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Secure Telephone Identity Credentials: Certificates
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Abstract

In order to prevent the impersonation of telephone numbers on the Internet, some kind of credential system needs to exist that cryptographically asserts authority over telephone numbers. This document describes the use of certificates in establishing authority over telephone numbers, as a component of a broader architecture for managing telephone numbers as identities in protocols like SIP.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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1. Introduction

The Secure Telephone Identity Revisited (STIR) problem statement [RFC7340] identifies the primary enabler of robocalling, vishing (voicemail hacking), swatting, and related attacks as the capability to impersonate a calling party number. The starkest examples of these attacks are cases where automated callees on the Public Switched Telephone Network (PSTN) rely on the calling number as a security measure -- for example, to access a voicemail system. Robocallers use impersonation as a means of obscuring identity. While robocallers can, in the ordinary PSTN, block (that is, withhold) their caller identity, callees are less likely to pick up calls from blocked identities; therefore, appearing to call from some number, any number, is preferable. Robocallers, however, prefer not to call from a number that can trace back to the robocaller, and therefore they impersonate numbers that are not assigned to them.

One of the most important components of a system to prevent impersonation is the implementation of credentials that identify the

parties who control telephone numbers. With these credentials, parties can assert that they are in fact authorized to use telephony numbers (TNs), and thus they distinguish themselves from impersonators unable to present such credentials. For that reason, the STIR threat model [RFC7375] stipulates that "The design of the credential system envisioned as a solution to these threats must, for example, limit the scope of the credentials issued to carriers or national authorities to those numbers that fall under their purview." This document describes credential systems for telephone numbers based on [X.509] version 3 certificates in accordance with [RFC5280]. While telephone numbers have long been part of the X.509 standard (X.509 supports arbitrary naming attributes to be included in a certificate; the telephoneNumber attribute was defined in the 1988 [X.520] specification), this document provides ways to determine authority more aligned with telephone network requirements, including extending X.509 with a Telephony Number Authorization List certificate extension, which binds certificates to asserted authority for particular telephone numbers or, potentially, telephone number blocks or ranges.

In the STIR in-band architecture specified in [RFC8224], two basic types of entities need access to these credentials: authentication services and verification services (or verifiers). An authentication service must be operated by an entity enrolled with the certification authority (CA) (see Section 5), whereas a verifier need only trust the trust anchor of the authority and also have a means to access and validate the public keys associated with these certificates. Although the guidance in this document is written with the STIR in-band architecture in mind, the credential system described in this document could be useful for other protocols that want to make use of certificates to assert authority over telephone numbers on the Internet.

This document specifies only the credential syntax and semantics necessary to support this architecture. It does not assume any particular CA or deployment environment. We anticipate that some deployment experience will be necessary to determine optimal operational models.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

3. Authority for Telephone Numbers in Certificates

At a high level, this specification details two non-exclusive approaches that can be employed to determine authority over telephone numbers with certificates.

The first approach is to leverage the existing subject of the certificate to ascertain that the holder of the certificate is authorized to claim authority over a telephone number. The subject might be represented as a domain name in the subjectAltName, such as an "example.net" where that domain is known to relying parties as a carrier, or represented with other identifiers related to the operation of the telephone network, including Service Provider Codes (SPCs) such as Operating Company Numbers (OCNs) or Service Provider Identifiers (SPIDs) via the TN Authorization List specified in this document. A relying party could then employ an external data set or service that determines whether or not a specific telephone number is under the authority of the carrier identified as the subject of the certificate and use that to ascertain whether or not the carrier should have authority over a telephone number. Potentially, a certificate extension to convey the URI of such an information service trusted by the issuer of the certificate could be developed (though this specification does not propose one). Alternatively, some relying parties could form bilateral or multilateral trust relationships with peer carriers, trusting one another’s assertions just as telephone carriers in the Signaling System 7 (SS7) network today rely on transitive trust when displaying the calling party telephone number received through SS7 signaling.

The second approach is to extend the syntax of certificates to include a new attribute, defined here as the TN Authorization List, which contains a list of telephone numbers defining the scope of authority of the certificate. Relying parties, if they trust the issuer of the certificate as a source of authoritative information on telephone numbers, could therefore use the TN Authorization List instead of the subject of the certificate to make a decision about whether or not the signer has authority over a particular telephone number. The TN Authorization List could be provided in one of two ways: as a literal value in the certificate or as a network service that allows relying parties to query in real time to determine that a telephone number is in the scope of a certificate. Using the TN Authorization List rather than the certificate subject makes sense when, for example, for privacy reasons the certificate owner would prefer not to be identified, or in cases where the holder of the certificate does not participate in the sort of traditional carrier infrastructure that the first approach assumes.

The first approach requires little change to existing Public Key Infrastructure (PKI) certificates; for the second approach, we must define an appropriate enrollment and authorization process. For the purposes of STIR, the over-the-wire format specified in [RFC8224] accommodates either of these approaches: the methods for canonicalizing, for signing, for identifying and accessing the certificate, and so on remain the same; it is only the verifier behavior and authorization decision that will change, depending on the approach to telephone number authority taken by the certificate. For that reason, the two approaches are not mutually exclusive, and in fact a certificate issued to a traditional telephone network service provider could contain a TN Authorization List or not, were it supported by the CA issuing the credential. Regardless of which approach is used, certificates that assert authority over telephone numbers are subject to the ordinary operational procedures that govern certificate use per [RFC5280]. This means that verification services must be mindful of the need to ensure that they trust the trust anchor that issued the certificate and that they have some means to determine the freshness of the certificate (see Section 10).

4. Certificate Usage with STIR

[RFC8224], Section 7.4 requires that all credential systems used by STIR explain how they address the requirements enumerated below. Certificates as described in this document address the STIR requirements as follows:

1. The URI [RFC3986] schemes permitted in the SIP Identity header "info" parameter, as well as any special procedures required to dereference the URIs: while normative text is given below in Section 7, this mechanism permits the HTTP [RFC7230], CID (Content-ID) [RFC2392], and SIP URI schemes to appear in the "info" parameter.

2. Procedures required to extract keying material from the resources designated by the URI: implementations perform no special procedures beyond dereferencing the "info" URI. See Section 7.

3. Procedures used by the verification service to determine the scope of the credential: this specification effectively proposes two methods, as outlined in Section 3: one where the subject (or, more properly, subjectAltName) of the certificate indicates the scope of authority through a domain name, and relying parties either trust the subject entirely or have some direct means of determining whether or not a number falls under a subject’s authority; and another where an extension to the certificate as described in Section 9 identifies the scope of authority of the certificate.

4. The cryptographic algorithms required to validate the credentials: for this specification, that means the signature algorithms used to sign certificates. This specification REQUIRES that implementations support both the Elliptic Curve Digital Signature Algorithm (ECDSA) with the P-256 curve (see [DSS]) and RSA PKCS #1 v1.5 ("PKCS" stands for "Public-Key Cryptography Standards") (see [RFC8017], Section 8.2) for certificate signatures. Implementers are advised that the latter algorithm is mandated only as a transitional mechanism, due to its widespread use in existing PKIs, but we anticipate that this mechanism will eventually be deprecated.

5. Finally, note that all certificates compliant with this specification:

   * MUST provide cryptographic keying material sufficient to generate the ECDSA using P-256 and SHA-256 signatures necessary to support the ES256 hashed signatures required by PASSporT [RFC8225], which in turn follows the JSON Web Token (JWT) [RFC7519].

   * MUST support both ECDSA with P-256 and RSA PKCS #1 v1.5 for certificate signature verification.

This document also includes additional certificate-related requirements:

- See Section 5.1 for requirements related to the JWT Claim Constraints certificate extension.

- See Section 7 for requirements related to relying parties acquiring credentials.

- See Sections 10 and 10.1 for requirements related to certificate freshness and the Authority Information Access (AIA) certificate extension.

5. Enrollment and Authorization Using the TN Authorization List

This document covers three models for enrollment when using the TN Authorization List extension.

The first enrollment model is one where the CA acts in concert with national numbering authorities to issue credentials to those parties to whom numbers are assigned. In the United States, for example, telephone number blocks are assigned to Local Exchange Carriers (LECs) by the North American Numbering Plan Administration (NANPA), who is in turn directed by the national regulator. LECs may also

receive numbers in smaller allocations, through number pooling, or via an individual assignment through number portability. LECs assign numbers to customers, who may be private individuals or organizations -- and organizations take responsibility for assigning numbers within their own enterprise. This model requires top-down adoption of the model from regulators through to carriers. Assignees of E.164 numbering resources participating in this enrollment model should take appropriate steps to establish trust anchors.

The second enrollment model is a bottom-up approach where a CA requires that an entity prove control by means of some sort of test that, as with certification authorities for web PKI, might either be (1) automated or (2) a manual administrative process. As an example of an automated process, an authority might send a text message to a telephone number containing a URL (which might be dereferenced by the recipient) as a means of verifying that a user has control of a terminal corresponding to that number. Checks of this form are frequently used in commercial systems today to validate telephone numbers provided by users. This is comparable to existing enrollment systems used by some certificate authorities for issuing S/MIME credentials for email by verifying that the party applying for a credential receives mail at the email address in question.

The third enrollment model is delegation: that is, the holder of a certificate (assigned by either of the two methods above) might delegate some or all of their authority to another party. In some cases, multiple levels of delegation could occur: a LEC, for example, might delegate authority to a customer organization for a block of 100 numbers used by an IP PBX, and the organization might in turn delegate authority for a particular number to an individual employee. This is analogous to delegation of organizational identities in traditional hierarchical PKIs who use the name constraints extension [RFC5280]; the root CA delegates names in sales to the sales department CA, names in development to the development CA, etc. As lengthy certificate delegation chains are brittle, however, and can cause delays in the verification process, this document considers optimizations to reduce the complexity of verification.

Future work might explore methods of partial delegation, where certificate holders delegate only part of their authority. For example, individual assignees may want to delegate to a service authority for text messages associated with their telephone number but not for other functions.

5.1. Constraints on Signing PASSporTs

The public key in the certificate is used to validate the signature on a JWT [RFC7519] that conforms to the conventions specified in PASSporT [RFC8225]. This specification supports constraints on the JWT claims, thereby allowing the CA to grant different permissions to certificate holders -- for example, those enrolled from proof-of-possession versus delegation. A Certificate Policy (CP) and a Certification Practice Statement (CPS) [RFC3647] are produced as part of the normal PKI bootstrapping process (i.e., the CP is written first, and then the CA says how it conforms to the CP in the CPS). A CA that wishes to place constraints on the JWT claims MUST include the JWT Claim Constraints certificate extension in issued certificates. See Section 8 for information about the certificate extension.

5.2. Certificate Extension Scope and Structure

This specification places no limits on the number of telephone numbers that can be associated with any given certificate. Some service providers may be assigned millions of numbers and may wish to have a single certificate that can be applied to signing for any one of those numbers. Others may wish to compartmentalize authority over subsets of the numbers they control.

Moreover, service providers may wish to have multiple certificates with the same scope of authority. For example, a service provider with several regional gateway systems may want each system to be capable of signing for each of their numbers but not want to have each system share the same private key.

The set of telephone numbers for which a particular certificate is valid is expressed in the certificate through a certificate extension; the certificate’s extensibility mechanism is defined in [RFC5280], but the TN Authorization List extension is specified in this document.

The subjects of certificates containing the TN Authorization List extension are typically the administrative entities to whom numbers are assigned or delegated. For example, a LEC might hold a certificate for a range of telephone numbers. In some cases, the organization or individual issued such a certificate may not want to associate themselves with a certificate; for example, a private individual with a certificate for a single telephone number might not want to distribute that certificate publicly if every verifier immediately knew their name. The certification authorities issuing certificates with the TN Authorization List extensions may, in accordance with their policies, obscure the identity of the subject,

though mechanisms for doing so are outside the scope of this document.

6. Provisioning Private Keying Material

In order for authentication services to sign calls via the procedures described in [RFC8224], they must hold a private key corresponding to a certificate with authority over the calling number. [RFC8224] does not require that any particular entity in a SIP deployment architecture sign requests, only that it be an entity with an appropriate private key; the authentication service role may be instantiated by any entity in a SIP network. For a certificate granting authority only over a particular number that has been issued to an end user, for example, an end-user device might hold the private key and generate the signature. In the case of a service provider with authority over large blocks of numbers, an intermediary might hold the private key and sign calls.

The specification RECOMMENDS distribution of private keys through PKCS #8 objects signed by a trusted entity -- for example, through the Cryptographic Message Syntax (CMS) package specified in [RFC5958].

7. Acquiring Credentials to Verify Signatures

This specification documents multiple ways that a verifier can gain access to the credentials needed to verify a request. As the validity of certificates does not depend on the method of their acquisition, there is no need to standardize any single mechanism for this purpose. All entities that comply with [RFC8224] necessarily support SIP, and consequently SIP itself can serve as a way to deliver certificates. [RFC8224] provides an "info" parameter of the Identity header; this parameter contains a URI for the credential used to generate the Identity header. [RFC8224] also requires that documents that define credential systems list the URI schemes that may be present in the "info" parameter. For implementations compliant with this specification, three URI schemes are REQUIRED: the CID URI, the SIP URI, and the HTTP URI.

The simplest way for a verifier to acquire the certificate needed to verify a signature is for the certificate to be conveyed in a SIP request along with the signature itself. In SIP, for example, a certificate could be carried in a multipart MIME body [RFC2046], and the URI in the Identity header "info" parameter could specify that body with a CID URI [RFC2392]. However, in many environments this is not feasible due to message size restrictions or lack of necessary support for multipart MIME.

The Identity header "info" parameter in a SIP request may contain a URI that the verifier dereferences. Implementations of this specification are REQUIRED to support the use of SIP for this function (via the SUBSCRIBE/NOTIFY mechanism) as well as HTTP and HTTPS.

Note well that as an optimization, a verifier may have access to a service, a cache, or other local store that grants access to certificates for a particular telephone number. However, there may be multiple valid certificates that can sign a call setup request for a telephone number, and as a consequence, there needs to be some discriminator that the signer uses to identify their credentials. The Identity header "info" parameter itself can serve as such a discriminator, provided implementations use that parameter as a key when accessing certificates from caches or other sources.

8. JWT Claim Constraints Syntax

Certificate subjects are limited to specific values for PASSporT claims with the JWT Claim Constraints certificate extension; issuers permit all claims by omitting the JWT Claim Constraints certificate extension from the certificate’s extension field [RFC5280]. The extension is non-critical, applicable only to end-entity certificates, and defined with ASN.1 [X.680] [X.681] [X.682] [X.683] later in this section. The syntax of the claims is given in PASSporT; specifying new claims follows the procedures in [RFC8225], Section 8.3.

This certificate extension is optional, but if present, it constrains the claims that authentication services may include in the PASSporT objects they sign. Constraints are applied by issuers and enforced by verifiers when validating PASSporT claims as follows:

1. mustInclude indicates claims that MUST appear in the PASSporT in addition to iat, orig, and dest. The baseline claims of PASSporT ("iat", "orig", and "dest") are considered to be permitted by default and SHOULD NOT be included. If mustInclude is absent, iat, orig, and dest MUST appear in the PASSporT.

2. permittedValues indicates that if the claim name is present, the claim MUST contain one of the listed values.

Consider two examples with a PASSporT claim called "confidence" with values "low", "medium", and "high":

- If a CA issues to an authentication service a certificate that contains the mustInclude JWTClaimName "confidence", then an authentication service MUST include the "confidence" claim in all

PASSporTs it generates; a verification service will treat as invalid any PASSporT it receives with a PASSporT claim that does not include the "confidence" claim.

- If a CA issues to an authentication service a certificate that contains the permittedValues JWTClaimName "confidence" and a permitted "high" value, then an authentication service will treat as invalid any PASSporT it receives with a PASSporT claim that does not include the "confidence" claim with a "high" value.

