be broken and the system will not work.

10.3.1. Extra Assurance

Although the certificates used with this document need not be validatable to a trust anchor via PKIX [RFC5280] procedures, certificates that can be validated may also be distributed via this mechanism. Such certificates potentially offer an additional level of security because they can be used with the secure (and partially isolated) certification authority user verification and key issuance toolset, rather than depending on the security of generic SIP implementations.

When a relying party receives a certificate that is not self-signed, it MAY attempt to validate the certificate using the rules in Section 6 of [RFC5280]. If the certificate validates successfully and the names correctly match the user's AOR (see Section 10.6), then the implementation SHOULD provide some indication that the certificate has been validated with an external authority. In general, failure to validate a certificate via this mechanism SHOULD NOT be used as a reason to reject the certificate. However, if the certificate is revoked, then the implementation SHOULD reject it.

10.4. SACRED Framework

This specification includes a mechanism that allows end users to share the same credentials across different end-user devices. This mechanism is based on the one presented in the Securely Available Credentials (SACRED) Framework [RFC3760]. While this mechanism is fully described in this document, the requirements and background are more thoroughly discussed in [RFC3760].

Specifically, Sections 7.5, 7.6, and 7.9 follow the TLS with Client Authentication (cTLS) architecture described in Section 4.2.2 of [RFC3760]. The client authenticates the server using the server's TLS certificate. The server authenticates the client using a SIP Digest transaction inside the TLS session. The TLS sessions form a strong session key that is used to protect the credentials being exchanged.

10.5. Crypto Profiles

Credential services SHOULD implement the server name indication extensions in [RFC4366]. As specified in [RFC5246], credential services MUST support the TLS cipher suite TLS_RSA_WITH_AES_128_CBC_SHA. In addition, they MUST support the TLS cipher suite TLS_RSA_WITH_AES_128_CBC_SHA256 as specified in [RFC5246]. If additional cipher suites are supported, then implementations MUST NOT negotiate a cipher suite that employs NULL encryption, integrity, or authentication algorithms.

Implementations of TLS typically support multiple versions of the Transport Layer Security protocol as well as the older Secure Socket Layer (SSL) protocol. Because of known security vulnerabilities, clients and servers MUST NOT request, offer, or use SSL 2.0. See Appendix E.2 of [RFC5246] for further details.

The PKCS #8 encryption in the clients MUST implement PBES2 with a key derivation algorithm of PBKDF2 using HMAC. Clients MUST implement this HMAC with both SHA-1 [RFC3370] and SHA-256 [RFC5754]. Clients MUST implement an encryption algorithm of id-aes128-wrap-pad as defined in [RFC5649]. Some pre-standard deployments of this specification used DES-EDE2-CBC-Pad as defined in [RFC2898] so, for some implementations, it may be desirable to also support that algorithm. A different password SHOULD be used for the PKCS #8 encryption than is used for authentication of the client. It is important to choose sufficiently strong passwords. Specific advice on the password can be found in Section 6 of [RFC5959].

10.6. User Certificate Generation

The certificates need to be consistent with [RFC5280]. The sha1WithRSAEncryption and sha256WithRSAEncryption algorithms for the signatureAlgorithm MUST be implemented. The Issuers SHOULD be the same as the subject. Given the ease of issuing new certificates with this system, the Validity field can be relatively short. A Validity value of one year or less is RECOMMENDED. The SubjectAltName must have a URI type that is set to the SIP URL corresponding to the user AOR. It MAY be desirable to put some randomness into the length of time for which the certificates are valid so that it does not become necessary to renew all the certificates in the system at the same time.

When creating a new key pair for a certificate, it is critical to have appropriate randomness as described in [RFC4086]. This can be challenging on some embedded devices, such as some IP phones, and implementers should pay particular attention to this point.

It is worth noting that a UA can discover the current time by looking at the Date header field value in the 200 response to a REGISTER request.

10.7. Private Key Storage

The protection afforded private keys is a critical security factor. On a small scale, failure of devices to protect the private keys will permit an attacker to masquerade as the user or decrypt their personal information. As noted in the SACRED Framework, when stored on an end-user device, such as a diskette or hard drive, credentials SHOULD NOT be in the clear. It is RECOMMENDED that private keys be stored securely in the device, more specifically, encrypting them using tamper-resistant hardware encryption and exposing them only when required: for example, the private key is decrypted when necessary to generate a digital signature, and re-encrypted immediately to limit exposure in the RAM to a short period of time. Some implementations may limit access to private keys by prompting users for a PIN prior to allowing access to the private key.

On the server side, the protection of unencrypted PKCS #8 objects is equally important. Failure of a server to protect the private keys would be catastrophic, as attackers with access to unencrypted PKCS #8 objects could masquerade as any user whose private key was not encrypted. Therefore, it is also recommended that the private keys be stored securely in the server, more specifically, encrypting them using tamper-resistant hardware encryption and exposing them only when required.

FIPS 140-2 [FIPS-140-2] provides useful guidance on secure storage.

10.8. Compromised Authentication Service

One of the worst attacks against the Certificate Management Service described in this document would be if the authentication service were compromised. This attack is somewhat analogous to a certification authority being compromised in traditional PKI systems. The attacker could make a fake certificate for which it knows the private key, use it to receive any traffic for a given use, and then re-encrypt that traffic with the correct key and forward the communication to the intended receiver. The attacker would thus become a "man in the middle" in the communications.

There is not too much that can be done to protect against this type of attack. A UA MAY subscribe to its own certificate under some other identity to try to detect whether the credential server is handing out the correct certificates. It will be difficult to do this in a way that does not allow the credential server to recognize the user's UA.

The UA MAY also save the fingerprints of the cached certificates and warn users when the certificates change significantly before their expiry date.

The UA MAY also allow the user to see the fingerprints of the cached certificates so that they can be verified by some other out-of-band means.

11. IANA Considerations

This specification defines two new event packages that IANA has added to the "Session Initiation Protocol (SIP) Event Types Namespace" registry.

11.1. Certificate Event Package

To: ietf-sip-events@iana.org
Subject: Registration of new SIP event package

Package Name: certificate

Is this registration for a template-package: No

Published Specification(s): This document

New Event header parameters: This package defines no new parameters

Person & email address to contact for further information:
Cullen Jennings <fluffy@cisco.com>

11.2. Credential Event Package

To: ietf-sip-events@iana.org
Subject: Registration of new SIP event package

Package Name: credential

Is this registration for a template-package: No

Published Specification(s): This document

Person & email address to contact for further information:
Cullen Jennings <fluffy@cisco.com>

11.3. Identity Algorithm

IANA added the following entry to the "Identity-Info Algorithm Parameter Values" registry.

"alg" Parameter Name	Reference
rsa-sha256	[RFC6072]

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