The JWT Claim Constraints certificate extension is identified by the following object identifier (OID), which is defined under the id-pe OID arc defined in [RFC5280] and managed by IANA (see Section 11):

```
id-pe-JWTClaimConstraints OBJECT IDENTIFIER ::= { id-pe 27 }
```

The JWT Claim Constraints certificate extension has the following syntax:

```
JWTClaimConstraints ::= SEQUENCE {
  mustInclude [0] JWTClaimNames OPTIONAL,
    -- The listed claim names MUST appear in the PASSporT
    -- in addition to iat, orig, and dest.  If absent, iat, orig,
    -- and dest MUST appear in the PASSporT.
  permittedValues [1] JWTClaimPermittedValuesList OPTIONAL }
    -- If the claim name is present, the claim MUST contain one of
    -- the listed values.
( WITH COMPONENTS { ..., mustInclude PRESENT } |
  WITH COMPONENTS { ..., permittedValues PRESENT } )

JWTClaimPermittedValuesList ::= SEQUENCE SIZE (1..MAX) OF
                                  JWTClaimPermittedValues

JWTClaimPermittedValues ::= SEQUENCE {
  claim  JWTClaimName,
  permitted  SEQUENCE SIZE (1..MAX) OF UTF8String }

JWTClaimNames ::= SEQUENCE SIZE (1..MAX) OF JWTClaimName

JWTClaimName ::= IA5String
```

9. TN Authorization List Syntax

The subjects of certificates containing the TN Authorization List extension are the administrative entities to whom numbers are assigned or delegated. When a verifier is validating a caller's identity, local policy always determines the circumstances under which any particular subject may be trusted, but the purpose of the

TN Authorization List extension in particular is to allow a verifier to ascertain when the CA has designated that the subject has authority over a particular telephone number or number range. The non-critical TN Authorization List certificate extension is included in the certificate's extension field [RFC5280]. The extension is defined with ASN.1 [X.680] [X.681] [X.682] [X.683]. The syntax and semantics of the extension are as follows.

The subjects of certificates containing the TN Authorization List extension are the administrative entities to whom numbers are assigned or delegated. In an end-entity certificate, the TN Authorization List indicates the TNs that it has authorized. In a CA certificate, the TN Authorization List limits the set of TNs for certification paths that include this certificate.

The TN Authorization List certificate extension is identified by the following object identifier (OID), which is defined under the id-pe OID arc defined in [RFC5280] and managed by IANA (see Section 11):

```
  id-pe-TNAuthList OBJECT IDENTIFIER ::= { id-pe 26 }
```

The TN Authorization List certificate extension has the following syntax:

```
 TNAuthorizationList ::= SEQUENCE SIZE (1..MAX) OF TNEntry

 TNEntry ::= CHOICE {
   spc   [0] ServiceProviderCode,
   range [1] TelephoneNumberRange,
   one   [2] TelephoneNumber
   }

 ServiceProviderCode ::= IA5String

 -- SPCs may be OCNs, various SPIDs, or other SP identifiers
 -- from the telephone network.

 TelephoneNumberRange ::= SEQUENCE {
   start TelephoneNumber,
   count INTEGER (2..MAX),
   ...
   }

 TelephoneNumber ::= IA5String (SIZE (1..15)) (FROM ("0123456789#*"))
```

The TN Authorization List certificate extension indicates the authorized phone numbers for the call setup signer. It indicates one or more blocks of telephone number entries that have been authorized

for use by the call setup signer. There are three ways to identify the block:

1. SPCs as described in this document are a generic term for the identifiers used to designate service providers in telephone networks today. In North American context, these would include OCNs as specified in [ATIS-0300251], related SPIDs, or other similar identifiers for service providers. SPCs can be used to indirectly name all of the telephone numbers associated with that identifier for a service provider.

2. Telephone numbers can be listed in a range (in the TelephoneNumberRange format), which consists of a starting telephone number and then an integer count of numbers within the range, where the valid boundaries of ranges may vary according to national policies. The count field is only applicable to start fields' whose values do not include "*" or "#" (i.e., a TelephoneNumber that does not include "*" or "#"). count MUST NOT make the number increase in length (i.e., a TelephoneNumberRange with TelephoneNumber=10 with a count=91 is invalid); formally, given the inputs count and TelephoneNumber of length D TelephoneNumber + count MUST be less than 10^D.

3. A single telephone number can be listed (as a TelephoneNumber).

Note that because large-scale service providers may want to associate many numbers, possibly millions of numbers, with a particular certificate, optimizations are required for those cases to prevent the certificate size from becoming unmanageable. In these cases, the TN Authorization List may be given by reference rather than by value, through the presence of a separate certificate extension that permits verifiers to either (1) securely download the list of numbers associated with a certificate or (2) verify that a single number is under the authority of this certificate. For more on this optimization, see Section 10.1.

10. Certificate Freshness and Revocation

Regardless of which of the approaches in Section 3 is followed for using certificates, a certificate verification mechanism is required. However, the traditional problem of certificate freshness gains a new wrinkle when using the TN Authorization List extension with telephone numbers or number ranges (as opposed to SPCs), because verifiers must establish not only that a certificate remains valid but also that the certificate's scope contains the telephone number that the verifier is validating. Dynamic changes to number assignments can occur due to number portability, for example. So, even if a verifier has a valid cached certificate for a telephone number (or a range

containing the number), the verifier must determine that the entity that created the PASSporT, which includes a digital signature, is still a proper authority for that number.

To verify the status of such a certificate, the verifier needs to acquire the certificate if necessary (via the methods described in Section 7) and then would need to either:

a. Rely on short-lived certificates and not check the certificate's status, or

b. Rely on status information from the authority (e.g., the Online Certificate Status Protocol (OCSP)).

The trade-off between short-lived certificates and using status information is that the former's burden is on the front end (i.e., enrollment) and the latter's burden is on the back end (i.e., verification). Both impact call setup time, but some approaches to generating a short-lived certificate, like requiring one for each call, would incur a greater operational cost than acquiring status information. This document makes no particular recommendation for a means of determining certificate freshness for STIR, as this requires further study and implementation experience. Acquiring online status information for certificates has the potential to disclose private information [RFC7258] if proper precautions are not taken. Future specifications that define certificate freshness mechanisms for STIR MUST note any such risks and provide countermeasures where possible.

10.1. Acquiring the TN List by Reference

One alternative to checking certificate status for a particular telephone number is simply acquiring the TN Authorization List by reference, that is, through dereferencing a URL in the certificate, rather than including the value of the TN Authorization List in the certificate itself.

Acquiring a list of the telephone numbers associated with a certificate or its subject lends itself to an application-layer query/response interaction outside of certificate status, one that could be initiated through a separate URI included in the certificate. The AIA extension (see [RFC5280]) supports such a mechanism: it designates an OID to identify the accessMethod and an accessLocation, which would most likely be a URI. A verifier would then follow the URI to ascertain whether the TNs in the list are authorized for use by the caller. As with the certificate extension defined in Section 9, a URI dereferenced from an end entity certificate will indicate the TNs which the caller has been authorized. Verifiers MUST support the AIA extension and the

dereferenced URI from a CA certificate limits the the set of TNs for certification paths that include this certificate.

HTTPS is the most obvious candidate for a protocol to be used for fetching the list of telephone numbers associated with a particular certificate. This document defines a new AIA accessMethod, called "id-ad-stirTNList", which uses the following AIA OID:

```
id-ad-stirTNList  OBJECT IDENTIFIER ::= { id-ad 14 }
```

When the "id-ad-stirTNList" accessMethod is used, the accessLocation MUST be an HTTPS URI. Dereferencing the URI will return the complete DER encoded TN Authorization List (see Section 9) for the certificate with a Content-Type of application/tnauthlist (see Section 11.2).

Delivering the entire list of telephone numbers associated with a particular certificate will divulge to STIR verifiers information about telephone numbers other than the one associated with the particular call that the verifier is checking. In some environments, where STIR verifiers handle a high volume of calls, maintaining an up-to-date and complete cache for the numbers associated with crucial certificate holders could give an important boost to performance.

11. IANA Considerations

11.1. ASN.1 Registrations

This document makes use of object identifiers for the TN certificate extension defined in Section 9, the "TN List by reference" AIA access descriptor defined in Section 10.1, and the ASN.1 module identifier defined in Appendix A. Therefore, per this document, IANA has made the following assignments, as shown on <https://www.iana.org/assignments/smi-numbers>:

- TN Authorization List certificate extension in the "SMI Security for PKIX Certificate Extension" (1.3.6.1.5.5.7.1) registry:

  26 id-pe-TNAuthList

- JWT Claim Constraints certificate extension in the "SMI Security for PKIX Certificate Extension" (1.3.6.1.5.5.7.1) registry:

  27 id-pe-JWTClaimConstraints

- TN List by reference access descriptor in the "SMI Security for PKIX Access Descriptor" (1.3.6.1.5.5.7.48) registry:

  14 id-ad-stirTNList

- The TN ASN.1 module in the "SMI Security for PKIX Module Identifier" (1.3.6.1.5.5.7.0) registry:

  89 id-mod-tn-module

11.2. Media Type Registrations

Type name: application
Subtype name: tnauthlist
Required parameters: None
Optional parameters: None
Encoding considerations: Binary
Security considerations: See Section 12 of [RFCTBD]
Interoperability considerations:
The TN Authorization List inside this media type MUST be DER-encoded TNAuthorizationList.
Published specification: [RFCTBD]
Applications that use this media type:
Issuers and relying parties of secure telephone identity certificates, to limit the subject's authority to a particular telephone number or telephone number range.
Fragment identifier considerations: None
Additional information:
Deprecated alias names for this type: None
Magic number(s): None
File extension(s): None
Macintosh File Type Code(s): None
Person & email address to contact for further information:
Jon Peterson <jon.peterson@team.neustar>
Intended usage: COMMON
Restrictions on usage: None
Author: Sean Turner <sean@sn3rd.com>
Change controller: The IESG <iesg@ietf.org>

[RFC editor's instruction: Please replace RFCTBD with the RFC number when this document is published.]

12. Security Considerations

This document is entirely about security. For further information on certificate security and practices, see [RFC5280], in particular its Security Considerations section.

If a certification authority issues a certificate attesting authority over many telephone numbers, the TNAuthList element can divulge to relying parties extraneous telephone numbers associated with the certificate which have no bearing on any given call in progress. The potential privacy risk can be exacerbated by the use of AIA, as

described in Section 10.1, to link many thousand of numbers to a single certificate. Even an SPC in a certificate can be used to link a certificate to a particular carrier and, with access to industry databases, potentially the set of numbers associated with that SPC. While these practices may not cause concern in some environments, in other scenarios alternative approaches could minimize the data revealed to relying parties. For example, a service provider with authority over a large block of numbers could generate short-lived certificates for individual TNs that are not so easily linked to the service provider or any other numbers that the service provider controls. Optimizations to facilitate acquiring short-lived certificates are a potential area of future work for STIR.

The TN Authorization List returned through a dereferenced URI is served over HTTPS; the TN Authorization List is therefore protected in transit. But, the TN Authorization List served is not a signed object and therefore the server is trusted to faithfully return the TN Authorization List provided to it by the list generator.

13. References

13.1. Normative References

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Appendix A. ASN.1 Module

This appendix provides the normative ASN.1 [X.680] definitions for the structures described in this specification using ASN.1, as defined in [X.680], [X.681], [X.682], and [X.683].

The modules defined in this document are compatible with the most current ASN.1 specifications published in 2015 (see [X.680], [X.681], [X.682], and [X.683]). None of the newly defined tokens in the 2008 ASN.1 (DATE, DATE-TIME, DURATION, NOT-A-NUMBER, OID-IRI, RELATIVE-OID-IRI, TIME, TIME-OF-DAY) are currently used in any of the ASN.1 specifications referred to here.

This ASN.1 module imports ASN.1 from [RFC5912].

```
 TN-Module-2016
   { iso(1) identified-organization(3) dod(6) internet(1) security(5)
     mechanisms(5) pkix(7) id-mod(0) id-mod-tn-module(89) }

 DEFINITIONS EXPLICIT TAGS ::= BEGIN

 IMPORTS

 id-ad, id-pe
 FROM PKIX1Explicit-2009  -- From [RFC5912]
   { iso(1) identified-organization(3) dod(6) internet(1) security(5)
     mechanisms(5) pkix(7) id-mod(0) id-mod-pkix1-explicit-02(51) }

 EXTENSION
 FROM PKIX-CommonTypes-2009  -- From [RFC5912]
   { iso(1) identified-organization(3) dod(6) internet(1) security(5)
     mechanisms(5) pkix(7) id-mod(0) id-mod-pkixCommon-02(57) }

 ;

 --
 -- JWT Claim Constraints Certificate Extension
 --
```

```
    ext-jwtClaimConstraints EXTENSION  ::= {
      SYNTAX JWTClaimConstraints IDENTIFIED BY id-pe-JWTClaimConstraints
      }

    id-pe-JWTClaimConstraints OBJECT IDENTIFIER ::= { id-pe 27 }

    JWTClaimConstraints ::= SEQUENCE {
      mustInclude [0] JWTClaimNames OPTIONAL,
        -- The listed claim names MUST appear in the PASSporT
        -- in addition to iat, orig, and dest.  If absent, iat, orig,
        -- and dest MUST appear in the PASSporT.
      permittedValues [1] JWTClaimPermittedValuesList OPTIONAL }
        -- If the claim name is present, the claim MUST contain one of
        -- the listed values.
    ( WITH COMPONENTS { ..., mustInclude PRESENT } |
      WITH COMPONENTS { ..., permittedValues PRESENT } )

    JWTClaimPermittedValuesList ::= SEQUENCE SIZE (1..MAX) Of
                                      JWTClaimPermittedValues

    JWTClaimPermittedValues ::= SEQUENCE {
      claim  JWTClaimName,
      permitted  SEQUENCE SIZE (1..MAX) OF UTF8String }

    JWTClaimNames ::= SEQUENCE SIZE (1..MAX) OF JWTClaimName

    JWTClaimName ::= IA5String

    --
    -- Telephony Number Authorization List Certificate Extension
    --

    ext-tnAuthList  EXTENSION  ::= {
      SYNTAX TNAuthorizationList IDENTIFIED BY id-pe-TNAuthList
      }

    id-pe-TNAuthList OBJECT IDENTIFIER ::= { id-pe 26 }

    TNAuthorizationList ::= SEQUENCE SIZE (1..MAX) OF TNEntry

    TNEntry ::= CHOICE {
      spc    [0] ServiceProviderCode,
      range  [1] TelephoneNumberRange,
      one    [2] TelephoneNumber
      }

    ServiceProviderCode ::= IA5String
```

```
    -- SPCs may be OCNs, various SPIDs, or other SP identifiers
    -- from the telephone network.

    TelephoneNumberRange ::= SEQUENCE {
      start TelephoneNumber,
      count INTEGER (2..MAX),
      ...
      }

    TelephoneNumber ::= IA5String (SIZE (1..15)) (FROM ("0123456789#*"))

    -- TN Access Descriptor

    id-ad-stirTNList OBJECT IDENTIFIER ::= { id-ad 14 }

    END
```

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Personal Assertion Token (PASSporT)
draft-ietf-stir-passport-11

Abstract

This document defines a method for creating and validating a token that cryptographically verifies an originating identity, or more generally a URI or telephone number representing the originator of personal communications. The PASSporT token is cryptographically signed to protect the integrity of the identity the originator and to verify the assertion of the identity information at the destination. The cryptographic signature is defined with the intention that it can confidently verify the originating persona even when the signature is sent to the destination party over an insecure channel. PASSporT is particularly useful for many personal communications applications over IP networks and other multi-hop interconnection scenarios where the originating and destination parties may not have a direct trusted relationship.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on August 13, 2017.

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1. Introduction

In today's IP-enabled telecommunications world, there is a growing concern about the ability to trust incoming invitations for communications sessions, including video, voice and messaging [RFC7340]. As an example, modern telephone networks provide the ability to spoof the calling party telephone number for many legitimate purposes including providing network features and services on the behalf of a legitimate telephone number. However, as we have seen, bad actors have taken advantage of this ability for illegitimate and fraudulent purposes meant to trick telephone users to believe they are someone they are not. This problem can be extended to many emerging forms of personal communications.

This document defines a method for creating and validating a token that cryptographically verifies an originating identity, or more generally a URI or telephone number representing the originator of personal communications. Through extensions defined in this document, in Section 8, other information relevant to the personal communications can also be added to the token. The goal of PASSporT is to provide a common framework for signing originating identity related information in an extensible way. Additionally, this functionality is independent of any specific personal communications signaling call logic, so that the assertion of originating identity related information can be implemented in a flexible way and can be used in applications including end-to-end applications that require different signaling protocols or gateways between different communications systems. It is anticipated that signaling protocol specific guidance will be provided in other related documents and specifications to specify how to use and transport PASSporT tokens, however this is intentionally out of scope for this document.

[I-D.ietf-stir-rfc4474bis] provides details of the use of PASSporT within SIP [RFC3261] signaling protocol for the signing and verification of telephone numbers and SIP URIs.

2. 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 RFC 2119 [RFC2119].

3. PASSporT Token Overview

JSON Web Token (JWT) [RFC7519] and JSON Web Signature (JWS) [RFC7515] and related specifications define a standard token format that can be used as a way of encapsulating claimed or asserted information with an associated digital signature using X.509 based certificates. JWT provides a set of claims in JSON format that can conveniently accommodate asserted originating identity information and is easily extensible for extension mechanisms defined below. Additionally, JWS provides a path for updating methods and cryptographic algorithms used for the associated digital signatures.

JWS defines the use of JSON data structures in a specified canonical format for signing data corresponding to JOSE header, JWS Payload, and JWS Signature. JWT defines a set of claims that are represented by specified JSON objects which can be extended with custom keys for specific applications. The next sections define the header and claims that MUST be minimally used with JWT and JWS for PASSporT.

PASSporT specifically uses this token format and defines claims that convey the identity of the origination and destination of personal communications. The originating identity, the primary value asserted in a PASSporT object represents the identity of the calling party or the initiator of a personal communications session. The signer of a PASSporT object may or may not correspond to the origination identity. For a given application’s use or using protocol of PASSporT the creation of the PASSporT object is performed by an entity that is authoritative to assert the callers identity. This authority is represented by the certificate credentials and the signature and PASSporT object is created and initiated to the destination(s) at the applications choice of authoritative point(s) in the network. For example, the PASSporT object could be created at a device that has authenticated with a user, or at a network entity with an authenticated trust relationship with that device and it’s user. Destination identities represent the intended destination of the personal communications, i.e. the identity(s) being called by the caller. The destination point(s) determined by the application need to have the capability to verify the PASSporT token and the digital signature. The PASSporT associated certificate is used to validate the authority of the originating signer, generally via a certificate chain to the trust anchor for that application.

4. PASSporT Header

The JWS token header is a JOSE header, [RFC7515] Section 4, that defines the type and encryption algorithm used in the token.

PASSporT header should include, at a minimum, the header parameters defined in the next three subsections.

4.1. "typ" (Type) Header Parameter

The "typ" (Type) Header Parameter is defined in JWS [RFC7515] Section 4.1.9. to declare the media type of the complete JWS.

For PASSporT Token the "typ" header MUST be the string "passport". This represents that the encoded token is a JWT of type passport.

4.2. "alg" (Algorithm) Header Parameter

The "alg" (Algorithm) Header Parameter is defined in JWS [RFC7515] Section 4.1.1. This definition includes the ability to specify the use of a cryptographic algorithm for the signature part of the JWS. It also refers to a list of defined "alg" values as part of a registry established by JSON Web Algorithms (JWA) [RFC7518] Section 3.1.

For the creation and verification of PASSporT tokens and their digital signatures, implementations MUST support ES256 as defined in JWA [RFC7518] Section 3.4. Implementations MAY support other algorithms registered in the JSON Web Signature and Encryption Algorithms registry created by [RFC7518]. The contents of that registry may be updated in the future depending on cryptographic strength requirements guided by current security best practice. The mandatory-to-support algorithm for PASSporT tokens may likewise be updated in future updates to this document.

Implementations of PASSporT digital signatures using ES256 as defined above SHOULD use deterministic ECDSA if/when supported for the reasons stated in [RFC6979].

4.3. "x5u" (X.509 URL) Header Parameter

As defined in JWS [RFC7515] Section 4.1.5., the "x5u" header parameter defines a URI [RFC3986] referring to the resource for the X.509 public key certificate or certificate chain [RFC5280] corresponding to the key used to digitally sign the JWS. Generally, as defined in JWS [RFC7515] section 4.1.5, this would correspond to an HTTPS or DNSSEC resource using integrity protection.

4.4. Example PASSporT header

An example of the header, would be the following, including the specified passport type, ES256 algorithm, and a URI referencing the network location of the certificate needed to validate the PASSporT signature.

```
{
  "typ":"passport",
  "alg":"ES256",
  "x5u":"https://cert.example.org/passport.cer"
}
```

5. PASSporT Payload

The token claims consist of the information which needs to be verified at the destination party. These claims follow the definition of a JWT claim [RFC7519] Section 4 and are encoded as defined by the JWS Payload [RFC7515] Section 3.

PASSporT defines the use of a standard JWT defined claim as well as custom claims corresponding to the two parties associated with personal communications, the originator and destination as detailed below.

Any claim names MUST use the US-ASCII character set. Any claim values can container characters that are outside the US-ASCII range, however MUST follow the default JSON serialization defined in [RFC7519] Section 7.

5.1. JWT defined claims

5.1.1. "iat" - Issued At claim

The JSON claim MUST include the "iat" [RFC7519] Section 4.1.6 defined claim Issued At. As defined the "iat" should be set to the date and time of issuance of the JWT and MUST the origination of the personal communications. The time value should be of the format defined in [RFC7519] Section 2 NumericDate. This is included for securing the token against replay and cut and paste attacks, as explained further in the security considerations in Section 10.

5.2. PASSporT specific claims

5.2.1. Originating and Destination Identity Claims

The origination and destination identities are represented by two claims that are required for PASSporT, the "orig" and "dest" claims. Both "orig" and "dest" MUST contain claim values that are identity claim JSON objects where the child claim name represents an identity type and the claim value is the identity string, both defined in subsequent subsections. Currently, these identities can be represented as either telephone numbers or Uniform Resource Indicators (URIs).

The "orig" claim is a JSON object with the claim name of "orig" and a claim value which is a JSON object representing the asserted identity of any type (currently either "tn" or "uri") of the originator of the personal communications signaling. There MUST be exactly one "orig" claim with exactly one identity claim object in a PASSporT object.

Note, as explained in Section 3, the originating identity represents the calling party and may or may not correspond to the authoritative signer of the token.

The "dest" is a JSON object with the claim name of "dest" and MUST have at least have one identity claim object. The "dest" claim value is an array containing one or more identity claim JSON objects representing the destination identities of any type (currently "tn" or "uri"). If the "dest" claim value array contains both "tn" and "uri" claim names, the JSON object should list the "tn" array first and the "uri" array second. Within the "tn" and "uri" arrays, the identity strings should be put in lexicographical order including the scheme-specific portion of the URI characters.

Note, as explained in Section 3, the destination identity represents the called party and may or may not correspond to the authoritative party verifying the token signature.

5.2.1.1. "tn" - Telephone Number identity

If the originating or destination identity is a telephone number, the claim name representing the identity MUST be "tn".

The claim value for the "tn" claim is the telephone number and MUST be canonicalized according to the procedures specified in [I-D.ietf-stir-rfc4474bis] Section 8.3.

5.2.1.2. "uri" - URI identity

If any of the originating or destination identities is of the form URI, as defined in [RFC3986], the claim name representing the identity MUST be "uri" and the claim value is the URI form of the identity.

5.2.1.3. Future identity forms

We recognize that in the future there may be other standard mechanisms for representing identities. The "orig" and "dest" claims currently support "tn" and "uri" but could be extended in the future to allow for other identity types with new IANA registered unique types to represent these forms.

5.2.1.4. Examples

Single originator, with telephone number identity +12155551212, to single destination, with URI identity ’sip:alice@example.com’, example:

```
{
  "dest":{"uri":["sip:alice@example.com"]},
  "iat":1443208345,
  "orig":{"tn":"12155551212"}
}
```

Single originator, with telephone number identity +12155551212, to multiple destination identities, with telephone number identity +12125551212 and two URI identities, sip:alice@example.com and sip:bob@example.com, example:

```
{
  "dest":{
    "tn":["12125551212"],
    "uri":["sip:alice@example.com",
      "sip:bob@example.net"]
  },
  "iat":1443208345,
  "orig":{"tn":"12155551212"}
}
```

5.2.2. "mky" - Media Key claim

Some protocols that use PASSporT may also want to protect media security keys delivered within their signaling in order to bind those keys to the identities established in the signaling layers. The "mky" is an optional PASSporT claim defining the assertion of media

key fingerprints carried in SDP [RFC4566] via the "a=fingerprint" attribute [RFC4572] Section 5. This claim can support either a single or multiple fingerprints appearing in a single SDP body corresponding to one or more media streams offered as defined in [I-D.ietf-mmusic-4572-update].

The "mky" claim MUST be formatted as a JSON object with an array including the "alg" and "dig" claims with the corresponding algorithm and hexadecimal values. If there is more than one fingerprint value associated with different media streams in SDP, the fingerprint values MUST be constructed as a JSON array denoted by bracket characters. For the "dig" claim, the claim value MUST be the hash hexadecimal value without any colons.

The "mky" claim is a JSON object with a claim name of "mky" and a claim value of a JSON array denoted by brackets. The "mky" claim value JSON array MUST be constructed as follows:

1. Take each "a=fingerprint" lines carried in the SDP.

2. Sort the lines based on the UTF8 encoding of the concatenation of the "alg" and "dig" claim value strings.

3. Encode the array in the order of the sorted lines, where each "mky" array element is a JSON object with two elements corresponding to the "alg" and "dig" objects, with "alg" first and "dig" second.

An example claim with "mky" claim is as follows:

For an SDP offer that includes the following fingerprint values,

a=fingerprint:sha-256 4A:AD:B9:B1:3F:82:18:3B:54:02:12:DF:3E:
5D:49:6B:19:E5:7C:AB:3E:4B:65:2E:7D:46:3F:54:42:CD:54:F1
a=fingerprint:sha-256 02:1A:CC:54:27:AB:EB:9C:53:3F:3E:4B:65
:2E:7D:46:3F:54:42:CD:54:F1:7A:03:A2:7D:F9:B0:7F:46:19:B2

the PASSporT Payload object would be:

```
{
  "dest":{"uri":["sip:alice@example.com"]},
  "iat":1443208345,
  "mky":[
    {
      "alg":"sha-256",
      "dig":"021ACC5427ABEB9C533F3E4B652E7D463F5442CD54
        F17A03A27DF9B07F4619B2"
    },
    {
      "alg":"sha-256",
      "dig":"4AADB9B13F82183B540212DF3E5D496B19E57C
        AB3E4B652E7D463F5442CD54F1"
    }
  ],
  "orig":{"tn":"12155551212"}
}
```

6. PASSporT Signature

The signature of the PASSporT is created as specified by JWS [RFC7515] Section 5.1 Steps 1 through 6. PASSporT MUST use the JWS Protected Header. For the JWS Payload and the JWS Protected Header, the lexicographic ordering and white space rules described in Section 4 and Section 5, and JSON serialization rules in Section 9 of this document MUST be followed.

Appendix A of this document has a detailed example of how to follow the steps to create the JWS Signature.

JWS [RFC7515] Section 5.1 Step 7 JWS JSON serialization is not supported for PASSporT.

JWS [RFC7515] Section 5.1 Step 8 describes the method to create the final JWS Compact Serialization form of the PASSporT Token.

7. Compact form of PASSporT

For a using protocol of PASSporT, the PASSporT Claims as well as the PASSporT Header may include redundant or default information that could be reconstructed at the destination based on information provided in the signaling protocol transporting the PASSporT object. In this case, it may be advantageous to have a more compact form of PASSporT to save the transmission of the bytes needed to represent the header and claims.

This specification defines the compact form of the PASSporT token, in the spirit of form defined in [RFC7515] Appendix F, with the use of

'..', two periods to represent the header and claim objects being removed, followed by PASSporT signature as defined in Section 6, and the need for the destination to reconstruct the header and claim objects in order to verify the signature.

In order to construct the Compact form of the PASSporT string, the procedure described in Section 6 with the exception of Step 8 described in JWS [RFC7515] Section 5.1. This step would be replaced by the following construction of the compact form of PASSporT, '..' || BASE64URL(JWS Signature).

The using protocol of the compact form of PASSporT MUST be accompanied by a specification for how the header and claims objects can be reconstructed from information in the signaling protocol being used.

Note that the full form of the PASSporT token, containing the entire header, payload, and signature, should also use the lexicographic ordering and white space serialization rules, particularly in the case where some using protocols or interworking between protocols may require switching between full and compact forms and maintaining the integrity of the signature.

7.1. Example Compact form PASSporT Token

The compact form of the following example token (with line breaks between period used for readability purposes only)

eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1IjoiaHR0cHM6Ly9j
ZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9
.
eyJkZXN0Ijp7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sImlhdCI
6IjE0NDMyMDgzNDUiLCJvcmlnIjp7InRuIjoiMTIxNTU1NTEyMTIifX0
.
rq3pjT1hoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjpjlk-cpFYpFYsojN
CpTzO3QfPOlckGaS6hEck7w

would be as follows (with line breaks between period used for readability purposes only)

..rq3pjT1hoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjpjlk-cpFYpFYsojN
CpTzO3QfPOlckGaS6hEck7w

8. Extending PASSporT

PASSporT includes the bare minimum set of claims needed to securely assert the originating identity and support the secure properties discussed in various parts of this document. JWT supports a straight

forward way to add additional asserted or signed information by simply adding new claims. PASSporT can be extended beyond the defined base set of claims to represent other information requiring assertion or validation beyond the originating identity itself as needed.

8.1. "ppt" (PASSporT) header parameter

Any using protocol can extend the payload of PASSporT with additional JWT claims. JWT claims are managed by an existing IANA registry as defined in [RFC7519] Section 10.1. Implementations of PASSporT MUST support the baseline claims defined in Section 5.2, and MAY support extended claims. If it is necessary for an extension to PASSporT to require that a relying party support a particular extended claim or set of claims in the PASSporT object, it can do so by specifying a "ppt" element for the PASSporT JOSE header. All values of "ppt" need to be defined in a specification which associates the new value of the "ppt" element with the required claims and behaviors. Relying parties MUST fail to validate PASSporT objects containing an unsupported "ppt".

Using protocols MUST explicitly define the how each claim is carried in the using protocol and the rules for how the header and payload objects are constructed beyond the lexicographical and serialization rules defined in this document.

Using protocols that carry the compact form of PASSporT, defined in Section 7, instead of the full form MUST use only mandatory extensions signaled with "ppt" - if a using protocol were to add additional optional claims to a PASSporT object it carried in compact form, relying parties would have no way to reconstruct the token. Moreover, using protocols that support the compact form of PASSporT MUST have some field to signal "ppt" to relying parties, as the compact form of PASSporT omits the JOSE header.

8.2. Example extended PASSporT header

An example header with a PASSporT extension type of "foo" is as follows:

```
{
  "alg":"ES256",
  "ppt":"foo",
  "typ":"passport",
  "x5u":"https://tel.example.org/passport.cer"
}
```

8.3. Extended PASSporT Claims

Specifications that define extensions to the PASSporT mechanism MUST explicitly specify what claims they include beyond the base set of claims from this document, the order in which they will appear, and any further information necessary to implement the extension. All extensions MUST include the baseline PASSporT claim elements specified in Section 5; claims may only be appended to the claims object specified; they can never be removed or re-ordered. Specifying new claims follows the baseline JWT procedures ([RFC7519] Section 10.1). Understanding an extension or new claims defined by the extension on the destination verification of the PASSporT token is optional. The creator of a PASSporT object cannot assume that destination systems will understand any given extension. Verification of PASSporT tokens by destination systems that do support an extension may then trigger appropriate application-level behavior in the presence of an extension; authors of extensions should provide appropriate extension-specific guidance to application developers on this point.

An example set of extended claims, extending the first example in Section 5.2.1.4 using "bar" as the newly defined claim would be as follows:

```
{
  "bar":"beyond all recognition"
  "dest":{"uri":["sip:alice@example.com"]},
  "iat":1443208345,
  "orig":{"tn":"12155551212"}
}
```

9. Deterministic JSON Serialization

JSON objects can include spaces and line breaks, and key value pairs can occur in any order. It is therefore a non-deterministic string format. In order to make the digital signature verification work deterministically, the JSON representation of the JWS Protected Header object and JWS Payload object MUST be computed as follows.

The JSON object MUST follow the following rules. These rules are based on the thumbprint of a JSON Web Key (JWK) as defined in Section 3 Step 1 of [RFC7638].

1. The JSON object MUST contain no whitespace or line breaks before or after any syntactic elements.

2. JSON objects MUST have the keys ordered lexicographically by the Unicode [UNICODE] code points of the member names.

3. JSON value literals MUST be lowercase.

4. JSON numbers are to be encoded as integers unless the field is defined to be encoded otherwise.

5. Encoding rules MUST be applied recursively to member values and array values.

Note: For any PASSporT extension claims, member names within the scope of a JSON object MUST NOT be equal to other member names, otherwise serialization will not be deterministic.

9.1. Example PASSport deterministic JSON form

This section demonstrate the deterministic JSON serialization for the example PASSporT Payload shown in Section 5.2.1.4.

The initial JSON object is shown here:

```
{
  "dest":{"uri":["sip:alice@example.com"]},
  "orig":{"tn":"12155551212"}
  "iat":1443208345,
  "mky":[
    {
      "alg":"sha-256",
      "dig":"021ACC5427ABEB9C533F3E4B652E7D463F5442CD54
        F17A03A27DF9B07F4619B2"
    },
    {
      "alg":"sha-256",
      "dig":"4AADB9B13F82183B540212DF3E5D496B19E57C
        AB3E4B652E7D463F5442CD54F1"
    }
  ],
}
```

The parent members of the JSON object are as follows:

o "dest"

o "orig"

o "iat"

o "mky"

Their lexicographic order is:

- "dest"
- "iat"
- "mky"
- "orig"

The final constructed deterministic JSON serialization representation, with whitespace and line breaks removed, (with line breaks used for display purposes only) is:

{"dest":{"uri":["sip:alice@example.com"],"iat":1443208345,"mky":
[{"alg":"sha-256","dig":"021ACC5427ABEB9C533F3E4B652E7D463F5442CD5
4F17A03A27DF9B07F4619B2"},{"alg":"sha-256","dig":"4AADB9B13F82183B5
40212DF3E5D496B19E57CAB3E4B652E7D463F5442CD54F1"}],
"orig":{"tn":"12155551212"}}

10. Security Considerations

10.1. Avoidance of replay and cut and paste attacks

There are a number of security considerations for use of the token for avoidance of replay and cut and paste attacks. PASSporT tokens SHOULD only be sent with application level protocol information (e.g. for SIP an INVITE as defined in [RFC3261]) corresponding to the required fields in the token. A uniqueness of the set of token claims and token signature is constructed using the originating identity being asserted with the 'orig' claim along with the following two claims:

- 'iat' claim should correspond to a date/time the message was originated. It should also be within a relative time that is reasonable for clock drift and transmission time characteristics associated with the application using the PASSporT token. Therefore, validation of the token should consider date and time correlation, which could be influenced by signaling protocol specific use and network time differences.
- 'dest' claim is included to prevent the valid re-use of a previously originated message to send to another destination party.

10.2. Solution Considerations

The use of PASSporT tokens based on the validation of the digital signature and the associated certificate requires consideration of the authentication and authority or reputation of the signer to

attest to the identity being asserted. The following considerations should be recognized when using PASSporT:

- The use of this token should not, in it's own right, be considered a full solution for absolute non-repudiation of the identity being asserted.

- In many applications, the end user represented by the asserted identity represents and signer may not be one in the same. For example, when a service provider signs and validates the token on the behalf of the user consuming the service, the provider MUST have an authenticated and secure relationship with the end user or the device initiating and terminating the communications signaling.

- Applications that use PASSporT should ensure the verification of the signature includes the means of verifying the signer is authoritative through the use of an application or service specific set of common trust anchors for the application.

11. IANA Considerations

11.1. Media Type Registration

11.1.1. Media Type Registry Contents Additions Requested

This section registers the "application/passport" media type [RFC2046] in the "Media Types" registry in the manner described in [RFC6838], which can be used to indicate that the content is a PASSporT defined JWT.

- Type name: application

- Subtype name: passport

- Required parameters: n/a

- Optional parameters: n/a

- Encoding considerations: 8bit; application/passport values are encoded as a series of base64url-encoded values (some of which may be the empty string) separated by period ('.') characters..

- Security considerations: See the Security Considerations Section of [RFC7515].

- Interoperability considerations: n/a

- Published specification: [RFCThis]
- Applications that use this media type: STIR and other applications that require identity related assertion
- Fragment identifier considerations: n/a
- Additional information:

  Magic number(s): n/a File extension(s): n/a Macintosh file type code(s): n/a
- Person & email address to contact for further information: Chris Wendt, chris-ietf@chriswendt.net
- Intended usage: COMMON
- Restrictions on usage: none
- Author: Chris Wendt, chris-ietf@chriswendt.net
- Change Controller: IESG
- Provisional registration? No

11.2. JSON Web Token Claims Registration

11.2.1. Registry Contents Additions Requested

- Claim Name: "orig"
- Claim Description: Originating Identity String
- Change Controller: IESG
- Specification Document(s): Section 5.2.1 of [RFCThis]
- Claim Name: "dest"
- Claim Description: Destination Identity String
- Change Controller: IESG
- Specification Document(s): Section 5.2.1 of [RFCThis]
- Claim Name: "mky"
- Claim Description: Media Key Fingerprint String

- Change Controller: IESG
- Specification Document(s): Section 5.2.2 of [RFCThis]

11.3. JSON Web Signature and Encryption Header Parameter Registry

11.3.1. Registry Contents Additions Requested

Header Parameter Name: "ppt"

- Header Parameter Description: PASSporT extension identifier
- Header Parameter Usage Location(s): JWS
- Change Controller: IESG
- Specification Document(s): Section 8.1 of [RFCThis]

11.4. PASSporT Extension Registry Request

The IANA is requested to create a new PASSporT Type registry for 'ppt' parameter values. That parameter and its values are defined in Section 8.1. New registry entries must contain the name of the 'ppt' parameter value and the specification in which the value is described. The policy for this registry is Specification Required.

12. Acknowledgements

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Appendix A. Example ES256 based PASSporT JWS Serialization and Signature

For PASSporT, there will always be a JWS with the following members:

- "protected", with the value BASE64URL(UTF8(JWS Protected Header))
- "payload", with the value BASE64URL (JWS Payload)
- "signature", with the value BASE64URL(JWS Signature)

This example will follow the steps in JWS [RFC7515] Section 5.1, steps 1-6 and 8 and incorporates the additional serialization steps required for PASSporT.

Step 1 for JWS references the JWS Payload, an example PASSporT Payload is as follows:

```
{
  "dest":{"uri":["sip:alice@example.com"]}
  "iat":1471375418,
  "orig":{"tn":"12155551212"}
}
```

This would be serialized to the form (with line break used for display purposes only):

```
{"dest":{"uri":["sip:alice@example.com"]},"iat":1471375418,
"orig":{"tn":"12155551212"}}
```

Step 2 Computes the BASE64URL(JWS Payload) producing this value (with line break used for display purposes only):

```
eyJkZXN0Ijp7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sImlhdCI
6MTQ3MTM3NTQxOCwib3JpZyI6eyJ0biI6IjEyMTU1NTUxMjEyIn19
```

For Step 3, an example PASSporT Protected Header comprising the JOSE Header is as follows:

```
{
  "alg":"ES256",
  "typ":"passport",
  "x5u":"https://cert.example.org/passport.cer"
}
```

This would be serialized to the form (with line break used for display purposes only):

```
{"alg":"ES256","typ":"passport","x5u":"https://cert.example.org
  /passport.cer"}
```

Step 4 Performs the BASE64URL(UTF8(JWS Protected Header)) operation and encoding produces this value (with line break used for display purposes only):

```
eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1IjoiaHR0cHM6Ly9j
ZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9
```

Step 5 and Step 6 performs the computation of the digital signature of the PASSporT Signing Input ASCII(BASE64URL(UTF8(JWS Protected Header)) || '.' || BASE64URL(JWS Payload)) using ES256 as the algorithm and the BASE64URL(JWS Signature).

```
VLBCIVDCaeK6M4hLJb6SHQvacAQVvoiiEOWQ_iUkqk79UD81fHQ0E1b3_GluIkb
a7UWYRM47ZbNFdOJquE35cw
```

Step 8 describes how to create the final PASSporT token, concatenating the values in the order Header.Payload.Signature with period ('.') characters. For the above example values this would produce the following (with line breaks between period used for readability purposes only):

```
eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1IjoiaHR0cHM6Ly9j
ZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9
.
eyJkZXN0Ijp7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sImlhdCI
6MTQ3MTM3NTQxOCwib3JpZyI6eyJ0biI6IjEyMTU1NTUxMjEyIn19
.
VLBCIVDCaeK6M4hLJb6SHQvacAQVvoiiEOWQ_iUkqk79UD81fHQ0E1b3_GluIkb
a7UWYRM47ZbNFdOJquE35cw
```

A.1. X.509 Private Key in PKCS#8 format for ES256 Example**

```
-----BEGIN PRIVATE KEY-----
MIGHAgEAMBMGByqGSM49AgEGCCqGSM49AwEHBG0wawIBAQQgi7q2TZvN9VDFg8Vy
qCP06bETrR2v8MRvr89rn4i+UAahRANCAAQWfaj1HUETpoNCrOtp9KA8o0V79IuW
ARKt9C1cFPkyd3FBP4SeiNZxQhDrD0tdBHls3/wFe8++K2FrPyQF9vuh
-----END PRIVATE KEY----
```

A.2. X.509 Public Key for ES256 Example**

```
-----BEGIN PUBLIC KEY-----
MFkwEwYHKoZIzj0CAQYIKoZIzj0DAQcDQgAE8HNbQd/TmvCKwPKHkMF9fScavGeH
78YTU8qLS8I5HLHSSmlATLcslQMhNC/OhlWBYC626nIlo7XeebYS7Sb37g==
-----END PUBLIC KEY-----
```

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Authenticated Identity Management in the Session Initiation Protocol (SIP)
draft-ietf-stir-rfc4474bis-16.txt

Abstract

The baseline security mechanisms in the Session Initiation Protocol (SIP) are inadequate for cryptographically assuring the identity of the end users that originate SIP requests, especially in an interdomain context. This document defines a mechanism for securely identifying originators of SIP requests. It does so by defining a SIP header field for conveying a signature used for validating the identity, and for conveying a reference to the credentials of the signer.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on August 13, 2017.

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Table of Contents

1. Introduction

This document provides enhancements to the existing mechanisms for authenticated identity management in the Session Initiation Protocol (SIP, [RFC3261]). An identity, for the purposes of this document, is defined as either a canonical address-of-record (AoR) SIP URI employed to reach a user (such as 'sip:alice@atlanta.example.com'), or a telephone number, which commonly appears in either a TEL URI [RFC3966] or as the user portion of a SIP URI.

[RFC3261] specifies several places within a SIP request where users can express an identity for themselves, most prominently the user-populated From header field. However, in the absence of some sort of cryptographic authentication mechanism, the recipient of a SIP request has no way to verify that the From header field has been populated appropriately. This leaves SIP vulnerable to a category of abuses, including impersonation attacks that facilitate or enable robocalling, voicemail hacking, swatting, and related problems as described in [RFC7340]. Ideally, a cryptographic approach to identity can provide a much stronger and assurance of identity than the Caller ID services that the telephone network provides today, and one less vulnerable to spoofing.

[RFC3261] encourages user agents (UAs) to implement a number of potential authentication mechanisms, including Digest authentication, Transport Layer Security (TLS), and S/MIME (implementations may support other security schemes as well). However, few SIP user agents today support the end-user certificates necessary to authenticate themselves (via S/MIME, for example), and for its part Digest authentication is limited by the fact that the originator and destination must share a prearranged secret. Practically speaking, originating user agents need to be able to securely communicate their

users' identity to destinations with which they have no previous association.

As an initial attempt to address this gap, [RFC4474] specified a means of signing portions of SIP requests in order to provide an identity assurance. However, RFC4474 was in several ways misaligned with deployment realities (see [I-D.rosenberg-sip-rfc4474-concerns]). Most significantly, RFC4474 did not deal well with telephone numbers as identifiers, despite their enduring use in SIP deployments. RFC4474 also provided a signature over material that intermediaries in existing deployments commonly altered. This specification therefore deprecates the RFC4474 syntax and behavior, reconsidering the problem space in light of the threat model in [RFC7375] and aligning the signature format with PASSporT [I-D.ietf-stir-passport]. Backwards compatibility considerations are given in Section 10.

2. Terminology

In this document, the key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" are to be interpreted as described in RFC 2119 [RFC2119].

In addition, this document uses three terms specific to the mechanism:

Identity: An identifier for the user of a communications service; for the purposes of SIP, either a SIP URI or a telephone number. Identities are derived from an "identity field" in a SIP request such as the From header field.

Authentication Service: A logical role played by a SIP entity that adds Identity headers to SIP requests.

Verification Service (or "Verifier"): A logical role played by a SIP entity that validates Identity headers in a SIP request.

3. Architectural Overview

The identity architecture for SIP defined in this specification depends on a logical "authentication service" which validates outgoing requests. An authentication service may be implemented either as part of a user agent or as a proxy server; typically, it is a component of a network intermediary like a proxy to which originating user agents send unsigned requests. Once the originator of the message has been authenticated, through pre-arranged means with the authentication service, the authentication service then creates and adds an Identity header field to the request. This

requires computing cryptographic information, including a digital signature over some components of messages, that lets other SIP entities verify that the sending user has been authenticated and its claim of a particular identity has been authorized. These "verification services" validate the signature and enable policy decisions to be made based on the results of the validation.

Policy decisions made after validation depend heavily on the verification service's trust for the credentials that the authentication service uses to sign requests. As robocalling, voicemail hacking, and swatting usually involve impersonation of telephone numbers, credentials that will be trusted by relying parties to sign for telephone numbers are a key component of the architecture. Authority over telephone numbers is, however, not as easy to establish on the Internet as authority over traditional domain names. This document assumes the existence of credentials for establishing authority over telephone numbers, for cases where the telephone number is the identity of the user, but this document does not mandate or specify a credential system; [I-D.ietf-stir-certificates] describes a credential system compatible with this architecture.

Although addressing the vulnerabilities in the STIR problem statement and threat model mostly requires dealing with telephone number as identities, SIP must also handle signing for SIP URIs as identities. This is typically easier to deal with, as these identities are issued by organizations that have authority over Internet domains. When a new user becomes associated with example.com, for example, the administrator of the SIP service for that domain can issue them an identity in that namespace, such as sip:alice@example.com. Alice may then send REGISTER requests to example.com that make her user agents eligible to receive requests for sip:alice@example.com. In other cases, Alice may herself be the owner of her own domain, and may issue herself identities as she chooses. But ultimately, it is the controller of the SIP service at example.com that must be responsible for authorizing the use of names in the example.com domain. Therefore, for the purposes of SIP as defined in [RFC3261], the necessary credentials needed to prove a user is authorized to use a particular From header field must ultimately derive from the domain owner: either a user agent gives requests to the domain name owner in order for them to be signed by the domain owner's credentials, or the user agent must possess credentials that prove that the domain owner has given the user agent the right to a name.

In order to share a cryptographic assurance of end-user SIP identity in an interdomain or intradomain context, an authentication service constructs tokens based on the PASSporT [I-D.ietf-stir-passport] format, which is special encoding of a JSON [RFC7159] object

comprising values derived from certain header field values in the SIP request. The authentication service computes a signature over those JSON elements as PASSporT specifies. An encoding of the resulting PASSporT is then placed in the SIP Identity header field. In order to assist in the validation of the Identity header field, this specification also describes a parameter of the Identity header field that can be used by the recipient of a request to recover the credentials of the signer.

Note that the scope of this document is limited to providing an identity assurance for SIP requests; solving this problem for SIP responses is outside the scope of this work (see [RFC4916]). Future work might specify ways that a SIP implementation could gateway PASSporTs to other protocols.

4. Identity Header Field Syntax

The Identity and Identity-Info header fields that were previously defined in RFC4474 are here deprecated. This revised specification collapses the grammar of Identity-Info into the Identity header field via the "info" parameter. Note that unlike the prior specification in RFC4474, the Identity header field is now allowed to appear more than one time in a SIP request. The revised grammar for the Identity header field builds on the ABNF [RFC5234] in RFC 3261 [RFC3261] Section 25. It is as follows:

```
Identity = "Identity" HCOLON signed-identity-digest SEMI
    ident-info *( SEMI ident-info-params )
signed-identity-digest = 1*(base64-char / ".")
ident-info = "info" EQUAL ident-info-uri
ident-info-uri = LAQUOT absoluteURI RAQUOT
ident-info-params = ident-info-alg / ident-type /
    ident-info-extension
ident-info-alg = "alg" EQUAL token
ident-type = "ppt" EQUAL token
ident-info-extension = generic-param

base64-char = ALPHA / DIGIT / "/" / "+"
```

In addition to the "info" parameter, and the "alg" parameter previously defined in RFC4474, this specification defines the optional "ppt" parameter (PASSporT Type). The 'absoluteURI' portion of ident-info-uri MUST contain a URI; see Section 7.3 for more on choosing how to advertise credentials through this parameter.

The signed-identity-digest contains a base64 encoding of a PASSporT [I-D.ietf-stir-passport], which secures the request with a signature

that PASSporT generates over the JSON header and payload objects; some of those header and claim element values will mirror values of the SIP request.

4.1. PASSporT Construction

For SIP implementations to populate the PASSporT header JSON object with fields from a SIP request, the following elements MUST be placed as the values corresponding to the designated JSON keys:

First, per baseline [I-D.ietf-stir-passport], the JSON "typ" key MUST have the value "passport".

Second, the JSON key "alg" MUST mirror the value of the optional "alg" parameter in the SIP Identity header field. Note if the "alg" parameter is absent from the Identity header, the default value is "ES256".

Third, the JSON key "x5u" MUST have a value equivalent to the quoted URI in the "info" parameter, per the simple string comparison rules of [RFC3986] section 6.2.1.

Fourth, if a PASSporT extension is in use, then the optional JSON key "ppt" MUST be present and have a value equivalent to the quoted value of the "ppt" parameter of the Identity header field.

An example of the PASSporT header JSON object without any extension is:

```
{ "typ":"passport",
  "alg":"ES256",
  "x5u":"https://www.example.com/cert.cer" }
```

To populate the PASSporT payload JSON object from a SIP request, the following elements MUST be placed as values corresponding to the designated JSON keys:

First, the JSON "orig" object MUST be populated. If the originating identity is a telephone number, then the array MUST be populated with a JSON object containing a "tn" element with a value set to the value of the quoted originating identity, a canonicalized telephone number (see Section 8.3). Otherwise, the object MUST be populated with a JSON object containing "uri" element, set to the value of the AoR of the UA sending the message as taken from the addr-spec of the From header field, per the procedures in Section 8.5.

Second, the JSON "dest" array MUST be populated. If the destination identity is a telephone number, then the array MUST be populated with a JSON object containing a "tn" element with a value set to the value of the quoted destination identity, a canonicalized telephone number (see Section 8.3). Otherwise, the array MUST be populated with a JSON object containing a "uri" element, set to the value of the addr-spec component of the To header field, which is the AoR to which the request is being sent, per the procedures in Section 8.5. Multiple JSON objects are permitted in "dest" for future compatibility reasons.

Third, the JSON key "iat" MUST appear. The authentication service SHOULD set the value of "iat" to an encoding of the value of the SIP Date header field as a JSON NumericDate (as UNIX time, per [RFC7519] Section 2), though an authentication service MAY set the value of "iat" to its own current clock time. If the authentication service uses its own clock time then the use of the full form of PASSporT is REQUIRED. In either case, the authentication service MUST NOT generate a PASSporT for a SIP request if the Date header is outside of its local policy for freshness (recommended sixty seconds).

Fourth, if the request contains an SDP message body, and if that SDP contains one or more "a=fingerprint" attributes, then the JSON key "mky" MUST appear with the algorithm(s) and value(s) of the fingerprint attributes (if they differ), following the format given in [I-D.ietf-stir-passport] Section 5.2.2.

For example:

```
{ "orig":{"tn":"12155551212"},
  "dest":{"tn":"12155551213"},
  "iat":1443208345 }
```

For information on the security properties of these SIP message elements, and why their inclusion mitigates replay attacks, see Section 12. Note that future extensions to PASSporT could introduce new claims, and that further SIP procedures could be required to extract information from the SIP request to populate the values of those claims; see Section 9 of this document.

The "orig" and "dest" arrays may contain identifiers of heterogeneous type; for example, the "orig" array might contain a "tn" claim, while the "dest" contains a "uri" claim. Also note that in some cases, the "dest" array may be populated with more than one value. This could for example occur when multiple "dest" identities are specified in a meshed conference. Defining how a SIP implementation would align

multiple destination identities in PASSporT with such systems is left as a subject for future specification.

After these two JSON objects, the header and the payload, have been constructed and base64-encoded, they must each be hashed and signed per [I-D.ietf-stir-passport] Section 6. The header, payload and signature components comprise a full PASSporT object. The resulting PASSporT may be carried in SIP in either a full form, which includes the header and payload as well as the signature, or a compact form which only carries the signature per [I-D.ietf-stir-passport] Section 7. The hashing and signing algorithm is specified by the 'alg' parameter of the Identity header field and the mirrored "alg" parameter of PASSporT. All implementations of this specification MUST support the required signing algorithms of PASSporT. At present there is one mandatory-to-support value for the 'alg' parameter: 'ES256', as defined in [RFC7519], which connotes an ECDSA P-256 digital signature.

4.1.1. Example Full and Compact Forms of PASSporT in Identity

As Appendix F of the JWS specification [RFC7515] notes, there are cases where "it is useful to integrity-protect content that is not itself contained in a JWS." Since the fields that make up the majority of the PASSporT header and payload have values replicated in the SIP request, the SIP usage of PASSporT may exclude the base64 encoded version of the header and payload JSON objects from the Identity header field and instead present a detached signature: what PASSporT calls its compact form, see [I-D.ietf-stir-passport] Section 7.

When an authentication service constructs an Identity header, the contents of the signed-identity-digest field MUST contain either a full or compact PASSporT. Use of the compact form is RECOMMENDED in order to reduce message size, but note that extensions often require the full form (see Section 9).

For example, a full form of PASSporT in an Identity header might look as follows (backslashes shown for line folding only):

```
Identity: eyJhbGciOiJFUzI1NiIsInR5cCI6InBhc3Nwb3J0IiwieDV1I \
joiaHR0cHM6Ly9jZXJ0LmV4YW1wbGUub3JnL3Bhc3Nwb3J0LmNlciJ9.eyJ \
kZXN0Ijp7InVyaSI6WyJzaXA6YWxpY2VAZXhhbXBsZS5jb20iXX0sImlhdC \
I6IjE0NDMyMDgzNDUiLCJvcmlnIjp7InRuIjoiMTIxNTU1NTEyMTIifX0.r \
q3pjT1hoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjpjlk-cpFYpFYs \
ojNCpTzO3QfPOlckGaS6hEck7w;info=<https://biloxi.example.org \
/biloxi.cert>
```

The compact form of the same PASSporT object would appear in the Identity header as:

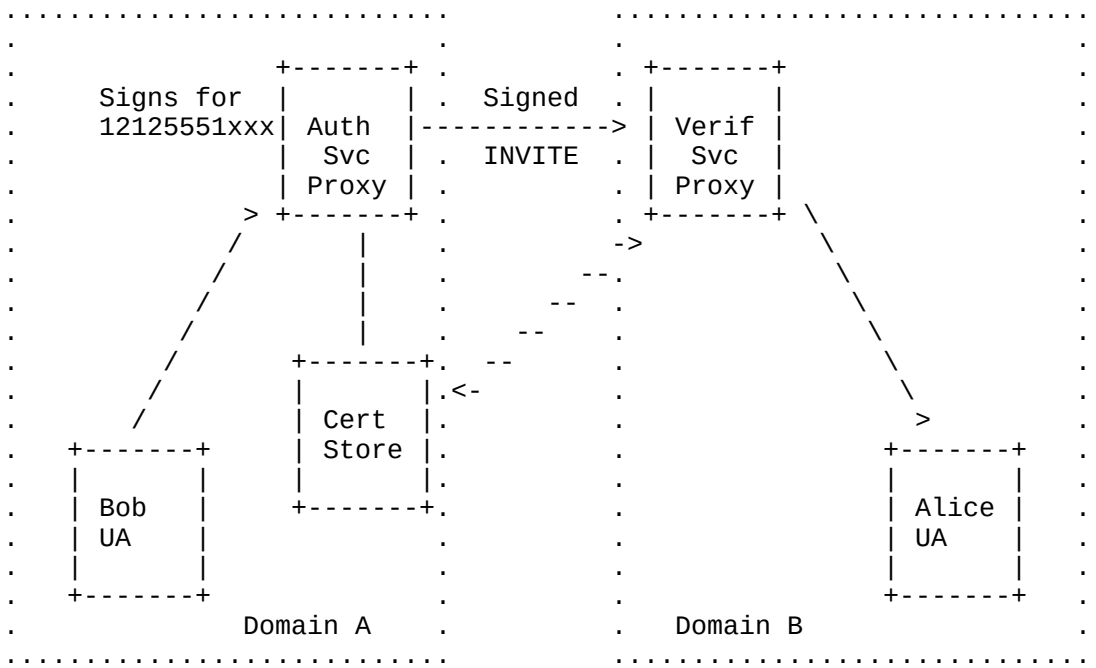
```
Identity: ..rq3pjT1hoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qj \
pjlk-cpFYpFYsojNCpTzO3QfPOlckGaS6hEck7w;                   \
info=<https://biloxi.example.org/biloxi.cert>
```

5. Example of Operations

This section provides an informative (non-normative) high-level example of the operation of the mechanisms described in this document.

Imagine a case where Bob, who has the home proxy of example.com and the address-of-record sip:12155551212@example.com;user=phone, wants to communicate with Alice at sip:alice@example.org. They have no prior relationship, and Alice implements best practices to prevent impersonation attacks.

Bob’s user agent generates an INVITE and places his address-of-record in the From header field of the request. He then sends an INVITE to an authentication service proxy for his domain.



The proxy authenticates Bob, and validates that he is authorized to assert the identity that he populated in the From header field. The proxy authentication service then constructs a PASSporT which contains a JSON representation of values which mirror certain parts of the SIP request, including the identity in the From header field value. As a part of generating the PASSporT, the authentication service signs a hash of that JSON header and payload with the private key associated with the appropriate credential for the identity (in this example, a certificate with authority to sign for numbers in a range from 12155551000 to 121555519999), and the signature is inserted by the proxy server into the Identity header field value of the request as a compact form of PASSporT. Alternatively, the JSON header and payload themselves might also have been included in the object when using the full form of PASSporT.

The proxy authentication service, as the holder of a private key with authority over Bob's telephone number, is asserting that the originator of this request has been authenticated and that he is authorized to claim the identity that appears in the From header field. The proxy inserts an "info" parameter into the Identity header field that tells Alice how to acquire keying material necessary to validate its credentials (a public key), in case she doesn't already have it.

When Alice's domain receives the request, a proxy verification service validates the signature provided in the Identity header field, and then determines that the authentication service credentials demonstrate authority over the identity in the From header field. This same validation operation might be performed by a verification service in Alice's user agent server. Ultimately, this valid request is rendered to Alice. If the validation were unsuccessful, some other treatment could be applied by the receiving domain or Alice's user agent.

5.1. Example Identity Header Construction

For the following SIP request:

```
INVITE sip:bob@biloxi.example.org SIP/2.0
Via: SIP/2.0/TLS pc33.atlanta.example.com;branch=z9hG4bKnashds8
To: Alice <sip:alice@example.com>
From: Bob <sip:12155551212@example.com;user=phone>;tag=1928301774>
Call-ID: a84b4c76e66710
CSeq: 314159 INVITE
Max-Forwards: 70
Date: Fri, 25 Sep 2015 19:12:25 GMT
Contact: <sip:12155551212gateway.example.com>
Content-Type: application/sdp
Content-Length: 147

v=0
o=UserA 2890844526 2890844526 IN IP4 pc33.atlanta.example.com
s=Session SDP
c=IN IP4 pc33.atlanta.example.com
t=0 0
m=audio 49172 RTP/AVP 0
a=rtpmap:0 PCMU/8000
```

An authentication service will create a corresponding PASSporT object. The properly-serialized PASSporT header and payload JSON objects would look as follows. For the header, the values chosen by the authentication service at "example.org" might read:

```
{"alg":"ES256","typ":"passport","x5u":"https://cert.example.org/
   passport.cer"}
```

The serialized payload will derive values from the SIP request (the From, To, and Date header field values) as follows:

```
{"dest":{"uri":["sip:alice@example.com"]},"iat":1443208345,
  "orig":{"tn":"12155551212"}}
```

The authentication service would then generate the signature over the object following the procedures in [I-D.ietf-stir-passport] Section 6. That signature would look as follows:

```
rq3pjT1hoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjpjlk-cpFYpFYs \
 ojNCpTzO3QfPOlckGaS6hEck7w
```

An authentication service signing this request and using the compact form of PASSporT would thus generate and add to the request an Identity header field of the following form:

```
Identity: ..rq3pjT1hoRwakEGjHCnWSwUnshd0-zJ6F1VOgFWSjHBr8Qjpj \
 lk-cpFYpFYsojNCpTzO3QfPOlckGaS6hEck7w; \
 info=<https://cert.example.org/passport.cer>
```

6. Signature Generation and Validation

SIP entities that instantiate the authentication service and verification service roles will, respectively, generate and validate the Identity header and the signature it contains.

6.1. Authentication Service Behavior

Any entity that instantiates the authentication service role MUST possess the private key of one or more credentials that can be used to sign for a domain or a telephone number (see Section 7.1). The authentication service role can be instantiated, for example, by an intermediary such as a proxy server or by a user agent. Intermediaries that instantiate this role MUST be capable of authenticating one or more SIP users who can register for that identity. Commonly, this role will be instantiated by a proxy server, since proxy servers are more likely to have a static hostname, hold corresponding credentials, and have access to SIP registrar capabilities that allow them to authenticate users. It is also possible that the authentication service role might be instantiated by an entity that acts as a redirect server, but that is left as a topic for future work.

An authentication service adds the Identity header field to SIP requests. The procedures below define the steps that must be taken when each Identity header field is added. More than one Identity header field may appear in a single request, and an authentication service may add an Identity header field to a request that already contains one or more Identity header fields.

Entities instantiating the authentication service role perform the following steps, in order, to generate an Identity header field for a SIP request:

Step 1: Check Authority for the Identity

First, the authentication service must determine whether it is authoritative for the identity of the originator of the request. The authentication service extracts the identity from the URI value from the "identity field"; in ordinary operations, that is the addr-spec component of From header field. In order to determine whether the signature for the identity field should be over the entire identity field URI or just a telephone number, the authentication service MUST follow the process described in Section 8.1. That section will either lead to the telephone number canonicalization procedures in Section 8.3 for telephone numbers, or to the URI normalization procedures described in Section 8.5 for domain names. Whichever the result, if the authentication service is not authoritative for the

identity in question, it SHOULD process and forward the request normally unless the local policy is to block such requests. The authentication service MUST NOT add an Identity header field if the authentication service does not have the authority to make the claim it asserts.

Step 2: Authenticate the Originator

The authentication service MUST then determine whether or not the originator of the request is authorized to claim the identity given in the identity field. In order to do so, the authentication service MUST authenticate the originator of the message. Some possible ways in which this authentication might be performed include:

If the authentication service is instantiated by a SIP intermediary (proxy server), it may authenticate the request with the authentication scheme used for registration in its domain (e.g., Digest authentication).

If the authentication service is instantiated by a SIP user agent, a user agent may authenticate its own user through any system-specific means, perhaps simply by virtue of having physical access to the user agent.

Authorization of the use of a particular username or telephone number in the user part of the From header field is a matter of local policy for the authentication service; see Section 7.1 for more information.

Note that this check is performed only on the addr-spec in the identity field (e.g., the URI of the originator, like 'sip:alice@atlanta.example.com'); it does not cover the display-name portion of the From header field (e.g., 'Alice Atlanta'). For more information, see Section 12.6.

Step 3: Verify Date is Present and Valid

An authentication service MUST add a Date header field to SIP requests that do not have one. The authentication service MUST ensure that any preexisting Date header field in the request is accurate. Local policy can dictate precisely how accurate the Date must be; a RECOMMENDED maximum discrepancy of sixty seconds will ensure that the request is unlikely to upset any verifiers. If the Date header field value contains a time different by more than one minute from the current time noted by the authentication service, the authentication service SHOULD reject the request. This behavior is not mandatory because a user agent client (UAC) could only exploit the Date header field in order to cause a request to fail verification; the Identity header field is not intended to provide a

perfect record of when messages are processed. Finally, the authentication service MUST verify that both the Date header field and the current time fall within the validity period of its credential.

See Section 12.1 for information on how the Date header field assists verifiers.

Step 4: Populate and Add the Identity Header

Subsequently, the authentication service MUST form a PASSporT object and add a corresponding Identity header field to the request containing either the full or compact form of PASSporT. For the baseline PASSporT header (headers containing no "ppt" parameter), this follows the procedures in Section 4; if the authentication service is using an alternative "ppt" format, it MUST add an appropriate "ppt" parameter and follow the procedures associated with that extension (see Section 9). After the Identity header field has been added to the request, the authentication service MUST also add a "info" parameter to the Identity header field. The "info" parameter contains a URI from which the authentication service's credential can be acquired; see Section 7.3 for more on credential acquisition.

An authentication service MAY use the full form of the PASSporT in the Identity header field. The presence of the full form is OPTIONAL because the information carried in the baseline PASSporT headers and claims is usually redundant with information already carried elsewhere in the SIP request. Using the compact form can significantly reduce SIP message size, especially when the PASSporT payload contains media keys. The syntax of the compact form is given in [I-D.ietf-stir-passport] Section 7; essentially, it contains only the signature component of the PASSporT.

Note that per the behavior specified in [I-D.ietf-stir-passport], use of the full form is mandatory when optional extensions are included. See Section 9.

6.1.1. Handling Repairable Errors

Also, in some cases, a request signed by an authentication service will be rejected by the verification service on the receiving side, and the authentication service will receive a SIP 4xx status code in the backwards direction, such as a 438 indicating a verification failure. If the authentication service did not originally send the full form of the PASSporT object in the Identity header field, it SHOULD retry the request with the full form after receiving a 438 response; however implementations SHOULD NOT retry the request more than once. Authentication services implemented at proxy servers

would retry such a request as a ssequential for, by re-processing the destination as a new target and handling it serially as described in Section 16.6 of [RFC3261].

The information in the full form is useful on the verification side for debugging errors, and there are some known causes of verification failures (such as the Date header field value changing in transit, see Section 12.1 for more information) that can be resolved by the inclusion of the full form of PASSporT.

Finally, the authentication service forwards the message normally.

6.2. Verifier Behavior

This document specifies a logical role for SIP entities called a verification service, or verifier. When a verifier receives a SIP message containing one or more Identity header fields, it inspects the signature(s) to verify the identity of the originator of the message. The results of a verification are provided as input to an authorization process that is outside the scope of this document.

A SIP request may contain zero, one, or more Identity header fields. A verification service performs the steps below on each Identity header field that appears in a request. If a verification service cannot use any Identity header in a request, due to the absence of Identity headers or unsupported "ppt" parameters, and the presence of an Identity header field is required by local policy (for example, based on a per-sending-domain policy, or a per-sending-user policy), then a 428 'Use Identity Header' response MUST be sent in the backwards direction. For more on this and other verifier responses, see Section 6.2.2.

In order to verify an Identity header field in a message, an entity acting as a verifier MUST perform the following steps, in the order here specified. Note that when an Identity header field contains a full form PASSporT object, the verifier MUST follow the additional procedures in Section 6.2.4.

Step 1: Check for an Unsupported "ppt"

The verifier MUST inspect any optional "ppt" parameter appearing in the Identity header. If no "ppt" parameter is present, then the verifier proceeds normally below. If a "ppt" parameter value is present, and the verifier does not support it, it MUST ignore the Identity header field. If a supported "ppt" parameter value is present, the verifier proceeds with Step 2, and will ultimately follow the "ppt" variations described in Step 5.

Step 2: Determine the Originator's Identity

In order to determine whether the signature for the identity field should be over the entire identity field URI or just a telephone number, the verification service MUST follow the process described in Section 8.1. That section will either lead to the telephone number canonicalization procedures in Section 8.3 for telephone numbers, or to the URI normalization procedures described in Section 8.5 for domain names.

Step 3: Identify Credential for Validation

The verifier must ensure that it has access to the proper keying material to validate the signature in the Identity header field, which usually involves dereferencing a URI in the "info" parameter of the Identity header field. See Section 7.2 for more information on these procedures. If the verifier does not support the credential described in the "info" parameter, then it treats the credential for this header field as unsupported.

Step 4: Check the Freshness of Date

The verifier furthermore ensures that the value of the Date header field of the request meets local policy for freshness (sixty seconds is RECOMMENDED) and that it falls within the validity period of the credential used to sign the Identity header field. For more on the attacks this prevents, see Section 12.1. If the full form of the PASSporT is present, the verifier SHOULD compare the "iat" value in the PASSporT to the Date header field value in the request. If the two are different, and the "iat" value differs from the Date header field value but remains within verification service policy for freshness, the verification service SHOULD perform the computation required by Step 5 using the "iat" value instead of the Date header field value.

Step 5: Validate the Signature

The verifier MUST validate the signature in the Identity header field over the PASSporT object. For baseline PASSporT objects (with no Identity header field "ppt" parameter) the verifier MUST follow the procedures for generating the signature over a PASSporT object described in Section 4. If a "ppt" parameter is present (and per Step 1, is supported), the verifier follows the procedures for that "ppt" (see Section 9). If a verifier determines that the signature in the Identity does not correspond to the reconstructed signed-identity-digest, then the Identity header field should be considered invalid.

6.2.1. Authorization of Requests

The verification of an Identity header field does not entail any particular treatment of the request. The handling of the message after the verification process depends on how the verification service is implemented and on local policy. This specification does not propose any authorization policy for user agents or proxy servers to follow based on the presence of a valid Identity header field, the presence of an invalid Identity header field, or the absence of an Identity header field, or a stale Date header field value, but it is anticipated that local policies could involve making different forwarding decisions in intermediary implementations, or changing how the user is alerted, or how identity is rendered, in user agent implementations.

The presence of multiple Identity header fields within a message raises the prospect that a verification services could receive a message containing some valid and some invalid Identity header fields. As a guideline, this specification recommends that only if a verifier determines all Identity header fields within a message are invalid should the request be considered to have an invalid identity. If at least one Identity header field value is valid and from a trusted source, then relying parties can use that header for authorization decisions regardless of whether other untrusted or invalid Identity headers appear in a request.

6.2.2. Failure Response Codes Sent by a Verification Service

RFC4474 originally defined four response codes for failure conditions specific to the Identity header field and its original mechanism. These status codes are retained in this specification, with some slight modifications. Also, this specification details responding with 403 when a stale Date header field value is received.

A 428 response will be sent (per Section 6.2) when an Identity header field is required, but no Identity header field without a "ppt" parameter, or with a supported "ppt" value, has been received. In the case where one or more Identity header fields with unsupported "ppt" values have been received, then a verification service may send a 428 with a human-readable reason phrase like "Use Supported PASSporT Format". Note however that this specification gives no guidance on how a verification service might decide to require an Identity header field for a particular SIP request. Such authorization policies are outside the scope of this specification.

The 436 ’Bad Identity Info’ response code indicates an inability to acquire the credentials needed by the verification service for validating the signature in an Identity header field. Again, given

the potential presence of multiple Identity header fields, this response code should only be sent when the verification service is unable to deference the URIs and/or acquire the credentials associated with all Identity header fields in the request. This failure code could be repairable if the authentication service resends the request with an 'info' parameter pointing to a credential that the verification service can access.

The 437 'Unsupported Credential' is sent when a verification service can acquire, or already holds, the credential represented by the 'info' parameter of at least one Identity header field in the request, but does not support said credential(s), for reasons such as failing to trust the issuing CA, or failing to support the algorithm with which the credential was signed.

The 438 'Invalid Identity Header' response indicates that of the set of Identity header fields in a request, no header field with a valid and supported PASSporT object has been received. Like the 428 response, this is sent by a verification service when its local policy dictates that a broken signature in an Identity header field is grounds for rejecting a request. Note that in some cases, an Identity header field may be broken for other reasons than that an originator is attempting to spoof an identity: for example, when a transit network alters the Date header field of the request. Sending a full form PASSporT can repair some of these conditions (see Section 6.2.4), so the recommended way to attempt to repair this failure is to retry the request with the full form of PASSporT if it had originally been sent with the compact form. The alternative reason phrase 'Invalid PASSporT' can be used when an extended full form PASSporT lacks required headers or claims, or when an extended full form PASSporT signaled with the "ppt" parameter lacks required claims for that extension. Sending a string along these lines will help humans debugging the sending system.

Finally, a 403 response may be sent when the verification service receives a request with a Date header field value that is older than the local policy for freshness permits. The same response may be used when the "iat" in the full form of a PASSporT has a value older than the local policy for freshness permits. The reason phrase "Stale Date" can be sent to help humans debug the failure.

Future specifications may explore ways, including Reason codes or Warning headers, to communicate further information that could be used to disambiguate the source of errors in cases with multiple Identity headers in a single request, or provide similar detailed feedback for debugging purposes.

6.2.3. Handling Retried Requests

If a verification service sends a failure response in the backwards direction, the authentication service may retry the request as described in Section 6.1.1. If the authentication service is instantiated at a proxy server, then it will retry the request as a sequential fork. Verification services implemented at a proxy server will recognize this request as a spiral rather than a loop due to the proxy behavior fix documented in [RFC5393] Section 4.2. However, if the verification service is implemented in an endpoint, the endpoint will need to override the default UAS behavior (in particular, the SHOULD in [RFC3261] Section 8.2.2.2) to accept this request as a spiral rather than a loop.

6.2.4. Handling the full form of PASSporT

If the full form of PASSporT is present in an Identity header, this permits the use of optional extensions as described in [I-D.ietf-stir-passport] Section 8.3. Furthermore, the verification service can extract from the "orig" and "dest" elements of the PASSporT full form the canonical telephone numbers created by the authentication service, as well as an "iat" claim corresponding to the Date header field that the authentication service used. These values may be used to debug canonicalization problems, or to avoid unnecessary signature breakage caused by intermediaries that alter certain SIP header field values in transit.

However, the verification service MUST NOT treat the value in the "orig" of a full form PASSporT as the originating identity of the call: the originating identity of the call is always derived from the SIP signaling, and it is that value, per the procedures above in Section 6.2 Step 2, which is used to recompute the signature at the verification service. That value, rather than the value inside the PASSporT object, is rendered to an end user in ordinary SIP operations, and if a verification service were to simply trust that the value in the "orig" corresponded to the call that it received without comparing it to the call signaling, this would enable various cut-and-paste attacks. As an optimization, when the full form is present, the verification service MAY delay performing that cryptographic operation and first compute its own canonicalization of an originating telephone number to compare it to the values in the "orig" element of PASSporT. This would allow the verification service to ascertain whether or not the two ends agree on the canonical number form; if they do not, then surely the signature validation would fail.

7. Credentials

This section gives general guidance on the use of credential systems by authentication and verification services, as well as requirements that must be met by credential systems that conform with this architecture. It does not mandate any specific credential system.

Furthermore, this specification allows either a user agent or a proxy server to provide the authentication service function and/or the verification service function. For the purposes of end-to-end security, it is obviously preferable for end systems to acquire their own credentials; in this case user agents can act as authentication services. However, for some deployments, end-user credentials may be neither practical nor affordable, given the potentially large number of SIP user agents (phones, PCs, laptops, PDAs, gaming devices) that may be employed by a single user. Synchronizing keying material across multiple devices may be prohibitively complex and require quite a good deal of additional endpoint behavior. Managing several credentials for the various devices could also be burdensome. Thus, for reasons of credential management alone, implementing the authentication service at an intermediary may be more practical. This trade-off needs to be understood by implementers of this specification.

7.1. Credential Use by the Authentication Service

In order to act as an authentication service, a SIP entity must possess the private keying material of one or more credentials that cover domain names or telephone numbers. These credentials may represent authority over one domain (such as example.com) or a set of domains enumerated by the credential. Similarly, a credential may represent authority over a single telephone number or a range of telephone numbers. The way that the scope of a credential's authority is expressed is specific to the credential mechanism.

Authorization of the use of a particular username or telephone number in the From header field value is a matter of local policy for the authentication service, one that depends greatly on the manner in which authentication is performed. For non-telephone number user parts, one policy might be as follows: the username given in the 'username' parameter of the Proxy-Authorization header field must correspond exactly to the username in the From header field of the SIP message. However, there are many cases in which this is too limiting or inappropriate; a realm might use 'username' parameters in Proxy-Authorization header field that do not correspond to the user-portion of From header fields, or a user might manage multiple accounts in the same administrative domain. In this latter case, a domain might maintain a mapping between the values in the 'username'

parameter of the Proxy-Authorization header field and a set of one or more SIP URIs that might legitimately be asserted for that 'username'. For example, the username can correspond to the 'private identity' as defined in Third Generation Partnership Project (3GPP), in which case the From header field can contain any one of the public identities associated with this private identity. In this instance, another policy might be as follows: the URI in the From header field must correspond exactly to one of the mapped URIs associated with the 'username' given in the Proxy-Authorization header field. This is a suitable approach for telephone numbers in particular.

This specification could also be used with credentials that cover a single name or URI, such as alice@example.com or sip:alice@example.com. This would require a modification to authentication service behavior to operate on a whole URI rather than a domain name. Because this is not believed to be a pressing use case, this is deferred to future work, but implementers should note this as a possible future direction.

Exceptions to such authentication service policies arise for cases like anonymity; if the AoR asserted in the From header field uses a form like 'sip:anonymous@example.com' (see [RFC3323]), then the 'example.com' proxy might authenticate only that the user is a valid user in the domain and insert the signature over the From header field as usual.

7.2. Credential Use by the Verification Service

In order to act as a verification service, a SIP entity must have a way to acquire credentials for authorities over particular domain names, telephone numbers and/or number ranges. Dereferencing the URI found in the "info" parameter of the Identity header field (as described Section 7.3) MUST be supported by all verification service implementations to create a baseline means of credential acquisition. Provided that the credential used to sign a message is not previously known to the verifier, SIP entities SHOULD discover this credential by dereferencing the "info" parameter, unless they have some implementation-specific way of acquiring the needed keying material, such as an offline store of periodically-updated credentials. The 436 'Bad Identity Info' response exists for cases where the verification service cannot deference the URI in the "info" parameter.

This specification does not propose any particular policy for a verification service to determine whether or not the holder of a credential is the appropriate party to sign for a given SIP identity. Guidance on this is deferred to credential mechanism specifications.

Verification service implementations supporting this specification may wish to have some means of retaining credentials (in accordance with normal practices for credential lifetimes and revocation) in order to prevent themselves from needlessly downloading the same credential every time a request from the same identity is received. Credentials cached in this manner may be indexed in accordance with local policy: for example, by their scope of authority, or the URI given in the "info" parameter value. Further consideration of how to cache credentials is deferred to the credential mechanism specifications.

7.3. 'info' parameter URIs

An "info" parameter MUST contain a URI which dereferences to a resource that contains the public key components of the credential used by the authentication service to sign a request. It is essential that a URI in the "info" parameter be dereferencable by any entity that could plausibly receive the request. For common cases, this means that the URI SHOULD be dereferencable by any entity on the public Internet. In constrained deployment environments, a service private to the environment MAY be used instead.

Beyond providing a means of accessing credentials for an identity, the "info" parameter further serves as a means of differentiating which particular credential was used to sign a request, when there are potentially multiple authorities eligible to sign. For example, imagine a case where a domain implements the authentication service role for a range of telephone numbers and a user agent belonging to Alice has acquired a credential for a single telephone number within that range. Either would be eligible to sign a SIP request for the number in question. Verification services however need a means to differentiate which one performed the signature. The "info" parameter performs that function.

7.4. Credential System Requirements

This document makes no recommendation for the use of any specific credential system. Today, there are two primary credential systems in place for proving ownership of domain names: certificates (e.g., X.509 v3, see [RFC5280]) and the domain name system itself (e.g., DANE, see [RFC6698]). It is envisioned that either could be used in the SIP identity context: an "info" parameter could for example give an HTTP URL of the Content-Type 'application/pkix-cert' pointing to a certificate (following the conventions of [RFC2585]). The "info" parameter might use the DNS URL scheme (see [RFC4501]) to designate keys in the DNS.

While no comparable public credentials exist for telephone numbers, either approach could be applied to telephone numbers. A credential system based on certificates is given in [I-D.ietf-stir-certificates], but this specification can work with other credential systems; for example, using the DNS was proposed in [I-D.kaplan-stir-cider].

In order for a credential system to work with this mechanism, its specification must detail:

which URIs schemes the credential will use in the "info" parameter, and any special procedures required to dereference the URIs

how the verifier can learn the scope of the credential

any special procedures required to extract keying material from the resources designated by the URI

any algorithms required to validate the credentials (e.g. for certificates, any algorithms used by certificate authorities to sign certificates themselves), and

how the associated credentials will support the mandatory signing algorithm(s) required by PASSporT [I-D.ietf-stir-passport].

SIP entities cannot reliably predict where SIP requests will terminate. When choosing a credential scheme for deployments of this specification, it is therefore essential that the trust anchor(s) for credentials be widely trusted, or that deployments restrict the use of this mechanism to environments where the reliance on particular trust anchors is assured by business arrangements or similar constraints.

Note that credential systems must address key lifecycle management concerns: were a domain to change the credential available at the Identity header field "info" parameter URI before a verifier evaluates a request signed by an authentication service, this would cause obvious verifier failures. When a rollover occurs, authentication services SHOULD thus provide new "info" URIs for each new credential, and SHOULD continue to make older key acquisition URIs available for a duration longer than the plausible lifetime of a SIP transaction (a minute would most likely suffice).

8. Identity Types

The problem statement of STIR [RFC7340] focuses primarily on cases where the called and calling parties identified in the To and From header field values use telephone numbers, as this remains the dominant use case in the deployment of SIP. However, the Identity header mechanism also works with SIP URIs without telephone numbers (of the form "sip:user@host"), and potentially other identifiers when SIP interworks with other protocols.

Authentication services confirm the identity of the originator of a call, which is typically found in the From header field value. The guidance in this specification also applies to extracting the URI containing the originator's identity from the P-Asserted-Identity header field value instead of the From header field value. In some trusted environments, the P-Asserted-Identity header field is used in lieu of the From header field to convey the address-of-record or telephone number of the originator of a request; where it does, local policy might therefore dictate that the canonical identity derives from the P-Asserted-Identity header field rather than the From header field.

Ultimately, in any case where local policy canonicalizes the identity into a form different from how it appears in the From header field, the use of the full form of PASSporT by authentication services is RECOMMENDED, but because the "orig" claim of PASSporT itself could then divulge information about users or networks, implementers should be mindful of the guidelines in Section 11.

8.1. Differentiating Telephone Numbers from URIs

In order to determine whether or not the user portion of a SIP URI is a telephone number, authentication services and verification services MUST perform the following procedure on any SIP URI they inspect which contains a numeric user part. Note that the same procedures are followed for creating the canonical form of a URI found in the From header field as they are for one found in the To header field or the P-Asserted-Identity header field.

First, implementations will ascertain if the user-portion of the URI constitutes a telephone number. Telephone numbers most commonly appear in SIP header field values in the username portion of a SIP URI (e.g., 'sip:+17005551008@chicago.example.com;user=phone'). The user part of SIP URIs with the "user=phone" parameter conforms to the syntax of the TEL URI scheme (RFC 3966 [RFC3966]). It is also possible for a TEL URI to appear in SIP header fields outside the context of a SIP or SIPS URI (e.g., 'tel:+17005551008'). Thus, in

standards-compliant environments, numbers will be explicitly labeled by the use of TEL URIs or the 'user=phone' parameter.

Alternatively, implementations in environments that do not conform to those standards MAY follow local policies for identifying telephone numbers. For example, implementations could infer that the user part is a telephone number due to the presence of the '+' indicator at the start of the user-portion. Absent even that indication, if there are numbers present in the user-portion, implementations might conceivably also detect that the user-portion of the URI contains a telephone number by determining whether or not those numbers would be dialable or routable in the local environment -- bearing in mind that the telephone number may be a valid [E.164] number, a nationally-specific number, or even a private branch exchange number. Implementations could also rely on external hints: for example, a verification service implementation could infer from the type of credential that signed a request that the signature must be over a telephone number.

Regardless of how the implementation detects telephone numbers, once a telephone number has been detected, implementations SHOULD follow the procedures in Section 8.3. If the URI field does not contain a telephone number, or if the result of the canonicalization of the From header field value does not form a valid E.164 telephone number, the authentication service and/or verification service SHOULD treat the entire URI as a SIP URI, and apply the procedures in Section 8.5. These URI normalization procedures are invoked to canonicalize the URI before it is included in a PASSporT object in, for example, a "uri" claim. See Section 8.5 for that behavior.

8.2. Authority for Telephone Numbers

In order for telephone numbers to be used with the mechanism described in this document, authentication services must receive credentials from an authority for telephone numbers or telephone number ranges, and verification services must trust the authority employed by the authentication service that signs a request. Per Section 7.4, enrollment procedures and credential management are outside the scope of this document; approaches to credential management for telephone numbers are discussed in [I-D.ietf-stir-certificates].

8.3. Telephone Number Canonicalization Procedures

Once an implementation has identified a telephone number, it must construct a number string. That requires performing the following steps:

Implementations MUST drop any "+"s, any internal dashes, parentheses or other non-numeric characters, excepting only the "#" or "*" keys used in some special service numbers (typically, these will appear only in the To header field value). This MUST result in an ASCII string limited to "#", "*" and digits without whitespace or visual separators.

Next, an implementation must assess if the number string is a valid, globally-routable number with a leading country code. If not, implementations SHOULD convert the number into E.164 format, adding a country code if necessary; this may involve transforming the number from a dial string (see [RFC3966]), removing any national or international dialing prefixes or performing similar procedures. It is only in the case that an implementation cannot determine how to convert the number to a globally-routable format that this step may be skipped. This will be the case, for example, for nationally-specific service numbers (e.g. 911, 112); however, calls to those numbers are routed in a very strict fashion which ordinarily prevents them from reaching entities that don't understand the numbers.

Some domains may need to take unique steps to convert their numbers into a global format, and such transformations during canonicalization can also be made in accordance with specific policies used within a local domain. For example, one domain may only use local number formatting and need to convert all To/From header field user portions to E.164 by prepending country-code and region code digits; another domain might have prefixed usernames with trunk-routing codes, in which case the canonicalization will need to remove the prefix. This specification cannot anticipate all of the potential transformations that might be useful.

The resulting canonical number string will be used as input to the hash calculation during signing and verifying processes.

The ABNF of this number string is:

```
tn-spec =  1*tn-char
tn-char = "#" / "*" / DIGIT
```

The resulting number string is used in the construction of the telephone number field(s) in a PASSporT object.

8.4. Authority for Domain Names

To use a SIP URI as an identity in this mechanism requires authentication and verification systems to support standard

mechanisms for proving authority over a domain name: that is, the domain name in the host portion of the SIP URI.

A verifier MUST evaluate the correspondence between the user's identity and the signing credential by following the procedures defined in [RFC5922], Section 7.2. While [RFC5922] deals with the use of TLS and is specific to certificates, the procedures described are applicable to verifying identity if one substitutes the "hostname of the server" for the domain portion of the user's identity in the From header field of a SIP request with an Identity header field.

This process is complicated by two deployment realities. In the first place, credentials have varying ways of describing their subjects, and may indeed have multiple subjects, especially in 'virtual hosting' cases where multiple domains are managed by a single application (see [RFC5922] Section 7.8). Secondly, some SIP services may delegate SIP functions to a subordinate domain and utilize the procedures in [RFC3263] that allow requests for, say, 'example.com' to be routed to 'sip.example.com'. As a result, a user with the AoR 'sip:alice@example.com' may process requests through a host like 'sip.example.com', and it may be that latter host that acts as an authentication service.

To address the second of these problems, a domain that deploys an authentication service on a subordinate host might supply that host with the private keying material associated with a credential whose subject is a domain name that corresponds to the domain portion of the AoRs that the domain distributes to users. Note that this corresponds to the comparable case of routing inbound SIP requests to a domain. When the NAPTR and SRV procedures of RFC 3263 are used to direct requests to a domain name other than the domain in the original Request-URI (e.g., for 'sip:alice@example.com', the corresponding SRV records point to the service 'sip1.example.org'), the client expects that the certificate passed back in any TLS exchange with that host will correspond exactly with the domain of the original Request-URI, not the domain name of the host. Consequently, in order to make inbound routing to such SIP services work, a domain administrator must similarly be willing to share the domain's private key with the service. This design decision was made to compensate for the insecurity of the DNS, and it makes certain potential approaches to DNS-based 'virtual hosting' unsecurable for SIP in environments where domain administrators are unwilling to share keys with hosting services.

8.5. URI Normalization

Just as telephone numbers may undergo a number of syntactic transformations during transit, the same can happen to SIP and SIPS URIs without telephone numbers as they traverse certain intermediaries. Therefore, when generating a PASSporT object based on a SIP request, any SIP and SIPS URIs must be transformed into a canonical form which captures the address-of-record represented by the URI before they are provisioned in PASSporT claims such as "uri". The URI normalization procedures required are as follows.

Following the ABNF of RFC3261, the SIP or SIPS URI in question MUST discard all elements after the "hostport" of the URI, including all uri-parameters and escaped headers, from its syntax. Of the userinfo component of the SIP URI, only the user element will be retained: any password (and any leading ":" before the password) MUST be removed, and since this userinfo necessarily does not contain a telephone-subscriber component, no further parameters can appear in the user portion.

The hostport portion of the SIP or SIPS URI MUST similarly be stripped of any trailing port along with the ":" that proceeds the port, leaving only the host.

The ABNF of this canonical URI form (following the syntax defined in RFC3261) is:

```
canon-uri =  ( "sip" / "sips" ) ":" user "@" host
```

Finally, the URI will be subject to syntax-based URI normalization procedures of [RFC3986] Section 6.2.2. Implementations MUST perform case normalization (rendering the scheme, user, and host all lowercase) and percent-encoding normalization (decoding any percent-encoded octet that corresponds to an unreserved character, per [RFC3986] Section 2.3). However, note that normalization procedures face known challenges in some internationalized environments (see [I-D.ietf-iri-comparison]) and that perfect normalization of URIs may not be possible in those environments.

For future PASSporT applications, it may be desirable to provide an identifier without an attached protocol scheme. Future specifications that define PASSporT claims for SIP as a using protocol could use these basic procedures, but eliminate the scheme component. A more exact definition is left to future specifications.

9. Extensibility

As future requirements may warrant increasing the scope of the Identity mechanism, this specification specifies an optional "ppt" parameter of the Identity header field, which mirrors the "ppt" header in PASSporT. The "ppt" parameter value MUST consist of a token containing an extension specification, which denotes an extended set of one or more signed claims per the type extensibility mechanism specified in [I-D.ietf-stir-passport] Section 8. Note that per the guidance in that section, "ppt" is used only to enforce a mandatory extension: optional claims may be added to any PASSporT object without requiring the use of "ppt", but the compact form of PASSporT MUST NOT be used when optional claims are present in the PASSporT payload.

The potential for extensions is one the primary motivations for allowing the presence of multiple Identity header fields in the same SIP request. It is envisioned that future extensions might allow for alternate information to be signed, or to explicitly allow different parties to provide the signatures than the authorities envisioned by baseline STIR. A request might, for example, have one Identity added by an authentication service at the originating administrative domain, and then another Identity header field added by some further intermediary using a PASSporT extension. While this specification does not define any such specific purpose for multiple Identity header fields, implementations MUST support receiving multiple header fields for future compatibility reasons.

An authentication service cannot assume that verifiers will understand any given extension. Verifiers that do support an extension may then trigger appropriate application-level behavior in the presence of an extension; authors of extensions should provide appropriate extension-specific guidance to application developers on this point.

10. Backwards Compatibility with RFC4474

This specification introduces several significant changes from the RFC4474 version of the Identity header field. However, due to the problems enumerated in [I-D.rosenberg-sip-rfc4474-concerns], it is not believed that the original Identity header field has seen any deployment, or even implementation in deployed products.

As such, this mechanism contains no provisions for signatures generated with this specification to work with RFC4474-compliant implementations, nor any related backwards-compatibility provisions. Hypothetically, were an RFC4474-compliant implementation to receive messages containing this revised version of the Identity header

field, it would likely fail the request with a 436 response code due to the absence of an Identity-Info header field. Implementations of this specification, for debugging purposes, might interpret a 436 with a reason phrase of "Bad Identity-Info" as an indication that the request has failed because it reached a (hypothetical) RFC4474-compliant verification service.

11. Privacy Considerations

The purpose of this mechanism is to provide a reliable identification of the originator of a SIP request, specifically a cryptographic assurance that an authority asserts the originator can claim the URI the identity stipulated in the request. This URI may contain or imply a variety of personally identifying information, including the name of a human being, their place of work or service provider, and possibly further details. The intrinsic privacy risks associated with that URI are, however, no different from those of baseline SIP. Per the guidance in [RFC6973], implementers should make users aware of the privacy trade-off of providing secure identity.

The identity mechanism presented in this document is compatible with the standard SIP practices for privacy described in [RFC3323]. A SIP proxy server can act both as a RFC3323 privacy service and as an authentication service. Since a user agent can provide any From header field value that the authentication service is willing to authorize, there is no reason why private SIP URIs that contain legitimate domains (e.g., sip:anonymous@example.com) cannot be signed by an authentication service. The construction of the Identity header field is the same for private URIs as it is for any other sort of URIs. Similar practices could be used to support opportunistic signing of SIP requests for UA-integrated authentication services with self-signed certificates, though that is outside the scope of this specification and is left as a matter for future investigation.

Note, however, that even when using anonymous SIP URIs, an authentication service must possess a certificate corresponding to the host portion of the addr-spec of the From header field value of the request; accordingly, using domains like ’anonymous.invalid’ will not be usable by privacy services that simultaneously act as authentication services. The assurance offered by the usage of anonymous URIs with a valid domain portion is "this is a known user in my domain that I have authenticated, but I am keeping its identity private".

It is worth noting two features of this more anonymous form of identity. One can eliminate any identifying information in a domain through the use of the domain ’anonymous.invalid," but we must then acknowledge that it is difficult for a domain to be both anonymous

and authenticated. The use of the "anonymous.invalid" domain entails that no corresponding authority for the domain can exist, and as a consequence, authentication service functions for that domain are meaningless. The second feature is more germane to the threats this document mitigates [RFC7375]. None of the relevant attacks, all of which rely on the attacker taking on the identity of a victim or hiding their identity using someone else's identity, are enabled by an anonymous identity. As such, the inability to assert an authority over an anonymous domain is irrelevant to our threat model.

[RFC3325] defines the "id" priv-value token, which is specific to the P-Asserted-Identity header field. The sort of assertion provided by the P-Asserted-Identity header field is very different from the Identity header field presented in this document. It contains additional information about the originator of a message that may go beyond what appears in the From header field; P-Asserted-Identity holds a definitive identity for the originator that is somehow known to a closed network of intermediaries. Presumably, that network will use this identity for billing or security purposes. The danger of this network-specific information leaking outside of the closed network motivated the "id" priv-value token. The "id" priv-value token has no implications for the Identity header field, and privacy services MUST NOT remove the Identity header field when a priv-value of "id" appears in a Privacy header field.

The full form of the PASSporT object provides the complete JSON objects used to generate the signed-identity-digest of the Identity header field value, including the canonicalized form of the telephone number of the originator of a call, if the signature is over a telephone number. In some contexts, local policy may require a canonicalization which differs substantially from the original From header field. Depending on those policies, potentially the full form of PASSporT might divulge information about the originating network or user that might not appear elsewhere in the SIP request. Were it to be used to reflect the contents of the P-Asserted-Identity header field, for example, then the object would need to be converted to the compact form when the P-Asserted-Identity header is removed to avoid any such leakage outside of a trust domain. Since, in those contexts, the canonical form of the originator's identity could not be reassembled by a verifier, and thus the Identity signature validation process would fail, using P-Asserted-Identity with the full form of PASSporT in this fashion is NOT RECOMMENDED outside of environments where SIP requests will never leave the trust domain. As a side note, history shows that closed networks never stay closed and one should design their implementation assuming connectivity to the broader Internet.

Finally, note that unlike [RFC3325], the mechanism described in this specification adds no information to SIP requests that has privacy implications - apart from disclosing that an authentication service is willing to sign for an originator.

12. Security Considerations

This document describes a mechanism that provides a signature over the Date header field of SIP requests, parts of the To and From header fields, and when present any media keying material in the message body. In general, the considerations related to the security of these header fields are the same as those given in [RFC3261] for including header fields in tunneled 'message/sip' MIME bodies (see Section 23 of RFC3261 in particular). The following section details the individual security properties obtained by including each of these header fields within the signature; collectively, this set of header fields provides the necessary properties to prevent impersonation. It addresses the solution-specific attacks against in-band solutions enumerated in [RFC7375] Section 4.1.

12.1. Protected Request Fields

The From header field value (in ordinary operations) indicates the identity of the originator of the message. The SIP address-of-record URI, or an embedded telephone number, in the From header field is the identity of a SIP user, for the purposes of this document. Note that in some deployments the identity of the originator may reside in P-Asserted-Id instead. The originator's identity is the key piece of information that this mechanism secures; the remainder of the signed parts of a SIP request are present to provide reference integrity and to prevent certain types of cut-and-paste attacks.

The Date header field value protects against cut-and-paste attacks, as described in [RFC3261], Section 23.4.2. That specification recommends that implementations notify the user of a potential security issue if the signed Date header field value is stale by an hour or more. To prevent cut-and-paste of recently-observed messages, this specification instead RECOMMENDS a shorter interval of sixty seconds. Implementations of this specification MUST NOT deem valid a request with an outdated Date header field. Note that per [RFC3893] Section 10 behavior, servers can keep state of recently received requests, and thus if an Identity header field is replayed by an attacker within the Date interval, verifiers can detect that it is spoofed because a message with an identical Date from the same source had recently been received.

It has been observed in the wild that some networks change the Date header field value of SIP requests in transit, and that alternative

behavior might be necessary to accommodate that use case. Verification services that observe a signature validation failure MAY therefore reconstruct the Date header field component of the signature from the "iat" carried in the full form of PASSporT: provided that time recorded by "iat" falls within the local policy for freshness that would ordinarily apply to the Date header, the verification service MAY treat the signature as valid, provided it keeps adequate state to detect recent replays. Note that this will require the inclusion of the full form of the PASSporT object by authentication services in networks where such failures are observed.

The To header field value provides the identity of the SIP user that this request originally targeted. Covering the identity in the To header field with the Identity signature serves two purposes. First, it prevents cut-and-paste attacks in which an Identity header field from a legitimate request for one user is cut-and-pasted into a request for a different user. Second, it preserves the starting URI scheme of the request, which helps prevent downgrade attacks against the use of SIPS. The To identity offers additional protection against cut-and-paste attacks beyond the Date header field. For example, without a signature over the To identity, an attacker who receives a call from a target could immediately cut-and-paste the Identity and From header field value from that INVITE into a new request to the target’s voicemail service within the Date interval, and the voicemail service would have no way knowing that the Identity header field it received had been originally signed for a call intended for a different number. However, note the caveats below in Section 12.1.1.

When signing a request that contains a fingerprint of keying material in SDP for DTLS-SRTP [RFC5763], this mechanism always provides a signature over that fingerprint. This signature prevents certain classes of impersonation attacks in which an attacker forwards or cut-and-pastes a legitimate request. Although the target of the attack may accept the request, the attacker will be unable to exchange media with the target as they will not possess a key corresponding to the fingerprint. For example, there are some baiting attacks, launched with the REFER method or through social engineering, where the attacker receives a request from the target and reoriginates it to a third party. These might not be prevented by only a signature over the From, To and Date, but could be prevented by securing a fingerprint for DTLS-SRTP. While this is a different form of impersonation than is commonly used for robocalling, ultimately there is little purpose in establishing the identity of the user that originated a SIP request if this assurance is not coupled with a comparable assurance over the contents of the subsequent media communication. This signature also reduces the potential for active eavesdropping attacks against the SIP media. In

environments where DTLS-SRTP is unsupported, however, no field is signed and no protections are provided.

12.1.1. Protection of the To Header and Retargeting

Armed with the original value of the To header field, the recipient of a request may be tempted compare it to their own identity in order to determine whether or not the identity information in this call might have been replayed. However, any request may be legitimately retargeted as well, and as a result legitimate requests may reach a SIP endpoint whose user is not identified by the URI designated in the To header field value. It is therefore difficult for any verifier to decide whether or not some prior retargeting was "legitimate." Retargeting can also cause confusion when identity information is provided for requests sent in the backwards direction in a dialog, as the dialog identifiers may not match credentials held by the ultimate target of the dialog. For further information on the problems of response identity see [I-D.peterson-sipping-retarget].

Any means for authentication services or verifiers to anticipate retargeting is outside the scope of this document, and likely to have equal applicability to response identity as it does to requests in the backwards direction within a dialog. Consequently, no special guidance is given for implementers here regarding the 'connected party' problem (see [RFC4916]); authentication service behavior is unchanged if retargeting has occurred for a dialog-forming request. Ultimately, the authentication service provides an Identity header field for requests in the dialog only when the user is authorized to assert the identity given in the From header field, and if they are not, an Identity header field is not provided. And per the threat model of [RFC7375], resolving problems with 'connected' identity has little bearing on detecting robocalling or related impersonation attacks.

12.2. Unprotected Request Fields

RFC4474 originally had protections for the Contact, Call-ID and CSeq. These are removed from RFC4474bis. The absence of these header field values creates some opportunities for determined attackers to impersonate based on cut-and-paste attacks; however, the absence of these header field values does not seem impactful to preventing the simple unauthorized claiming of an identity for the purposes of robocalling, voicemail hacking, or swatting, which is the primary scope of the current document.

It might seem attractive to provide a signature over some of the information present in the Via header field value(s). For example, without a signature over the sent-by field of the topmost Via header

field, an attacker could remove that Via header field and insert its own in a cut-and-paste attack, which would cause all responses to the request to be routed to a host of the attacker's choosing. However, a signature over the topmost Via header field does not prevent attacks of this nature, since the attacker could leave the topmost Via intact and merely insert a new Via header field directly after it, which would cause responses to be routed to the attacker's host "on their way" to the valid host, which has exactly the same end result. Although it is possible that an intermediary-based authentication service could guarantee that no Via hops are inserted between the sending user agent and the authentication service, it could not prevent an attacker from adding a Via hop after the authentication service, and thereby preempting responses. It is necessary for the proper operation of SIP for subsequent intermediaries to be capable of inserting such Via header fields, and thus it cannot be prevented. As such, though it is desirable, securing Via is not possible through the sort of identity mechanism described in this document; the best known practice for securing Via is the use of SIPS.

12.3. Malicious Removal of Identity Headers

In the end analysis, the Identity header field cannot protect itself. Any attacker could remove the header field from a SIP request, and modify the request arbitrarily afterwards. However, this mechanism is not intended to protect requests from men-in-the-middle who interfere with SIP messages; it is intended only to provide a way that the originators of SIP requests can prove that they are who they claim to be. At best, by stripping identity information from a request, a man-in-the-middle could make it impossible to distinguish any illegitimate messages he would like to send from those messages sent by an authorized user. However, it requires a considerably greater amount of energy to mount such an attack than it does to mount trivial impersonations by just copying someone else's From header field. This mechanism provides a way that an authorized user can provide a definitive assurance of his identity that an unauthorized user, an impersonator, cannot.

12.4. Securing the Connection to the Authentication Service

In the absence of user agent-based authentication services, the assurance provided by this mechanism is strongest when a user agent forms a direct connection, preferably one secured by TLS, to an intermediary-based authentication service. The reasons for this are twofold:

If a user does not receive a certificate from the authentication service over the TLS connection that corresponds to the expected

domain (especially when the user receives a challenge via a mechanism such as Digest), then it is possible that a rogue server is attempting to pose as an authentication service for a domain that it does not control, possibly in an attempt to collect shared secrets for that domain. A similar practice could be used for telephone numbers, though the application of certificates for telephone numbers to TLS is left as a matter for future study.

Without TLS, the various header field values and the body of the request will not have integrity protection when the request arrives at an authentication service. Accordingly, a prior legitimate or illegitimate intermediary could modify the message arbitrarily.

Of these two concerns, the first is most material to the intended scope of this mechanism. This mechanism is intended to prevent impersonation attacks, not man-in-the-middle attacks; integrity over parts of the header and body is provided by this mechanism only to prevent replay attacks. However, it is possible that applications relying on the presence of the Identity header field could leverage this integrity protection for services other than replay protection.

Accordingly, direct TLS connections SHOULD be used between the UAC and the authentication service whenever possible. The opportunistic nature of this mechanism, however, makes it very difficult to constrain UAC behavior, and moreover there will be some deployment architectures where a direct connection is simply infeasible and the UAC cannot act as an authentication service itself. Accordingly, when a direct connection and TLS are not possible, a UAC should use the SIPS mechanism, Digest 'auth-int' for body integrity, or both when it can. The ultimate decision to add an Identity header field to a request lies with the authentication service, of course; domain policy must identify those cases where the UAC's security association with the authentication service is too weak.

12.5. Authorization and Transitional Strategies

Ultimately, the worth of an assurance provided by an Identity header field is limited by the security practices of the authentication service that issues the assurance. Relying on an Identity header field generated by a remote administrative domain assumes that the issuing domain uses recommended administrative practices to authenticate its users. However, it is possible that some authentication services will implement policies that effectively make users unaccountable (e.g., ones that accept unauthenticated registrations from arbitrary users). The value of an Identity header field from such authentication services is questionable. While there is no magic way for a verifier to distinguish "good" from "bad"

signers by inspecting a SIP request, it is expected that further work in authorization practices could be built on top of this identity solution; without such an identity solution, many promising approaches to authorization policy are impossible. That much said, it is RECOMMENDED that authentication services based on proxy servers employ strong authentication practices.

One cannot expect the Identity header field to be supported by every SIP entity overnight. This leaves the verifier in a compromising position; when it receives a request from a given SIP user, how can it know whether or not the originator's domain supports Identity? In the absence of ubiquitous support for identity, some transitional strategies are necessary.

A verifier could remember when it receives a request from a domain or telephone number that uses Identity, and in the future, view messages received from that source without an Identity header field with skepticism.

A verifier could consult some sort of directory that indicates whether a given caller should have a signed identity. There are a number of potential ways in which this could be implemented. This is left as a subject for future work.

In the long term, some sort of identity mechanism, either the one documented in this specification or a successor, must become mandatory-to-use for the SIP protocol; that is the only way to guarantee that this protection can always be expected by verifiers.

Finally, it is worth noting that the presence or absence of the Identity header fields cannot be the sole factor in making an authorization decision. Permissions might be granted to a message on the basis of the specific verified Identity or really on any other aspect of a SIP request. Authorization policies are outside the scope of this specification, but this specification advises any future authorization work not to assume that messages with valid Identity header fields are always good.

12.6. Display-Names and Identity

As a matter of interface design, SIP user agents might render the display-name portion of the From header field of a caller as the identity of the caller; there is a significant precedent in email user interfaces for this practice. Securing the display-name component of the From header field value is outside the scope of this document, but may be the subject of future work, such as through the "ppt" name mechanism.

In the absence of signing the display-name, authentication services might check and validate it, and compare it to a list of acceptable display-names that may be used by the originator; if the display-name does not meet policy constraints, the authentication service could return a 403 response code. In this case, the reason phrase should indicate the nature of the problem; for example, "Inappropriate Display Name". However, the display-name is not always present, and in many environments the requisite operational procedures for display-name validation may not exist, so no normative guidance is given here.

13. IANA Considerations

This document contains a number of actions for IANA. Primarily, the previous references to RFC4474 in the sip-parameters registry should, unless specified otherwise below, be updated to point to [RFCthis].

13.1. SIP Header Fields

The Identity-Info header in the SIP Header Fields registry should be marked as deprecated by [RFCThis].

Also, the Identity-Info header reserved the compact form "n" at its time of registration. Please remove that compact form from the registry. The Identity header however retains the compact form "y" reserved by RFC4474.

13.2. SIP Response Codes

The Reason phrase for the 436 response default reason phrase should be changed from "Bad Identity-Info" to "Bad Identity Info" in the SIP Response Code registry.

The 437 "Unsupported Certificate" default reason phrase should be changed to "Unsupported Credential".

13.3. Identity-Info Parameters

The IANA manages a registry for Identity-Info parameters. The specification asks the IANA to change the name of this registry to "Identity Parameters".

This specification defines one new value for the registry: "info" as defined in this specification in Section 7.3.

13.4. Identity-Info Algorithm Parameter Values

This IANA manages an Identity-Info Algorithm Parameter Values registry which this specification deprecates. We request that the IANA deprecate and close this registry. Since the algorithms for signing PASSporTs are defined in [I-D.ietf-stir-passport] rather than in this specification, there is no longer a need for an algorithm parameter registry for the Identity header field.

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15. Changes from RFC4474

The following are salient changes from the original RFC 4474:

Generalized the credential mechanism; credential enrollment, acquisition and trust is now outside the scope of this document

Reduced the scope of the Identity signature to remove CSeq, Call-ID, Contact, and the message body; signing of key fingerprints in SDP is now included

Deprecated the Identity-Info header field and relocated its components into parameters of the Identity header field (which obsoletes the previous version of the header field)

The Identity header field can now appear multiple times in one request

Replaced previous signed-identity-digest format with PASSporT (signing algorithms now defined in a separate specification)

Revised status code descriptions

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